ista 2008

the 21st annual congress of
the international society for technology in arthroplasty

october 1 - 4, 2008
hotel shilla, seoul, korea
BIOCERAMICS AND ALTERNATIVE BEARINGS IN JOINT ARTHROPLASTY

The 13th International BIOLOX® Symposium

September 4th – 5th 2009
Marriott® Dalmahoy Hotel & Country Club, Edinburgh, United Kingdom
President Justin P. Cobb (Imperial College London)

Important Dates

Submission of Abstracts: 15th January 2009
Acceptance of Abstracts: 15th February 2009
Delivery of final manuscripts: 15th May 2009

Topics of the Symposium

Session 1: Ceramic Materials in THA
Session 2: Clinical Experience with Ceramics
Session 3: Tribology
Session 4: In Vivo and in Vitro Performance of different Bearing Couples in THA
Session 5: Complications and Revision Strategy
Session 6: Tips and Tricks
Session 7: Knee and other applications
Session 8: Free papers

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ISTA2008
The 21st Annual Congress of the International Society for Technology in Arthroplasty

Abstracts Book

October 1 - 4, 2008
Hotel Shilla, Seoul, Korea
Dear Colleagues,

Welcome to ISTA 2008 Seoul Congress!

ISTA is the only scientific orthopaedic society dedicated to the idea of providing a constructive environment for surgeons, scientists, engineers and representatives of industry to come together and share their work and knowledge.

The goal of this meeting are to promote advances in the science and technology of joint replacement as well as international friendship between arthroplasty professionals.

This abstracts book are sorted by key-note lectures and symposia handout followed by podium and poster abstracts, sponsored lectures and comprise some of the most exciting topics presented at the ISTA 2008 Seoul Congress. We hope that exchange of information during meeting can contribute to development of advanced technologies for the future arthroplasty.

We wish to thank all participants, who have generously devoted their time and efforts to take part in the ISTA 2008 Seoul Congress.

Sincerely yours,

Chairs of the organizing committee for ISTA 2008
Chang-Dong Han, Yong-San Yoon, and Won-Yong Shon
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Korean Foot and Ankle Society
Spine Arthroplasty Society Korea
# Program at a Glance

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Keynote Lecture
Wear of High Performance Bearings in the Hip
Influence of Material, Head Size and Component Position

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Young and active patients require bearing materials that can last up to 200 million walking steps, ten fold greater than conventional polyethylene bearings. Cross linked polyethylene provides reduced wear rate compared to conventional polyethylene, and further advantage is gained from using ceramic femoral heads. However in polyethylene bearings wear increases with the head diameter, and there is currently little opportunity to use head sizes greater than 36mm diameter. There is evidence of polyethylene fracture with steeply positioned cups. Ceramic on ceramic bearings provide substantially lower wear rates than polyethylene bearings. Steep cups, lateralised heads or neck impingement can lead to head contact on superior rim of the cup and stripe wear, but this still results in very low wear rates. Recently developed ceramic matrix composites Biolox Delta provide greater resistance to stripe wear. In a few patients stripe wear may lead to squeaking. Metal on metal bearings also provide substantially lower wear than polyethylene bearings. However there remains concern about elevated metal ion levels in a few patients and resultant risk of hypersensitivity reactions. In metal on metal bearings larger head sizes and reduced diametrical clearance can lead to reduced wear. Increased wear is associated with steep cups and lateralised heads resulting in rim wear. Ceramic on metal bearings have been introduced recently as the first differential hard on hard bearings. These bearings show substantial reduction in wear, corrosive wear mechanisms, metal ion levels in laboratory simulators and initial clinical studies have shown a reduction in metal ion levels in vivo compared to metal on metal bearings.
Alumina-on-Alumina THA; What We Learn from more than 10 Year Experiences

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Investigation performed at the Department of Orthopaedic Surgery,
Seoul National University College of Medicine, Seoul, Korea

Background: Ceramic-on-ceramic couplings are an attractive alternative bearing surfaces to eliminate or reduce problems related to polyethylene wear debris. Past disappointing experiences with alumina ceramic bearings have led to many improvements in the manufacture and the design of ceramic implants. The purpose of this study was to report the results of contemporary alumina-on-alumina total hip arthroplasties (THAs) with regard to wear, osteolysis, and fracture of the ceramic after a 10-year minimum follow-up.

Methods: We evaluated the results of a series of 66 primary alumina-on-alumina THAs with a metal-backed socket and a cementless stem in 59 patients. All of the patients were 64 years old or younger (mean, 42 years), and a single surgeon performed all of the procedures. They were evaluated clinically and radiographically at the 120 to 126 months follow-up (average, 123 months). During the follow-up, special regards were addressed to wear, periprosthetic osteolysis and ceramic failure.

Results: During the follow-up period, two patients (two hips) had died with the prosthesis in situ as the result of an unrelated medical condition. The mean Harris hip score was 94 points at the latest follow-up evaluation. All of the prostheses had radiographic evidence of a bone ingrowth. No implant was loosened radiographically and no implant was revised. Ceramic wear was not detectable in the 28 hips where differentiation of the femoral head from the cup was possible on radiographs. Periprosthetic osteolysis was observed in no hip. A fracture of the alumina femoral head and a peripheral chip fracture of the alumina insert occurred in one hip following a major motor vehicle accident. A periprosthetic femoral fracture, which required open reduction and internal fixation with metal cables, had occurred in one hip. This fracture healed without problem.

Conclusion: The results of contemporary alumina-on-alumina THAs with a metal-backed socket and a cementless stem were encouraging after a minimum follow up of 10 years. We believe that these improved alumina-on-alumina bearing implants offer a promising option for younger active patients.

Level of Evidence: Therapeutic study, Level IV
Introduction: Shoulder surface replacement arthroplasty has been established for several decades as a mean to restore comfort and function of the shoulder for many afflictions that derange the normal anatomy. The surface replacement may offer some advantages over the stemmed prostheses.

Purpose: The purpose of the study was to evaluate the clinical and radiological result of Copeland cementless surface replacement arthroplasty (CSRA) applied in patients with a degenerative arthritis.

Patients and Methods: The study was conducted on 76 patients with degenerative joint disease of the shoulder that were operated on between 1999 and 2006. The patients were prospectively followed up clinically and radiologically for a mean of 26.2 months (range, 9-80 months). There were 41 female and 35 male shoulders. The mean age was 64.4 years (range, 54-86). The mean operative time was 42 minutes (range, 27-62 minutes). The clinical assessment was performed with the Constant score.

Results: The constant score significantly improved from a mean of 16.32 points preoperatively to 68.72 points postoperatively. The average pain score increased from 0.2 points to 10.2 points. The average ROM score increased from 9.22 points to 24.73 points. The humeral offset increased from 24.2 mm to 29.2 mm.

Conclusion: The shoulder surface replacement arthroplasty shows good mid-term results in patients with degenerative shoulder disease.
Histological Studies on Bone / Bone Cement Interface Retrieved 4 to 21 Years after Cemented THA with HA (IBBC)

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Introduction: Since 1984, we began to use Interface Bioactive Bone Cement (IBBC) technique by interposing osteoconductive and not resorbable crystalline HA granules of 0.3 to 0.6 mm in diameter between bone and bone cement at cementation during surgery. We expected super long term longevity of bone/bone cement bonding in IBBC technique.

Materials and Methods: Specimens were retrieved at the revision THA from the eight patients. They were operated for hip due to OA and RA. Revision THAs were done 4, 6, 8, 10, 13, 14, 18, 19 and 21 years after primary THA due to separation of polyethylene cup with metal-back from the bone cement, late infection and ceramic cup breakage. The specimens were obtained in bloc to keep the bone cement-HA granules-bone interface intact. Non-decalcified specimens were cut perpendicular to the interface and were stained by Toluidine blue. They were investigated by an optical microscopy.

Result: Cancellous bone entered into the space of HA granules from the cancellous bone base and cortical bone entered into the space of HA granules from the cortical bone base. When several layers of HA granules were smeared densely on the bone, bone ingrowth into the spaces of HA granules was obvious and thick bone layer with HA granules directly contacted to the bone cement. When HA granules were smeared sparsely even if several layer of HA granules were smeared, bone ingrowth into the spaces of HA granules was not dense. Even if one layer of HA granules was smeared sparsely, bone formation was seen around the HA. Through out 4 to 21 years bone ingrowth into the spaces of HA granules was the same at the interface of bone/bone cement. However, at the area existing no HA granule, bone formation at the interface of bone/bone cement decreased after the onset of osteoporosis due to aging.

Discussion: When HA granules were smeared in several layers and densely, thick bone layer with HA granules directly contacted to the bone cement even after 21 years after surgery and after onset of osteoporosis due to aging. As previously reported, the appearance rate of radiolucent line on the radiograph was extremely low even 21 years after surgery. Form these clinical results long term longevity over 30 to 40 years could be expected.
Results of Hip Resurfacing Arthroplasty (HRA) in Patients with Osteonecrosis of the Femoral Head

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Although total hip arthroplasty (THA) is quite predictable and durable in older patients, young and active patients have higher rates of revision and these rates are especially increased when the etiology is osteonecrosis. Recent advancement of hip resurfacing technology, HRA has been revived again. Numerous advantages and promising results of HRA have been published. But patient selection and techniques etc still remain issues for HRA in general and especially for patients with osteonecrosis. In the case of HRA in patients with osteoarthritis, the bone quality is stronger and there is no head necrosis and surgical techniques are fundamentally different when compared to osteonecrosis. In osteonecrosis, there is a higher risk and greater concern of the neck fracture due to necrosis and osteoporosis, insecure fixations as well as a progression of necrosis in the subchondral bone. These factors should be considered when assessing hips with osteonecrosis. The ultimate assessment is the condition of the prepared femoral head. This makes resurfacing arthroplasty for osteonecrosis a challenging procedure.

This study was performed to assess the overall clinical and radiological results of the total resurfacing arthroplasty for the patients with osteonecrosis of the femoral head (ONFH) after a minimum 5 year-follow-up. 444 hips of ONFH received resurfacing arthroplasty from Sep 1998 to Mar 2008. 88 hips which were followed up minimally 5 years were included in this study.

Among 88 hips (79 patients) of ONFH that have undergone hip resurfacing arthroplasties from Dec 1998 to Apr 2003, 85 hips (76 patients) were available for the complete study. The mean age at the time of operation was 37 (16-67) years old. The average follow-up period was 80 (60-112) months. The patients were clinically evaluated with the Harris hip score, hip or thigh pain, limb length discrepancy and range of motion. As a radiological evaluation, we observed the changes of implant position, patterns of bone remodeling in the neck and complications such as femoral neck fracture, loosening and osteolysis. Metal ion in the serum was also analysed.

The Harris hip score increased from 77.8 preoperatively to 98.4 at the final visit. Hip abduction/adduction and rotations significantly improved after the operation. Flexion contracture disappeared and further flexion also returned to almost normal. No patient complained of limb length discrepancy and pain on the hip or thigh at the last visit. Although they are not related to the clinical result, some cases showed various types of radiographic changes in the neck of the proximal femur. Neck narrowing was observed in 3 hips. There was no detectable wear or change of position of the acetabular cup and femoral stem.

Our experience with resurfacing arthroplasty in osteonecrosis of the femoral head indicates that the overall results are superior to conventional THA in the aspect of pain relief, the range of hip motion, earlier rehabilitation and earlier return to preoperative activity. This procedure of his resurfacing arthroplasty could be an alternative between joint preserving procedures and THA in the case of early-to-mid staged osteonecrosis of the femoral head especially in younger patients who need arthroplasty. Extent and location of necrosis, and bone quality are the most important factors in resurfacing arthroplasty in osteonecrosis. Precise preoperative planning and meticulous surgical technique is needed to perform resurfacing arthroplasty. But long-term studies are needed to determine the survivorship and to evaluate the metal toxicity after resurfacing arthroplasty.
Sixty primary hip arthroplasties were performed in Crowe grade 2 to 4 hip dysplasia since 1973 using a modified transtrochanteric osteotomy which is reliable short cut to reach down the lateral aspect of the greater trochanter. Our hypothesis consists of the adaptability of Thomas test to show the reducibility of the dislocation in the coronal plane. In practice, if the dynamic potential while abduction and flexion exceeds from the 90° to coronal plane, the femoral head slips down to the acetabulum through poor sciatic notch. Thereby led to Protrusio acetabuli which implicative compromised capsular insufficiency but assessment of outcome study has been improved.

The results have been reasonably acceptable, with the longest follow-up greater than 35 years. We confirmed that the frog leg lateral radiography is effective for determining the operative indication of high riding dislocation of the DDH. However irreducible frog leg lateral position is absolutely contraindicated in these situation. We also aware of not only the complexity in abductor length but abundant amount of vastus lateralis when reattaching the trochanter, which may arises against stability of the abductors and vastus lateralis in continuity.
Femoral revision is frequent, due to femoral loosening, thigh pain, recurrent dislocation, osteolysis or sepsis. Whatever the reason, with the exception of some difficult septic cases, our strategic approach is similar. Some of our expertise concern femoral stem retrieval. Our reconstruction strategy is different if we are revising total hip in active and young patient or if it is an old and inactive one.

First step is always an large “en bloc” tissue excision. For old and inactive, it is sometimes possible to retain the stem if not loosed and perform a “in cement” cementation; In this group we select usually metal or alumina on polyethylene couple and cemented implants; In young and active, we select alumina on alumina combination which resumed in cementless acetabular fixation, and cementless or cemented stem.

Stem retrieval of a well fixed cementless stem is performed via a large transtrochanteric approach associated with a transfemoral one. Repair is performed using cerclage and long cemented stem.

Cement retrieval is performed since 9 years using Ultra sound (Oscar*) material, which in our hand is very successful specially for cement retractor retrieval. Then medullary canal is reamed in order to get a bloody healthy bone receive either a cemented or sometimes a cementless stem, depending on the bone quality.

To compensate femoral bone destruction and enhance cemented stem fixation, we used a modified Ling technique replacing allogenic morcelised bone by hydroxyapatite granules. Granules of 5 mm in diameter are made of 70% HA and 30% of TCP. Mechanical resistance is excellent and biological activity is high. Thus stem stability can be obtained easily. This can be done either with a cemented or a cementless stem (about 60 cases).

In case of very severe bone loss and osteolysis, we performed massive allogenic bone transplant associated with long cemented stem and distal HA granules with cement (17 cases).

As we usually performed one stage revision for septic cases, strategy is not different; It is only in selected cases with many sepsis recurrence and specially aggressive bacteria that we performed a two stage procedure.
Imaging Technologies for Quantifying Bone and Arthroplasty Kinematics in vivo

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Kinematics of human joints have been studied using various methods of observation for millennia, including cadaver dissection, mechanical tests, and more recently photogrammetric gait analysis. For just over sixteen years, dynamic single-plane radiographic observations have been used to quantitatively characterize the motions of anatomic and prosthetically replaced joints. These observations have improved the understanding, in particular, of knee function and the influence of prosthetic design and surgical technique on knee kinematics and patient function. Other studies have reported the kinematics of the hip, shoulder, spine and foot/ankle. It is clear that advances in the technologies to acquire and quantify radiographic images of the skeleton in motion can have a major impact on joint mechanics research and, ultimately, clinical diagnosis. This lecture will highlight two avenues of development in our laboratory: open-source software for determining skeletal kinematics from radiographic images, and a novel robotic imaging platform for observing the skeleton in motion.

Our group is working on an open-source shape-matching software application that will be freely available to anyone who wishes to use it (sourceforge.net/projects/jointtrack/). This flexible platform will allow the modular addition of new capabilities as plug-in components written in a wide range of languages (C++, Python, Java, etc.), and makes heavy use of other open-source and public libraries (I.C.E., OpenGL, VTK, ITK). All of our future developments will use this platform so that the latest results will be available to all, and hopefully other users will share their advances collaboratively. We currently have created a graphical user interface for performing single-plane model-image registration (Figure 1), and are currently working to expand this to handle bi-plane imaging.

We also are developing a robotic platform to permit radiographic imaging of human joints during normal, unrestricted, dynamic activities (Figure 2). This platform will move the x-ray source and sensor in response to the patient’s unconstrained motion, providing views with greater diagnostic potential than are acquired with fixed or c-arm imaging systems. This same imaging platform will also provide an extremely flexible platform for cone-beam tomography, so that a single system will be able to perform all imaging functions required for skeletal model-image registration based kinematic measurements.

The goal of these endeavors is to advance the possibility that dynamic radiographic analysis of joint motion will soon be a useful, accurate, and routine diagnostic and measurement tool available to enhance the efforts of orthopaedic surgeons in the treatment of their patients.
Meniscectomy, induces osteoarthritis. Options for repair of a damaged meniscus are an allograft meniscus, an implant made of natural scaffold materials (the collagen meniscus implant; CMI) or an implant made of polymers. Allograft menisci and the CMI are already clinically used for a considerable number of years. In this educational lecture the focus is on a comparison between the three implant types and the status of a tissue-engineered meniscus. The allograft meniscus is already used for at least ten years. It is intended for the younger patient with a previous total meniscectomy, with moderate cartilage degeneration and with a good alignment of the knee. The clinical outcome is based on function and pain scores. In this lecture the functional scores, the survival rate and the histology of allograft menisci will be highlighted.

The CMI meniscus implant is intended for a different patient group. To enable implantation of the CMI the rim of the native meniscus should be intact. Patient series that should demonstrate the efficacy of this type of implant are still small and are mainly of the inventors of the implant. In general patients tolerated the implant well. Tissue ingrowth and remodelling into a fibro-cartilaginous tissue was found in animals and patients.

Polymers may be a good alternative for the allograft and CMI implant. Previously they were used to guide vascularized new repair tissue through an ingrowth channel to the avascular lesion. We developed a porous polymer meniscus scaffold with properties to allow tissue infiltration and regeneration of a neomeniscus. It was implanted in dog knees and compared with total meniscectomy. The tissue infiltration and redifferentiation in the scaffold, the stiffness of the scaffold, and the articular cartilage degeneration were evaluated.

Three months after implantation, the implant was completely filled with fibrovascular tissue. After 6 months, the central areas of the implant contained cartilage-like tissue with abundant collagen type II and proteoglycans in their matrix. The foreign-body reaction remained limited to a few giant cells in the implant. The compression modulus of the implant-tissue construct still differed significantly from that of the native meniscus, even at 6 months. Cartilage degeneration was observed both in the meniscectomy group and in the implant group.

The improved properties of these polymer implants resulted in a faster tissue infiltration and in phenotypical differentiation into tissue resembling that of the native meniscus. However, the material characteristics of the implant need to be improved to prevent degeneration of the articular cartilage.
Management of Osteolysis after Total Knee Replacement

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Periprosthetic osteolysis following total knee replacement is a well recognized intermediate to long term complication. Over the last four decades, the prevalence of osteolysis following total knee replacement has increased. Development of periprosthetic osteolysis after knee replacement surgery is related to three factors, generation of wear debris, access of that debris to bone, and the biologic reaction to the wear debris. Although more common in association with loose components, osteolysis can occur with stable cementless implants and less commonly stable cemented implants.

Polyethylene particles have been isolated from tissue around failed total knee replacements. When compared to total hip replacements, polyethylene wear particles from knee replacements are larger. However, the majority of particles are still less than one micron in size and are biologically active. Several important factors impact polyethylene wear. The polyethylene itself is one of the most important variables. Research over the past decade has demonstrated the importance of manufacturing technique, sterilization methods, packaging and shelf life on wear performance. It is now known that polyethylene sterilized with gamma radiation and stored in oxygen with a long shelf life is associated with higher prevalence of osteolysis. Oxidized polyethylene has a lower resistance to wear thus increasing the particle load.

Modularity has been associated with a higher prevalence of osteolysis most likely because it can result in a higher particle load from backside wear. One study compared the prevalence of osteolysis with all polyethylene tibial components and modular tibial components. At comparable follow-up, none of the patients with all polyethylene tibial components developed osteolysis. In contrast, 18% of the patients with modular tibial baseplates developed peri-prosthetic osteolysis. Although there was a bias in favor of the all polyethylene components since they had been implanted in lower demand patients, this study suggests that backside wear is a clinically important source of biologically important wear particles. The stability of the tibial insert locking mechanisms impacts backside wear.

Excessive motion can accelerate backside wear and result in the generation of both polyethylene and metallic particles. Knee implant design has attempted to improve the effectiveness of tibial locking mechanisms to decrease backside motion and thus wear debris generation. Mobile bearing designs address this issue by using polished cobalt chrome tibial base plates to minimize the debris generation between the insert and base plate. It is unclear whether the total particle load is less with a mobile bearing design compared to a modular fixed bearing design with a well-designed insert lock detail.

Technical issues that affect knee alignment and ligament balancing can impact wear. Perfect alignment is difficult to achieve. Slight malalignment may not represent a functional problem for the patient, but can result in increased stresses in the polyethylene and potentially accelerate wear. Ligament balancing and implant design act in concert to dictate knee stability. A tight flexion gap most commonly associated with under release of the posterior cruciate in cruciate retaining knee designs, can lead to accelerated polyethylene wear postero-medially. Patients with a loose flexion gap and minimally conforming implants are prone to increase anterior-posterior translation of the femur on the tibia during gait, so called “paradoxical motion.” Translation of the femur on the tibia increases shear stresses in the polyethylene and may accelerate wear.

Finally, the patients who undergo total knee replacement have changed dramatically over that time period. Many total knee replacements patients today expect to return to active lives. Higher activity creates greater wear volume that in turn increases the likelihood of osteolysis. A study from Charlotte, North Caroline documented the multi-factorial nature of osteolysis. Of the 1287 Press-Fit Condylar knees with more than five year follow-up, 8.3% had a wear related failure. Cox hazard analysis demonstrated five factors that correlated with a wear related failure. These included patient age, patient gender, polyethylene shelf life, polyethylene finishing method and polyethylene sheet vendor. This study emphasized the fact that relatively small changes in polyethylene manufacturing can have a significant effect on wear. It should also be noted that these inserts were gamma sterilized in air and the results cannot be generalized to implants sterilized by other methods.

Access to the implant bone interface and peri-prosthetic bone is affected by implant design and surgical technique. In general, access to bone is more of an issue with cementless components compared to cemented components. Wear debris can gain access to periprosthetic bone through screw holes in the tibial baseplate and regions of the implant bone interface that lack bone ingrowth. Incomplete porous coatings also provide an access channel for wear debris. So called “hybrid cemented technique” for tibial implantation may increase the risk of wear debris access to the proximal tibia. In one study, hybrid cementing was associated with a high rate of tibial osteolysis and loosening.

Although polyethylene wear is the driving force in the development of periprosthetic osteolysis after total knee replacement, because of the complex geometry of knee implants, measurement of polyethylene wear in knee is difficult. As a result, the first radiographic sign of significant wear may in fact be osteolysis. The complex geometry of knee implants and the distal femur and proximal tibia can make recognition and quantitation of osteolysis difficult. Periprosthetic after total knee replacement occurs in the cancellous bone of the distal femur and proximal tibia. Not only do the implants obscure the bone, but since cancellous bone is less radiodense bone loss is less obvious. The posterior aspect of the femoral condyles and the medial femoral condyle under the medial collateral ligament are areas that appear...
to be prone to the development of osteolysis especially with cementless femoral components. Oblique radiographs are sometimes helpful in evaluating the posterior femoral condyles. Radiographs typically underestimate osteolysis. Both CT and MRI have been used to more accurately quantitate lesion extent.

Little data exists to help the surgeon guide management of distal femoral or proximal tibial osteolysis at revision surgery. Although not always the case, osteolysis in association with cemented components is usually associated with a loose implant. The decision to revise is based on the degree of bone loss and the patient’s symptoms. In contrast, severe osteolysis can develop after cementless knee replacement in association with osseointegrated cementless components. Clinically, patients can remain asymptomatic despite extensive bone loss. Often however, osteolysis of the knee is associated with complaints of swelling or late instability. Wear particles can result in synovitis that results in an effusion. The synovitic process can effect knee stability especially with cruciate retaining implants as it can result in damage to the posterior cruciate ligament.

When there is osteolysis and the implants are well-fixed, the decision to operate is based on the degree of bone loss and patient symptoms. The decision to recommend revision surgery is more difficult in patients who are asymptomatic. In addition to the degree of bone loss, other factors to take into account include patient age and activity level, patient comorbidities and the risk for the development of a pathologic fracture. No objective data exists to guide optimal timing for surgical intervention.

When the implants are stable, the surgeon has a choice to graft the osteolytic lesion and exchange the tibial insert or revise the component. Again, there is very little data available to direct treatment. Insert exchange with impaction grafting of lytic lesions can be successful provided the implant is otherwise well aligned and the knee can be made ligamentously stable with a new insert. It is important to remember that the posterior cruciate ligament can be damaged as part of the synovitic process. As a result, a standard tibial insert may not be sufficient to provide stability. Although most knee systems offer a more constrained tibial insert for their cruciate retaining designs, the actual impact these more constrained inserts have on articular stability varies significantly between designs. Knees the had early wear related failure likely have technical or implant related factors that contributed to the failure process. In such cases, revision surgery should be considered. In contrast, patients who functioned well for many years and then had a wear related failure are reasonable candidates for an insert exchange provided the implants are well fixed.

Management of bone defects is performed using a combination of allograft bone chips and structural grafts as well as metal augments. In general defects at the level of the distal femur or proximal tibia can be managed with metal augments. Larger defects usually require grafting. Contained defects can be treated with impaction grafting of allograft bone chips. This can be performed in the presence of well fixed components. Commercially available bone substitute putties may be helpful in containing the intra-articular communication with the defect once it has been packed with bone chips. Non-contained defects are managed with structural allografts. Femoral heads usually suffice for management of these larger defects, although a distal femoral or proximal tibial allograft may be necessary in some cases. Tibial and femoral extension stems should be used when grafting has been performed to help stress protect the graft. Less commonly, patients with severe bone loss and associated collateral ligament loss will require a hinge prosthesis. In these cases, the bone defects can usually be managed with the implant and not require grafting.

We have recently reviewed our experience with management of large osteolytic defects at the time of revision knee replacement. Twenty-eight knees underwent revision TKA requiring surgical management of major osteolytic defects. Three groups of osteolytic defects were identified based upon the degree of implant stability and the magnitude of bone loss. Outcome measures included the KSCRS, visual analog pain score, and radiographs. At a mean follow-up of 48 months, the average knee pain scores, range of motion, and KSCRS improved (p<.05). Eighty-six percent demonstrated clinical and functional improvement and were satisfied with the outcome. Radiographs for 24 revision TKA’s demonstrated component stability and incorporation of both cancellous and structural allografts. Revision TKA for major osteolytic defects may be effectively performed using a variety of bone grafting techniques. Both morselized and structural bone grafting, in combination with stemmed components was successful in managing revision TKA in the setting of major osteolysis. Significant improvement in clinical and radiographic outcomes may be anticipated using these surgical techniques.
**Total Knee Arthroplasty in the Valgus Knee**

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**Purpose:** To analyze the clinical and radiographic results after TKA in the valgus knee.

**Materials and Methods:** Thirty six knees in 27 patients with a valgus alignment of more than 10 degrees of femorotibial angle underwent TKA. The average follow-up period was 7 years 2 months (1 year to 14 years 5 months). 18 (50%) knees were implanted with a cruciate retaining prosthesis, 17 (47.2%) knees with a posterior stabilized prosthesis, and one (2.8%) knee with a constrained condylar prosthesis. In knees with a preoperative 15 degrees or greater femorotibial angle, the posterior stabilized prostheses were necessary in 85%. Medial parapatellar approach was used in 27 knees with a preoperative valgus 20 degrees or lesser femorotibial angle. With 20 to 29 degrees valgus, medial parapatellar approach was used in 5 knees and lateral parapatellar approach in 2 knees. With 30 degrees or greater valgus, lateral parapatellar approach was used in 2 knees.

**Results:** The mean postoperative Hospital for Special Surgery knee scores were 89.5 points. Postoperative range of motion averaged 114.4 degrees. Postoperative alignment averaged 6.5 degrees valgus. Radiolucent line or loosening was not seen in any knee. There were 2 deep infection in patients whose preoperative femorotibial angle was greater than valgus 20 degrees using lateral parapatellar approach.

**Conclusion:** Clinical and functional results after TKA in valgus knee were similar to those in varus. But, prevention of deep infection in patients with marked valgus angle was important, especially using lateral parapatellar approach. Cruciate retaining, posterior stabilized and constrained condylar prostheses were used in our cases. A more constrained prosthesis was frequently used in more significant valgus deformity. Both medial and lateral parapatellar approaches were used in our cases. But, in severe valgus knee more than 30 degrees, lateral parapatellar approach was necessary.
HA Coated Femoral Components in Total Knee replacements

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Three hundred and fifty-eight Tri Con 2 total knee replacements were done between 1987 and 1993. There were three versions of the femoral component, smooth for cement, porous coated and HA coated. Fifty-nine died or were lost to follow-up within two years leaving 229 cases with a follow-up of between 2 and 17 years. Eighteen were cemented, 162 porous coated and 51 HA coated. No porous or cemented femoral components were revised. Three (5.9) HA components were. One was revised at 2 years for unexplained pain. Revision did not help. In 2 cases the tibia loosened. The HA femoral component was tight. There was significant femoral osteolysis. It was possible to knock off the femoral component fairly easily. Virtually no HA remained on the components. There was significant 3-body wear of the polyethylene.

The conclusions are that the advantage of an HA coating is that well-fixed femoral component can be knocked off with a simple application of force. This can never be done with a well fixed porous component. The disadvantage is that HA fixation does not seal against osteolysis. The incidence of 3-body wear is possibly increased and HA coating may have a finite life expectancy.
The Variables of Successful Long-Term Results of TKA

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Purpose of Study: To know how to succeed and survive for his or her whole life after the primary TKA by studying the causes of aseptic failure of the cruciate retaining type primary TKA.

Materials & Methods: One hundred and seventy nine cases of revision of the TKA were analyzed concerning the causes of failure. The longest follow-up period was 25 years. All cases of the immediate postoperative and pre-revision weight bearing x-rays were reviewed. The operative findings of the revision surgery were compared with the pre-revision x-rays and physical findings.

Results:
1. The incidence of wear of the tibial polyethylene insert was predominant.
2. The most severe disability before revision was instability and dislocation of the joint due to excessive eccentric wear of the posteromedial part of the tibial polyethylene insert.
3. All cases showed full ROM after primary TKA.
4. The causes of the failures could be classified as follows;
   1) Implant Design:
      (a) Flat surfaced tibial polyethylene insert could be related with an eccentric wear and a resultant instability.
      (b) Posterior pegs of the tibial base plate might be related with a stress fracture of the posteromedial part of tibial condyle, which ended up with an eventual fracture of the tibial base plate and dislocation of the tibial polyethylene insert.
      (c) The metal backed patella could cause early wear of the patellar polyethylene insert.
   2) Bone Cutting: The most common cause of the failure related with the bone cutting was insufficient valgus of the femorotibial angle, which was related with a wear of the medial side of the tibial polyethylene insert. Less than 5° of valgus could be related with an early wear of the tibial polyethylene insert.
   3) Soft tissue balance: Most important factors were insufficient medial release and tight PCL, which caused early wear of the posteromedial portion of the tibial polyethylene especially in high flexion knees.
   4) Fixation: All cases of loosening occurred in cases of cementless TKA.
   5) The excessive body weight which is known to be one of the causes of early failure was not a significant factor in this series.

Conclusion: All aseptic failures occurred in high flexion knees. The causes of failures could be classified into four, the implant design, the bone cutting and the soft tissue balance and fixation. Long time survival could be achieved if those factors are perfect.
Symposium
Abstract book for ISTA 2008

10:30-11:20 Symposium 1 Dynasty Hall 1

SA01-01 Clinical and Biological Aspects of Metal-of-Metal Bearings

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Modern metal-on-metal bearings were reintroduced on the market by Prof. B.G. Weber in 1988. Since this date, more than 500,000 bearings have been implanted worldwide with excellent clinical results. The goals of this presentation are to review critically the long-term published clinical results for metal-on-metal bearings (small and large diameter) and to investigate the current concerns (ions release, allergic reactions, pseudotumours...) about metal-on-metal bearings. Based on this review, the benefice-risk ratio of metal-on-metal bearings will be discussed.

SA01-02 Correlating Wear Performance in-vitro to 10-years Experience 28mm Metal-Metal Bearings

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FDA approval of metal on metal (MOM: 28, 32mm) bearings has provided 10 years of US clinical experiences. However there has been no detailed mapping of wear phenomena in 28mm retrieval cases. We present an analysis of 28 MOM retrievals with 1 to 10 years follow-up. Main cause for revision was progressive radiographic findings of osteolysis and associated pain. Patients ranged from 36 to 76 years of age; 54% were males. The 28mm ball diameter was represented in 86% (largest diameter = 52mm). Only 7 femoral stems were recovered but all had impingement marks. Stripe wear was evident on 71% of CoCr balls with medial stripes twice as common as lateral. Stripe wear was identified in only 25% of CoCr liners and extended 25-160° circumference around the liners. There are many limitations to such retrieval studies. These data are biased to cases that failed due to hip pain, radiographic signs of progressive osteolysis and some with high levels of metal ions. There was also the bias of having predominantly a CoCr sandwich design (polyethylene adaptor in 75% of cases). Use of the small ball added the well known risks of impingement, subluxation and dislocation with rigid cups. Using the ‘damage modes’ from McKellop, normal mode-1 wear occurred in only 14% of cases whereas modes 2-4 had an incidence approaching 30% each and signs of cup impingement were evident in 64% of cases. Thus summarizing MOM wear phenomena in 28mm sandwich cup designs, there was retrieval evidence showing that damage modes 2-4 likely placed these patients at risk for adverse wear effects.
Success and Failure in Hip Resurfacing - a personal perspective over 10 years?

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In a personal series of over 550 hip resurfacing operations performed since 1995, 34 hips have required revision operations. Only one has been for infection, a single stage revision was performed at 33 months following primary implantation, and the revised hip is still functioning well over 7 years later.

There have been five femoral neck fractures, all became symptomatic within 100 days of surgery. The first four were revised to Taperfit cemented stems with large modular heads, the fifth was revised to a Trifit uncemented stem with large head. The first of these patients developed aseptic loosening at the bone/cement interface, and was revised at 18 months to a cemented Exeter stem with ceramic head and uncemented socket with plastic liner. At over 7 years, the hip continues to function well clinically with no radiological signs of loosening.

The remaining four patients have all had satisfactory results at a mean follow up of 69.3 months (range 52 - 96 months).

Ten hips have required revision operations for femoral head loosening or collapse. The mean time after initial surgery was 54.6 months (range 23 - 107 months). In every case, the original socket was preserved and a stem with large modular head was used. The first two were using a Taperfit cemented stem and are still functioning well at 52 and 69 months. The next was with a Trifit uncemented stem, and remains satisfactory at 36 months. The remaining five have all been revised with a Plus Orthopaedics Zweymuller stem. The mean follow up is 13.8 months (range 5 - 33 months) and all are currently satisfactory.

There have been 18 sockets which required revision operations for loosening. The three earliest of these underwent revision surgery at 16, 17 and 27 months, and probably represent sockets which were inadequately seated at the time of implantation and failed to osseointegrate. This is evident on the initial post op radiographs in two patients. The third patient had unexplained discomfort in the hip from the outset, and eventually the hip was explored; at operation the socket was found to be loose after the hip had been opened and the head excised. Only one other patient required the head to be removed; the bone loss in the socket around the loose acetabular socket required revision with a larger socket than would allow the head to be preserved.

There was a cluster of five sockets which were revised between 50 and 57 months, the remaining five sockets were revised between 78 and 98 months. The timing of these failures suggests different modes of failure.

One patient had a revision with a dysplasia socket but no graft and 12 months later had clinical and radiological signs of loosening. One patient developed a post operative infection and the implants were removed.

The remaining patients have a mean follow up of 36.5 months (range 8 - 61 months), with no signs of failure of the revised socket or the original femoral component.
SEVERE EVALUATION OF MECHANICAL PROPERTIES AND PHASE STABILITY IN ADVANCED CERAMIC COMPOSITE FOR ARTIFICIAL JOINTS

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Combined techniques of fracture mechanics and confocal Raman microprobe spectroscopy were applied to characterize, after increasing periods of environmental exposure, bulk and surface toughness values in an advanced alumina/zirconia composite. This material is used in joint prostheses (BIOLOX® delta femoral heads, manufactured by CeramTec AG). Besides conventional fracture mechanics characterizations, including different types of fracture toughness test, Raman and fluorescence microprobe spectroscopy provided a microscopic insight into the effect of environmentally assisted processes of zirconia phase transformation at the surface on the fracture toughness of the material. We have found that the tetragonal-to-monoclinic polymorphic transformation occurs in the studied composite material as a consequence of an environmentally assisted process, although severe exposures are needed for to obtain a substantial increase of the monoclinic content. Such severe exposures in vitro correspond to exposures in human body of several lifetimes. The effect of an exposure of 10 h in autoclave (in vitro accelerated test) was carefully examined, because this span of time corresponds: (i) to the period of time recommended for testing in vitro by ISO standard; and, (ii) to approximately the lifetime expected for a prosthesis in vivo. The main experimental outcomes of confocal Raman spectroscopy and fracture mechanics assessments can be summarized as follows: (i) the crack-tip toughness level measured in the as-received material was comprehensive of a tangible contribution by transformation toughening, thus showing that phase transformation in the zirconia dispersoids plays a positive role in the toughening behavior of the material; (ii) after the material was environmentally aged in vitro for periods of the order of hundreds of hours, its surface toughness was reduced by about 1/3; but, even in the case of such a severe exposure, the surface toughness of the composite was at least the same as that of monolithic alumina; (iii) the observed decrease of fracture toughness by about 1/3 was limited to the very surface of the material (i.e., to a layer of the order of the tens of microns) and did not affect the bulk fracture behavior of the composite. It appears that concerns arising from the brittleness of alumina-based materials and, thus, from their vulnerability to fracture due to unexpected load situation, can be successfully counteracted by properly adding a dispersion of zirconia particles to the alumina matrix. Such an addition enables the obtainment of a composite material, whose fracture resistance is greatly enhanced by a crack-shielding effect due to phase-transformation processes occurring in the zirconia dispersoids.
Clinical experience with the ceramic on ceramic articulation in THR in the USA

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Traditional total hip arthroplasty (THA) using metal-on-polyethylene bearings has been established as a reliable procedure but wear and wear debris-associated osteolysis are among the most frequent reasons for revision. Ceramic-ceramic bearings represent an alternative for THA with improved wear characteristics and low biological reactivity of wear particles. We investigated the clinical outcome of alumina ceramic-ceramic THA in a series of more than 400 THAs.

418 alumina ceramic-ceramic THAs performed in 360 patients treated between 1997 and 2007 were studied prospectively. All patients had an uncemented titanium acetabular component with a flush mounted alumina ceramic-ceramic bearing (Wright Medical Technology, Inc. and Ceramtec AG). The mean age at operation was 51.7 ± 12.3 years (range, 18-79 years). 47 cases (11%) had previous hip surgery. The indication for surgery included primary osteoarthrosis or impingement (58%), developmental dysplasia of the hip (32%), osteonecrosis of the femoral head (5%), posttraumatic osteoarthrosis (2%), and other indications (3%). In 202 (48%) a minimally invasive approach, the superior capsulotomy, was used with the help of the surgical navigation for acetabular component placement. There were no cases of osteolysis or wear. We found 7 (1.7%) implant revisions: 1 acute cup displacement, 1 acetabular liner fracture, 1 case with failure of osseointegration of the cup, and 4 trochanteric wafer nonunions. A dislocation of the hip was found in 2 (0.5%) cases. The 10-year Kaplan Meier survivorship of the implants (revision of any component for any reason) was 98.4% (95% confidence interval 97.1-100%).

The results of alumina ceramic-ceramic THA after one to ten years are promising, especially considering the young age and high incidence of previous surgery in this patient population. The data are especially encouraging since no hip has demonstrated osteolysis. In particular, we are not aware of any other bearing that has shown an absence of lysis and 10 years follow-up. Since many of these patients are quite young, we await further assessment at 15 and 20 years.

Long-term results of cementless THA using a third generation ceramic-on-ceramic bearing

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To analyze the long term results of a third generation ceramic on ceramic bearing in cementless total hip arthroplasty (THA), we reviewed the clinical and radiological results of 100 consecutive THAs performed in 86 patients (68 females, 80 hips; 18 males, 20 hips) between 1996 and 1998. The average age at operation was 55 years with a range of 26 to 73 years. The diagnoses were osteoarthrosis in 83 hips, osteonecrosis in 10 hips and rheumatoid arthritis in 7 hips. The articulation was composed of a hemispherical titanium porous bead-coated cup (AnCA), a Biolox Forte alumina ceramic cup liner and a ball with a diameter of 28-mm. The modular ceramic liner was fixed directly to the metal cup without polyethylene sandwich or metal rim. A press-fit technique of 1 mm under-reaming without screws was used for cup fixation. The ceramic head was fixed to a 12/14 taper cone of a modular neck which allowed changes in neck-shaft angle, anteversion, and offset. All operations were performed via a posterolateral approach under general anesthesia. To measure the cup orientation, an ellipse was fitted to the acetabular component rim on the early postoperative AP radiographs using computer software. The average cup inclination and anteversion in the radiographic definition were 41 (range 28 to 63) and 17 (range 3 to 34) degrees, respectively. 22 cups were outside the Lewinnek safe zone. All patients were radiographically evaluated in term of implant stability at two years using Engh’s criteria. All of the acetabular components radiologically were judged to be bone-ingrown stable at two years except one cup. 98 stems were judged to be bone-ingrown stable and the remaining two stems were judged to be fibrous stable at two years. After two years, all patients except for two were followed up clinically and radiologically for at least 10 years or until revision or death. One unstable cup was revised at 2.5 years. This case had a previous Chiari’s pelvic osteotomy and insufficient press-fit of the cup was assumed to have led to loosening. One of the two fibrous stable stems was revised at six years due to aseptic loosening. One rheumatoid arthritis hip with stable bone ingrown fixation developed late infection at six years and was revised. One stable cup showed chipping of the acetabular liner at 8 years and required revision. The orientation of this cup was 55 degrees of inclination and 17 degrees of anteversion and the high inclination was thought to be related to the ceramic liner chipping. The remaining hips showed no osteolysis or loosening at the final follow-up. There were no squeaking hips. The 10-year survivorships with the endpoint of mechanical loosening or revision were 96.7% and 95.6%, respectively. We conclude that the third generation ceramic on ceramic hip bearing without polyethylene sandwich provided long term stability and eliminated periprosthetic osteolysis.
Highly Cross-Linked Polyethylene in Total Hip Replacement: Pros and Cons

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Summary: Highly crosslinked polyethylenes have now been in use for more than 5 years clinically. To date, clinical studies have supported the in vitro studies demonstrating a statically significant reduction in wear. There remains some ongoing concerns as it relates to the mechanical properties of the polyethylene which may limit its use in certain situations. In general unsupported polyethylene should be avoided as there is a risk for fracture regardless of whether the material is highly crosslinked or not.

Abstract: Highly crosslinked polyethylenes have been developed by several manufacturers and have been released to the market. In vitro studies have demonstrated several important factors. First, there is a relationship between radiation dose and wear reduction. As the radiation dose increases, the wear of the material decreases. This begins to plateau at approximately 10 mrads rounds of radiation. Secondly, studies that are available suggest that highly crosslinked polyethylenes are relatively insensitive to femoral head size. This potentially allows the surgeon to use large femoral heads increasing hip stability and reducing postoperative dissipation while at the same time not compromising wear. Thirdly, radiation negatively affects the mechanical properties of the material. However, it is important to remember that all materials implanted meets industry guidelines for polyethylene and its mechanical properties.

There have been several clinical studies looking at different highly crosslinked polyethylenes. It’s important to remember that these materials are manufactured using different techniques and may perform differently over time. Thus, ongoing studies evaluating the different products that have been released to the market are important and need to be continued as it’s quite possible that all materials may not behave the same. The good news is that to date, all clinical studies have demonstrated statically significant improvement in wear over a relatively short time period. There have been some fractures of polyethylene liners. Analysis of these cases suggests that these fractures are more related to implant position and loading of unsupported polyethylene than they are related to the mechanical properties of the material.
VITAMIN E STABILIZED HIGHLY CROSSLINKED UHMWPE - MATERIAL PROPERTIES, OXIDATION RESISTANCE AND WEAR PROPERTIES

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Vitamin E stabilized highly crosslinked UHMWPE (E-Poly™) was developed to improve upon the properties of first generation highly crosslinked UHMWPEs. The post-crosslinking processing for E-Poly™ maximizes the strength of the material while at the same time stabilizing residual free radicals that remain after irradiation. E-Poly™ is crosslinked with 100 kGy gamma irradiation prior to infusion of vitamin E. The infusion process involves diffusing vitamin E into the crosslinked material at temperatures beneath the melt temperature.

Small punch testing (ASTM F2183-02) was completed to evaluate strength of E-Poly™ compared to gamma-inert sterilized UHMWPE. The results showed that the E-Poly™ material had equivalent or better properties before and after accelerated aging than the gamma-inert sterilized UHMWPE (96-105 N vs. 75-88 N unaged; 100-115 N vs. 42-56 N 2-week aged).

Environmental stress crack testing evaluated the resistance to oxidation while the material was subjected to fatigue testing. A constant stress beam was tested for 5 weeks at 80°C. Failure was defined as the appearance of cracks or fracture of the specimen. All 4 specimens of gamma sterilized components showed evidence of cracking prior to the completion of the test. 2 of 4 sequentially crosslinked and annealed specimens fractured prior to completion. None of the E-Poly™ specimens showed cracks during testing. An examination of the amount of oxidation induced during this testing showed that the addition of fatigue loading increased the oxidation index for UHMWPE’s that had unstabilized free radicals. The surface oxidation index for gamma sterilized UHMWPE increased from ~0.3 to 1.1 and for sequentially crosslinked UHMWPE from ~0.3 to 0.7; the oxidation index for E-Poly™ was negligible for all test condition.

Hip simulator testing (ISO 14242-1) showed that the volumetric wear rates for E-Poly™ were 95-99% less than that of ArCom. For 28mm head diameters the rates were 53.3 mm³/Mc for ArCom and 0.24 mm³/Mc for E-Poly™. Wear particle morphology analysis showed that the E-Poly™ wear particles were similar to ArCom. Qualitatively, there appeared to be fewer E-Poly™ particles.

Knee simulator testing (ISO14243-1) was performed on both cruciate retaining and posterior stabilized Vanguard® knees. The E-Poly™ tibial bearing, CR and PS, showed 86% less wear than direct compression molded UHMWPE, the current gold standard. Fatigue testing of the PS post before and after accelerated aging (ASTM F2003) loaded to 1300lbs showed no degradation or failure of the post following 3 million cycles.

Vitamin E stabilized highly crosslinked UHMWPE has demonstrated excellent material properties, wear properties, and resistance to oxidation. These properties have been optimized through the combination of crosslinking, processing below the melt temperature subsequent to crosslinking, and the stabilization effect of vitamin E. These properties provide rational support to the utilization of vitamin E stabilized highly crosslinked UHMWPE for hip and knee applications.
RETRIEVAL STUDY OF IN VIVO WEAR AND OXIDATION OF HIGHLY CROSS-LINKED POLYETHYLENE ACETABULAR CUP AGAINST CERAMIC HEAD

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One of important issues of concern in total hip arthroplasty (THA) is osteolysis due to wear debris of ultra-high molecular weight polyethylene (PE), and it often leads to aseptic loosening. Reduction of PE wear debris is essential to prevent osteolysis, and different bearing interfaces as well as improvement of the bearing material itself have been attempted. Alumina ceramics as the bearing material for THA was introduced in Europe and Japan in the 1970s in aim to reduce the PE wear debris. The clinical results have proved the superiority of ceramic on PE couples to metal on PE couples in wear resistance. PE materials cross-liked by irradiation have also demonstrated a significant low wear by in vitro studies. Several types of highly cross-linked polyethylene (CLPE), with the irradiation dose of 50 to 105 kGy, have been developed and extensively used since 1998. In this study, the in vivo wear and oxidation of CLPE acetabular cup combined with ceramic femoral head were evaluated using retrieved cups.

Eight retrieved CLPE acetabular cups (Aeonian; Kyocera Corp., Kyoto, Japan, currently Japan Medical Materials Corp., Osaka, Japan) with clinical use for 3-80 months (mean 34 months) were examined. All cups were used against alumina or zirconia ceramic femoral heads. The linear wear of the retrieved CLPE cups was measured using a three-dimensional coordinate measurement machine. The worn surfaces of retrieved CLPE cups were observed by a scanning electron microscope (SEM). Oxidative degradation of the retrieved CLPE cups was expressed in terms of an oxidation index which was calculated from microscopic Fourier transformed infrared spectroscopy analysis, according to ASTM F2102.

The linear wear rate of retrieved CLPE cups was in 0.006-0.08 mm/year range, which was similar to the results reported by the previous radiographic study. In the worn surface of the CLPE cup retrieved after clinical use shorter than 39 months, machine marks were observed. In contrast, those retrieved after clinical use of 70 and 80 months were smooth. Oxidation indices of retrieved CLPE cups were: 0.12-0.37 in worn surface and 0.13-0.34 in unworn surface, respectively. There was no difference in the oxidation indices between the worn surface and unworn surface. The retrieved CLPE acetabular cups in this study showed low and stable wear rates. The results showed a notable reduction in wear of the CLPE cups compared to that of conventional PE cups in the previous studies. And also, the oxidation indices of the retrieved CLPE cups were the same level as conventional PE cups. These findings from this retrieval study showed that there is neither progressive wear in the clinical use for 3-80 months, material failures due to wear, delamination nor cracks. The lower wear rate and smooth surface of the CLPE acetabular cup suggest the possibility of reduced wear debris from those cups articulated against the ceramic femoral head. We expect that the CLPE acetabular cup has favorable wear properties in long-term clinical use.
The Squeaking Ceramic Hip
Retrieval, Radiographic, Acoustic and Finite Element Analyses

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Squeaking in hip arthroplasty is now well-documented but hitherto poorly understood. In this paper, we report data progressively accumulated from a series of studies undertaken by our group to investigate the mechanisms of noise production associated with ceramic-on-ceramic bearings. We reviewed demographic and radiographic data comparing squeaking with silent hips. Edge loading of the acetabular components was investigated on retrieved bearings and with finite element analysis. The squeaking sound itself was further investigated through acoustic analysis. Squeaking occurs in younger, heavier, and taller patients. We found a higher incidence of acetabular component malposition in squeaking hips and edge loading appears to be a causative factor. Finite element analysis revealed a stiffness mismatch between the shell and liner which may allow the shell to oscillate producing an audible squeak. Acoustic and modal analysis show that squeaking is due to a forced vibration and that the natural frequencies of the ceramic components are above the audible range, suggesting that resonance occurs in the metallic, not the ceramic parts. This phenomenon is related to patient factors, surgical factors, and implant factors, which may produce sound by a combination of edge loading of the ceramic and forced vibration of the acetabular shell and or the femoral stem.
Avoiding complications in the use of the alumina ceramic on ceramic articulations: pearls and pitfalls

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Alumina ceramic-ceramic bearings have the benefit of very low wear and studies showing the complete absence of osteolysis during the first decade of close study. However, good results depend on several critical factors including surgical exposure, surgical technique, component placement, and choice of component design. The following abstract discusses our experience with several of these factors.

Initially, there were concerns that the use of ceramic-ceramic bearings would lead to a higher incidence of hip dislocation since the bearings have fewer femoral head-length choices and the absence of lipped-liners. In our prospective study of 418 hips the incidence of hip dislocation at 1 to 10 year followup is 0.5% (2/418). This experience suggests that the use of alumina ceramic-ceramic bearings is not associated with an increased incidence of dislocation.

More recently, concerns about squeaking of alumina ceramic-ceramic bearings have been reported, particularly from centers in the United States. To investigate this issue, we reviewed information on 1275 consecutive revision THAs and 1039 consecutive primary ceramic-ceramic THA that had been performed at two institutions between 1996 and 2007. To identify the influence of the implant design on the incidence of squeaking we divided the primary hips into three groups with group 1: flush mounted ceramic liner; group 2a: recessed ceramic liner mated with a stem made of TiAlV; and group 2b: recessed ceramic liner mated with a stem made of a beta titanium alloy comprised of 12% molybdenum, 6% Zirconium, and 2% Iron.

Analysis of the 1275 revision hips revealed 5 alumina ceramic-ceramic hips in patients who complained of squeaking or grinding. All 5 hips were designs that included a ceramic liner that was recessed inside of an elevated metal rim. All 5 hips also demonstrated metallosis at the time of revision.

In primary THA, Group 2b had statistically significantly more squeaking (9 of 118) than group 2a (10 of 321) which had statistically significantly more squeaking than group 1 (6 of 700). In addition, the severity of squeaking between the groups was qualitatively different. Patients in Group 2b who complained of squeaking would often experience squeaking frequently throughout the day and could be demonstrated in the physician’s office. By contrast, patients in Group 1 who noted squeaking stated that the hip squeaked once a day to once a year. No patient in Group 1 complained of frequent squeaking or could demonstrate squeaking in the physician’s office. Further, joint fluid analysis from a patient in Group 2b who complained of squeaking revealed metal from both the femoral (Mo) and acetabular (Al) components.

As reported in another abstract at this meeting, 10 year survivorship of flush-mounted alumina ceramic-ceramic THA is 98.4% (95% confidence interval 97.1-100%)% and no patient in that prospective clinical studies demonstrated radiographic evidence of osteolysis or wear.

These experiences demonstrate that THA using alumina ceramic-ceramic tha is extremely reliable with low revision and dislocation rates and an absence of osteolysis. Significant squeaking is not associated with flush-mounted alumina ceramic liners and is clearly associated with elevated metal rims and metallosis. Finally, squeaking is statistically significantly associated with femoral components made of a beta titanium alloy consisting of Titanium, Molybdenum, Aluminum, and Iron.
SYMPOSIUM 4  
**DESIGN RATIONALE FOR A LARGE DIAMETER CERAMIC ON CERAMIC HIP BEARING**

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Current CoC hip bearing ranges are typically from 28mm to 36mm diameter, but to improve stability and range of motion, a novel large diameter hip bearing is introduced, with bearing diameter from 32mm to 48mm. To minimise acetabular bone loss, a low profile acetabular component is required and achieved with a ceramic wall thickness of 3.5mm and metal shell thickness of 1.5mm at the acetabular rim. This paper presents some of the testing required to develop this novel design.

Finite element (FE) modelling was performed to simulate the standard 46kN burst loading of the acetabular cup for 5 different geometries of ceramic liner and metal (titanium) shell. By smoothing the facets on the back of the ceramic and thinning the metal shell, the stresses in the ceramic were reduced by 20% and failure was not predicted for the burst test. Reducing the thickness of the metal shell increased the stresses in the metal, but these were kept below the yield strength of the material. When assembled, the hoop stresses in the titanium shell caused a greater volume of the ceramic to be in compression and the strength of the assembled cup was therefore increased.

To assess the effect of fatigue loading on the ceramic/titanium taper-lock, cups were loaded at 45° to the horizontal for 10,000 cycles in Ringer’s solution at 37°C. The load required to push the ceramic from the metal shell were recorded after the test and compared to the push out load of unloaded specimens. There was no significant decrease in the push-out load (mean 2kN) indicating that the taper lock retains its strength during fatigue loading.

The new CoC acetabular cup design is assembled under controlled conditions before packaging. To demonstrate the effectiveness of this, the new device was compared to a commercially available intraoperatively assembled Ti/ceramic device which had a metal shell thickness of 5mm. The cups were placed in reamed cavities of polyurethane foam and the rims impacted with increasing impact energy until the ceramic came loose from the metal shell. An average impact energy of 4J (1kg dropped from 400mm) was necessary to separate the ceramic from the metal liner of the new design compared to 2J for the commercially available design. The thicker titanium wall thickness and intraoperative assembly method of the commercially available design limited the amount of shell deformation/hoop stress generated, and therefore limited the ‘grip’ of the Ti/ceramic interface. The thinner titanium shell (1.5mm) and controlled assembly load of the new design allowed greater shell deformation/hoop stress which produced a two-fold improvement in interface strength. Further effects of assembly *in vivo*, in particular the effects of periprosthetic or lavage fluids, remain to be investigated. In any case, incomplete ceramic liner seating has been reported in 16% of procedures *in vivo* (Langdown, JBJS Br 2007) and the preassembled design therefore represents a notable and necessary improvement to current technology.
Past and Future of Robot-assisted Surgery

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Computers arrived late in orthopaedic surgery. While the rest of the world already happily integrated computers into daily life, business and production, surgeons remained sceptical and denied any need for help from modern technology. It was in the mid-eighties though, that a young veterinary surgeon from California, specializing in total hip replacement in dogs, was contemplating the problems that he encountered during surgery. This veterinary surgeon, the late Hap Paul, was one of the founding members of the custom - implant society, from which evolved ISTA. He struggled with wrong positioning of implants and broken bones, and wondered why implants that were manufactured with highest technology finally were placed into the bone with crude instruments reminding of a carpenters workshop. With the help of IBM and engineers from the University of California he created a system which he called Robodoc, and it became the first computer based system helping the surgeon during an orthopaedic procedure. The technological effort was huge, as almost any part of the system and of the procedure had to be invented from scratch. There was nothing there they could copy, and the system they invented - an active robot performing a critical part of surgery - represented a very ambitious step forward. Some compare the development of Robodoc with the technological history of the Concorde: very sophisticated technology, very early and very advanced, very expensive and with an aura of adventure.

Of course this was not the only and ultimate solution of bringing computers into surgery. Other researchers took a step back: they invented systems that helped the surgeon to navigate instruments and implants within the surgical field, so-called navigation systems. These were initially used by neurosurgeons to navigate probes within the brain. As neurosurgeons were closely related to and depending on CT-scan, the logic step was to use the CT- datasets, match them with real world (the process of registration) and create a virtual 3D space that is congruent to the real 3D space. With the help of optical systems (other options are mechanical or magnetic systems) instruments can be tracked outside and inside the surgical object and allow precise preparation of tissue or placement of implants. Very early application of this navigation technology was spine surgery in the mid-nineties, where utmost precision was needed during the placement of pedicle screws. Further applications were knee replacement, hip replacement and numerous applications in trauma surgery. Also the source of data was further developed: from the very precise but costly CT-scan to simple radiographs taken during surgery to so-called image free surgery, where data are retrieved directly from the surgical object. Navigation systems, in contrast to the elder robotic system, presented two major advantages: they were much cheaper, and they allowed the surgeon to use his standard instruments and, most important, to play an active part in the surgery, to stay in the loop (Tony DiGioia).

Today there are thousands of navigations systems in routine use all over the world. Published results show the benefits, but also the limits. Surgery has become more precise and results are more reproducible, yet there are still outliers which mainly stem from technical problems, but which are hard to detect and cause significant inaccuracy. Therefore the era of the robots is not over: robotic technology is currently revisited by numerous groups, and smaller, technically more advanced robots are developed and currently under testing. Also different modes of robots (active vs. passive robots, systems with constraint motion) are ready to move into the theatre. And Robodoc, the forefather of all computer-assisted orthopaedic systems, is still around and actively applied during surgery, with published good results and high reliability.

The history of Robodoc is a master piece of technological history. After initial successful human surgeries, embedded in the feasibility study required by the FDA, the next step was more difficult: the randomized study for FDA approval to prove the benefits almost killed the company and with it the technology. In early optimistic statement the inventors foresew major benefits, but overlooked the difficulties to prove these in the postoperative outcome. Disadvantages of the system, like longer OR times and higher blood loss, at least prevalent in the FDA study, were obvious while the “clear” benefits in outcome were not so obvious. Thus marketing abroad became a major option, and Europe became the prime target. The attempt was successful, and rapidly 30 systems were busy all over Europe. This development was brought to a halt by a couple of lawsuits in Germany and an unprecedented press campaign accompanying this effort. The lawsuits were sponsored by the illusion to finally sue an American company and gain millions from that lawsuit. This process started in the early days of this century, and so far, in spite of numerous sentences proclaimed, not one court has condemned the technology or found any wrong doing in applying it. In parallel to the declining European market, the Asian market was developed, and surgeons here benefited from the experiences in Europe and the consecutive improvements of the system. Currently robot-assisted TKR and THR are routinely performed in Japan, Korea and India.

This process let to recovery of the company, which tells us that technological progress also in medicine is inherently coupled to economic success. Although the first system applied in CAOS, Robodoc still is the most advanced system in technological terms. This is finally also accepted by the very critical FDA, which procrastinated approval for such a long time because the system represents an autonomous robot working on patients. Initial problems like bulkiness, software bugs and invasiveness have been overcome. What needs to be done - and which work is in progress - is the refinement of the system: still lesser invasive, more flexible and further applications, like uni knee, hip resurfacing and cup in THR. These developments are in testing. In the meantime the CAOS community, i.e. the surgeons and engineers primarily working in application and development of the existing systems, more and more become convinced that computer assisted surgery undoubtedly is heading towards the integration of robotic systems into surgery: this is where Robodoc came from.
Metal-on-metal hip arthroplasty is nowadays a well spread technique for hip replacement. It is a technically demanding procedure with sine qua non steps. Most of the large Australian, British and north-American clinical outcomes found about 20% early failure, within 3 months, during the steep part of the learning curve. In a biomechanical study on cadaver we showed that valgus and version placements should be appropriate in order to get the most effective strength in compression. But valgus placement is drastically limited by lateral neck notching which leads to early fracture. Anteversion also should be manage to address the cam-type shape of the ventro-lateral femoral neck, since most of the young patient with hip arthritis present retroverted misalignment of the head along the neck axis. The size of the femoral head is another issue because big head component needs a big acetabular cup. Sparing large amount of bone on the femoral side might lead to bone lost on the pelvic side. In order to enhance the placement of the femoral component - smallest one, in valgus, without retroversion and without neck notching - manufacturers propose mechanical device based on neck intraoperative palpation. Digitalized versions of this principle are also available. These systems still demand experienced surgeon to make slight adjustment on entry point and trajectory of the guidewire. Imageless computer navigation based on proximal femur palpation and atlas is interesting on almost normal bone but could be inaccurate on altered bone, especially cam-type shape. Navigation based on CT scan gives exact 3D information and accurate planning but is still time consuming. Navigation on 2D fluoroscopic view shows good clinical results with only about 20 minutes more than a standard procedure.

We proposed a bone morphing procedure with emphasis of surface palpation on head-neck junction to get accurately the personal shape of each femur. Preliminary results on pathological bones showed safe reaming of the head without notching.
HIP-SPINE RELATIONSHIPS: BASIC PRINCIPLES, RADIOLOGICAL EXPLORATION AND DIRECT APPLICATIONS FOR TOTAL HIP REPLACEMENTS (RANGE OF MOTION, WEAR AND IMPINGEMENTS)

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Hip-spine relationships should be better investigated in THP as lumbo-sacral orientation in the sagittal plane plays a critical role in the function of the hip joints. Lateral X-rays showing spine and hips together in standing, sitting or squatting positions characterize the adaptations of the sagittal balance and the functional interactions between hips and spine.

Acetabular cup implantation has to be planned for frontal inclination, axial anteversion, and sagittal orientation. The later refers to the sacro-acetabular angle, key-point in the spine - hip relationships, and that is redefined by the surgeon at the time of implantation.

Usual standard CT-sections are biased for evaluating acetabular anteversion. The conventional CT procedure does not refer to the pelvic bony frame and the measured anteversion is a projected angle on a transverse plane, depending on the pelvic adaptation in lying position. This measured angle is often considered as anatomical anteversion, leading to some confusion. Therefore this angle is only a "functional" supine anteversion, reflecting the anterior opening angle of the acetabulum in a specific position. According to the sagittal orientation of the pelvis, the true functional acetabular orientation can virtually be assessed in various postures from adjusted CT-scan sections.

The EOS™ low irradiation 2D-3D X-ray scanner is an innovative technology already used for global evaluation of the spine. This technology allows simultaneously "full body" frontal and lateral X-rays with the patient in standing, sitting or squatting positions; a tridimensional patient specific bone reconstruction can be performed and the cup anteversion can be directly assessed according to the position.

We investigated the lumbo-pelvic parameters influencing the tridimensional orientation of the acetabulum. We compared the data obtained for real postural situations using the EOS™ system and the measures from plane X Rays and classical CT scan cuts replicating standing, and sitting positions. 368 patients with cementless THP were involved in a prospective follow-up protocol. Sacral slope and pelvic tilt, incidence angle, acetabular frontal and sagittal inclination were evaluated on AP and lateral standard X-Rays. Functional anteversion of the cup has been measured using a previously described protocol with CT-scan cuts oriented according to standing and sitting sacral slope. The mean difference between CTscan and EOS™ system was 4.4° with comparable accuracy and reproducibility.

Sacral slope decrease in sitting position was linked to anteversion increase (38.8° ± 5.4°). Sacral slope increase in standing position was linked to lower anteversion (31.7° ± 5.6°). The anatomical acetabular anteversion, the frontal inclination, and the sagittal inclination were functional parameter which significantly varied between the standing, sitting, and lying positions. We noticed that the acetabular parameters in lying position highly correlated to the one in standing position, while poorly correlated with the one in sitting position. The difference between the lying and the sitting positions was about 10°, 25°, and 15° for the cup anteversion (CA) and the frontal and sagittal inclinations (FI,SI) respectively. The poor correlation between the lying and sitting positions suggests that the usual CT scan protocol is biased and not fully appropriate for investigating the cases of posterior THP dislocation and subluxation, which happen in sitting position. On the contrary, a strong correlation was observed between lying and standing measurements with all the acetabular parameters (CA,FI,SI), suggesting that the classical CT assessment of the cup anteversion remains an interesting source of information in case of anterior THP.

Each patient is characterized by a morphological parameter, the incidence angle. High incidence angle is linked to low acetabular anteversion, increasing the instability risk and anterior impingement in sitting and squatting position; higher anteversion angles are observed in low incidence angle patients, leading to more internal rotation of the hip in any position.

Lumbo-sacral orientation in the sagittal plane influences the tridimensional orientation of the acetabulum, especially for anteversion. Aging of the hip-spine complex is linked to progressive pelvic posterior extension. Impingement phenomenons, orientation of stripe wear zones and some instability situations can be interpreted according to those data.

This study points out the opportunity to adjust the CT scan sections to the sacral slope in functional position for properly investigating the orientation of the acetabular cup, mainly in case of posterior dislocation.

In addition, the mobility of the lumbo-sacral junction could be a crucial parameter in the mechanical functioning and the stability of a THP due to its impact on sacral slope and pelvic tilt. Therefore we also recommend doing dynamic lateral radiographs of the lumbo sacral junction in standing and sitting position for planning a THP implantation in order to detect stiff lumbo-sacral junction or sagittal pelvic malposition.
Total Hip Replacement after Inter trochanteric Osteotomy

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Proximal femoral osteotomy was a common procedure prior to modern total hip replacement. It is seldom done now as the results were unpredictable, complications common and morbidity substantial. Eventually almost all required a total hip replacement.

In carrying out a total hip replacement after inter-trochanteric osteotomy there may be a problem with hardware removal which is sometimes best done as an interval procedure as the hardware may have been in place for decades and the appropriate screw driver not available, necessitating the use of a crown drill to remove the screws. After a varus inter trochanteric osteotomy the tip of the greater trochanter may overlie the medullary canal necessitating re-osteotomy. Most subtrochanteric osteotomies will require re-osteotomy.

A review has been carried out with the author’s personal cases. There were fourteen previous varus osteotomies two being non-unions. There was one non-union of a re-osteotomy and 17% continued to have a severe limp. Harris scores were acceptable in all. There were 20 valgus osteotomies. Limp was mild in 20% and severe in 3.5%. The Harris Hip Score was acceptable in 95%. There were eleven subtrochanteric osteotomies. There was one non-union of a re-osteotomy. Limp was mild in 27.3% and severe in 27.3%. The Harris Hip Scores were acceptable in all.

The results in terms of limp are disappointing. The de-functioned glutei may never recover in the same way a long standing rotator cuff muscles may undergo fatty degeneration. The patient should be warned of this possibility pre-operatively.

Curved Periacetabular Osteotomy for the Treatment of Secondary Osteoarthritis due to Acetabular Dysplasia

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Dysfunction of acetabular dysplasia is a complex problem which includes excessive stresses on the cartilage, dynamic instability and muscular fatigue eventually leading to degenerative osteoarthrosis if left uncorrected. The most physiologic solution for a young adult with this problem is to redirect the acetabulum into a normal position. Rotational acetabular osteotomy developed in Japan aims to transfer the position of the acetabulum en bloc by circumacetabular osteotomy using the curved osteotome. Because of same curvatures of osteotomy surfaces, this osteotomy produces the greater contact among bony surfaces, stable fixation and early solid union. However, this osteotomy requires abductors splitting, leaves acetabular teardrop in its original position, and has the risk of postoperative avascular necrosis of the transferred acetabulum. Bernese periacetabular osteotomy developed by Ganz also provides good coverage of the femoral head by redirecting the acetabulum. This osteotomy preserves the vascular supply of the transferred acetabulum and allows medialization of the hip joint. On the other hand, it poses the risk of considerable morbidities due to extensive exposure through the Smith-Petersen approach, and postoperative complications, such as bleeding complications, reflex sympathetic dystrophy, motor nerve palsy and heterotopic ossification. In order to reduce these disadvantages, we developed a curved periacetabular osteotomy (CPO), for the treatment of hip dysplasias. Both an imaging of the margin of the hip presumed to be on the quadrilateral surface and a sophisticated operative technique are needed for CPO. However, the extent of soft tissue dissection is limited with abductors left intact, and the osteotomy surfaces retain their original curvature. These advantages seem to reduce postoperative complications and promote early postoperative rehabilitation. In this lecture, I would like to present the dynamic instability of the acetabular dysplasia and describe operative techniques of CPO.
Revision for Recurrent Dislocation after THA

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Dislocation after THA is the most common complication in modern THA. The reported failure rate of reoperation for recurrent instability is higher than any other indication for revision surgery.

Treatment of dislocation after THA

Non-operative treatment:
The first episode of dislocation after THA is usually treated by close reduction with or without brace treatment. There is no agreement about the role and effectiveness of bracing. Generally, bracing is indicated in the following circumstances:
- First dislocation
- Early laxity
- No component malposition
- Patients with poor general condition

The main management issues are about managing recurrent instability. Treatment choice is often complex and management begins by identifying the cause of instability.

Causes to consider:
- Component issue
- Impingement
- Soft tissue imbalance
- Laxity
- Abductor weakness
- Trochanteric non-union

Surgical Treatment:
The decision to use operative treatment to stabilize the hip joint is complex and the surgeon must take into consideration:
- How many times the hip dislocated
- Intervals between dislocation
- How long after THA the dislocation occur
- Can the problem be solved by an operation
- Operative risks

Treatment choices depend on the underlying mechanism of dislocation:
- Correction of malposition
- Correction of soft tissue laxity
- Release contractures
- Addressing problems of impingement
- Using a large femoral head
- Constrained liners
MINIMAL INVASIVE SURGERY OF UNI-COMPARTMENT KNEE ARTHROPLASTY
- FREE HAND TECHNIQUE

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The goals of knee arthroplasty are to relieve pain, to provide motion while maintaining stability, and to correct deformity. According to advantages of minimally invasive surgical procedure (MIS) are to facilitate the patient’s recovery, less pain, earlier mobilization, shorter hospital stay, and quicker rehabilitation. The surgeon takes responsibility between each other and makes the decision, makes the cuts, checks accuracy of surgery even he/she uses jigs or not. From April 2005 to February 2008, more than 50 unicompartmental knee arthroplasty (UKA) were performed at our medical center (*NCKU) with free hand technique. With this free hand technique of MIS UKA, the small incision, short operative time, less blood loss, quick recovery, accurate alignment, and reduced fat or thromboembolism risk were impressed, also the extra advantage is preservation of patellar-femoral joint.

Navigation Prediction for Balancing of Soft Tissue & Flexion-Extension GAP in Primary Total Knee Arthroplasty and Its Mid Term Clinical Results

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The study is to evaluate mid-term follow-up clinical results and navigation prediction of the first 106 TKAs, which was performed based on the soft tissue balancing technique using the OrthoPilot navigation system (B.Braun Aesculap, Tuttingen, Germany). All the 106 cases were diagnosed as osteoarthritis with varus deformity. After anatomical and kinematic registration, the mechanical axis was restored to neutral (±2°) at full extension with step by step meticulous medial soft tissue release and osteophyte removal. Proximal tibial bone cutting was performed under real-time navigation system control. Flexion and extension gaps were measured at full extension and at 90° of flexion using a tensioning device (V-STAT tensor, Zimmer) and a special torque wrench set at 50lb/inch before femoral bone cutting. The flexion and extension gap was evaluated and its difference was classified into 3 kinds; balanced, tight flexion gap and tight extension gap. Sixty-one (57.5%) knees were classified as having a ‘balanced gap’ (meaning that flexion and extension gaps were within 2 mm), 20 (18.9%) knees as having a ‘tight flexion gap’ (an extension gap at least 3mm more than the corresponding flexion gap), and 25 (23.6%) knees as having a ‘tight extension gap’ (a flexion gap at least 3mm more that the corresponding extension gap). Depending extension/flexion, and medial/lateral gap difference, the level of distal femoral cut and the rotation of femoral component was determined. Following the final bone cuts and completion of soft tissue release, assessment of the flexion and extension gap was repeated. Balanced flexion and extension gap (difference between flexion and extension gap ≤ 3mm) was confirmed in 99 cases (94%).

A mobile bearing prosthesis (e-motion FP, B.Braun Aesculap) was used. One patient (bilateral TKAs) died of unrelated causes at postoperative 2 year. One knee was revised due to infection. One hundred three cases were followed up at least more than 4 years, 53 months in average. Overall survival rate is 97%. Average preoperative HHS scores and range of motion (ROM) were 65.4 points (range, 33~82) and 126.8 degrees (80~140). At the last follow-up, HHS score and ROM were 95.0 points (78~100) and 131.4 degrees (110~140). Statistically significant improvement in HHS score and ROM were observed (p<0.05). The mean mechanical axis was 179.44 ± 1.83° (175~184°) with 8 cases of outliers (more than ±3° of optimum). There was no radiolucency, osteolysis, subsidence, or loosening at the last follow-up.

In conclusion, navigation is an excellent predictor for achieving balanced soft tissue & flexion-extension gap in primary total knee arthroplasty. Navigated TKAs using soft tissue balancing technique showed excellent clinical results and is effective methods achieving accurate mechanical axis and reducing prosthetic alignment outlier.
AVOIDING STEMMED IMPLANTS IN SITUATIONS OF BONE LOSS IN PRIMARY KNEE ARTHROPLASTY

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The stemmed tibial implant has enabled the salvage of challenging situations of bone loss in primary knee arthroplasty. By relying on distal fixation the toggle effect at the level of the tibial tray is obviated. It is therefore not surprising that it has become commonplace in the setting of primary knee arthroplasty in situations of bone loss. This ease of use has unfortunately led to the adoption of stemmed implants in situations where this may not be warranted. The paper examines the original recommendations of dealing with tibial metaphyseal bone loss in relation to available solutions. In general uncontained defects of less than 5 mm may be dealt with using cement fill techniques. Defect of less than 10mm require bone grafting techniques and those above 10 mm require stems and wedges. In the third category however long term results suggest that good results are only attainable in 65% of cases whether graftS or wedges are used. The use of intramedullary guides in this setting is re-addressed to allow the accurate placement of cuts enabling the use of pegged (or non-stemmed) implants. In addition with the advent of navigation this may be a special situation where non-stemmed implants may be selected over stemmed implants.
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Total knee arthroplasty (TKA) seeks to reduce pain and restore function in patients suffering from degenerative joint disease. TKA has become quite common and does provide predictable pain relief and return to some level of function. However, knees with TKA are not normal knees and do not perform like normal knees, and these facts motivate efforts to improve the functional performance of TKA. In this lecture, we will briefly review observations supporting the perspective that TKA function is strongly influenced by joint mechanics and implant design. In particular, we will discuss data relating joint mechanics and implant design to maximum knee flexion and to functional strength.

A number of studies on various designs of TKA with a range of patient cohorts have identified fairly specific relationships between several aspects of knee mechanics and flexion range. First, posterior translation of the femur with respect to the tibia increases maximum flexion (about 1.4° flexion for each mm of posterior femoral translation). Second, maintaining the natural posterior condylar offset is important to retain or enhance knee flexion (6° flexion are lost for each mm less posterior condylar offset from the natural state). Finally, posterior slope of the tibia can, with some designs, increase the flexion angle before posterior impingement (1.7° more flexion for each addition 1° tibial posterior slope). Various designs can combine these ‘ingredients’ to create unique ‘recipes’ for knee function and flexion. For example, a posterior cruciate ligament (PLC) retaining design can emphasize the second two ingredients, since it is relatively less predictable how the PCL will control anterior-posterior femoral translation. Designs of this type have shown excellent flexion, and significant improvements from past designs (Figure 1). A posterior-cruciate substituting design can emphasize the first ingredient to achieve satisfying flexion. Many other examples can be discussed.

Functional knee strength is another critical element of TKA patient function and also has been studied for decades. In this arena, there seems to be less of a consensus about specific mechanical factors that affect functional knee strength. Posterior femoral translation with respect to the tibia is thought to increase the quadriceps moment arm, and thereby provide greater functional knee strength in demanding tasks. It also has been proposed that the shape of the femoral component can be modified to provide a posterior axis for flexion, which also could increase the quadriceps moment arm. Finally, some argue that joint stability is critical to the normal physiologic co-activation of the quadriceps and hamstrings - where unstable joints recruit greater hamstrings activity and render the quadriceps less functionally effective. Gait laboratory studies are cited to support several of these design paths. Surveys of patient preference give strongest support to the stability hypothesis.

It is clear there is opportunity to improve the function of patients with TKA. By carefully assessing the relationships between patient function and knee arthroplasty mechanics, we can continue evolving TKA designs to better meet the needs of our patients.

Figure 1. A comparison of pre- and post-operative knee flexion in 228 consecutive knees at 1-6 years follow-up shows that TKA patients can expect to gain flexion if they have up to 125° flexion preoperatively. Schurman et al. (orange line) reported in 1985 that patients could only expect to gain flexion after TKA if they had ~95° flexion or less preoperatively.
In vivo kinematics of high flex posterior stabilized total arthroplasty in weight-bearing deep knee bending -comparison of three different prosthesis designs-

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The objective of this study was to evaluate the kinematics of a high-flexion, posterior-stabilized total knee arthroplasty (TKA) in weight-bearing, deep knee bending motion. Fifteen patients implanted with the Legacy Posterior Stabilized Flex (8; mobile bearing and 7; fixed bearing), 18 patients with Scorpio NRG, and 8 patients with PFC sigma RP-F were examined during a deep knee bending motion using fluoroscopy. Femorotibial motion was determined using a 2-dimensional to 3-dimensional registration technique, which used computer-assisted design models to reproduce the position of metallic implants from single-view fluoroscopic images. The average flexion ranges of motion between the metallic implants were 120° with Legacy Flex, 125° with NRG and 121° with RP-F. The average rotation of the femoral component was 11° external rotation (ER) with Legacy Flex, 12° with NRG and 11° with RP-F. The mean kinematic pathways were early rollback, lateral pivot with ER, and bicondylar rollback with Legacy Flex, medial pivot with ER and bicondylar rollback with NRG and central pivot with ER and bicondylar rollback with RP-F. The in vivo kinematics was different due to the prosthesis designs to obtain weight-bearing deep knee bending motion.
Do We Need A High-Flex Total Knee Prosthesis To Improve Range of Knee Motion?

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Introduction: The high-flex total knee arthroplasty system was introduced to enhance knee flexion and to facilitate tibiofemoral articulation at high-flexion by the design modification of an increased thickness of the posterior wall of the femoral component by 2 mm compared with the standard total knee prosthesis. However, several clinical studies on the effectiveness of designs intended to provided high flexion following total knee arthroplasty have produced conflicting results. We performed a prospective, randomized study to compare the ranges of motion of the high-flex and standard total knee replacements in patients who were managed with simultaneous bilateral total knee arthroplasty.

Materials and Methods: This study comprised of three independent groups of patients.
1. The first group: Fifty patients (mean age, 68 years old) received a standard NexGen LPS prosthesis in one knee and a NexGen LPS-Flex prosthesis in the contralateral knee. Two patients were men, and 48 were women. At a mean of 2.1 years postoperatively, the patients were assessed clinically and radiographically with use of the knee-rating systems of the KS and HSS.
2. The second group: Fifty-four patients (mean age 69.7 years) received a NexGen CR prosthesis in one knee and a NexGen CR-Flex prosthesis in the contralateral knee. Five patients were men, and 49 were women. The minimum follow-up was 3 years (mean, 3.1 years). At each follow-up, the WOMAC score and range of knee motion were evaluated and patients were assessed clinically and radiographically with use of the knee-rating systems of the KS and HSS.
3. The third group: Two hundred and fifty patients (mean age, 71.6 years) received a NexGen CR-Flex knee prosthesis in one knee and a NexGen LPS-Flex knee prosthesis in the contralateral knee. Ten patients were men and 240 were women. At each follow-up (mean follow-up, 2.3 years) the patients were assessed clinically and radiographically with use of the knee-rating systems of the KS and HSS.

Results:
1. The first group: The mean postoperative HSS knee score was 90 points for the knees treated with the NexGen LPS prosthesis and 89.4 points for those treated with the NexGen LPS-Flex prosthesis. At the time of the final follow-up, the knees with the NexGen LPS prosthesis had a mean range of motion of 135.8° (range, 105° to 150° ) and those with a NexGen LPS-Flex prosthesis had a mean range of motion of 138.6° (range, 105° to 150°). No knee had aseptic loosening, revision, or osteolysis.
2. The second group: The mean postoperative KS and HSS knee scores were 93.7 and 89 points, respectively in the knees with a NexGen CR prosthesis and those were 93.9 and 90 points, respectively in the knees with a NexGen CR-Flex prosthesis. The mean postoperative WOMAC score was 22 points. Postoperatively, the mean non-weight and weight bearing ranges of motion were 131° (range, 90° to 150° ) and 115° (range, 75° to 145°), respectively in the knee with a NexGen CR prosthesis and those were 133° (range, 90° to 150°) and 118 (range, 75° to 145°), in the knees with a NexGen CR-Flex prosthesis. Patients satisfaction and radiographic results were similar in both groups. No knee had aseptic loosening, revision, or osteolysis.
3. The third group: The mean postoperative KS and HSS knee scores were 95 and 90 points, respectively in the knees with a NexGen CR-Flex prosthesis and those were 95 and 91 points, respectively in the knees with a NexGen LPS-Flex prosthesis. Postoperatively, the mean non-weight and weight bearing ranges of motion were 133° (range, 90° to 145°) and 118° (range, 75° to 135°), respectively in the knees with a NexGen CR-Flex prosthesis and those were 135° (range, 85° to 140°) and 122° (range, 70° to 135°), respectively in the knees with a NexGen LPS-Flex prosthesis. No knee had aseptic loosening, revision, or osteolysis.

Conclusions: After a minimum follow-up of two years, we found no significant differences among the first, second and the third groups with regard to range of knee motion, or clinical and radiographic results.
MEASUREMENT OF LIGAMENT BALANCING BEFORE AND AFTER TKR

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Proper ligamentous balancing is an important step during TKR. Intra-operative measurement of the ligament balance is mandatory to control the actual ligament tension and perform appropriate releases. Post-operative measurement of the ligament balance is rarely performed, because of technical difficulties, but it is the only quality control of the intra-operative balancing.

We performed a prospective, observational study about 20 patients operated on for a primary knee osteoarthritis, with implantation of either a total knee replacement or a medial unicompartmental knee replacement. All replacements were performed under control of the non-image based navigation system OrthoPilot from the Aesculap company.

We performed pre-operative and post-operative measurement of medial and lateral laxity in extension and in flexion with stress X-rays, using the technique described by Staehelin. We also performed intra-operative measurement of medial and lateral laxity in extension and in flexion with the navigation system before and after implantation. We compared radiographic and navigated measurements with a paired Wilcoxon t-test and a Spearman correlation test.

The significance level was set at 0.05.

For the pre-operative medial laxity in extension, we observed a significant difference between the x-ray and navigated measurements, but there was a strong correlation between the two measurements for one given patient. Similar results were observed for the pre-operative lateral laxity in extension, for the pre-operative medial laxity in flexion and for the pre-operative lateral laxity in flexion. For the post-operative medial laxity in extension, we observed no significant difference between the x-ray and navigated measurements, but there was only a poor correlation between the two measurements for one given patient. For the post-operative lateral laxity in extension, we observed again no significant difference between the x-ray and navigated measurements, but the correlation between the two measurements for one given patient was strong.

The conclusion of this study is that the navigation system does not measure the same laxity than the stress X-rays do, but we actually do not know which technique is more accurate. By comparison to the standard X-ray measurements one might argue that navigation is better, but this has still to be proven. However, the navigated technique of measurement is easy to use when the surgeon is used to navigation. It is an objective tool, it is highly reproducible. It may be a teaching tool for trainees. It actually allows a fine tuning of ligamentous balance during implantation of a knee replacement.
How to obtain balanced flexion-extension gaps.

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Soft tissue balancing remains the most subjective and most artistic of current techniques in total knee arthroplasty. The flexion gap is traditionally measured at approximately 45 degree of hip flexion and 90 degree of knee flexion on the operation table. Despite of aiming equal joint gaps or tensions in flexion and extension, influence of the thigh weight on the flexion gap has not been documented. Therefore, the purpose of this study was to examine the flexion gaps in the 90-90 degree flexed position and the traditional 45-90 degree flexed position of hip-knee joints.

Thirty patients with osteoarthritic knee underwent total knee arthroplasty. After the PCL sacrifice, soft tissue releases, and bone cuts. Biomechanical properties of the soft tissue were obtained during the surgery, using the specially designed system. The system consists of two electric load cells in the tensioning device, digital output indicators, and an XY plotter. Load displacement curves were obtained in extension and in flexion. 160N was applied to open the joint gaps in the traditional 45-90 degree flexed position and the 90-90 degree flexed position of hip-knee joints. The flexion gap in the 90-90 degree flexed position of hip-knee joints was 2.11.2mm wider than that in the traditional 45-90 degree flexed position of hip-knee joints. The flexion gap had significant difference between the two different hip flexion angles (p<0.001). Interestingly, the stiffness of curves obtained from the lateral in flexion is 1/3 lower than the other three.

In the traditional 45-90 degree flexed position of hip-knee joints on the operation table, the flexion gap is approximately 45 degree to the gravitation and influenced by the thigh weight. To avoid the influence of the thigh weight and obtain equal joint gaps or tensions in flexion and extension, the flexion gap should be checked in the 90-90 degree flexed position of hip-knee joints. Extension and flexion gaps on the sagittal plane, and medial and lateral gaps on the coronal plane have to be well balanced. However, it is very difficult to match these four. It is still very questionable whether we can adjust these materials precisely and constantly or not.

A new Extramedullary Femoral Alignment System for Total Knee Arthroplasty

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Several reports suggest that the clinical transepicondyle axis which is known as the transverse flexion axis of knee rotation most consistently recreates a balanced flexion space and normal patella-femoral tracking. However the problem is that it is difficult to find the exact location of both femoral epicondyles intraoperatively. We suggest a method to determine femoral external rotation which parallel to the T-E axis using the femoral extramedullary(EM) system.

By definition, T-E axis is the line across each epicondyle and knee center, which is perpendicular to the mechanical axis of the femur in the coronal plane. Mechanical coronal plane perpendicular to mechanical sagittal plane is represented by the plane made of three points; femoral head center, lateral femoral epicondyle and knee center. T-E axis is parallel to the coronal plane, therefore if we position the distal femoral block parallel to the mechanical coronal plane, the position of distal femoral block should be parallel to the T-E axis. If the EM system is in its correct position sagittally and coronally, the T-E axis can be traced automatically.

Determination of femoral external rotation which parallel to the transepicondylar axis using the EM system could be one of the useful method to determine the external rotation of the femoral component and it will also improve the patello-femoral tracking.
HAPTIC-ROBOTICS FOR MINIMALLY INVASIVE, MODULAR KNEE ARTHROPLASTY

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Total knee arthroplasty (TKA) has evolved over the past 40 years to a point where it now is a routine treatment with fairly predictable outcomes. However, TKA is an end-stage treatment which frequently is used when only one or two compartments in the knee are damaged. Ideally, treatments for earlier stage and isolated disease would be available to provide the same high level of outcome predictability, but provide for isolated treatment of the affected compartments, greater levels of postoperative physical activity and the shorter convalescence demanded by younger, more active, and often employed patients. One approach to a compartment-by-compartment treatment regime is the utilization of discrete condylar unicompartmental prostheses and a patello-femoral prosthesis in any combination. This approach has been practiced in some European clinics for decades with good reported outcomes. However, it remains a major surgical challenge to optimally place multiple discrete arthroplasty components using conventional tools and small incisions. This lecture will present a detailed overview of a unified approach to minimally invasive, modular knee arthroplasty using haptic robotic instrumentation (Tactile Guidance System 2.0, MAKO Surgical, top right) and implants designed specifically for robotic installation in a customized modular treatment regime (MAKO Modular Knee, MAKO Surgical, bottom right).

Haptic robotics provide a ‘virtual cutting guide’ capability permitting precise sculpturing of bone surfaces using near-zero-visibility minimally invasive incisions. The use of a single-multifunctional tool eliminates many of the instrument trays commonly needed for these procedures. The surgeon has complete control in manipulating the bone cutting tool within the desired bone-removal area, but the haptic robotics prohibit the cutting tool from removing bone outside the planned bone removal volume. Precise bone sculpturing has the potential to minimize bone removal and optimize the alignment and fixation of the prosthetic components.

Haptic robotic cutting tools obviously can be used with off-the-shelf prosthetic components, but this approach would fail to fully take advantage of the precision surfaces that can be achieved using robot assisted bone sculpting. Instead, a purpose built system of modular knee components can be defined that work in any combination (medial or lateral unicompartmental, bi-unicondylar, medial or lateral plus patellofemoral, or tricompartmental), require minimum bone removal, can be placed through very small incisions, give great flexibility to customize implant placement to fit the patient’s anatomy, and take advantage of the types of fixation features which easily are created with a robotically controlled bone cutting device.

The current treatment implementation and implant design will be presented. Clinical results for unicompartmental procedures and in vitro results for multiple-compartment procedures will be presented and discussed.

* MAKO Surgical has provided research funding to The University of Florida for studies in support of the design of the MAKO Modular Knee system.
THE EFFECT OF APPROACH AND NAVIGATION ON ALIGNMENT IN TOTAL KNEE ARTHROPLASTY

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Restoration of proper alignment is one of the principal goals of TKA. Various methods are popular, including intramedullary (IM) and extramedullary (EM) mechanical guides, and recently computer assisted navigation (CAS). In addition, minimally invasive surgery has added an extra level of complexity to achieving satisfactory alignment. The purpose of this study was to determine the effect of approach (standard arthrotomy vs MIS) and alignment technique (Mechanical vs CAS) upon component alignment in TKA.

Methods: Three consecutive cohorts of patients were included: Group I--Standard arthrotomy with Mechanical guides; Group II-MIS approach with Mechanical guides; Group III-MIS approach with CAS. A single surgeon performed the Standard Mechanical cohort, and a second surgeon performed all surgeries in the other two cohorts. For the mechanical groups, IM femoral and EM tibial guides were used. For CAS, the Orthosoft system was used. All components were NexGen (Zimmer) Postoperative x-rays were used to measure component alignment relative to the IM axes, including femoral valgus and flexion, and tibial varus and slope, and patellar tilt. In addition, joint line position was measured. Students’ t-test was used to determine level of significance.

Results: For Groups I, II and III, there were 41, 38 and 39 patients, respectively. For femoral alignment in the coronal plane, results were 4.83±4.29 degrees, 3.82±2.72 degrees, and 3.36±2.49 degrees, respectively. Femoral flexion was 2.93±2.82 degrees, 3.18±2.93 degrees, and 2.46±2.79 degrees, respectively. Tibial alignment was 0.44±3.98 degrees of varus, 1.00±2.83 degrees of valgus, and 0.95±2.58 degrees of varus, respectively. Slope was 6.78±3.23 degrees, 3.23±3.21 degrees, and 3.93±2.85 degrees, respectively. Patellar tilt was 2.15±3.51 degrees lateral, 1.73±2.67 degrees lateral, and 1.03±2.28 degrees lateral, respectively. The joint line was raised 1.18±3.54 mm and 0.05±4.92 mm in Groups I and III, respectively, and lowered 0.33±4.78 mm in Group II. There were no statistically significant differences in any measurement between any groups.

Discussion: Satisfactory alignment can be achieved with either mechanical guides or navigation systems. MIS approaches do not worsen alignment with either alignment methodology. Whether having fewer outliers translates into improved clinical outcomes remains to be seen. More importantly, CAS provides an intraoperative tool that may allow more accurate reproduction of a customized plan for an individual, rather than simply attempting to achieve the mean for a population. Again, the value of achieving such a goal is unknown since the threshold for improvement with off-the-shelf knee components may have already been maximised.
PRECISION OF THE POSITIONING OF A REVISION TOTAL KNEE REPLACEMENT BY A NAVIGATION SYSTEM

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Revision TKR is not an infrequent procedure. In the USA, among 350,000 TKR performed yearly, 35,000 are revision TKR, and the rate of revision TKR is about the same in France. Revision TKR is a demanding procedure. Especially, the possible bone defects involve possible difficulties in defining the classical intra-operative landmarks for implant alignment. It is well accepted that these difficulties lead to results which are not equal to primary TKR.

We are currently using the OrthoPilot non image based navigation system on a routine basis for all primary TKR. Our hypothesis was that the standard navigated technique might be used without modification for a revision TKR. Intra-operative anatomic and kinematic registration was performed on the index prosthesis, even if it was loose. The usual resection guides were used for additional resections or to measure the height of the bone defects. Alignment was controlled with the trial implants before final implantation.

We performed a monocentric study including 37 consecutive cases of navigated revision TKR. We analyzed the accuracy of implantation on post-operative long-leg X-rays. We measured the mechanical coronal femoro-tibial angle and the orientation of each component on coronal and sagittal planes. We defined the global positioning of the TKR as the summary of all individual items for each patient.

Results were analyzed for the 33 cases with a complete X-ray evaluation. The mean coronal femoro-tibial angle was 1° of valgus, with a standard deviation of 3° and a range from 8° of valgus to 5° of varus. 26 cases have less than 4° off the neutral angle (79%). The mean coronal femoral orientation was 1° of valgus, with a standard deviation of 2° and a range from 6° of valgus to 2° of varus. 31 cases have less than 4° off the neutral angle (94%). The mean coronal tibial orientation was 0°, with a standard deviation of 1° and a range from 2° of valgus to 2° of varus. All cases have less than 4° off the neutral angle. The mean sagittal tibial orientation was 1° of posterior slope, with a standard deviation of 2° and a range from 5° of anterior slope to 7° of posterior slope. 27 cases have less than 4° off the neutral angle (82%). When summarizing all items, the global positioning was perfect in more than 50% of the cases, and only few cases had more than one error.

Our experience showed that the standard software allows controlling the orientation of the resection. The standard software allows controlling the ligamentous balance as well. However, the standard software does not allow controlling the level of the joint line, controlling the orientation of the stem extensions, or controlling the defect filling. We are now developing a dedicated software which will allow 1) to compensate the level of the joint space; 2) to navigated the stem extensions; 3) to deal with the bone defects. However, even with the standard software, navigation actually allows a comprehensive approach to revision TKR with individual reconstruction.
Can Vitamin E Impregnation address concerns of Highly-Cross-Linked UHMWPE in TKR?

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Concerns about reduced strength, fatigue resistance, and oxidative stability of highly crosslinked UHMWPE have limited the acceptance of these materials for TKR. It was hypothesized that a new crosslinked UHMWPE stabilized with vitamin E would substantially improve wear performance and resistance to oxidative degradation without compromising mechanical properties. The purpose of this study was to comprehensively test this hypothesis in vitro. GUR1020 was machined from isostatic molded barstock, crosslinked with 100 kGy, and then doped with vitamin E. This material was compared to direct molded GUR1050 UHMWPE. Both materials were gamma irradiation sterilized as for clinical use. Small punch testing, crack growth rate fatigue testing and oxidation index measurements were performed on each material before and after accelerated aging. Knee simulator testing evaluated wear of each material for 5-million walking cycles. CR knees were tested on a 6-station AMTI knee simulator; PS knees were tested on two 4-station Instron-Stanmore knee simulators. Statistical differences in all metrics were evaluated for significance with ANOVA (p < 0.05).

After 4-week accelerated aging, the control material showed elevated oxidation, loss of small punch mechanical properties and decreased fatigue crack growth resistance. In contrast, the vitamin E stabilized material had minimal changes in these properties. Further, the vitamin E stabilized material exhibited 85% reduction in wear for both the CR and PS designs.

Highly crosslinked UHMWPE stabilized with vitamin E appears to be promising for use as a bearing surface in TKA.
In designing artificial joints the main criteria are to reduce the wear-rate of the material and the reaction of the body to the wear particles produced. These can be achieved by using harder materials (metals, ceramics) or by reducing the chances of producing a wear particle by the choice of material and design. This paper will look at combinations of PEEK-OPTIMA against different counterfaces with the aim of reducing the wear-rate of artificial hips and knees.

**Pin-on-Plate Studies:** Twenty-six different sets of experiments combining PEEK-OPTIMA in different formulations and against different counterfaces were conducted to evaluate the lowest wear combination. The lowest wear-rate combination was CFR-PEEK PAN against low carbon CoCrMo alloy \( (K=0.144 \times 10^{-6} \text{ mm}^3/\text{Nm}) \) which is only about 1/8th of the wear of UHMWPE against stainless-steel \( (1.1 \times 10^{-6} \text{ mm}^3/\text{Nm}) \). Gamma radiation sterilisation did not seem to affect the PEEK wear-rate.

**Hip Simulator Studies:** A 25 million cycle wear study has been conducted on the Durham Hip Simulator using 54 mm diameter alumina heads against CFR-PEEK thin-walled acetabular cups (MITCH). Five joints were in active stations and one acted as a loaded control. Wear was measured gravimetrically. Particles were analysed using a NanoSight LM10 instrument at 0.5, 10 and 25 million cycles. Also an Atomic Force Microscope (AFM) was used to look at particles above 2\( \mu \text{m} \) which is the limit of the NanoSight instrument. The wear-rate was linear over the whole 25 million cycle test at 1.16 mm\(^3\)/million cycles (range 0.811-1.392 mm\(^3\)/million cycles). As the test progressed, the number of particles reduced and the dominant particle size increased from about 40nm to circa 200 nm. The AFM showed some particles as large as 3\( \mu \text{m} \) to exist also. No fluid film lubrication was observed to be generated in these joints so the low wear-rate was due to the inherent low-wear properties of the material combination.

**Knee Simulator Studies:** CFR-PEEK was moulded into the interpositional bearings for experimental lateral and medial unicompartmental knee designs and tested for 5 million cycles using 5 pairs of active joints and one pair of loaded controls in the Durham Knee Simulator. Wear was measured gravimetrically. Whilst the CFR-PEEK components gave a total wear-rate (both medial and lateral) of 2.72 mm\(^3\)/million cycles, UHMWPE inserts in a similar application (1), gave 9.67 mm\(^3\)/million cycles. This represents a reduction of 72 per cent for the wear of the CFR-PEEK components.

**Conclusions:** CFR-PEEK used in the correct combination and application can give a much reduced wear-rate compared with UHMWPE. It does not have the problem of metal ion release and has been shown by others (2), not to exhibit cytotoxicity (2).

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**References**
General Concept of Tribology in TKA

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'Tribology’ is derived from the Greek word "tribos" and means the "science of rubbing". Friction, lubrication, and wear mechanism in the common English language means the precise field of interest of tribology. Wear of PE insert has often been reported in TKA to be primary causes of complications and failure.
As a friction, the wear that occurs in TKA is system properties rather than intrinsic material properties and is therefore affected by multiple variables such as design, material properties, duration and alignment. The contact area on each condyles varies from about 150 mm² for moderate to high-conformity knees in flexion, down to 30 mm² for low-conformity. The corresponding maximum compressive pressure in activity is 10 to 50 MPa, which favor fatigue and deformation of UHMWPE (yield stress: 15MPa). In contrast, fully conforming mobile bearing knees have contact area of at least 300 mm² on each condyles, giving maximum pressure of only 5 MPa. There are several mechanisms whereby small PE particles are released in TKA. Some of these mechanisms are fatigue processes requiring numerous cycles of sliding. Multidirectional sliding is more damaging than sliding in same direction. The wear mechanisms in TKA are as follows:
* Adhesive wear
* Abrasive wear (2-body, 3-body)
* Third body wear
* Corrosion wear
* Fatigue wear (delamination): the most destructive of all wear mechanism

There have been a number of published studies on the in vivo wear measured on retrieved total knee bearings. These studies indicated more clinical wear on the medial side. Patterns of wear varied greatly among individual knees; a majority showed very similar extents of wear on the medial and lateral sides, however there were cases with significantly more wear on one condylar articulation than the other. Evidence of edge loading was common and seen most frequently in the central zone of the medial condylar area.

References
JST Classification and treatment algorithm of a valgus knee

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The patho-anatomy of a valgus knee could be divide into two categories as bony hypoplasia and/or deficiency and soft tissue imbalance. The soft tissue in the lateral side of the knee (including illio-tibial band, lateral collateral ligament, poplitous tendon, posterior-lateral ligament, and hamstrings etc) is contracted with or without medial soft tissue attenuation.

There are many reasons explain why dealing with a valgus knee is much more difficult than dealing with a varus knee. The most important three factors are: ① There is much less room or space to release a LCL, ② The MCL could be attenuated, ③ A fixed valgus deformity is always associated with bone deficiency or hypoplasia.

This is arbitrary, and in many times, it is wrong to take it for granted that a valgus knee is always associated with a tight LCL. In this article, the author mainly introduce the rationale and clinical application of a LCL tension based classification and treatment algorithm of a valgus knee. The details of how to judge if the LCL is tight, loose or normally tensioned; Is the valgus knee purely or associated with an extra-articular deformity will also be discussed.

**JST Classification of a Valgus Knee**

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<tr>
<th>Femoral deformity</th>
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<tr>
<td>Type F1</td>
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<tr>
<td>Valgus in Extension only</td>
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<tr>
<td>F1a Intra-articular deformity, LCL is loose when the knee extends, while LCL maintains normal tension when the knee flexes.</td>
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<tr>
<td>F1b Extra-articular deformity which is close to knee joint (supra-condylar deformity), LCL remains normal length and tension through all the range of motion.</td>
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<tr>
<td>Type F2</td>
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<tr>
<td>Valgus in both extension and flexion</td>
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<tr>
<td>Intra-articular deformity, LCL remains through all the range of motion, hypoplasia or bone deficiency in both distal and posterior lateral femoral condyle.</td>
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<tr>
<th>Tibial deformity</th>
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<tr>
<td>Type T1</td>
</tr>
<tr>
<td>Intra-articular deformity, lateral tibial plateau deficiency</td>
</tr>
<tr>
<td>Type T2</td>
</tr>
<tr>
<td>Extra-articular deformity, tibial metaphyseal osrhsha deformity.</td>
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**Treatment algorithm of a valgus knee**

**Type F1a**

This type valgus knee is the easiest to deal with. The LCL length is well maintained, and LCL is loose when knee extends. What is tight and restrains the deformity as a fixed valgus one is: ITB and posterior-lateral capsule instead of LCL and poplitous tendon. The deformity is corrected simply by releasing ITB & posterior-lateral capsule and bony graft or using a metal block to augment the deficient or hypoplastic lateral distal femoral condyle. At the same time, the loose LCL is properly tensioned by bone graft of metal augmentation. Since both ITB & posterior capsule are secondary stabilizers, the LCL and poplitous tendon is properly tensioned, the knee is pretty stable.

**Method A: lateral condyle distal sliding osteotomy**

The essence of a sliding osteotomy is converting a F1b deformity into a F1a deformity. By distally sliding osteotomy, the LCL becomes loose when the knee extends, and the valgus deformity is shifted into the collateral ligament frame.

**Method B: Soft tissue releasing + constrained total knee**

The LCL of a F1b valgus knee is normal tensioned with normal length, over releasing lateral soft tissue will lead to imbalanced flexion gap, in this meaning, it may not possible to balance a F1b valgus knee properly in both flexion and extension. In such a knee, if the patient is old and is not going to lead an active life, a constrained prosthesis such as CCK or TC III can be used.

**Method C: One stage or two stage supra-condylar osteotomy + TKA**

Since a F1b valgus knee is actually a normal knee combined with a supera-condylar deformity, it is understandable to correct deformity by an supra-condylar osteotomy. The osteotomy can be done in one stage or two stage style. Theoretically, a supera-condylar osteotomy is done in the most deformed region, and is done within cancellous bone, bone union can be predictably expected. But if a total knee and osteotomy is performed in one stage, the operator could encounter the following difficulties: ① Conventional instruments can not guarantee correct bone cut because a supera-condylar deformity deviates intramedullary guiding rod; ② the canal in distal femoral metaphyseal part is quite expended, it is difficult to achieve solid fixation either by a stem extension or retrograde intramedullary nailing. ③ Total knee replacement, supera-condylar osteotomy and intramedullary could severely damage blood supply to osteotomy line leading to nonunion. The author prefer a two stage TKA and osteotomy for a F1b valgus knee. In one stage TKA and osteotomy, the author will use frontal epicondyle axis instead of intra-medullary rod to guide distal femoral cut.
Type F2
This type knee is consistently valgus no matter the knee extends of flexes, indicating both distal distal and posterior part of lateral femoral condyle is deficient of dysplastic and LCL is contracted. Lateral soft tissue, including LCL and some times popolitous tendon, is inevitable in managing type F2 valgus knee. If soft tissue releasing alone can’t balance medial and lateral part of the knee, a bidirectional sliding osteotomy can be done to shift proximal insertion of LCL both distally and posteriorly, releasing the LCL.

Type T deformity
Type T deformity is sparse, Type T1 is typically seen in a rheumatoid arthritis, and Type T2 is usually iatrogenic(over corrected high tibia osteotomy) or after malunion of a tibia metapyseal or proximal shaft fracture. It is possible try to augment the lateral tibial plateau deficiency and release the lateral soft tissue for a Type T1 valgus knee. But for a Type T2 knee, a correctional osteotomy concomitant to a total knee is usually needed.

JST Algorithm of Dealing With Valgu knees
KINEMATIC AND WEAR PERFORMANCE OF A NEW GUIDED MOTION HINGE KNEE DESIGN

Ramprasad Papannagari, Jonathan Nielsen, Jeff Sprague, Ryan Dees, Paul Crabtree, Sam Nasser

PURPOSE
A new hinge knee system (LEGION HINGE, Smith & Nephew) was designed to treat gross knee instability resulting from loss of collateral ligament function, femoral and/or tibial bone loss including the insertions of the collateral ligaments or patellar tendon, or comminuted fractures of the proximal tibia or distal femur. The knee system is composed of several functional mating parts including both metal and polyethylene components and is offered with an insert that guides the motion of the implant for kinematic improvement. The purpose of this study was to evaluate kinematic and wear performance of this novel hinge knee replacement system.

MATERIALS AND METHODS
Kinematics and kinetics of the Guided Motion (GM) hinge knee was assessed for a deep knee bend using a numerical lower leg simulator. Measurements of A/P translation and I/E rotation were compared to 3D MRI data of healthy weight bearing knees and measurements of M/L patella shear forces were compared to a standard primary knee implant.

Three GM knee systems were tested for wear performance. All metal components were fabricated from cobalt chrome except for the Ti-6Al-4V insert locking screw. All plastic components were fabricated from UHMWPE. Wear testing was conducted on an AMTI 6-station force controlled knee simulator for approximately 5 million cycles under ISO 14243-1 load/motion profiles and soft tissue constraints.

RESULTS
Simulation results showed that up to 130° of flexion the A/P translation and I/E rotation followed a similar path over the flexion range compared to the MRI data. The magnitude of A/P translation at 130° was 9.5 mm for the GM design compared to 15.7 mm for the MRI design. The magnitude of I/E rotation at 130° was 18° for the GM design compared to 20.8° for the MRI data. The GM design showed a maximum M/L patella shear force of 456.8 N compared to 1152.4 N for a standard primary knee design over the flexion range.

All constructs successfully completed wear testing and were fully functional with no issues for binding of the mating parts. All polyethylene components showed only burnishing on the articulating surfaces. The volumetric wear rate of polyethylene components was 17.54±1.24 mm³/Mcycle. The volumetric wear rate of the metal components (excluding femoral and tibial tray) was 0.045±0.01 mm³/Mcycle.

DISCUSSION
Testing showed the GM design has A/P and I/E kinematics that are similar to those seen in a normal healthy knee and good patella tracking as evidenced by the low M/L patella shear forces. The wear rate of the polyethylene parts was within the range of wear rates published in the literature for primary knee designs (up to 35.8 mm³/Mcycle). The low metal wear rate indicates that fretting and corrosion of the components was minimal.

The GM design has been shown to more closely replicate the kinematics of the natural knee without compromising the wear characteristics which could lead to better outcomes for the patient population that requires a hinge knee implant.
Ligament Balancing in Revision TKA

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Instability is one of the leading causes of clinical failure after total knee arthroplasty. Instability can be categorized according to four type: extension instability, flexion instability, genu recurvatum and global instability. Basically flexion and extension gap should be equal. And also medial and lateral gap should be equal balance. we should know basic concepts, the effect of the ligament or capsular structure release. And also surgeon should understand of the nine gap-balancing permutation that can occur during revision TKA. After bony mechanical and rotational alignment correction, flexion gap correction first then adjust extension gap method will be easier to adjust ligament balancing. Joint line elevation should be avoid if possible because this can lead to mid-flexion instability, decreased range of motion soft tissue impingement or anterior knee pain associated with patella infera. Varus / valgus constrained components should be considered only in the presence of adequate inherent or to stabilize the knee until a ligament repair or reconstruction heal. In a situation of severe varus /valgus, or global instability where the knee cannot be stabilized other than through the implant, use of a rotating hinge or linked component is advocated.

Revision TKRA - How I do it

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The result of the revision TKRA relies upon the causes of failure after total knee arthroplasty. Instability can be categorized according to four type: extension instability, flexion instability, genu recurvatum and global instability. Basically flexion and extension gap should be equal. And also medial and lateral gap should be equal balance. we should know basic concepts, the effect of the ligament or capsular structure release. And also surgeon should understand of the nine gap-balancing permutation that can occur during revision TKA. After bony mechanical and rotational alignment correction, flexion gap correction first then adjust extension gap method will be easier to adjust ligament balancing. Joint line elevation should be avoid if possible because this can lead to mid-flexion instability, decreased range of motion soft tissue impingement or anterior knee pain associated with patella infera. Varus / valgus constrained components should be considered only in the presence of adequate inherent or to stabilize the knee until a ligament repair or reconstruction heal. In a situation of severe varus /valgus, or global instability where the knee cannot be stabilized other than through the implant, use of a rotating hinge or linked component is advocated.

For removal of implants, I used microsaw instead of Gigli saw. This is because microsaw has advantages of preserving the bone by easy approach to notch and posterior condylar area and less contamination risk. After partial separation of bone and implant interface by microsaw, I would not remove the implant immediately. Instead I will tap medial and lateral condylar portion alternately with mallet repeatedly until I can see the movement of the prosthesis, and then I will gently remove the prosthesis. By this maneuver, the prosthesis is easily removed with less bony defect.

Before removal of femoral prosthesis, for joint line preservation, I will mark 5-6 cm proximal to the joint line on the femoral metaphyseal area with drill bit. In most revision cases, as the height of femoral prosthesis is maintained, this mark can be good landmark for the joint line insert of the trial prosthesis later at that level, thus the joint line can be preserved.

Varus / valgus constrained components should be considered only in the presence of adequate inherent or to stabilize the knee until a ligament repair or reconstruction heal. In a situation of severe varus /valgus, or global instability where the knee cannot be stabilized other than through the implant, use of a rotating hinge or linked component is advocated.
“HAP” Paul Award
MRI IN THE DETECTION OF EARLY PARTICLE DISEASE IN PATIENTS FOLLOWING TOTAL HIP ARTHROPLASTY: A PROSPECTIVE STUDY

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The ability of optimized MRI to detect periarticular bony and soft tissue pathology in the post-arthroplasty hip is well documented; specifically it is able to detect early stages of particle disease well before osteolysis is apparent on radiographs. This is a prospective study designed to utilize MRI for the detection of early particle disease in asymptomatic patients after total hip arthroplasty.

Patients who underwent routine non-cemented THA were recruited from three different groups: metal-on-polyethylene, ceramic-on-ceramic, and ceramic-on-polyethylene bearing surfaces. All patients enrolled underwent optimized MRI one to three years (mean 1.7) after the index procedure. Images were analyzed for the presence of synovial proliferation, fibrous membrane formation or osteolysis. Particle disease was correlated with type of bearing surface, pain, activity level, patient satisfaction, and clinical outcome scales.

Thirty-two hips have been enrolled in the study to date. Early particle disease was seen in two of seven metal-on-polyethylene hips (29%), four of twelve ceramic-on-ceramic hips (33%), and six of thirteen ceramic-on-polyethylene hips (46%). Focal osteolysis was seen in one patient with a ceramic-on-polyethylene hip. These values were not statistically significant among the groups. The presence of early particle disease did not correlate with pain, activity level, patient satisfaction, or other clinical outcome scales.

This study allows patients with a well functioning total hip arthroplasty to be prospectively followed with MRI. It is the first to document the natural history of particle disease in vivo and considerably enhances our knowledge of periarticular pathology in the post-operative hip. These results demonstrate early particle disease is relatively common yet asymptomatic; they do not demonstrate advantages of any bearing couple over another for protection against particle disease at short-term follow-up.
Oral Session
TISSUE ENGINEERED COMPOSITES OF DEMINERALIZED BONE MATRIX AND FIBRIN GLUE

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Deminerilized bone matrix (DBM) is currently used in various types of orthopaedic applications because of osteoconductive and osteoinductive properties. Fibrin glue is also used in surgery due to its haemostatic, chemotactic and mitogenic properties and also as scaffolds for cell culture and transplantation. After total hip replacement surgery, it takes long time to complete bone fusion. If patients have excess weight load after surgery, the artificial joint may not be adhered with patient’s bone. That’s why surgeons have to use any effective treatments for bone fusion for patient’s safety. In order to adapt to these surgical sites, DBMs are shaped in blocks or granules and preferable in porous forms. Combining these DBMs with fibrin glue provides a mouldable and self-hardening composite biomaterial. This material will be applied to total hip replacement surgery for the effective fusion between bone and artificial joint. The aim of this work is to study the osteogenic properties of this composite material using in vivo and ex vivo.

The formation of newly formed bone and bone healing capacity has been studied in the muscles of rat and cell seeded composites. The different implantations sites were filled with composite material associating DBM and fibrin glue. The fibrin glue was composed of fibrinogen, thrombin and other biological factors. After both intramuscular or intraosseous implantations for various week points, samples were analyzed using histology and histomorphometry and mechanical test. In all cases, the newly formed bone was observed in close contact and around the composites.

The osteogenic property of DBM and fibrin glue composite materials was studied in vivo and ex vivo. In radiological study, the DBM composite had been absorbed during 1 week since implantation surgery and after 2 weeks, some radio-opaque spots were observed in implantation sites. In histology study, Bone tissue had formed extopically in contact with the surface of the appeared well-mineralized, forming trabeculae between the granules, and had characteristics similar to those of cancellous bone. Bone growth in the tissue engineered filled with DBM and fibrin glue materials increased with implantation time.

In summary, these DBM and fibrin glue composites exhibited interesting biological and mechanical properties for filling large bone defect. These composites may be used in total hip replacement surgery for the effective fusion between patient’s bone and artificial joint.
RESORPTION MECHANISM OF HYDROXYAPATITE AND \(\beta\)-TRICALCIUM PHOSPHATE COATING ON TITANIUM SURFACE

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Beta-tricalcium phosphate (\(\beta\)-TCP) coating layer is known to be resorbed much faster than hydroxyapatite (HA), however, there has been few reports explaining the exact mechanism until now. Therefore, we investigated whether the resorption mechanisms of these two compounds are same, if not, what is the difference.

Eighty titanium discs with 12mm in diameter and 2mm in thickness were coated with HA (n=40) or \(\beta\)-TCP (n=40) by dip and spin coating method. In each group, the specimens were divided into 2 subgroups respectively; Dissolution (D, n=20) group and Osteoclast culture (C, n=20) group. The coated discs in D group were immersed in the cell culture media for 5 days, whereas, in C group, osteoclast-like cells (5x10^3 cells/500\(\mu\)L), which were isolated form human giant cell tumor, were seeded on the specimens and cultured for 5 days. Cultured cells were defined as osteoclast by the determination of osteoclast marker (tartrate-resistant acid phosphatase, TRAP). After immersion or osteoclast culture, the dissolution characteristics of coating surface were observed using light microscope (LM) and scanning electron microscope (SEM). And the area fraction of resorption lacunae formed by osteoclast was analyzed by image analysis to evaluate the activity of osteoclastic degradation.

After 5 days of dissolution, there were much more cracks and denuded areas in \(\beta\)-TCP coating compared to HA coating. In C group, the osteoclasts covering the coating layer were identified on LM and SEM images. Mean area fraction of resorption lacunae in HA-C group was 11.62%, which was significantly higher than that of 0.73% of \(\beta\)-TCP-C group (p=0.001).

We concluded that the resorption mechanism of HA and \(\beta\)-TCP coating layers was different each other in vitro study. The coated \(\beta\)-TCP was degraded mainly by dissolution and also tended to be separated from implant, on the other hand, the HA coating layer was resorbed by osteoclastic activity.

Growth factors reduce the suppression of proliferation and osteogenic differentiation by titanium particles on MSCs

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This study was conducted to test the hypothesis that growth factors can reduce the suppressive effect of titanium particles on MSCs. Cultured human MSCs at passage 3 were challenged with prepared cpTi particles at a concentration of 500 particles/cell along with one of the following growth factors: TGF-beta(1) (10 ng/mL), FGF-2 (10 ng/mL), IGF-I (100 ng/mL), and BMP-6 (50 ng/mL). After various periods of time, the treatment effects on cellular proliferation, viability, and osteogenic differentiation were measured. All the four growth factors positively promoted cell proliferation and viability to a varying extent. FGF-2 most effectively enhanced cell proliferation, whereas IGF-1 was the most effective growth factor for enhancing cell viability. FGF-2, IGF-I, and BMP-6 reversed the titanium-mediated suppression of osteogenic differentiation, BMP-6 being the most effective one. Various growth factors can mitigate the suppressive effects of titanium particles on MSCs and enhance cell proliferation, viability, and osteogenic differentiation.
Relation between hip prosthesis function and serum concentrations of metals from prostheses, and plasma concentrations of cytokines

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We presently conduct a clinical study on four hybrid bearing combinations of hip prostheses. The main purpose of the study is to assess the function of the joints with prosthesis during a 10-year follow-up period. Serum concentrations of the metals from which the prostheses were made, and a range of cytokines, chemokines and related proteins, have been determined in blood samples drawn 3 years after arthroplasty. Subsequent blood samples will be drawn at 1-year intervals until completion of the 10-year follow-up period or patient drop-out and subjected to determination of the same substances, in order to elucidate their possible value as predictors of dysfunction or loosening of the hip prosthesis. Below we give results referring to the initial 3-year period observation period:

A total of 300 patients were randomly allocated to four prosthesis combinations: Type A: zirconia ceramic head, polyethylene cup insert, Universal RingLoc metal back; Type B: cobalt-chrome-molybdenum head and cup insert, Universal RingLoc metal back; Type C: zirconia ceramic head, polyethylene cup insert, Asian metal back; Type D: Alumina head and cup insert, Universal RingLoc metal back. A BiMetric titanium-aluminium-vanadium (Ti6Al4V) stem was used with all four head and cup combinations. All components were manufactured by Biomet. Serum concentrations of metals were measured by graphite furnace atomic absorption spectrometry (GFAAS). Plasma concentrations of cytokines and other proteins were determined by ELISA.

The groups were equal at the time of arthroplasty as regards age, sex distribution, body height, weight and Body Mass Index, side of arthroplasty, and bone mineral density in the seven Gruen zones. Nearly all patients had primary osteoarthritis or avascular necrosis of the femoral head, but a few had rheumatoid arthritis.

Harris Hip Score prior to arthroplasty was equally low in the groups, and increased significantly in all groups, with no significant differences between them.

The serum concentrations of prosthesis metals (mean ± SD) in units µg/L were: Cobalt (Co) Type A 0.20 ± 0.29; Type B 1.85 ± 2.26; Type C 0.27 ± 0.65; Type D 0.14 ± 0.24. Chromium (Cr) Type A 0.47 ± 0.33; Type B 4.58 ± 3.46; Type C 0.64 ± 0.68; Type D 0.43 ± 0.34; Molybdenum (Mo) Type A 0.90 ± 1.88; Type B 0.95 ± 2.11; Type C 0.82 ± 1.53; Type D 0.48 ± 0.85; Titanium (Ti) Type A 0.72 ± 1.57; Type B 0.46 ± 0.86; Type C 1.25 ± 3.46; Type D 0.51 ± 1.16. A significant difference between groups is seen with Co and Cr (p<0.001), namely significantly elevated concentrations of these metals in the only group using cobalt-chrome-molybdenum head and cup insert.

Plasma concentrations of cytokines IL-1β, IL-6, IL-8, IL-10, TNF-α, TNF-R1, VEGF, OPG, GM-CSF, or TGF-β1 did not differ significantly between the prosthesis groups, but a strong correlation between several of them within the same subject was apparent. Elevated levels of IL-1β, IL-10 and TNF-R1 were seen in patients with asthma. IL-6, TNF-α and VEGF were elevated in rheumatoid arthritis or asthma. IL-8 and TGF-β1 were higher in osteoarthritis, and GM-CSF was high in patients with asthma or diabetes.

In conclusion, the elevated serum concentrations of Co and Cr were seen in the group of patients using a prosthesis head and cup from these metals, and it remains to be elucidated if single, particularly high serum concentrations of prosthesis metals signify dysfunction of the prosthesis. When no sign of prosthesis loosening is present, concentrations of plasma cytokines are mainly related to the patient’s diagnosis. The proinflammatory cytokines are elevated in rheumatoid arthritis or asthma as compared to osteoarthritis.
SUITABLE EVALUATION METHOD FOR IN VITRO ANTIBACTERIAL ACTIVITY OF BIOMATERIALS

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Introduction: Bacterial infection related to orthopaedic implants is one of the serious complications. Recently, it has been reported about antibacterial biomaterials. However, antibacterial evaluations of each material are various, intercomparison of the antibacterial performance is difficult. This study was focused on the Japanese Industrial Standard test (JIS Z2801), which is used for antibacterial evaluation of commodities, investigated the suitable evaluation method for in vitro antibacterial activity of biomaterials. In 2007, JIS Z2801 test was approved as international standard ISO 22196.

Materials and Methods: Hydroxyapatite (HA) powder containing 3wt % of silver oxide (Ag) was sprayed on surface of titanium disks with the thermal spraying method using acetylene torch. This coating has been shown strong antibacterial activity by the elementary study. Antibacterial activity was examined with JIS Z2801 test and modified JIS Z2801 test. The bacterial strains used in JIS Z2801 test were Escherichia coli (E.coli), Staphylococcus aureus (S.aureus). Bacterial culture medium was instill onto surface of test disks (about 10⁶ cells/ml) and covered with polystyrene films. After cultivation in 1/500 Nutrient Broth for 24h at 35°C, the bacteria were washed out with broth. The numbers of viable bacteria in the broth were counted with agar plate culture method. Modified JIS Z2801 test was changed the experimental condition in part. Modified points were adding the bacterial strain of biofilm-forming methicillin-resistant S.aureus (BF-MRSA), using Fetal Bovine Serum (FBS) as culture medium and cultivating at 37°C.

Result: In JIS Z2801 test, Antibacterial activity values of HA-Ag disk against E.coli and S.aureus were 4.1 and 5.0. In modified JIS Z2801 test, antibacterial activity values against E.coli, S.aureus and BF-MRSA were 8.2, 5.5, and 7.1. When this value is more than two, it shows antibacterial activity existance. Namely, the titanium disk coated HA-Ag showed antibacterial activity with both tests.

Discussion: It is poor nutritional environment in bacterial culture system of JIS Z2801 test because it evaluates for commodities. However, the environment in the body is eutrophic. It is easy to make bacterial growth. For this reason, it is necessary to evaluate for biomaterials with suitable method considered in vivo. In this study, to examine in the condition like in the body, we cultivated in FBS at 37°C. In addition, the antibacterial activity against BF-MRSA was examined to consider the bacterial infection related to orthopaedic implants. Modified JIS Z2801 test was shown that it is suitable evaluation method for in vitro antibacterial activity of biomaterials.
PREPARATION OF BIOACTIVE Ti-15Zr-4Ta-4Nb ALLOY BY CALCIUM SOLUTION TREATMENT

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Titanium alloys such as Ti-6Al-4V and Ti-6Al-7Nb have been widely used as orthopedic implants such as artificial hip joint, because of their high mechanical strengths and good biocompatibilities. Recently, new kinds of titanium-based alloys free from elements such as V and Al, which are suspicious for cytotoxicities, are being developed. Ti-15Zr-4Ta-4Nb (Ti-15-4-4) is one of such alloys and shows high mechanical strength and corrosion resistance which are comparable to those of the Ti-6Al-4V alloy. In the present study, chemical treatments for providing bone-bonding ability to this alloy were investigated. Apatite-forming ability in a simulated body fluid (SBF) was used as an indication of the bone-bonding ability.

Ti-15-4-4 alloy plates 10 \times 10 \times 1 \text{ mm}^3 in size were soaked in 5M-NaOH solution at 60 ^\circ \text{C} for 24 h, soaked in 100mM-CaCl_2 solution at 40 ^\circ \text{C} for 24 h, heated at 600 ^\circ \text{C} for 1 h and then soaked in hot water at 80 ^\circ \text{C} for 24 h. Surface structural changes of the alloy with these treatments were analyzed by a field emission scanning electron microscope (FE-SEM) attached with an energy-dispersive X-ray spectrometer (EDX), Thin-film X-ray diffraction (TF-XRD) and Fourier transform confocal laser Raman spectroscopy (FT-Raman). Scratch resistance of surface layer of the alloy was measured by a thin-film scratch tester. Apatite-forming ability of the specimens was examined by soaking them in SBF for 3 days. Long-term stability of the apatite-forming ability was examined after keeping the specimens in an incubator with relative humidity of 95 % at 80 ^\circ \text{C} for 1 week.

A sodium hydrogen titanate layer about 500 nm in thickness was formed on the surface of the alloy by the NaOH treatment. This specimen formed some amounts of apatite in SBF within 3 days, but its scratch resistance was as low as less than 10 mN. When the NaOH-treated specimen was subsequently heat treated, the sodium hydrogen titanate transformed into sodium titanate to give scratch resistance as high as 92 mN, but lost its apatite-forming ability. When the NaOH-treated specimen was soaked in CaCl_2 solution, the sodium hydrogen titanate was isomorphously transformed into calcium hydrogen titanate. Thus treated specimen increased its apatite-forming ability, but its scratch resistance was still low. When the NaOH- and CaCl_2-treated specimen was subsequently heat treated, the calcium hydrogen titanate transformed into calcium titanate to give scratch resistance as high as 169 mN. However, its apatite-forming ability was lost. Thus treated specimen was then soaked in hot water. As a result, its apatite-forming ability remarkably increased without decreasing scratch resistance. It showed high apatite-forming ability even after a long-term-stability test.

The NaOH-, CaCl_2-, heat- and hot-water-treated Ti-15-4-4 alloy is believed to be promising materials for artificial joints, because of its high apatite-forming ability with long-term stability as well as high scratch resistance.
BASIC RESEARCHES AND CLINICAL RESULTS OF TITANIUM CEMENTLESS TOTAL HIP ARTHROPLASTY WITH ALKALINE AND HEAT TREATMENT

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Kokubo and one of the present authors (T.N) have developed a new technique of bioactive coating using alkaline and heat treatment, which induces the formation of a thin HA layer on the surface of titanium after implantation in the body. This new coating technique is not associated with degradation or separation of the HA coating, because a bone-like apatite layer of 1 μm in width begins to form in the body tissue after implantation. Chemically and thermally treated titanium possesses bone-bonding ability, which has been confirmed by detachment tests. Bone ingrowth into bioactive titanium continues to increase throughout the 26 weeks of implantation, whereas bone ingrowth into non-treated or HA plasma coating implants tends to decrease between 6 and 12 weeks. These findings suggest the long-term stability and osteoconduction of the bioactive layer of chemically and thermally treated titanium. Osteoinduction of porous bioactive titanium metal has been observed when treated porous blocks were implanted into the back muscles of mature dogs for 12 months, which was the first report of bone induction in a non-osseous site by titanium metal.

We carried out a series of 70 cementless primary total hip arthroplasties using this coating technique on a porous titanium surface, and followed up the patients for a mean period of 4.8 years. There were no instances of loosening or revision, or formation of a reactive line on the porous coating. Although radiography just after surgery showed a gap between the host bone and the socket in 70% of cases, all the gaps disappeared within a year, indicating the good osteoconduction provided by the coating. Alkaline-heat treatment of titanium to provide a HA coating has several advantages over plasma-spraying, including no degeneration or absorption of the HA coating, simplicity of the manufacturing process, and cost effectiveness. In addition, this method allows homogeneous deposition of bone-like apatite within a porous implant.

Although this was a relatively short-term study, treatment that creates a bioactive surface on titanium and titanium alloy implants has considerable promise for clinical application.
The osteoconductivity is the most desirable characteristic to achieve early fixation of the cementless-type artificial joints with bone. Apatite deposition on the surface of materials can induce the osteoconductivity in bony defect. In previous studies, various surface treatments have been proposed to provide titanium-based artificial joints with the osteoconductivity. The most popular surface treatment for commercial artificial joints is plasma-spray coating with apatite. Although the technique has been widely used for commercial artificial joints in the world, it remains some disadvantages attributed to high temperature during the process, such as fracture at the interface between metal and apatite, changes in the composition, crystallinity and structure of plasma-sprayed apatite. The chemical surface treatment with NaOH and H2O2 solution to provide spontaneous apatite-forming ability in the body could overcome the problems of plasma-spray process, since the treatments could be expected to not only continually express the apatite-forming ability in the body but also deposit the bone-like apatite having the similar crystal structure, crystallinity and composition of bone apatite. Therefore, surface treatments provided the spontaneous apatite-forming ability would be effective for titanium-based artificial joints with osteoconductivity.

Recently, our research group developed the extremely simple technique for providing the spontaneous apatite-forming ability to titanium by both spatial design and thermal oxidation, denoted as GRAPE technology. Pure titanium with machined micro-groove of less than 800μm in depth and 1000μm in width and thermally oxidized at 400°C in air induced apatite deposition in the internal space of micro-grooves during exposure to simulated body fluid. In this study, the application possibility of GRAPE technology was examined by using Ti-6Al-4V and Ti-15Zr-4Ta-4Nb. Apatite formed on the thermally oxidized Ti-15Zr-4Ta-4Nb at 500 and 600°C with micro-groove 500μm wide and depth in the simulated body fluid for 7 days. In contrast, no apatite formation was observed on the thermally oxidized Ti-6Al-4V at 400, 500 and 600°C with micro-groove 500μm wide and depth in the simulated body fluid for 7 days. Okazaki et al. reported that Ti-15Zr-4Ta-4Nb shows higher corrosion resistance, mechanical properties and cytocompatibility than Ti-6Al-4V. Hence, it is expected that the Ti-15Zr-4Ta-4Nb with GRAPE technology could be innovative cement-less artificial joints to achieve early fixation through its osteoconductivity and excellent performances.
NEXT - GENERATION ANTIBACTERIAL HA COATING - DEVELOPMENT OF SILVER-CONTAINING HA COATING TECHNOLOGY AND ITS CHARACTERIZATION -

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Bacterial infection related to orthopaedic implants is a significant complication today. One of the ways to reduce the incidence of implant-associated infections is assumed to give antibacterial activity to surface of implant itself. We focused attention on silver (Ag), because it has a broad antibacterial spectrum, strong antimicrobial activity and low toxicity. In the previous works, sputtering, electrochemically deposition and sol-gel coating of Ag-containing hydroxyapatite (HA) have been reported. However, since practical technique of HA coating widely used for medical and dental implants has been the "thermal spraying" technique over the last two decades, we aimed at developing the novel "thermal spraying" technology for Ag-HA coating with antibacterial activity. In this study, physical and chemical properties, in vitro antibacterial activity, inhabitation activity of bacterial attachment, HA-forming ability, cytotoxicity and release of Ag ions of the thermal-sprayed Ag-HA coating were evaluated. HA powder containing 3wt % of silver oxide was sprayed on surface of titanium disks by the thermal spraying method using acetylene torch. SEM images showed a typical structure of the thermal-sprayed coating and the X-ray diffraction (XRD) pattern of the coating showed an amorphous structure. Ag residue in the coating was determined by the elementary analysis. The coating showed strong antibacterial activity and inhabitation activity of bacterial attachment to the methicillin-resistant Staphylococcus aureus (MRSA) in fetal bovine serum (FBS). On the other hand, the coating showed fast HA-forming ability in simulated body fluid (SBF) and no cytotoxicity related to Ag contained in the coating. Therefore, it is expected that the thermal-sprayed Ag-HA coating provides antibacterial and bone-bonding ability on the surface of the implant itself. In addition, though the HA coating is generally liable to adhere bacteria, the thermal-sprayed Ag-HA coating overcomes this problem. Pre-evaluation of release of Ag ions from the Ag-containing ceramic powders indicated that the releasing behavior of Ag ions in SBFs is dependent on the existing form of Ag in the Ag-containing material. It is assumed that most of Ag components in the Ag-HA coating are not retained as metallic Ag but as Ag2O in the amorphous layer. Time-course release tests of Ag ions from the coating in FBS showed a large release rate of Ag ions until 24 h after the immersion. It is expected that the Ag-HA coating could show strong antibacterial activity at the early post-operative stage. In the repeated release testing, the amount of released Ag ions was about 6500 ppb for the first release test, after which it gradually decreased. However, a significant release amount of Ag ions was observed even after the sixth repeat test. Therefore, it was assumed that the thermal-sprayed Ag-HA coating has a slow-release property of Ag ions in FBS.
Uncemented total hip arthroplasty with second generation metal on metal articulation in young patients less than fifty years old -minimal 10 years results-

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Introduction: Total hip arthroplasty with use of second generation metal-on-metal bearings has been reintroduced for active young patients because of theoretical advantages such as reduced wear and lower incidence of osteolysis. The purpose of this study is to identify clinical and radiographic results of uncemented total hip arthroplasties with the use of Metasul™ metal on metal bearings.

Methods: Our study included 78 hips in 61 patients from January 1994 and February 1997. Mean age was 39 years and average follow-up period was 11.7 years. We used Metasul™ metal on metal bearing with Wagner standard cup and proximal hydroxyapatite coated CLS stem. Postoperative clinical and radiographic results were examined. Serum cobalt levels were also evaluated in hips with or without osteolysis.

Results: Mean Harris hip score had improved from 51.4 points preoperatively to 95.2 points finally. There were 2 hips with progressive osteolysis around the acetabular cup. Of them, one hip was revised due to loosening of the cup, and the other was observed because of patient’s refusal to revise. In histopathologic findings on osteolytic area, a lot of macrophage phagocytizing metal debris and perivascular lymphocyte infiltration was found. In immunohistochemical analysis, CD4 and CD8 positive T-cells, and CD68 positive macrophages were found, which suggested delayed metal hypersensitivity. Serum cobalt levels in hips with osteolysis were not higher than those in hips without osteolysis.

Conclusions: Clinical and radiographic results using second generation metal on metal bearing in young patients were favorable in terms of low incidence of osteolysis with undetectable wear, low incidence of cup loosening and no loosening of stem. But early osteolysis with sudden onset of groin pain in few hips probably due to metal hypersensitivity remains a concern.

Key words: total hip arthroplasty, second generation metal on metal bearings, young patient

Metal-On-Metal Cementless Arthroplasty for the Treatment of Arthritis Following Congenital Hip Disease

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Little is published about the use of cementless conical stems in primary hip arthroplasty for congenital hip disease. A conical stem was designed in the 80’s by Prof. Wagner. The stem is made of a rough blasted titanium alloy with a cone angle of 5° and 8 sharp longitudinal “ribs” that cut into the inner cortex, designed to achieve rotational stability. The ribs depth of penetration ranges between 0.1 and 0.5 mm and is also very important to achieve osteo-integration. The CCD angle is 135°. The stem is straight and can be implanted in any degree of version thus being very useful for dysplastic arthritis with significant femoral neck anteversion.

Between 1993 and 1998 the senior author (RB) implanted 92 conical stems in 88 consecutive patients with dysplastic arthritis. The acetabular component was cementless and titanium with tridimensional porosity. The articulating surface was a second generation Metal-on-Metal with a femoral head of 28 mm. According to the Hartofilakidis classification 63 patients had type A, 18 type B and 11 type C.

The average follow-up was 11.2 years (range 10.1-14.8). Using the Harris Hip Scoring system we had 82 (89%) satisfactory results, with excellent correction of pre-op pain (42/44 Harris) and no case of anterior thigh pain; 88% of patients had no or slight limp at followup. No patient required revision of the stem, but one cup required revision for loosening (Type C class). We had one dislocation (1%) that was treated conservatively.

Radiographically, all stems were osteo-integrated. 17% showed some resorption in femoral zone 1 and 7. In the same zones we observed 4 cases of real osteolysis without loosening. No radiolucent line was observed in other femoral zones. In the acetabular side we had 13 cases (14%) of radiolucency, but in only 1 case (1%) it was progressive.

A straight conical titanium femoral stem gave very satisfactory clinico-radiographical results in dysplastic arthritis at a mean of 11.2 years of followup.
CEMENTLESS TOTAL HIP ARTHROPLASTY WITH A CONTEMPORARY SECOND-GENERATION METAL-ON-METAL BEARING

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Metal-on-metal bearing was re-introduced with the aim of eliminating polyethylene wear and resulting complications of osteolysis and aseptic loosening in total hip arthroplasty (THA). However, authors of recent studies have reported periprosthetic osteolysis and aseptic failure following second-generation metal-on-metal THA. The purpose of this study is to report the results at a minimum of five years following cementless total hip arthroplasty with a contemporary metal-on-metal articulation. Our study included findings of histologic examination on periprosthetic tissues from revised hips and wear and roughness analysis of retrieved implants.

A consecutive series of 158 cementless THAs that were performed in 154 patients using a contemporary metal-on-metal bearing were assessed at a mean of 6.5 years (range, 5 to 8 years). There were eighty men and seventy-nine women with a mean age of 53 years (range, 21 to 80 years). The patients were assessed clinically with use of the Harris hip score, and the hips were assessed radiographically. Histological analysis was performed on specimens retrieved from the revised hips, and wear and roughness measurements were made for the explanted prostheses. The average Harris hip score improved from 45 points preoperatively to 92 points at the final follow-up examination. There was no aseptic loosening of the femoral or acetabular components. One hip was revised because of recurrent dislocation and one was managed two-stage reimplantation for deep infection. Thirteen hips (8%) had osteolysis; 11 had osteolysis localized within the greater trochanter and 2 had both femoral and acetabular osteolysis. Of these, 5 patients who had a persistent pain and osteolysis underwent revision operation for the consideration of bearing exchange to a ceramic-on-ceramic or ceramic-on-polyethylene combination. All these revised hips showed extensive synovial-like tissue hypertrophy and perivascular infiltration of lymphocytes on histological examinations. Annual volumetric wear rate measured on one retrieved femoral head was 1.04 mm³/yr, and roughness measured on three retrieved femoral heads was consistently very low between 8 nm and 117 nm. After the revision surgery, all the patients noticed disappearance of pain as well as radiographic evidence of healing of the osteolytic lesion.

Our mid-term follow-up of cementless THA using a contemporary metal-on-metal bearing revealed an unexpectedly high rate of periprosthetic osteolysis possibly in association with metal hypersensitivity. In patients with persistent hip pain and osteolysis after contemporary metal-on-metal THA, surgeons should consider an exchange of the articulation surface to a ceramic-on-ceramic or ceramic-on-polyethylene combination because they can be cured only after an elimination of the source of hypersensitivity reaction.
OSA04-01

Contemporary cementless total hip arthroplasty with alumina bearings: 6 to 9 Year outcomes in patients with osteonecrosis of the femoral head less than 50 years

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Background: We prospectively investigated the outcomes including fracture or noise of cementless total hip arthroplasty using contemporary alumina bearings for patients with osteonecrosis of the femoral head less than 50 years.

Methods: Seventy-one total hip arthroplasties in 60 patients with osteonecrosis less than fifty years were performed consecutively at single institute by single surgeon. The mean age of the patients was 39 years (range, 18 to 49 years) and the average follow-up period was 7.1±1.1 years (range, 6 to 9 years).

Results: The mean Harris hip score at the final follow-up was 97.0±3.3 points (range, 89 to 100). A noise was reported in 14 hips (19%); “clicking” in 13 hips and “squeaking” in 1 hip. The mean inclination angle of acetabular components was 40.9±5.0° (range, 32 to 54°). Wear could not be measured. No hip demonstrated loosening or osteolysis. The mean limb length discrepancy was 0.9±2.5 mm (range, -8 to 7 mm). Two linear femoral fractures were treated with cerclage wires intraoperatively and healed without complication. There was no fracture of the alumina head or chip fracture of the insert. No hip dislocated and no infection occurred. No hip was revised for any kind of reason.

Conclusions: Based on the encouraging outcome of the present study, the authors believe that contemporary cementless THA with an alumina bearing surface offers a promising option for younger, active patients with osteonecrosis. However, a close longer-term follow-up is necessary to draw any conclusions on ceramic fractures and noise issues.

OSA03-04

METAL ON METAL BIG HEADS ANALYSIS OF FIRST FAILURES AND CORRELATION WITH METAL IONS

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INTRODUCTION: Metal on Metal coupling in total hip replacement has been widely used since many years. After the rebirth of resurfacing a new trend to use very large diameter metal-metal coupling with “conventional” prostheses has been started. New prostheses, old and new problems. We analyze first failures with new large diameter metal on metal coupling.

MATERIALS AND METHODS: The analysis focused on 7 early failures of large diameter metal-metal prostheses (2 resurfacing and 5 large head). Synovial fluid aspiration have been performed in all patients searching for metal ions and bacterial proliferation. Moreover, it was also studied prosthetic component positioning as a possible “primum movens” of failures. Some failed patients underwent epicutaneous Patch test for metals.

RESULTS: The 2 resurfacing failures resulted from avascular necrosis and consequent fracture of the femoral neck. Out of the 5 failures of “conventional” metal-metal prosthesis with large head, one was the result of an infection, one had an infected metallosis with a huge intraabdominal mass and the other three were the result of aseptic loosening. Three showed clear metallosis caused by wrong positioning (cup inclination > 50°). All of these three presented an articular noise. The last revision was done on a patient with good component positioning but epicutaneous allergic reaction to Cobalt. Also one of the three patients with metallosis resulted allergic to Cobalt. The blood and sinovial metal ion values were always elevated but particularly high in patients with cup inclination over 50°. The patient with the abdominal mass underwent a lumbotomy to evacuate the abdominal retroperitoneal mass before prosthesis removal for a two step procedure.

CONCLUSIONS: Large head metal on metal prostheses are very sensible to positioning. Blood and sinovial metal ion determination helps to promptly diagnose a bad prosthetic functioning. A more accurate analysis about the different metals available on the market and their resistance to edge wear should not be delayed any further.
Total hip arthroplasty (THA) in patients with DDH has been associated with increased rates of complications and revision. Hip instability and wear-induced osteolysis are among the more common and serious of these problems. The current investigation prospectively assessed the survivorship and clinical results of patients with DDH treated by alumina ceramic-ceramic THA.

We investigated 123 consecutive hips in 108 patients with DDH classified as Crowe type I (116 hips, 94%) and II (7 hips, 6%) treated between 1997 and 2006. All patients had an uncemented titanium acetabular component with a flush mounted alumina ceramic-ceramic bearing. The mean age at operation was 47.6 ± 12.7 years (range, 18 – 75 years). The preoperative Merle d’Aubigné score was 11.1 ± 1.7 (6 – 14). Ninety-seven cases (79%) had not had previous surgery. 65 hips (53%) were replaced with the use of surgical navigation for acetabular component positioning. The mean cup diameter was 50.1 ± 3.6 mm (46 - 60 mm). 61 (49%) bearings were 28mm and 62 (451%) bearings were 32mm.

At a mean follow-up of 4.7 ± 1.9 years (2 - 10 years), the mean Merle d’Aubigné score was 17.4 ± 1.0 (14 - 18). There were no cases of osteolysis or dislocations. There was one reoperation of an early displaced cup. In addition, there was one calcar crack that was cerclaged, one intraoperative trochanteric fracture also repaired at surgery. No patient complained of squeaking. Specific squeaking questionnaires were completed for 88 of the 123 hips. None reported ever hearing a squeak. The 10-year Kaplan Meier survivorship of the implants (revision of any component for any reason) was 99.2% (95% confidence interval 98.1-100%).

Results of ceramic-ceramic THA in young patients with low to middle graded DDH after two to ten year follow-up are promising with no radiographic signs of osteolysis or dislocation.
Alumina on Alumina Bearing With Uncemented Implant for Dysplastic Hips Aged Sixty or Below: A Five Years Minimum Follow-up Study-To Advantage the Bearing Property from a Viewpoint of the Surgeon

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Expecting the low wear property and the longevity, since October 1998, we have been using the alumina on alumina bearing for the hip arthroplasty. Until July 2008, for dysplastic 1078 hips we have implanted the bearing couple. Among them, we evaluated 86 hips in 79 patients (male 3, female 76) with the primary arthroplasty, Spongiosa Metal II Total Hip System (GHE: ESKA implants, Lubeck, Germany / Biolox Forte®: Ceramtec AG, Plochingen, Germany), osteoarthritis secondary to developmental dysplasia, age 60 or below, and a minimum of five years follow-up. The preoperative diagnosis included the failed pelvic and / or femoral osteotomy, avascular necrosis after DDH, dislocation, and subdislocation. The average age at the surgery was 53 (27 to 60). The average of follow-up period was 6.3 (4.6 to 9.1) years. The implants have a macro-porous structure on the surface. To set the metal shell in the intended position, the sclerotic lesion was adequately resected by the chisels and then we used the acetabulum reamers. Otherwise the sclerotic lesion would prevent the reamer to go into the suitable direction. We reamed the acetabulum until the lamina interna to use the maximum size of the metal shell (i.e. to use the liner as thick as possible) and at the same time for the medialization of the hip center. To avoid impingement, the osteophyte was resected without hesitating. We added the adductor tenotomy for 19 hips, the extensive release of the flexor tendons (including the quadriceps origin, the sartroius origin, and the glutueus maximus insertion) for three hips, and the release of the extensor insertion (the glutueus maximus) for two hips, and the release of the flexor insertion (the iliopsoas) for two hips.

The hip score was improved in all patients. The average amount of the hip score was 59 before the surgery and was 90 at the final follow-up. A positive Trendelenburg sign was observed in 53 hips (62%) before the surgery and 12 hips (14%) at the final follow-up. We had no revision, no bearing failure (alumina fracture or excessive wear), no dislocation, and no squeaking in these patients. The average inclination angle of the cup was 41 (29 to 49) degrees. The average anteversion angle of the cup was 19 (13 to 27) degrees. No patient required the revision surgery. At the final follow-up, all implants were stable. In the acetabulum, the radiolucent line was observed in two hips (2%) (zone I). In the femur the line was observed in 13 hips (15%). All lines existed in the proximal femur. There was no cystic osteolytic lesion. The prevalence of these periprosthetic reactions was less than those in the same type implant with the polyethylene on alumina bearing.

Some authors alerted that the alumina on alumina articulation should only be applied in when the optimized implant orientation is obtained so as to prevent the impingement and dislocation. Fortunately the alignment in this study was within the safe zone. However, we must always be very careful of the joint alignment, range of motion, and the muscle tension during the surgery to avoid the bearing failure, as setting an adequate alignment and obtaining a firm uncemented fixation of the cup is relatively difficult in dysplastic hips. From this view point, Spongiosa Metal II cup suits the use of the alumina on alumina bearing especially for dysplastic hips.
PROSPECTIVE RANDOMIZED TRIAL COMPARING ALUMINA CERAMIC-ON-CERAMIC WITH CERAMIC-ON-CONVENTIONAL POLYETHYLENE BEARINGS IN TOTAL HIP ARTHROPLASTY. UP TO 10 YEARS FOLLOW-UP IN PATIENTS UNDER AGE 60.

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Total hip replacement in the young active patient remains one of the major challenges in orthopaedics today. The use of ultra high molecular weight (UHMW) polyethylene acetabular liners is known to cause polyethylene wear related osteolysis, the major limiting factor in its use in the younger active patient. Modern alumina ceramic articulations have been developed in order to reduce wear and avoid polyethylene debris. This prospective randomized long-term study aims to compare the outcome between an alumina ceramic-on-ceramic (CC) articulation with a ceramic on UHMW polyethylene articulation (CP). In the younger active patient, is one option superior to the other with regard to patient satisfaction, osteolysis and implant longevity?

56 hips in 55 patients with mean age 42.2 (range 19-56) each received uncemented components (Wright Medical) and a 28mm alumina head with acetabular liner selected via sealed envelope randomization following anesthetic induction. Subsequent regular clinical and radiologic follow up measured patient outcome scores and noted any radiological changes.

26 CP hips and 30 CC hips were evaluated. One failure required revision in each group. Mean St Michael’s outcome score for each group with up to 10 years follow-up (median 8 years, range 1-10) was 22.8 and 22.9 respectively (p=0.057). Radiographs with a minimum 5 years post-operative follow-up were analyzed in 42 hips (23 CC and 19 CP). Radiolucency of all 3 acetabular zones was identified in one of the CP hips. There was no evidence of osteolysis or loosening identified in the remaining hips. The mean time of wear measurement for the CC group was 8.3 years (SD 1.3, Range 4.8-10.1 years) and for the CP group was 8.1 years (SD 0.9, Range 6.1-9.2 years)(p=0.471). Wear was identified in all but one of the CP replacements but only 12 of 23 CC articulations. The mean wear for the CC group was 0.14 mm (SD 0.16, Range 0-0.48 mm) and for the CP group was 0.89 mm (SD 0.6, Range 0-2.43 mm)(p<0.001). Extrapolating the annual wear rate from these figures, the respective wear is 0.02mm for the CC group compared to 0.11mm per year for the CP group.

To our knowledge this is the first long term randomized trial comparing in vivo ceramic-on-ceramic with ceramic-on-conventional polyethylene hip articulations. Other than significantly greater wear in the polyethylene group there was no significant difference in long-term outcome scores between the two groups with up to 10 years of follow-up. The use of a ceramic-on-ceramic bearing is a safe and durable option in the young patient avoiding the concerns of active metal ions and osteolytic polyethylene debris. These patients remain under review.
THIRD-GENERATION CERAMIC-ON-CERAMIC BEARINGS IN REVISION TOTAL HIP ARTHROPLASTY

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Total Hip Arthroplasty (THA) has been more frequently performed for relatively young patients with osteonecrosis of the femoral head in Korea. Moreover, squatting and sitting with crossed legs are more common in Asian cultures than in Western cultures. Wear debris generated by conventional metal-on-PE articulations has been giving rise to extensive osteolysis. Due to these characteristics, higher incidence of pelvic osteolysis was observed after THA in Korea. As a result, interest in alternative bearings such as ceramic-on-ceramic bearing has been increased. Furthermore, the patients who require revision THA are still young in Korea. With this point of view, an application of ceramic-on-ceramic bearing throughout revision THA seems to be reasonable. The clinical and radiographical outcomes after revision THA with use of third generation ceramic-on-ceramic bearing in Korean patients were evaluated.

Materials and Methods: We have analyzed 42 hips (37 patients; 17 men and 20 women), in whom revision THAs were performed using cementless cups with ceramic-on-ceramic bearing (Biolox Forte; CeramTec, Plochingen, Germany). They underwent THA at a single institution between February 2000 and December 2004, and were consecutively enrolled in this study. Their mean age was 48.8 years (32 - 59 years), and their mean weight was 61.5 ± 5.8 kg (50 - 72 kg) and BMI was 23.8. The mean interval from primary to revision THA was 9.5 ± 3.2 years (3.3 - 16.1 years). The preoperative diagnoses for primary THA were osteonecrosis of the femoral head in 31 hips, neglected femoral neck fracture in 3, rheumatoid arthritis in 2, degenerative osteoarthritis in 2, pyogenic arthritis in 2, tuberculosis arthritis in 1, and fused hip in 1. Dissociation of PE liner was observed in 21 hips (50%). For acetabular cup revision, Trilogy ceramic acetabular cups (Zimmer, Warsaw, IN) were used in 22 hips, EP-FIT plus cups (Plus Orthopedics, Rotkreuz, Switzerland) in 14 hips, and Duraloc Option Ceramic cups (DePuy, Warsaw, IN) in 6 hips. Stems were revised in all hips. The follow-up protocol included radiographic and clinical evaluations, and the mean duration of follow-up monitoring after revision THA was 5.4 ± 1.7 years (3.2 - 8.0 years). At final follow-up examination, clinical outcomes including Harris Hip Score and complications were assessed. All changes in inclination were documented radiographically. The presence of radiolucent lines, vertical or horizontal migration of acetabular cup (> 2 mm), and osteolysis were also evaluated.

Results: At final follow-up evaluation after revision, the average Harris Hip Score was 91.3. There were no revised hips during follow-up period. In 6 hips (14.3%), minor complications were observed: 3 heterotopic ossifications, 2 dislocations, 1 infection. No revision was necessary for the treatment of these complications. There were no hips with radiolucent lines, vertical or horizontal acetabular cup migration or osteolysis during the follow-up period. In 21 hips with bone graft, incorporation of bone graft was observed radiographically at final follow-up examination.

Conclusions: Our data showed that clinical and radiographical outcomes after revision THA using third generation ceramic-on-ceramic bearing were favorable. Revision THA with the use of ceramic-on-ceramic bearing surfaces can be preferentially considered especially in young patients. Further studies with long-term follow-up data are warranted.
Primary fixation of finite element model of IMC stem evaluated by micromotion

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The primary fixation of cementless hip prostheses is related to the shape of the stem. When there is a complication of
loading in several directions, the mechanical fixation of a hip stem is considered to provide good primary fixation.
The purpose of this study was to evaluate whether the IMC stem with its characteristic fixation method, which was
developed by a group at Kitasato University, contributes to primary fixation by finite element analysis.
Analysis was performed at a friction coefficient of 0.1 with automatic contact, under the restriction of the distal
femoral end. The following three loading conditions were applied: i) step loading of the joint resultant force in the
region around the hip stem, ii) loading in the rotational direction, simulating torsion, and iii) loading of the femoral
head equivalent to that during walking. Micromotion of the IMC stem along the x-, y-, and z-axes direction was
calculated by simulation, and the stress distributed on the stem and femur was determined.
Micromotion along the z-axis, which is a clinical problem in hip prosthesis stems, was lower in the IMC stem than in
other stems reported. Micromotion of the stem along the z-axis was low, indicating a low risk of sinking. The
interlocking mechanism, which is a characteristic of the IMC stem, functioned to suppress its micromotion, indicating
that the locking method of this stem contributed to the stability. Since no stress concentration was detected, it was
considered that there are no risks of breakage of the IMC stem and femur.
It was suggested that effective fixation of the finite element model of the IMC stem can be achieved because the
micromotion and stress level are appropriate for primary fixation.
JOINT FORCE GENERATES DISLOCATING COMPONENT INFLUENCED BY ACETABULAR LINER HEAD CENTER INSET

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Introduction: Previous studies suggested that the shallow Ultra High Molecular Weight Polyethylene (UHMWPE) acetabular socket liner or the liner with no head center inset can significantly increase the risk of hip joint dislocation. Independent to the traditional neck impingement models, the purpose of this study was to investigate an additional dislocation force pushing the femoral head out of UHMWPE acetabular liner bearing under direct hip joint loading and the factors including the head center inset affecting the magnitude of this force.

Materials and methods: The 3D Finite Element Analysis (FEA) models were constructed by (30) 10 mm thick UHMWPE liners with six inner bearing diameters ranging from 22 mm to 44 mm and five head center insets in each bearing size from 0 mm to 2 mm. A hip joint load of 2,446 N was applied through the corresponding CoCr femoral head center to the rim of the liner. The Intrinsic Dislocating Force (DF) forcing femoral head out of liner was recorded as a function of liner inset height and head diameter. The results were verified by the physical tests of two 28 mm head bearing liners with 0 and 1.5 mm head center insets respectively.

Results: The results showed that the highest DF was 1,269 N per 2,446 N joint load in 0 mm head center inset for 22 mm head or the case of easiest to dislocate. The lowest DF was 171 N per 2,446 N in 2 mm inset for 44 mm head which therefore was least likely to dislocate. The DF decreased as the inset and head size increased. When inset increased from 0 mm to 1 mm, the DF was reduced more than 50%. Two experimental data points were consistent with the trend of DF curve found in the FEA.

Discussion: We concluded that the new intrinsic dislocating force DF can be induced by the rim directed joint loading force alone and can reach as high as 51% of the femoral loading force. This can be the addition to the dislocating moment generated by the neck impingement. A head inset above 1mm can effectively reduce DF to less than 25% of the joint force. Furthermore, the larger head diameter generates less DF. The DF is likely caused by the wedge effect between the deformed polyethylene bearing and the femoral head. The inset allows the femoral head to be separated from the spherical bearing surface, thus reducing the wedge effect. Our observation of the stabilizing effect trend of the head center inset was consistent with reported clinical data. However, the increased height of the capture wall also reduces the range of motion. It is therefore necessary to minimize the inset height with the maximum benefit of the stabilizing effect. This study suggested the larger femoral head has the advantage of reducing the DF and the stabilizing effect is more effective when combining with the inset wall. The result of this study should provide the guidance to improve acetabular poly liner design for better joint stability.
INVESTIGATION OF BUFFERED IMPLANT FIXATION IN RAT MODEL: MEASUREMENT OF INTERFACE STRENGTH IN COMPARISON WITH CEMENTED IMPLANT FIXATION

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We suggested a new concept of buffered implant fixation. It is a cementless fixation using a buffer instead of the cement between the bone and the implant. We investigated the feasibility of the buffered implant fixation using a rat model. In our previous study, we measured the amount of bone around the implant to compare the buffered implant fixation with the cemented fixation. The results showed the difference in change of BV/TV with time between the buffered fixation and the cemented fixation. Now, in this study, we are comparing the mechanical interface strength between two fixations.

After micro CT scanning, the specimens were used for mechanical push-out test to measure the interface shear strength at the buffer-bone or cement-bone interface. The distal side of the femur was carefully removed to expose the whole distal region of the implant while the proximal side of femur was cut carefully with diamond saw (Metsaw, R&B Inc., Korea) until the proximal end of cement or buffer is exposed. The femur was embedded into a push-out jig with a plaster. The push-out jig was mounted in a material testing machine (KSU-10M, Kyungsung testing machine, Korea) and loaded at a rate of 0.01mm/sec. The apparent interface strength was calculated by dividing the peak force by the surface area of the buffer or cement.

After 2 weeks, the apparent interface strength is 217.0 ± 280.0 (average ± standard deviation) for buffer and 472.4 ± 381.1 for cement; after 4 weeks, 92.9 ± 67.6 and 268.1 ± 197.9; after 12 weeks, 441.9 ± 467.1 and 201.8 ± 132.3, respectively. The buffered fixation showed gain in strength with time while the cemented fixation showed reverse tendency but the interaction by ANOVA was not significant (p=0.125). Even though the excellence of buffer fixation was not clearly confirmed because of small sample size and high variance, the feasibility of the buffer fixation was shown.

However, further studies are necessary to improve the buffered implant fixation. To enhance the cell adhesion and biocompatibility, it is necessary to modify the surface of PEEK such as by plasma treatment or biological coating. Also, an animal test using a higher level animal such as dog or pig is necessary.

COMPARISON OF 2-D V.S. 3-D FILL OF THE HIP STEM MEASUREMENT
- TOWARDS THE NEW METHOD-

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Objective: Establishment of the new method to evaluate fill of the hip stem.

Background: The fill of the hip stem is one of the important parameters to estimate the quality of planning or positioning of the cementless stem. It has been defined as a stem-canal width ratio on the A-P plain of X-ray images so far. However, it is quite a problem to get the correct AP images on basis so that positional difference may affect the measurement. According to our data, the fill was measured significantly different in 15, 30, 45, 60 degrees erroneous direction. First, we tried to figure out the fill of the hip stem three-dimensionally rather 2-dimensionally. Next, our new method was compared to conventional method.

Material and Methods: Leg CAT scans were performed on 32 hips of 20 patients (2 male, 18 female). Images of the canal of femora were reconstructed using CAD software. We made 2-types of canal model with or without lesser trochanter. The geometries of our lateral flare stems with different sizes were compared to each canal geometry in the CAD software and proper size was decided. Then images were observed from an accurate vertical direction of the coronal plane of the stem. We measured the 2-D fill on this plane and the 3-D fill of every 5 mm slice from the 5mm above to the 100mm below the head of lesser trochanter line (reference line). We also examined the stems 1-size smaller or larger than the appropriate ones.

Results: The mean age was 61.1 ± 14 (range 24-82). The average of 3-D fill of Lateral flare stem was 51%/59% with/without lesser trochanter, and 2-D one was 74%/77%. The numerical and distributional results by these two methods to measure fill were alike but different. For example, in case without lesser trochanter, the 3-D fill showed the maximum value in the area just below the reference line. The maximum 2-D fill was recorded in 10mm caudal from the reference line. In general, this stem occupied much space in the distal area and around the lesser trochanter.

Future Plan: Extension of this evaluation method into various kinds of stems.
The Utility of Pre-Operative CT-Based Surgical Planning in THA Using the Profemur Z -

Koya Kamikawa

Introduction: 'Fit and fill' of the femoral component was originally thought essential for stability of cementless stems. However, the Zweymuller stem was designed for 'fit without fill', (particularly flat tapered stem) and remains highly successful since its inception in 1979. We have performed primary cementless THA with the Profemur Z system (Wright Medical Technology, Inc.) mainly for dysplastic hip. The concept of Profemur Z stem with a modular neck system is the same as the Zweymuller grit-blasted titanium femoral stem. Traditional templating for dysplastic hips often led to errors in sizing, cup positioning and femoral stem direction. A CT-based surgical planning system called Hip-Op is a three dimensional planning software program that uses DICOM images to represent the relevant anatomical objects by means of multiple views. The purpose of this study was to evaluate the utility of the Hip-Op system to accurately predict implant size, insertion angle and the fixation manner of the femoral stem.

Materials and Methods: One hundred and three non-selected, consecutive THA in 96 patients were performed as primary cementless THA with the Profemur Z system by the same surgeon. There were 81 women and 15 men in this group, with a mean age at surgery of 63 years (range: 35~87 years). Postoperatively, the predicted implant sizes planned with Hip-Op system and with standard X-ray templates were compared to the actual components selected at the time of surgery. Clinical evaluation was done by using the Harris Hip Score (HHS). The femoral stem was evaluated in both the anterior posterior and lateral projections of the radiographs. Insertion angle and the fixation manner of the femoral stem were also examined postoperatively using X-ray and CT.

Results: 3D templating with Hip-Op system accurately predicted the exact size of the femoral component 65% of the time, was within 1 size 96% of the time and within 2 sizes 100% of the time. Acetabuli were correctly predicted 80% of the time, within 1 size 98% of the time and within 2 sizes 100% of the time. Conventional templating predicted the exact size 48% of the time in femoral components, and 66% in acetabuli, within 1 size 76% and 82%, within 2 sizes 89% and 92%, respectively. The average preoperative HHS was 46.3 points and the latest HHS was 83.2 points on average. Three patients required slow physiotherapy due to greater trochanteric fractures. Two patients suffered from anterior dislocation. There was no femoral component subsidence. The insertion angle from neutral position of the stem was 0.4 degree in A-P view, and 1.6 degree in profile view. The fixation manner of the Zweymuller stem in the canal was obtained by contact with the four corners of the stem in 6.7%, three corners in 16.7%, two corners in 70%, respectively.

Discussion: The Zwemuller stem design provides primary axial stability through its dual longitudinal taper and primary rotational stability through contact with the corners of the stem to cortical bone in the canal. This study clearly shows the advantages of CT-based 3D templating over conventional X-ray templates. The surgical planning performed
**PREOPERATIVE THREE-DIMENSIONAL PLANNING FOR FEMORAL COMPONENT - CORTEX/STEM RATIO MAPPING ON STEM SURFACE**

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**Introduction:** Three dimensional preoperative planning for each patient has been done in our institution. Anatomical designs of prosthesis are necessary to realize primary stability. The purpose of this study is to visualize the area which concerns about initial stability and load transfer post-operatively.

**Methods:** A preoperative three-dimensional planning based on CT-scan data was performed. Two different contour prostheses (Versys and Revelation) were studied for each patients.
Distance from central axis of the stem to inside wall of the femoral cortex (A) and distance from central axis of the stem to the surface of the stem (B) were measured. We defined B/A as cortex-stem ratio and mapped it on the surface of the stem like contour lines.

**Results:** Cortex-stem ratio of Versys stem of proximal femur indicated over 90% at medial, but no more than 70% at anterior, posterior and lateral. In a circumference of distal stem, that ratio was high. On the contrary, cortex-stem ratio of Revelation represented 90~100% at medial and lateral,85~95% at anterior portion.

**Discussion:** High rate region of cortex-stem ratio represent a great difference between Versys stem and Revelation stem. These region participate in primary fixation and lord transport to femoral cortex. Preoperative three-dimensional mapping is useful technique to better understand the relative position between the stem and the femur, to evaluate which regions were concerned in initial stability after operation and lord transfer later. The visualized result can also suggest the surgeons where and how to prepare the canal efficiently for each design of the stems.

**SELECTION OF REVELATION STEM USING 3-D PREOPERATIVE COMPUTER PLANNING SYSTEM**

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**Introduction:** The success of cementless THA (total hip arthroplasty) mainly depends on the choices of stem, its size and accuracy of stem orientation. Selection of the optimal stem judging only by plain X-ray is not so easy. Because deformity varies in each case and it is impossible to obtain profile view of the hip. As osteoarthritic patients tend to develop external rotation contractures, radiographic position of the patients with correct rotation is very difficult. To override these problems, we have been using 3-D preoperative planning system. As for the stem selection, we have been mainly using Revelation stem, because it has a structure called lateral flare that provide proximal physiological load transfer. In the present study, the usefulness of our preoperative planning system especially for the determination of the size and stem orientation with Revelation stem.

**Materials and Method:** Pre-operative planning was performed in 55 osteoarthritic hips in 50 patients (10 male and 40 females), and the mean age at the operation was 64.05 years old. The 3-dimensinal geometries of the femora femora were reconstructed from the CAT scan DICOM data. The geometry of femur and components were placed on the same coordinate. Cross-sectional images from many directions were observed, and the optimal location and the size of the stem were selected. According to the result, actual operations were done. Planed sizes and selected sizes at the surgeries were compared. For several patients, post-operative CAT scans were performed, then planed stem position and actual stem position were compared.

**Result:** Stems preoperatively defined were used in 50hips (90.9%) ,1 size large ones were used in 2 hips (3.6%) and 1 size large ones were used in 3 hips (5.5%).

**Discussion:** As Revelation stems have very high proximal fit-and-fill, the end point of the stem insertion is very definite. The characteristics made the accuracy of the preoperative planning. So it was not so difficult to perform THA according to the preoperative planning as it had been imagined.
PER-OPERATIVE VIBRATION ANALYSIS: A VALUABLE TOOL FOR DEFINING CORRECT STEM INSERTION

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The operation technique and prosthetic materials for total hip replacement (THR) have continuously improved. Still, determining the end-point of the prosthetic stem insertion into the femur canal relies on the feeling of the orthopaedic surgeon. This consists of a sense of mechanical stability when exerting torque forces on the prosthesis as well as a feeling of the prosthesis being well fixed and not displaceable along the axis of the femur. Stability and survival of the implant is directly related to the long term fixation stability of the prosthesis stem. But, excessive press-fitting of a THR femoral component can cause intra-operative fractures.

In our centre custom made stem prostheses are commonly used to increase the optimal fit in the femoral canal. We report the first per-operative use of a non invasive vibration analysis technique for the mechanical characterization of the primary bone-prosthesis stability.

From in vitro studies a protocol has been derived for per-operative use. The prosthesis neck was attached to a shaker using a stinger provided with a clamping system. The excitation was realized through white noise in the range 0-12.5 kHz, introducing a power of approximately 0.5W into the femur-prosthesis system. The input force and the response acceleration were measured in the same point with an impedance head mounted between the shaker and the stinger. The FRF was measured and recorded by a Pimento vibration analyzer connected to a portable computer provided with the appropriate software. All equipment was installed in the surgical theatre but outside the so-called laminar flow area.

The surgeon inserted the implant in the femoral canal through repetitive controlled hammer blows. After each blow, the FRF of the implant-bone structure was measured directly on the prosthesis neck. The hammering was stopped when the FRF graph does not change noticeably anymore.

The amount of FRF change between insertion steps was quantified by the Pearson’s correlation coefficient R between successive FRFs. A correlation between the FRFs of successive stages of R=(0.99 +/- 0.01) over the range 0-10000 Hz is proposed as an endpoint criterion.

Non cemented custom made stem insertion was studied in 30 patients. In 26/30 cases (86.7%), the correlation coefficient between the last two FRFs was >0.99 when the surgeon stopped the insertion. In 4 cases, the surgeon decided to stop the insertion because of suspected bone fragility, the final correlation coefficient was lower.

In one case an abnormal change in the FRF graph triggered inspection of the femur bone. A small fracture was observed and insertion was stopped.

In a second case FRF graph showed an oscillating behavior, while the stem was visibly not completely inserted. After withdrawal of the stem and readjustment of the femoral canal, the stem could be reinserted and the Pearson’s correlation index at end of insertion was 0.998.

The use of custom made stem prosthesis, made exactly to fit into the femoral canal increases the risk of excessive press fit and intra-operative fractures. Vibration analysis showed to be a useful tool to define end of the stem insertion.
WHAT IS ANTEVERSION, WHERE IS IT LOCATED, HOW DOES IT EFFECT TO THE STEM DESIGN AND HIP ARTHROPLASTY?


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Introduction: One of the most important characteristic of the developmental dysplastic hip (DDH) is high anteversion in femoral neck. Neck-shaft angle is also understood to be higher (i.e. coxa-valga) in DDH femora. From this understanding many DDH intended stems were designed having larger neck shaft angle. According to the result of our prior study; reported in ISTA 2005 etc.; using computer 3-D virtual surgery of high fit-and-fill lateral flare stem into high anteversion patients, it was revealed that the geometry of proximal femur itself does not have big difference from normal femora but they are only rotated blow lesser trochanter.

It is very important to know what anteversion is and where anteversion is located to design better stem and to decide more proper surgical procedures for DDH cases with high anteversion.

In the present study, the geometry of 57 femora was assessed in detail to reveal the geometry of anteversion and its location in the DDH femora.

Materials and methods: Fifty seven CAT scan data with many causes were analyzed. Thirty-two DDH, 3 RA, 2 metastatic bone tumors, 4 AVN, 1 knee arthritis, 12 injuries, and 3 normal candidates were included. Whole femoral geometries were obtained from CAT scan DICOM data and transferred to CAD geometry data format. All the following landmarks were measured its direction by the angle from posterior condyler line. The assessed landmarks were i) anteversion, ii) lesser trochanter, iii) linea aspera at the middle of the femur, and two more (upper 1/6, 2/6 level of aspera) linea aspera directions were assessed between ii) and iii). All the directions were measured by the angle from the medial of the femur.

Results: The direction of anteversion and lesser trochanter were well correlated, (R=0.55, Y=0.56X-35) i.e. femoral head and lesser trochanter were rotated together. The direction of lesser trochanter and aspera in upper 1/6 section had no relation even they are located very close with only several cm distance, (R=0.03, Y=-0.02X-88) i.e. however the lesser trochanter was rotated, the upper most aspera was located almost at the same direction (-87.5+/−7.58 degree). The direction of aspera at upper 1/6 and middle femur were strongly correlated. (R=0.63, Y=0.81X-22) i.e. they stay at the same direction.

Conclusion: The results mean that the anteversion is a twist between normal proximal femur (from femoral head and lesser trochanter) and normal distal femur. The twist was located just blow lesser trochanter within several centimeter.

Discussion: The anteversion has been understood as the abnormal mutual position between femoral neck and femoral shaft. In high anteversion hips the neck shaft angle was also believed to be higher, so several DDH oriented stems have higher neck shaft angle i.e. coxa-valga geometries. It has been believed that the location of the anteversion was around neck part. This study revealed that the deformity was located in the very narrow part just below lesser trochanter. It has been discussed that DDH oriented stems should have fit to different canal geometries, but understanding the biomechanics of abnormal anteversion and its treatment should be more important.
DELTA Motion Monoblock cup system What can we expect?

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In almost all countries performing Total Hip Replacement (THR), dislocation is one of the major reasons for revision. Hence, in the last years the trend to larger bearings has been observed, following an improve in the bearing materials, the operation technique, and fixation techniques of stem and shell. Larger bearings allow for more range of motion and higher stability than conventional 28 mm bearing couples, leading to a better postoperative mobility. On the other hand, size limitations on the acetabular side are given by the anatomy of the human pelvic bone as well as the deformation and fracture behaviour of the used artificial materials. Therefore, the best solution to be achieved provides a maximum physiological outcome along with a minimized risk of intraoperative and in-vivo failures.

Investigating the wall thickness of the metal shell which is press-fitted in the human pelvic bone, the general trend towards a smaller wall thickness yielding an increased compliance can be observed with larger bearing diameters. This may lead to deformations of the metal shell making it difficult for the surgeon to properly introduce the insert. Hence, taking into account that a proper seating of the insert is absolutely necessary when using a ceramic insert in order to avoid point loads, operation time may strongly increase especially when minimal invasive surgery technique is used. With decreasing overall wall thickness of the acetabular components the volumetric stresses increase by definition. Therefore, an optimal component coupling between insert and metal shell is necessary in order to avoid point loads and resulting stress concentrations. With pre-assembled systems, this optimal coupling is reached by the force-controlled insertion of the insert in the metal shell without any prior deformation of the shell. This procedure enables to design acetabular components with a much lower overall wall thickness than conventional systems. As an example, in the case of the DELTA motion system, this overall wall thickness has been decreased to 5mm allowing e.g. for a usage of a 36mm bearing couple together with a 46mm outer diameter of the metal shell. Additionally, the coating of the metal shell allows for direct bone ingrowth. Problems involved with larger bearing diameters may also arise from higher wear rates inducing possibly osteolysis and aseptic loosening. Investigations concerning the wear behaviour of large ceramic bearings have shown that there is no increase in the wear volume with increasing diameter.
THREE DIMENSIONAL PREOPERATIVE PLANNING OF ACETABULAR RECONSTRUCTION FOR DEVELOPMENTAL DISPLASTIC HIPS' TOTAL ARTHROPLASTY


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Introduction: Since 1993, we have been developing preoperative planning system based on CAT scan data. In early period it was used to decide cup diameter and orientation for Total Hip Arthroplasty (THA). It was done using hemisphere object locating proper position and orientation. According to our progress, we have started using it for custom stem designing, stem selection and stem size planning too since 1995. Since 2001, we have been using it for almost all THA cases. We also have started use it for any case we have question about 3D geometries. Since 2005 we started computer planed 2 staged THA after leg elongation for high riding hips and reported at ISTA 2007 too. Now our policy became that every tiny question we have we shall analyze and plan preoperatively.

In our population, the incidence of the developmental dysplastic hips is higher. The necks often have bigger anteversion, and less acetabular coverage. So we often use screws for cup fixation. The screw direction allowed in thin shell thickness is limited and less bone coverage makes good cup fixation difficult. With highly defected cases and with revision cases the situation is more difficult.

In the present study, we have developed acetabular 3D preoperative planning method with screw direction, length, and for the cases with defect, cup supporter pre-shaping with models and prediction of the allograft volume.

Materials and Methods: For the less defect cases, geometries of cup with screw holes were requested to the maker and were provided for us. Screws were attached perpendicular to each screw hole. Screw geometries have marks at every 5mm to plan proper length. The cup was located as much as closer to the original acetabular edge, keeping in the limit to avoid dislocation. Small space above the cup was accepted if anterior and posterior cup edge could be supported by original bone. Then the cup was rotated until we can obtain proper screw fixation.

For the cases with severe defects, we use cup supporters and allografts. Cup supporters are designed to be bent and fit to the pelvis during the surgery. But to shape it a properly; for good coverage and strong support; is very difficult and takes long through the limited window with fatty gloves. And meanwhile we get more bleeding. The geometries were obtained by CAT scan of the devices. Then proper size was determined as cup size. Chemiwood model was made and proper size supporter was opened and bent preoperatively using the model. It was scanned again and compared again.

Results: Using cluster cups, no dangerous screw was found as long as normal cup orientation was decided and screws were less than 30mm. Posterior screws were often too short then rotated anterior and found to have good fixation. Pre-bending could reduce surgical time remarkably.

Discussion: As long as we could know, no navigation system can control the cup rotation. But acetabular preoperative planning was very useful and could reduce operative invasion. It could be done easily without using navigation system.
AUTOGENOUS BULK STRUCTURAL BONE GRAFTING FOR RECONSTRUCTION OF THE ACETABLUM IN PRIMARY TOTAL HIP ARTHROPLASY: AVERAGE 12 YEARS FOLLOW UP

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Background: Total hip arthroplasty (THA) often requires complex reconstruction for acetabular bone defect in patients with developmental dysplasia. We performed autogenous bulk structural bone grafting to deal with the lack of acetabular bone stock. The purpose of the present study was to assess the clinical and radiographic results after mean follow-up of 12 years.

Methods: Between April 1992 and December 1997 the single senior author performed 75 consecutive primary THA for patients with degenerative osteoarthritis. Acetabular bone grafting was performed for 27 joints. Of these, six patients (six hips) were lost to follow up. Left 20 patients (21 hips) included in the study. There were two male and 18 female with a mean age at the time of the operation of 54.5 years (40-66 years). The mean duration of follow-up was 12 years (8-15 years). The diagnosis for all hips at the time of operation was secondary osteoarthritis due to developmental dysplasia. The degree of subluxation as categorized according to the classification of Crowe et al was group I in 11 hips, group II in 6 hips, group III in 4 hips. All operations were performed through a posterolateral approach using the femoral head for the graft. The grafts were screwed to the superolateral aspect of the acetabular roof. We used the Bioceram implant (Kyocera, Kyoto, Japan) with a 26 mm alumina-ceramic head. Both acetabular and femoral components were fixed with cement using the double-thumb technique in all procedures. Harris hip score was used for clinical evaluation. Standard anteroposterior radiographs were used for radiographic evaluation. The presence of a radiolucent line at the cement-bone interface in the three zones of DeLee and Charnley was recorded. Loosening of the acetabular component was classified according to the criteria of Hodgkinson et al. The remodeling process of the grafted bone was analyzed according to the method described by Knight et al. The initial postoperative anteroposterior radiographs were measured to define the proportion of the socket covered by bone graft according to the method described by Inao and Matsuno.

Results: The mean Harris hip score improved from 45.0 (24-60-) before operation to 90.4 (77-100) at the final follow-up. At the final follow-up, 13 sockets showed the presence of a radiolucent line at the cement-bone interface and three sockets showed radiological evidence of loosening. According to the criteria of Hodgkinson et al, two sockets were type 3 and one were type 4. Bridging tarbeculation across the graft-host interface was seen in all cases. One case had the graft collapsed with migrated socket. The mean proportion of the socket covered by bone graft was 23.1% (9.8 - 42.3%). Three patients with loosed sockets had candidate for revision surgery, but no revision surgery was done because they had mild pain and did not demand the operation.

Conclusion: Autogenous bulk structural bone grafting for reconstruction of the acetabulum presented favorable results during mean follow-up of 12 years in the condition that the proportion of coverage of graft was less than 50%.
RESULTS OF THE OPERA CEMENTED ACETABULAR COMPONENT

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Cemented acetabular components continue to be used in more than half of the total hip replacements performed in the United Kingdom. The implants are relatively inexpensive but the results rely heavily on precise surgical technique, with restoration of the centre of rotation of the hip and the creation of an equal cement mantle with good pressurisation and penetration of the cement into the bone.

The Opera all polyethylene acetabular component was designed with a malleable flange, which could be independently pressurised, a long posterior wall to promote stability and instrumentation which ensured that pressurisation could be maintained throughout the curing process.

We present for the first time, the medium-term results of 409 consecutive cemented flanged Opera acetabular components performed in 374 patients.

247 operations were performed via a trochanteric osteotomy and 162 via a posterior approach, using multiple key holes, cement pressurisation and Palacos-R cement. Autograft was used in 32 cases.

Cemented femoral components were used in all cases. There were 241 Charnley stems with 22mm heads and 168 polished triple tapered C-stems (146 with 22mm heads and 22 with 26mm heads).

The average age at the time of surgery was 68.2 years (32 - 87) and the average duration of follow-up was 89 months (60 - 130). 54 patients (56 hips) died during the follow-up period.

The acetabulum was assessed using the zones of DeLee and Charnley, and the Hodgkinson classification.

There was one temporary femoral nerve palsy, two dislocations and 3 non-fatal pulmonary emboli.

Both components were revised in two hips for deep sepsis, and in two hips only the femoral implant was revised, one for a fractured stem and one for aseptic loosening, with the original acetabular components remaining in situ.

Of the remaining original acetabular components 6% have shown progressive radiological demarcation, none have migrated, but in two hips there is evidence of rapid wear and the development of osteolysis.

Improved Cementing Technique - Interface Bioactive Bone Cement (IBBC)

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A short term result of interface bioactive bone cement technique which includes smearing hydroxyapatite granules just before cementing combined with modern cementing technique was excellent.

Purpose: One of the drawbacks of cemented total hip arthroplasty (THA) is aseptic loosening after long period, major reason for which is bioinertness of PMMA bone cement. To improve longevity of THA, interface bioactive bone cement technique combined with modern cementing technique has been used in our institute, and was evaluated clinically and radiologically.

Method: The present study includes 44 cases of primary THA with an average age at operation of 64 years old (ranging 48 to 81). Mean postoperative follow up period was 4 (ranging 3.5 to 5) years.

Results: Pre- and postoperative evaluation using Merle d’Aubigné score were 8.0 and 16.2 points, respectively. Postoperative cementing grade using Barrack’s classification was A or B. At final follow up, radiolucent line at bone-cement interface was not observed, except one case of rheumatoid arthritis patient at zone 3 described by Delee and Charnley in the acetabular side. Neither osteolysis nor loosening was observed in every case. No major complications, such as infection, dislocation, pulmonary embolization, were observed.

Conclusion: The present study revealed excellent short-term result was obtained by IBBC technique combined with modern cementing technique for primary THAs. Most important technical point required for IBBC is to obtain dry bony surface just before cementing. Compressive reamed bone and gauze packing was effective for complete hemostasis just before cementing for the acetabular side, and plugging the isthmus using bone chips was effective for reducing bleeding for the femoral side.
The Fate of Rough Blasted Cemented Femoral Stem in Second generation of The Metal on Metal Total Hip Arthroplasty - EDS and BTE Studies For Retrieval Stem -

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Background: We observed early osteolysis and loosening of the rough surface-cement stem with a second generation metal-on-metal articulation. This study was to investigate the possible etiologic role of stem loosening and osteolysis by examination of the surface of the rough blast cement and related periprosthetic tissues that have been retrieved at revision.

Methods: We retrospectively analyzed 39 hips (37 patients) with use of metal metal-on-metal total hip arthroplasty. Of the femoral stem, rough surface-cement stem used in 18 hips and cementless Ti-alloy stem in 21 hips. The mean duration of follow-up was 10.2 years. Of these eight rough blast cement stem were revised, seven in loosening and one in recurrent dislocation. By using energy disperse spectroscopy and back scattered electron image, histologic studies were performed to the samples of periprosthetic tissues. Skin patch tests for metal hypersensitivity were done to select patients.

Results: All of cementless stems and cups showed excellent results at the last follow-up. However, eight cement hips were revised. Light microscopy showed polishing effect on retrieval femoral stem affected by the rotational force. EDS and BSE image revealed that there were abundant cement and related metal particles with size of 5-10 μm. However there were few metal particles and had greater size (20-100 μm) in periprosthetic tissues. Histologic finding shows perivascular infiltration of lymphocytes and accumulation of macrophages No relation was found between skin patch test and loosening.

Conclusion: These findings raise the possibility that early osteolysis and loosening in patients with metal-on-metal hip replacement were associated with rough blast surface cement stem. These mixed particles such as Fe and Zr maybe trigger lymphocytic reactivity suggestive delayed type hypersensitive reaction. This study suggests that cement stem which have rough blasted surface should be considered in metal-on-metal total hip arthroplasty.

Level of Evidence: Therapeutic level III-1(case-control study). See instructions to authors for a complete description of level of evidence.

Key Words: Metal on metal total hip arthroplasty, Rough blasted surface-cement stem
RESULTS OF THE C-STEM POLISHED TRIPLE TAPERED FEMORAL COMPONENT

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The use of polished femoral implants employing the taper-slip philosophy now dominates the cemented portion of the hip arthroplasty market in the United Kingdom. Despite this fact, there have been very few published or presented series reporting the medium to long-term results of double tapered implants and only one previously reported series looking at the results of the triple tapered stem.

We present the results of 500 consecutive polished triple tapered C-stem femoral components performed in 455 patients.

All operations were performed using a posterior approach, with cemented all polyethylene acetabular components and the use of third generation femoral cementing techniques, restrictors, centralisers and Palacos-R cement.

There were 282 female patients (62%) and 173 males (38%). The average age at the time of surgery was 68.3 years (23 to 92), with an average duration of follow-up of 71 months (36 to 112). 47 patients (51 hips) died during the follow-up period at an average of 54 months (1 - 87).

There were 3 dislocations, 2 on one occasion and one twice, at an average of 4 years. There were 2 deep infections, one of which required revision, and 4 non-fatal pulmonary emboli. There were 3 undisplaced trochanteric cracks treated by cerclage wiring and 3 nerve palsies: 2 femoral (temporary) and one sciatic (permanent). There was only one case of significant heterotopic ossification (Brooker Class 4).

The stem was neutral in 89% of cases, varus in 7% and valgus in 4%. Subsidence within the cement mantle occurred in 79% of cases, with an average of 0.87 mm. 9 stems subsided 2 to 4 mm but all stopped at 2 years and there was no further subsidence thereafter.

One hip was revised for deep infection but none of the remaining implants demonstrated any progressive radiolucencies in any Gruen zones and none demonstrated any features suggestive of current or future loosening. There was no evidence of negative bone remodelling.

The data was collected prospectively and the study is ongoing.

Quality of life indicators and radiological outcomes with the Exeter femoral stem:
Does it matter who does the surgery?

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Aim: It is widely accepted that surgical skills improve with experience. Part of this experience comes from operating on patients while honing new skills. Total hip arthroplasty is one such procedure. This paper examines outcomes in relation to the primary surgeon

Methodology: All patients who had an Exeter femoral component implanted and 2 years follow-up in the hospital joint register had their X-Ray, outcome scores and complications reviewed. Complications are routinely recorded as part of the joint register and hospital computer discharge system. Radiological outcome measures were taken as recommended by Johnston et al. Procedures were recorded as either performed by consultant surgeon or registrar supervised by consultant surgeon.

Results: Post operative WOMAC scores at six months and 2 years were similar in both groups (Consultant 19.6, registrar 22.32 at 6 months) SF-36 figures were similar at six months (Consultant performed 78.56, consultant supervised 75.39). There was a difference in SF-36 at 2 years (72.77 vs 63.11) but this was not statistically significant. Average abduction angle was lower in consultant supervised than consultant performed procedure. (36.75 vs 47 deg) Barrack cement grading was similar in both groups. Consultant inserted stems were more likely to be in neutral position compared to consultant supervised stems (84% vs 56%)

Conclusion: In both groups the quality of life indexes do show a difference in outcome which relates to the primary surgeon. However decreased abduction angle may lead to decreased range of motion post operatively and should be addressed intraoperatively.
SIMULATION OF THE DIRECTION AND DEPTH OF REAMING WITHOUT NOTCHING IN HIP RESURFACING

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Hip resurfacing has many advantages such as proximal bone conservation and easy revision including conversion to total hip arthroplasty. The major complication in the hip resurfacing is notching at the lateral cortical bone and fracture of the neck. In this research, we simulated the range of direction of reaming without causing notch. One left femur model was used for the simulation. The femoral head was fitted by a sphere and the origin of Cartesian coordinate was set at the center of the sphere. The simulation was made by imposing a cylindrical cut to the femoral head in varying direction and location. The existence of notching was decided comparing the maximum distance from reaming axis to neck section contour and the radius of cylindrical cut. If the maximum distance is bigger than the radius of cut, the notching exists and vice versa. We simulated existence of notching by varying inclination(\(\alpha\)) from 20 to 70 degrees, anteversion(\(\beta\)) from 0 to 30 degree and depth passing through the head center(\(d\)) from 0 to 5mm. The implant used for the simulation was Durom \(^*\) and Zimmer\(^*\). We selected the implant size that is close to the fitted sphere of femoral head. No notching was made for any direction when the depth \(d\) was less than 2mm. When the depth was 3mm, notching did not generate in the range of \(\alpha\) from 43 degrees to 60 degrees and \(\beta\) from 0 to 25 degrees. When the range of depth was from 4mm to 5mm, notching did not generate in ranges of \(\alpha\) from 41 degrees to 60 degrees and \(\beta\) from 0 to 29 degrees. The no-notching angle range had tendency increasing slightly when the depth was increased. The angle between the stem of the implant and the neck shaft axis without notching can be calculated from the angle \(\alpha\). When the depth was from 4mm to 5mm, the corresponding angle between stem of implant and the shaft axis was from 120 degrees to 139 degrees.

A SLOT TECHNIQUE TO IMPROVE FEMORAL CEMENTATION DURING HIP RESURFACING ARTHROPLASTY

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Introduction: Variability in femoral head preparation and high cement pressures may be associated with failure to seat femoral components during hip resurfacing. Furthermore, excessive pressures may lead to over penetration of bone by cement with resulting necrosis of the underlying bone. We designed an experimental model to test the hypothesis that partial-length pressure-relief slots made longitudinally in the proximal bone of the femoral head, without extending to the head-neck junction, would allow controlled leakage of cement during initial insertion of a femoral head resurfacing component, but would then become sealed during final insertion to prevent excessive loss of cement while still allowing accurate seating of the component.

Methods: 31 resurfacing femoral components were cemented onto foam femoral head models. The clearance between foam model and implant was measured to determine the minimum space available for cement. 11 components were inserted using hand pressure alone, 20 were hammered. Pressure relief slots were prepared in 10 femoral heads. The slots, 4mm deep grooves, were made in the proximal bone only, without extending to the head-neck junction. Cement pressure inside the component was measured during insertion. Implants were sectioned after implantation in order to determine whether they had been fully seated or not. The clinical relevance of the measures taken was tested by measuring the diameter of prepared femoral heads during 20 hip resurfacing operations in order to determine the extent of variability in intra-operative femoral head preparation.

Results: Mean intraoperative clearance between bone and implant was -0.19mm (0.11 to -0.93mm). Mean clearance between foam model and implant was -0.30mm (0.35 to -0.94mm). 22/31 components were fully seated. Of those not fully seated, all had clearance less than -0.74mm. Full seating with a clearance of less than -0.35mm was only possible when pressure relief slots had been made in the femur. The use of a pressure relief slot longer than half the femoral head length allowed full seating in 9/9 cases, compared to 13/22 without. Cement pressure obtained with a hand pressure technique was less than half that observed with hammering (20.8 vs 56.0psi, p=0.0009) but was not associated with failure to seat the implant if a slot was used.

Conclusion: Variability of the actual diameter of the femoral head prepared may be associated with difficulty in fully seating resurfacing components. The same degree of variability in the space available for cement was observed in both intra-operative and test specimens. The use of a pressure-relief slot allows full seating of resurfacing implants with hand pressure alone, thereby halving cement pressure, in an experimental model, even when clearance between implant and bone is less than optimal.
EFFECT OF IMPLANT POSITION AND MICRO-LATERALISATION ON THE CONTACT MECHANICS OF METAL-ON-METAL HIP RESURFACING PROSTHESIS

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Metal-on-metal hip resurfacing has been introduced recently, due to its potential advantages of biomechanics and biotribology. However, a number of problems have been identified from clinical retrievals, including significant elevation of wear when the implant is mal-positioned. Our hypothesis is that implant mal-position and micro-lateralisation can result in edge contact, leading to increases in wear. The aim of this study was to investigate the combined effect of cup position and micro-lateralisation on the contact mechanics of metal-on-metal hip resurfacing prosthesis, in particular to identify conditions which resulted in edge contact.

Finite element (FE) method was used. A generic metal-on-metal hip resurfacing prosthesis was modelled. The bearing diameters of the femoral head and acetabular cup components were 54.49mm and 54.6mm respectively, with a diametral clearance between the head and the cup of 0.11mm. The resurfacing components were implanted into a hemi-pelvic hip joint bone model and all the materials in the FE model were assumed to be homogenous, isotropic and linear elastic (Udofia et al 2007). The FE models consisted of approximately 80,000 elements, which were meshed in I-DEAS (Version 11, EDS, USA) and solved using ABAQUS (Version 6.7-1, Dassault Syst mes). For this study, the femoral component was fixed with an inclination angle of 45° and an anteversion angle of 10°. The orientation of the acetabular cup was varied, using inclination angles of 35° and 65°, and anteversion angles between -10° to 30°. Contact at the bearing surface between the cup and femoral head was modelled using frictionless surface-based elements, simulating a fully lubricated situation, as coefficients of friction less than 0.1 would not have appreciable effects on the predicted contact mechanics. The femoral component was fixed into the femur (except the guide pin) using PMMA cement with an average thickness of approximately 1mm. The other contact interfaces in the FE model (cup/acetabulum, cement/bone and cement/femoral component) were all assumed to be rigidly bonded. The hip joint model was loaded through a fixed resultant hip joint contact force of 3200N, and was applied through medial, anterior muscle forces and subtrochanteric forces to simulate the mid-to-terminal stance phase (approximately 30% - 50%) of the gait cycle (Bergmann et al., 1993). Micro-lateralisation was modelled through displacing the femoral head laterally, up to 0.5mm, relative to the centre of the cup.

Edge contact was detected once the inclination angle became greater than 65°. The effect of ante-version was to further shift the contact area towards the edge of the cup, nevertheless no edge contact was found for ante-version angles up to 25° and inclination angles below 55°. However, when the micro-lateralisation was introduced, edge contact was detected at a much smaller inclination angle. For example, even with a micro-lateralisation of 0.5 mm, edge contact occurred at an inclination angle of 45°. This study highlights the importance of surgical techniques on the contact mechanics and tribology of metal-on-metal hip resurfacing and potential outcome of these devices.
Comparison of results of resurfacing arthroplasty performed using a navigation system and conventional technique

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Purpose: The exact alignment of the femoral component is crucial for the success of hip resurfacing arthroplasty. This prospective study was performed to find whether the imageless computer-assisted navigation surgery can improve the accuracy during hip resurfacing arthroplasty by comparing the alignment of the femoral component implanted with navigation system and conventional-mechanical guided system.

Materials & Methods: Forty patients were randomly allocated into two groups for resurfacing hip arthroplasty using Birmingham hip resurfacing system. In the conventional group, femoral component positioning was assisted by mechanical alignment guides. In the navigation group, it was assisted by an imageless computer-assisted surgical system of Vectorvision (BrainLAB, Germany). We measured the difference between the preoperative plan of femoral component’s position and postoperative results on radiographs in two groups.

Results: In the conventional group, a median difference of the stem alignment was 5.4° (0.2°-10.9°) and a median difference of the stem anteversion was 2.6° (0°-6.5°). In the navigated group, a median difference of the stem alignment was 2.3° (0.2°-4.9°) and a median difference of the stem anteversion was 1.0° (0°-3.6°). These differences of two groups were statistically significant (P<0.05).

Conclusions: In resurfacing arthroplasty with a hip navigation, the procedure showed a good performance and reliability. It is achieved with greater precision with a navigation system than a mechanical alignment system.

METAL-ON-METAL HIP RESURFACING COMPARES FAVORABLY TO TOTAL HIP ARTHROPLASTY IN THE US: UPDATE ON A PROSPECTIVE SINGLE INSTITUTION US STUDY WITH 1-YEAR FOLLOW-UP

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In May 2006, the US FDA approved the first type of metal-on-metal hip resurfacing (MOMHR) for distribution in the US because of promising survivorship achieved in Europe for patients with a diagnosis of primary osteoarthritis. No long-term US survivorship data currently exists for the Birmingham Hip Resurfacing (BHR) implant. The purpose of this study was to demonstrate early efficacy with validated outcome measures and survivorship comparable to total hip arthroplasty (THA).

A cohort of 79 consecutive MOMHR patients was compared to a similar cohort of 71 THA patients, controlling for age, gender and comorbidities. Mean fu was 14.1 ± 5 mos (range 12-24 mos). The mean age for the MOMHR group was 50 ± 9 yrs, and mean body mass index (BMI) was 29 ± 5. The THA group had a mean age of 52 ± 9 yrs and a mean BMI of 30 ± 6. Outcomes were prospectively assessed with the SF-12 and WOMAC. For both groups, pre-op pain and function scores were similar. At 1 yr fu, MOMHR showed significantly more improvement (p<0.05) in stiffness, pain and physical function compared to the THA. The overall complication rate was 7% in the MOMHR group and 9% in the THA group. There were no instances of displaced femoral neck fracture, component loosening, dislocation or chronic deep infection in any patient in the MOMHR cohort. These early results are promising, but longer-term follow-up is needed to properly compare MOMHR to THA which remains the current gold standard.
PIN-ON-PLATE STUDIES ASSESSING THE WEAR PERFORMANCE OF CFR-PEEK AGAINST CoCrMo

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In the majority of cases, failure of conventional metal-on-ultra-high molecular weight polyethylene (UHMWPE) artificial joints is due to wear particle induced osteolysis. Therefore, new materials have been introduced in an attempt to produce bearing surfaces that create lower, more biologically compatible wear. Polyetheretherketone (PEEK-OPTIMA) has been successfully used in a number of implant applications due to its combination of mechanical strength and biocompatibility.

MATERIALS AND METHODS: Multi-directional pin-on-plate wear tests were performed on carbon fibre reinforced PEEK-OPTIMA (CFR-PEEK) against CoCrMo. PAN-based CFR-PEEK was tested against both low carbon and high carbon CoCrMo and Pitch-based CFR-PEEK was tested against high carbon CoCrMo only. The multi-directional motion of the pin-on-plate machine replicated the crossing of the wear paths that would be expected in vivo. For each test, four pin and plate samples were tested for 2 million cycles at a cycle frequency of 1 Hz under a 40 N load (which resulted in a contact stress of about 2 MPa). The lubricant used was bovine serum diluted with distilled water to a protein content of 15 gl⁻¹. This was maintained at 37°C. The wear was determined gravimetrically. Soak control specimens were used to account for any weight changes due to lubricant absorption.

RESULTS AND DISCUSSION: The average steady state wear for the CFR-PEEK pins was found to be 0.144, 0.176 and 0.123 x 10⁻⁶ mm³N⁻¹m⁻¹ for the CFR-PEEK PAN pins against low carbon CoCrMo, CFR-PEEK PAN pins against high carbon CoCrMo and CFR-PEEK Pitch-based pins against high carbon CoCrMo. A comparison of the results from the low and high carbon plates articulating against the PAN-based pins shows that the high carbon CoCrMo produced slightly higher wear than the low carbon CoCrMo. The protruding carbides on the high carbon CoCrMo plates may have caused this increase in wear. The lowest wearing material combination in this study was CFR-PEEK Pitch against high carbon CoCrMo. Published papers on the wear of UHMWPE against stainless steel [1] have shown higher wear factors (1.1 x 10⁻⁶ mm³N⁻¹m⁻¹).

CONCLUSIONS: Pitch and PAN-based CFR-PEEK against CoCrMo (low carbon or high carbon) provided low wear rates. On average, the Pitch-based material against high carbon CoCrMo provided the lowest wear in these tests. All the material combinations gave lower wear than found for UHMWPE tested under similar conditions. This gives confidence in the likelihood of this material combination performing well in orthopaedic applications. The authors wish to thank INVIBIO Ltd. for funding this research.

A NEW WAY TO DETERMINE ULTRA LOW WEAR RATES IN A HIP SIMULATOR BY MEASURING THE ION AND PARTICLE RELEASE.

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Introduction: In hip joint simulator studies, wear measurement is usually performed gravimetrically. This procedure is reliable for metal-on-polyethylene or ceramic-on-polyethylene bearings, in which relatively high amounts of abrasive wear particles are produced. With modern hard-on-hard bearings, volumetric wear decreases significantly up to 100 to 200-fold. The gravimetric method reaches its detection limit with metal-on-metal bearings and even more so with ceramic-on-ceramic bearings. This study establishes a new method of determining wear in hard-on-hard bearings by measuring the amount of worn particles/ions in the serum of hip simulators.

Methods: A wear study on three resurfacing hip implants (BHR®, Smith&Nephew) was conducted using a hip joint simulator. Prior to the wear study, tests were performed to validate the detection power for HR-ICP-MS. More importantly the system’s accuracy was compared to the gravimetric method, which is described in ISO 14243-2. The simulator was altered to run completely metal ion free. The ion concentration in the serum was measured every 100,000 cycles up to 1,500,000 cycles and subsequently in intervals of 500,000 cycles using HR-ICP-MS. The implants were neither removed from the simulator nor excessively cleaned during the course of the simulation. Serum was refreshed every 500,000 cycles. The serum samples were digested with purified nitric acid and hydrogen peroxide using a high pressure microwave autoclave in order to measure wear particles as well as dissolved ions. All steps were carried out under clean room conditions. Wear was calculated using the ion concentration and measured serum volume. Wear rates and transition from running-in to steady-state wear phases were calculated.

Results: A detection power better than 0.028 ug/l for Co, 0.017 ug/l for Cr and 0.040 ug/l for Mo was found for HR-ICP-MS. The validation of HR-ICP-MS showed good agreement between gravimetric data and measured ion concentrations. The tested implants showed similar wear behaviour. Implant wear resulted in high ion concentrations during the first 380,000 to 920,000 cycles. During this period, a mean wear rate of 6.96 mm³/10⁶ cycles was determined. Subsequently, the wear rate significantly decreased to a mean wear rate of 0.37 mm³/10⁶ cycles. Thus, a mean ratio between running-in and steady-state wear of 18.8 was found. The mean overall wear volume at the end of the simulation was 4.42 mm³.

Conclusion: This study showed that measuring the ion concentrations in the serum of hip simulators can be used to determine wear in metal-on-metal bearings. The main advantages of this new method are the ability to detect ultra-low wear rates and to precisely specify the duration of different wear phases. Because the implants do not have to be removed from the simulator and aggressive cleaning processes may be skipped, fluctuations in wear detection are extremely low. This in turn leads to a shorter duration of the simulation. Wear rates of the tested implants are low compared to polyethylene. Transferring the results to patient activity, wear would be the same during the first 4-6 months after implantation as in the next ten years. Minimizing the duration of running-in would be most effective in further reducing wear of metal-on-metal bearings.
A TRIBOLOGICAL AND PARTICLE DEBRIS STUDY OF AS-CAST AND HEAT TREATED COCRMO ALLOY

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Introduction: The generation of particle debris from ultra high molecular weight polyethylene against metal hip joints has been shown to lead to osteolysis and joint loosening in the medium to long term (aseptic loosening) (1). To reduce the volume of wear debris, attention has moved to metal-on-metal prostheses as the total volume of wear debris is less. However, the size, shape and number of the particles are also important as well as the total volume since these affect the body’s response.

Materials and Methods: The Durham Mk I Hip Joint Simulator was used to generate CoCrMo wear particles in a series of four successive tests. Initially 50 mm Birmingham hip resurfacing devices were tested where both the head and the cup were as-cast CoCrMo alloy. A second test was conducted where the components were 38mm diameter and both heads and cups were again as-cast CoCrMo. A third test using 50 mm diameter components was completed where both heads and cups were double heat treated CoCrMo alloy and in a final test, both components were 50 mm diameter. The heads were new as-cast components and the cups were the as-cast ones used in test 1, which had been pre-worn to 5 million cycles. Bovine serum with a concentration of 17g/l of protein was used as a lubricant and particles were sampled every half million cycles. The volumetric wear was also obtained gravimetrically. A double enzymatic digestion protocol was used to cleave the proteins from the particles taking care to minimise any effect on the particles. Finally the particles were suspended in distilled, de-ionised water and analysed using a NanoSight LM10 particle analyser which yielded their size distributions. These were confirmed by placing an aliquot of the suspended particles onto a carbon coated copper grid, drying them under a lamp and then imaging them in the TEM. Energy Dispersive X-ray analysis was used to obtain the chemical composition of the particles.

Results: The results indicated a strong correlation between the gravimetric wear and the number of particles. All the as-cast CoCrMo alloy tests showed a consistent particle modal average size. The double heat treated particles were shown to be smaller, with occasional large flake like particulates which were identified under the TEM. This particle data correlates well with previous data from simple pin on plate experiments. The average modal size for the as-cast particles at 2.5 million cycles pin-on-plate test was 200 nm and for the simulator at 2 million cycles 200nm.

Discussion: Previous studies have used microscopy to investigate the size and morphology of the particulate debris (2), however, these studies are limited due to the time taken to image the particles. This current method allows many more particles to be analysed, thus the data accumulated are more statistically based. An added advantage is that these data may be compared with the wear volumes calculated gravimetrically.

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Wear Friction and Surface Analysis of 38mm Ceramic-on-Metal Total Hip Replacements

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Aseptic loosening caused by UHMWPE wear debris induced osteolysis is a major cause of revision in total hip arthroplasty (THA) [1]. While second generation hard-on-hard bearings, metal-on-metal (MOM) and ceramic-on-ceramic (COC) have been shown clinically to address the wear issues associated with conventional UHMWPE bearings, there remain some concerns over the potential effects of metal ions produced by MOM and the risk of liner fracture in COC. Recently, hybrid ceramic-on-metal (COM) articulation has received a great deal of attention as a promising alternative bearing.

Advantages include reduced wear and metal ion release compared with MOM. In addition, it is thought that there may be a reduced tendency for fracture of the ceramic component due to the softer metallic cup.

In this study a 5 million cycle wear test was carried out on the Mark II Durham Hip Wear Simulator. A set of six, 38mm diameter HIPed alumina heads and as-cast CoCr alloy cups were tested in bovine serum. Surface topography analysis was carried out at 0, 2, 3 and 5 million cycles. Additionally imaging of the bearing surfaces using ESEM and AFM was undertaken on the final bearing surface. Friction testing, using the Durham Hip Friction Simulator was carried out on one of the joints worn to 5 million cycles and the results were compared with theoretical calculations.

Wear of the ceramic heads was virtually undetectable using the conventional gravimetric methods. However, minor surface damage in the form of grain pull out and abrasive scratches was observed in the wear patch when the bearing surfaces were analysed using ESEM and AFM. The grains were not visible in the unworn sections of the head. The average surface roughness remained constant throughout the test. The CoCr cups showed a decrease in roughness between 0 and 2 million cycles, after which it remained relatively constant. This was consistent with the wear results in which a biphasic wear rate was found. The more frequently obtained wear results showed running in wear rate of 1.02 ± 0.078mm³/million cycles between 0-0.5 million cycles, followed by a steady state wear rate of 0.030 ± 0.011mm³/million cycles. These results are consistent with those of a recent study undertaken elsewhere [2]. Friction testing produced a Strubeck curve which was indicative of full fluid film lubrication with a friction factor of 0.027 ± 0.002 for 25% bovine serum (η=0.0014 Pa s⁻¹). Other tests were also carried out using carboxy methyl cellulose fluid as the lubricant to investigate the effect of proteins. This showed that there was a small decrease in friction factor when proteins were absent from the lubricant. It is thought that the difference in friction factors is due to adsorption of the proteins onto the bearing surfaces, when lubricated in bovine serum. This introduces large proteins between the bearing surfaces, which penetrate the lubricant film, causing protein on protein interactions, in addition to the friction caused by shearing of the lubricant film.

SIMULATOR WEAR STUDY OF ALUMINA-MATRIX-COMPOSITE HIP JOINTS COMPARED TO 1ST RETRIEV AL STUDIES - 2 AMC CASES FOLLOWED 3 AND 7 YEARS

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Ceramic-on-ceramic bearings (alumina - ALX) have been used for human hip joints over almost 40 years. However a new alumina matrix composite with zirconia (AMC) was introduced in year 2000 as a high-strength ceramic with almost double the fatigue resistance (AMC: Al2O3=80.5%, ZrO2 =18 vol%). However there do not appear to be any retrieval studies reported for this new ceramic implant. The wear maps generated on two AMC retrieved femoral heads were compared to in-vitro wear data. Our laboratory study evaluated 36mm ceramic balls and liners using a physiologically appropriate, micro-separation test mode. Our ‘severe’ wear model was capable of producing stripe wear zones on the 3ceramic balls and liners. Wear rates were determined for 4 combinations of ALX and AMC, mapping of wear stripes, monoclinic transformation in AMC and compared by means of surface topographical analysis and debris morphology studies.

The ALX/ALX combination revealed the highest run-in and steady-state wear rates (6.3 and 2 mm3/Mc respectively). The AMC/AMC combination had lowest wear rates (0.5 and 0.1 mm3/Mc). The wear rates with hybrid ball: cup combinations (ALX: AMC; AMC: ALX) were similar and showed a 3-fold reduction compared to ALX/ALX bearing. With hybrid combinations, AMC ceramic wore preferentially more than its ALX counterparts regardless if present as a ball or cup implant. Therefore the AMC ball contributed 66% to the AMC/Al total wear whereas the forte ball contributed only 33% of the Al/AMC total wear.

This study showed for the first time the wear phenomena on two retrieved AMC balls. One case featured an intact 28mm AMC ball and one case had a fractured ball from an FDA IDE study (at 3 and 6 years follow-up, respectively). Both had been combined with alumina liners. Wear was analyzed by laser interferometry, SEM mapping and x-ray diffraction for phase transformation in zirconia grains. Main wear zones, stripe wear zones, metal contamination and sites of implant impingement were characterized. Surface roughness and in-vivo aging were quantified for both non-worn and worn areas.

SEM studies showed well-preserved articular surfaces, some with faint parallel scratches still evident. These were likely the manufacturer’s original polishing marks. Multiple stripe wear sites were identified with roughness 25-65nm (Sa) whereas polished wear zones averaged a low 2-3nm. Metal impingements sites increased roughness to 140nm. Mildly worn areas of intact AMC ball averaged 10% transformation in the zirconia phase (tetragonal to monoclinic). In the multiple stripe wear zones, the monoclinic phase increased to 30%. The taper-bore and fracture surfaces averaged 30% and 40% monoclinic, respectively.

In general in-vivo worn surfaces of AMC femoral heads corresponded well to our hip simulator wear model. The stripe wear and black metal contamination on these retrieved 28mm balls were correlated to multiple impingement sites on the rim of the alumina liner and titanium shell. This study appears to be the first documentation of wear in AMC bearing surfaces as retrieved from patients and as such provided good confirmation of the wear features produced in our micro-separation wear model.

Keywords: ceramic, retrievals, simulator, impingement, wear stripe
TRIBOLOGICAL AND MATERIAL ANALYSES OF RETRIEVED ALUMINA AND ZIRCONIA CERAMIC HEADS CORRELATED WITH POLYETHYLENE WEAR AFTER TOTAL HIP REPLACEMENT

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The purpose of this study was to examine surface characteristics of 30 alumina and 24 zirconia ceramic femoral heads and to identify phase transformation in zirconia heads. We also studied penetration rate of alumina and zirconia heads into UHMWPE liner. The alumina heads had been implanted for a mean of 11.3 years (8.1 to 16.2) and zirconia heads for a mean of 9.8 years (7.5 to 15).

The mean surface roughness values of explanted alumina heads (Ra 40.12 nm and Rpm 578.34 nm) were similar to those for the explanted zirconia heads (Ra 36.12 nm and Rpm 607.34 nm). The mean value of monoclinic phase of two control non-implanted zirconia heads was 1% (0.8-1.5) and 1.2% (0.9-1.3), respectively. The mean value of monoclinic phase of 24 explanted zirconia heads was 7.3% (1% to 26%).

In the alumina head group, mean linear penetration rate of UHMWPE liner was 0.10 mm/yr (0.09 to 0.12) in hips with low Ra and Rpm values (13.22 nm and 85.91 nm, respectively). The mean linear penetration rate of UHMWPE liner was 0.13 mm/yr (0.17 to 0.23), in the hips with high Ra and Rpm values (198.72 nm and 1329 nm, respectively). This difference was significant (P=0.041) In the zirconia head group, the mean linear penetration rate of UHMWPE liner was 0.09 mm/yr (0.07 to 0.14) in hips with low Ra and Rpm values (12.78 nm and 92.99 nm, respectively). The mean linear penetration rate of UHMWPE liner was 0.12 mm/yr (0.08 to 0.22) in hips with high Ra and Rpm values (199.21 nm and 1381 nm, respectively). This difference was significant (P=0.039). The explanted zirconia heads which had a minimal phase transformation had similar surface roughness and a similar penetration rate of UHMWPE liner as the explanted alumina head.
Improving accuracy in wear measurement on clinical Radiographs
- Introduction to PowerPoint Method

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Introduction: Wear of the polyethylene liner in Total hip arthroplasty (THA) is associated to aseptic component loosening. With low wear bearing surfaces and metal backing in acetabular components the manual methods of measurements have not fared well. Computerized methods increased the ease and accuracy of wear measurement. The average clinician has no access to these methods. In this study we proposed to develop a method of manual wear measurement (PowerPoint - PP method) using a simple office PC and (1) quantify its accuracy and reproducibility (2) compare the accuracy with Livermore and Dorr method and (3) determine the accuracy in different degrees of wear.

Materials and Methods: The study population was divided into class 1 (C1), Class 2 (C2) and Class (C3) group. C1 group had 13 patients who had undergone liner change for high wear. This class simulated a high wear situation. C2 group had 24 patients who were implanted with HXLP. This class simulated very low wear situation. 10 patients were included in C group. The same 6 week postoperative radiograph was paired as a set of x-rays for analysis. This mimics a zero wear situation.

Result: PP method had more consistency with Livermore method for C1 group. For C2 and C3 groups all the three methods did not provide consistent results. The correlation coefficient values for wear measurement by PP method showed good correlation between observers in C1 and C2 wear (P values <0.05). For C3 with true zero wear there was poor correlation between the observers (r = -0.659, 0.028, 0.638). The paired T test P values for all classes and both observers were > 0.05. There was no statistically significant difference in the reading of the two observers. Pearson correlation coefficient for all methods showed good correlation for C1 and C2 groups. All the methods had errors while measuring true zero in C3. The one way ANOVA analysis was done to identify the ability of the three methods to differentiate between C2 and C3. The PP method had the ability (P value < 0.05) to differentiate between C1, C2 and C3. The Dorr’s and Livermore’s methods could only differentiate the C1 from C2 and C3.

Discussion: Computerized methods have certain limitations. Matthew Collier et al reported a mean liner wear rate of 0.4(0.04-0.86) and 0.27 (0.01-0.56) by computerized in radiographs with true zero wear. In C3 group the average wear rate by PP method was 0.22=0.206 mm. In PP method ability to work at 400% magnifications, ability to correct for rotation on X axis, grouping function of PowerPoint program leads to less chances of errors. The PP method has a good reproducibility for clinical use (r>0.930). The ability of the PP method to differentiate between C2 and C3 should make it a preferred manual method of wear assessment.

The PP method has limitations. The least measurement is limited by diameter of the femoral head. It cannot be utilized for wear analysis in cup loosening or migration. It can be regarded as a supplement to the existing methods of manual wear measurements.
Aggressive 3rd body wear challenge to conventional and highly crosslinked polyethylene cups: -A hip simulator model

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Wear in polyethylene liners appears to be exacerbated by 3rd-body abrasion effects with the CoCr ball combinations used for total hip replacements. This has implications for various wear modes encountered in patients. Yet clinical and laboratory studies have offered weak and sometimes contradictory wear relationships with respect to crosslinking, ball diameter and roughness, and 3rd-body wear effects. Our hip simulator model investigated the effect of severe wear challenges by 3rd-body cement particles, using large diameter CoCr and alumina balls, with highly-crosslinked polyethylene liners (HXPE) irradiated to 75kGy compared to contemporary controls (CXPE 35kGy).

The polyethylene liners were gamma-irradiated to 35/75kGy under N2 (CXPE/HXPE). We used 32 and 44mm CoCr balls (ENCORE, Austin, TX) and 44mm alumina-ceramic (Biolox-forte, CeramTecAG) as ‘scratch-resistant’ standard of comparison. We compared 5 bearings pairs with different roughness characteristics using both new and pre-worn polyethylene liners. A 12-station orbital hip simulator with a physiological load profile (0.2kN-3kN load, frequency 1Hz) with cups mounted in Inverted- position. Diluted bovine serum (Hyclone Inc., Logan, UT) was used as lubricant (20mg/ml protein, 400ml volume). In phase I, all cups were run in standard (‘clean’) lubricant for 1.5 million cycles (1.5Mc). In phase II, the liners were run in a PMMA slurry of serum (5mg/ml) for 2Mc. In phase III, implants were run ‘clean’ for 1.5Mc. Wear-rate was measured each 0.25Mc event, and surface roughness measured by SEM (XL-30FEG) and white light interferometry (Zygo-Newview600, Zygo) every 0.5Mc.

In phase I, Wear with new CXPE and HXPE liners averaged 182mm3/Mc and 30mm3/Mc. Thus the HXPE liners averaged a 6.0-fold wear reduction compared to controls. Compared to new liners, the pre-worn CXPE and HXPE liners showed 10% and 25%, greater wear respectively. Here it was noted that CoCr balls maintained similar roughness (Sa:8-12nm). And alumina balls showed small, gradual increase (Sa:2 to 2.5nm). The HXPE maintained a superior finish to CXPE controls. Roughness revealed a gradual decrease with time, pre-worn CXPE from 0.28 to 0.15um and pre-worn HXPE from 0.18 to 0.04um (Sa). In contrast, new HXPE showed a dramatic smoothing (0.8 to 0.1um) 92.8% decreased in first 0.5Mc. These effects have not been previously quantified. In phase II with abrasive mode, the liner wear-rates increased dramatically by 6 and 80-fold for CXPE and HXPE, respectively. These data confirmed that HXPE was sensitive to ‘severe’ wear against CoCr and alumina balls. In phase III, the polyethylene roughness dropped by >90% and wear decreased to phase-I values. The wear-ratio was now 2:1 for CXPE:HXPE as predicted by the ‘diameter’ and ‘crosslinking’ algorithms.

It was clear that surface roughness was not a confounding factor for either the CoCr or alumina balls. It was the polyethylene surface roughness that appeared to influence wear rates. Our analysis showed that there was a transient due to patches of abrasive cement transferring onto CoCr ball surfaces. Overall the actual roughness of the CoCr balls did not change and was therefore not a factor in increased polyethylene wear.

Keywords: highly-crosslinked polyethylene, 3rd-body wear, Hip simulator, Surface roughness
DEGRADATION OF GAMMA INERT-IRRADIATED HIGHLY-CROSNILKED UHMW POLYETHYLENE DURING SHELF-STORAGE

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Introduction: The material properties of gamma irradiated Ultra High Molecular Weight (UHMW) polyethylene are known to degrade during exposure to air. Though gamma inert-sterilization has been developed to decrease free radicals, the rate of degeneration of UHMW polyethylene in vivo has not well known. This study aimed to compare the properties of gamma inert-irradiated highly-crosslinked UHMW polyethylene samples after exposure to air and the properties of gamma inert-irradiated highly-crosslinked UHMW polyethylene samples after exposure to liquid.

Materials and Methods: UHMW polyethylene samples were machined from heat-compressed sheet made of medical grade GUR 1050 (Ticona, Kelsterbach, Germany). Samples were rectangular, where the dimensions were 50mm in length, 5 mm in width and 2 mm in thickness. Samples were divided into four groups of 0, 6, 10 and 20 Mrad irradiation in N2 gas. These samples were then exposed to air or Ringer’s solution for half a year. Dynamic viscoelastic measurements and, Fourier Transform Infrared Spectrometry (FTIR) and Electron Spin Resonance (ESR) analyses were performed on samples immediately after inert-irradiation, after half-year-exposure to 25°C air (Air-exposure) and after half-year-exposure to 37°C Ringer’s solution (Liquid-exposure). Dynamic viscoelastic measurements were conducted over a temperature range of -150 to 350°C using a Dynamic Mechanical Spectrometer (Seiko Instruments, Osaka, Japan). FTIR analysis was conducted using a Perkin-Elmer Spectra BX (Norwalk, CT) with 100-μm thick slices. ESR analysis was also conducted using a JES-TE200 (Nippon-Denshi, Akishima, Japan).

Results: Although the dynamic viscoelastic performance of 0 Mrad irradiated storage sample was not different from that of original sample, the loss tangent value (tanδ, E’/E’) of 6, 10 and 20 Mrad irradiated storage samples was different from that of original samples (Fig. 1). The difference of Liquid-exposure was larger than that of Air-exposure. Although a FTIR peak at 1718 cm⁻¹ wave numbers was not observed in 0 Mrad irradiated storage sample, obvious peak was observed in 10 and 20 Mrad irradiated storage samples (Fig. 2). The peak of Liquid-exposure was larger than that of Air-exposure. The ESR analysis showed free radicals in storage samples.

Discussion: The dynamic viscoelastic performance of 6, 10, 20 Mrad irradiated storage sample was different from that of original sample, whereas the performance of 0 Mrad irradiated storage sample was not different from that of original sample. The difference of Liquid-exposure was larger than that of Air-exposure. The storage modulus value of 6, 10, 20 Mrad irradiated Liquid-exposure decreased and the reason for this was thought to be chain scission by oxidation for half-year exposure to Ringer’s solution. Obvious FTIR peak at 1718 cm⁻¹ wave numbers was observed in 10 and 20 Mrad irradiated storage samples. The peak of Liquid-exposure was larger than that of Air-exposure. This indicated that the oxidation of Liquid-exposure quickly progressed during half-year storage and the reason for this was thought to be chain scission by high liquid temperature. The results of the present study suggested that the properties of gamma irradiated UHMW polyethylene quickly degraded in vivo.
Audible squeaking following ceramic-on-ceramic total hip arthroplasty is a rare but troublesome problem. The aim of the present study was to assess the incidence and causes of squeaking in a group of predominantly oriental patients following third generation ceramic on ceramic THA.

A total of 1007 third generation ceramic-on-ceramic total hip arthroplasties were performed between May 1999 and Jan 2008 by a single surgeon. Fourteen of the 15 patients who complained of squeaking were examined clinically and radiologically. Squeaking was defined as a squeaking, clicking or grating sound arising from the THA during motion. Patient age, sex, height, weight, and BMI were recorded. Patients were also questioned about the activities that precipitated the squeaking. Implant type and size were recorded The movements of the hip or activities which resulted in squeaking were recorded. Squeaking was graded on a subjective scale of 1 to 10. Digital radiographs of all 14 patients were examined by an independent observer to assess acetabular component position and limb length discrepancy. This data was compared to a matched control group to identify potential causes of squeaking.

There were 12 males and 2 females of mean age 44.5 years, mean height 167.71 cm, mean weight 73.14 kg, and mean BMI 25.98 kg/m². Mean BMI in the squeaking group was significantly higher than the other ceramic-on-ceramic THA patients (P=.005) . The mean age of the patient group was also 4.26 years less than that of the other THA patients. The indication for THR was avascular necrosis in 10 patients, post traumatic osteoarthritis in 2 patients, and tubercular coxitis in 1 patient, and ankylosing spondylitis in 1 patient. All except 1 patient were operated upon using the modified MIS-2-Incision technique. Delta (Lima-Lto Udine Italy) acetabular shell was used in 8 patients, and a Secur-Fit™ (Stryker Osteonics , New Jersey, USA) acetabular shell was used in 6 patients. All patients were fitted with an alumina Biolox®Forte neutral liner and an alumina-Biolox®Forte modular head. The head diameter was 28 mm in 3 patients, 32 mm in 4, and 36 mm in 7. The neck lengths used were short in 6, medium in 6 and large in 2 patients . Conical stem was used in 4 and an ML taper stem in 10 patients.

The acetabular cup orientation and post operative limb length discrepancy were found to be independent risk factors for occurrence of squeaking. The mean lateral opening angle was found to be lower (34.26°) in these patients than in a matched control group (37.46°) (p=.016). Limb length shortening of more than 5mm was observed in 12 of the 14 patients as compared to only 4 of 14 patients in the matched control group. Mean Harris Hip Score (HHS) improved from 44 to 94 and most patients (13/14) were satisfied with the outcome of surgery.

Squeaking is a potentially worrisome complication of ceramic on ceramic THR but its incidence is low (15 of 1007 in our series). Proper patient selection, implant placement, and avoidance of joint laxity are likely to further reduce the incidence of this complication.
THREE-DIMENSIONAL MODELING OF THE HIP KINEMATICS UNDER MICRO-SEPARATION REGIME AFTER TOTAL HIP REPLACEMENT WITH PARTICULAR REFERENCE TO SQUEAKING

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Introduction: The use of hard-on-hard hip prostheses has highlighted specific problems like the stripe-wear and the squeaking. Many authors have related these phenomena to a micro-separation between the cup and the head. The goal of the study was to model the hip kinematics under micro-separation regime in order to develop a computational simulator for total hip prosthesis including a joint laxity, and to use it to perform a sound analysis.

Method: A three-dimensional model of the Leeds II hip simulator was developed on ADAMS® software. A spring was used to introduce a controlled micro-separation (less than 500 microns) during the swing phase of the walking cycle. The increase of the load during the stance phase induced a relocation of the head in the cup. Values of the medial-lateral separation predicted from the model were compared to experimental data measured using a LVDT of less than 5 microns precision. Theoretical wear path predicted from the model was compared to the literature data. The frequencies of the vibratory phenomena were determined, using the Fourier transformation.

Results: There was an excellent correlation between the theoretical prediction and the experimental measurement of the medial-lateral separation during the walking cycle (0.92). Edge-loading contact occurred during 57% of the cycle according to the model and 47% according to the experimental data. Velocity and acceleration were increased during the relocation phase in a chaotic manner, leading to vibration. The contact force according to the model had also a chaotic variation during the micro-separation phase, suggesting a chattering movement. Fourier transformation showed many frequencies in the audible area.

Discussion: A three-dimensional computational model of the kinematics of the hip after total replacement was developed and validated with an excellent precision under microseparation. It highlighted possible explanations for the squeaking that may occur during either relocation phase or edge loading.

RESONANCE OF THE METALLIC COMPONENTS GENERATES THE SOUND IN SQUEAKING CERAMIC-ON-CERAMIC HIP REPLACEMENTS
- AN ACOUSTIC AND FINITE ELEMENT ANALYSIS

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Squeaking in ceramic on ceramic bearing total hip arthroplasty is well documented but its aetiology is poorly understood. In this study we have undertaken an acoustic analysis of the squeaking sound recorded from 31 ceramic on ceramic bearing hips. The frequencies of these sounds were compared with in vitro acoustic analysis of the component parts of the total hip implant. Analysis of the sounds produced by squeaking hip replacements and comparison of the frequencies of these sounds with the natural frequency of the component parts of the hip replacements indicates that the squeaking sound is due to a friction driven forced vibration resulting in resonance of one or both of the metal components of the implant. Finite element analysis of edge loading of the prostheses shows that there is a stiffness incompatibility between the acetabular shell and the liner. The shell tends to deform, uncoupling the shell/liner taper system. As a result the liner tends to tilt out of the acetabular shell and slide against the acetabular shell adjacent to the applied load. The amount of sliding varied from 4-40μm. In vitro acoustic and finite element analysis of the component parts of a total hip replacement compared with in vivo acoustic analysis of squeaking hips indicate that either the acetabular shell or the femoral stem can act as an "oscillator" in a forced vibration system and thus emit a squeak.
IMPINGEMENT OF METAL NECK ON CERAMIC LINER IN CERAMIC-ON-CERAMIC THA

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We evaluated 3 cases of ceramic-on-ceramic THA in that the evidence of the impingement between the metal neck and the ceramic liner was found. Between July 2007 and January 2008, impingement between the metal and the ceramic liner was found in 3 cases of ceramic-on-ceramic THA during reoperation. The reoperation was performed 3-6 years after the primary surgery because of ceramic head fracture, deep infection and cup loosening. All patients frequently sat on the floor in tailor fashion but did not have any sound in the hip after THA. In all cases, V-shaped indented wear scar was found on the postero-superior aspect of the metal neck. Two ceramic liniers could be retrieved. Both showed black staining in the postero-superior portion of the rim. The outer edge of the bearing surface of the retrieved acetabular liniers was evaluated with SEM. The black stained area of the acetabular liner rim was found to be roughened. A micro-crack propagating into the deep portion of the ceramic liner was observed in one liner.

Our observations suggest that impingement between the ceramic liner and the metal neck can cause crack formation leading to ceramic liner failure in vivo.

DESIGN AND LABORATORY EVALUATION OF HARD-ON-HARD BEARING COUPLES

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Design of hard-on-hard bearing couples has traditionally been characterized by the material of the bearing couple, clearance between the bearing surfaces, sphericity of the components, surface roughness, and the radii of the components. All of these factors play a role in the lambda ratio and fluid film thickness calculations. However, the fluid film for hard on hard bearings can be interrupted by issues like the presence of 3rd body particles, intermittent walking, jogging, and subluxation. Only recently have researchers begun to simulate some of these disruptions in the fluid film for hard on hard bearings.

Recent laboratory testing has looked at the effects of utilizing different materials and methodologies to evaluate hard-on-hard bearings. Ceramic-on-metal is a unique combination of components that is currently available. Several authors have shown that this combination can reduce the amount of metal wear generated during the test by a factor of 4-100. However, an occasional anomaly has shown up in some of these tests where a wear couple in a steady state wear mode will have a several-fold increase in wear for a short duration.

For bearing couples that have a metal component, ion analysis of the serum lubricant can be utilized to monitor the amount of wear. This technique can provide real-time data on the amount of wear seen in simulator testing without removing the specimens from the machine. Further, there are some designs of metal cups that cannot be removed from the simulator without causing damage to the component. Data from a ceramic-on-metal simulator test confirmed that the short-term anomaly in gravimetric wear correlated with an increase in metal ion levels.

Distraction testing evaluates the change in wear due to the unintended subluxation of the hip. This may occur during a standard walking gait if the hip is loose, during impingement, or during deep-knee bends, squatting, or rising from a chair. Distraction testing has various effects on wear depending on the material of the bearing couple. UHMWPE is insensitive to this additional mode of simulator testing. Metal-on-metal and ceramic-on-ceramic can increase in wear by up to an order of magnitude. The utilization of Biolox-delta rather than Biolox-forte can reduce the amount of wear seen during distraction testing. Diamond-on-diamond is insensitive to this wear mode and showed immeasurable wear. Other issues during testing of hard-on-hard bearings are still being explored. It is well known that 3rd body particles will disrupt fluid films and can increase wear. But the results from adding particles is variable. Metal-on-metal tests can have one specimen with very little increase while another specimen has an order of magnitude increase. Deformation of the shell caused by insertion during surgery has been shown to occur. Currently, this deformation has not been able to be replicated in a simulator, therefore, its effects are unknown.

The design and laboratory testing of hard-on-hard bearings has improved significantly over the past decade. Further research is still needed to evaluate designs that may potentially increase resistance to failure modes other than standard walking gait cycles.
Minimum 10 year clinical, radiographic and densitometric follow up of an off the shelf Lateral Flare THR femoral component design

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This is a report on the first 100 THR patients treated with an off the shelf version of a novel Lateral Flare femoral component. A prior published report has documented the up to 19 year follow up of custom fabricated stems of an identical design concept as being successful in patients <55 years of age.

HHS, radiographic measure of bone morphology, implant stability and densitometric measure of bone response after THR with an off the shelf version. Revelation Lateral Flare, femoral component, confirm excellent bone preservation and implant stability with this design concept. DEXA analysis of a 20 consecutive patient subset of these 100 patients, documented preservation of more than 95% of proximal femoral bone stock in Gruen zone 1 and 102% of total bone stock in Gruen zones 1-7. Implant stability measurement documented <0.5mm of subsidence in spite of patients being permitted immediate post-operative full weight bearing activity.

These findings support reasonable optimism for expectation of successful long term results being achievable with the use of an off the shelf version of the Lateral Flare design concept, in young, high demand patients suffering with early onset osteoarthrosis of the hip.

A New Approach To Neck Sparing THA Stem

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Introduction: Architectural changes in the proximal femur after THA continue to be a problem. In an attempted, to reduce these changes some surgeon designers have advocated the concept of neck sparing stem designs. To-date neck-sparing stems have been disappointing in their ability to maintain the calcar. A new approach was undertaken to improve load transfer and to create a tissue-sparing stem that would be simple in design, reproducible in technique and provide for fine-tuning joint mechanics while maintaining compressive loads to the calcar.

Methods: Review of previous published work was evaluated along with FEA modeling in creating a new approach to neck sparing stems for THA. The MSA™ Stem is a simple curved stem with a unique lateral T-back designed for torsional stability, ease of preparation and insertion. The proximal design has a novel proximal conical shape designed to transfer compressive forces to the calcar. A modular neck provides for fine-tuning joint mechanics.

Results: FEA modeling will be reviewed. Strain patterns for the MSA™ stem demonstrated better patterns vs. long stems or the short Biodynamic stem.

Discussion:
In theory neck retaining devices provide for:
Bone and Tissue sparring
Restoration of joint mechanics
Minimal blood loss
Potential reduction in rehabilitation
Ease of revision
Simple surgical technique
Options for bearing surface
Selection of femoral head diameter
Standard surgical approach to the hip

We are encouraged and believe there are advantages in the concept of neck sparing stems. Clinical / surgical evaluation is now underway and will be reported on in the future.
ULTRA-SHORT ANATOMIC NECK SPARING CEMENTLESS FEMORAL STEM: EARLY OUTCOME IS PREDICTABLY SUCCESSFUL

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Background: Architectural changes in occurring in the proximal femur (resorption) after total hip arthroplasty (due to stress shielding) continues to be a problem. In an attempt to reduce these bony changes the concept of short and femoral neck sparing stem designs have been advocated. The purpose of this study was to evaluate the early clinical and radiological results, especially stem fixation and bone remodeling of proximal femur after total hip arthroplasty.

Methods: A total of forty-five patients (fifty-four hips) were included in the study. There were twenty men and twenty-five women. The mean age at the time of operation was 53.9 years (range, twenty-six to seventy-five years). Clinical and radiological evaluation were performed at each follow-up. Bone densitometry was carried out on all patients one week after operation and at the final follow-up examination. The mean follow-up was 1.3 years (range, one to two years).

Results: The mean preoperative Harris hip score was 45 points (range, 15 to 48 points), which improved to a mean of 96 points (range, 85 to 100 points) at the final follow-up. No patient complained of thigh pain at any stage. No acetabular or femoral osteolysis was observed and no hip required revision for aseptic loosening of either component. One hip (2%) required open reduction and fixation with a cable for calcar femorale fracture. Bone mineral densitometry revealed a minimal bone remodeling in the acetabulum and proximal femur.

Conclusions: The geometry of this ultra-short anatomic neck sparing cementless femoral stem has proved to provide effective initial stability even without the diaphyseal portion of the stem. We believe that femoral neck preservation and lateral flare of the stem provide an axial and torsional stability and more natural loading of the proximal femur.
UNCEMENTED CUSTOM FEMORAL COMPONENTS IN HIP ARTHROPLASTY. A PROSPECTIVE CLINICAL STUDY.

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18 years ago laboratory studies were started to develop a CT-based uncemented customised femoral stem in order to optimise the fixation and strain distribution to the proximal femur in uncemented femoral components. An individual design also aimed to optimise the biomechanics of the joint and to enable use of uncemented stems in femurs with abnormal shape and dimension. The developed prosthesis has now been in clinical use for 13 years. The aim of this paper is to present the preliminary results of a prospective clinical study of this prosthesis.

Patients and Methods: 685 hips have been operated. 58.8 % of the patients were women. Mean age was 51 years (20-69). 42.3 % of the hips were dysplastic. A high number of hips without major anatomic abnormality of the upper femur were included. The prostheses were designed to obtain a neck anteversion of 10 degrees after insertion, optimised medial femoral head offset and correction of leg length discrepancies up to 3 cm. All patients were followed with radiological and clinical examination. Merle d'Aubigné score was used. RSA and DEXA-studies have been performed in some groups of the patients. Finally, study of the gluteal muscular function in hips with optimised medial femoral head offset after insertion of custom stems was compared to hips where optimisation had not been achieved with use of standard stems.

Results: We experienced that use of this type of prosthesis is very simple and offers obvious advantages in abnormal size and geometry of the upper femur. Nine patients sustained a peroperative fissure in the proximal femur (1.3 %). These fissures were treated successfully with cerclage wires. Eight patients sustained a femoral fracture by a fall accident. Four fractures healed after osteosynthesis without loosening of the prosthesis. A long stem prosthesis had to be used in the other four. No stem loosening was seen except in one case where a non-union after subtrochanteric osteotomy prevented stem fixation. Dislocation occurred in ten hips (1.5%). In four of these the acetabular component had to be replaced. Average total score at 7 years (125 hips) was 17.1 (preop 9.4), at 10 years (56 hips) 17.0 (preop 9.4). The pain scores at the corresponding observations were 5.7 (preop 2.7) and 5.6 (preop 2.8). DEXA-studies showed comparable preservation of femoral bone stock in hips treated with custom and standard stems (ABG). RSA-studies showed no significant stem migration. Superior function of the gluteal muscles was obtained after normalisation of the medial femoral head offset after insertion of a custom stem when compared to hips where normalisation had not been achieved by a standard stem.

Conclusions: Use of custom femoral components enables optimisation of the biomechanics of the hip and eliminates the need for highly modular femoral stems. The rate of peroperative fissures and postoperative instability is relatively low indicating adequate fit of the stem and adequate design of the femoral neck. Use of custom prostheses offers obvious advantages in highly abnormal femurs. The mid-term clinical results up to 10 years are promising with a very low risk of aseptic loosening. However, it remains to see whether use of such prostheses will give superior long term results compared to standard uncemented stems in normal femurs.
THE RATIONALE FOR GENDER SPECIFIC FEMORAL STEMS FOR TOTAL HIP ARTHROPLASTY

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Differences in femoral anatomy have been partially ascribed to gender differences. Traditionally, femoral stems for THA have been designed across an entire population including both males and females. The purpose of this study was to compare the applicability of two femoral stem systems in male and female populations via preoperative templating.

Methods: All patients seen during a single month who presented complaining of knee pain had screening pelvis x-rays. These x-rays formed a consecutive cohort of hips for the templating study. During templating, the acetabular component was placed in a fully medialised position at 45° of abduction. The center of rotation was marked. The femoral neck osteotomy was set at 15 mm proximal to the lesser trochanter. Templates of equal magnification were utilized for both systems. System 1 had a double tapered wedge body design, a fixed 135° neck-shaft angle with two different offsets (6 mm difference) and two different neck lengths (4 mm difference). There were 7 head options with different lengths. System 2 had the same body design with a modular neck offering 20 different offsets/lengths and 7 different neck-shaft angles, with only one head option. Neck length and offset were independent of body size for both systems. Based upon templating, the categories were: No obvious advantage of either system, System 1 preferred, System 2 preferred, Neither system appropriate. Preference was determined based upon providing at least one additional length or offset option, and avoiding the extra extended offset option in System 2 based upon the theoretical risk of disassociation due to extremely high moments.

Results: There were 20 female patients contributing 40 hips and 27 males contributing 54 hips. Among the males, there was no obvious advantage in 20/54 hips (37%), System 1 was preferred in 11/54 hips (20.4%), System 2 was preferred in 15/54 hips (27.8%), and neither system was appropriate in 8/54 hips (14.8%). In addition, System 1 could have been used in 33/54 hips (61.1%), while System 2 could have been used in 42/54 hips (77.8%). Overall, 46/54 male hips (85.2 %) could be implanted with this stem. Among the females, there was no obvious advantage in 17/40 hips (42.5%), System 1 was preferred in 1/40 hip (2.5%), System 2 was preferred in 13/40 hips (32.5%), and neither system was appropriate in 9/40 hips (22.5%). In addition, System 1 could have been used in 22/40 hips (55%), while System 2 could have been used in 31/40 hips (77.5%). Overall, 31/40 female hips (77.5 %) could be implanted with this stem.

Discussion: Significantly, there are gender differences in applicability of femoral stems. Specifically, more neck length and offset options seem to be required for females. One criticism of this study would be that the neck osteotomy length was fixed. In practical application, surgeons frequently adjust the level of the neck osteotomy to successfully reconstruct the hip. Further study is necessary to determine the role of neck-shaft angle, bone quality and adjustment of neck osteotomy height.
OSA14-01  Fifteen to Twenty Year Follow-up Results of Hip Arthroplasty using CLS(Cementless Spotorno) Femoral Stem

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Purpose: The purpose of this study is to evaluate the clinical and radiological results of the total hip arthroplasty using the CLS stem, of which we were able to follow up for 15-20 years after operations.

Materials and Methods: Among 104 patients who underwent the total hip arthroplasty using the CLS stem from February 1988 to August 1993, we evaluated the clinical and radiological results of 65 hips of 51 patients, which were able to be followed up for more than 15 years. The average age at the operation was 45.2 years old (22-62 years old) and the average follow-up duration was 17 years and 2 months (15 years-20 years 5 months). The majority of preoperative diagnoses was avascular necrosis of femoral head with 52 cases (80%), followed by osteoarthritis with 7 cases (11%) and the other 6 cases. Used as acetabular components were 15 cases of the Expansion cup, 26 cases of the HG II cup, 11 cases of the CLW cup, 2 cases of the Spherical cup and 11 cases of Bipolar cup (54 cases of the total hip arthroplasty and 11 cases of bipolar hemiarthroplasty).

Results: No femoral stem revision was performed. The average Harris hip score improved from 52.2 preoperatively to 94.3 at the final follow-up. There was no patient who complained a severe thigh pain. Radiographically, small osteolytic lesions were found in 23 cases (35.4%), endosteal bone formation in 63 cases (96.9%), calcar femoral atrophy in 7 cases (10.8%) and cortical hypertrophy in 15 cases (23.1%). Acetabular cup loosening occurred in 4 cases and liner dissociation occurred in 2 cases among 54 total hip arthroplasty cases, and the acetabular cup revisions were performed in those cases and a liner change was additionally performed in 1 case. The conversion total hip arthroplasty was performed in 1 case among 11 bipolar hemiarthroplasty cases due to a snap fit design failure. Complications included a periprosthetic fracture (1 case) and a dislocation (1 case). The periprosthetic fracture, which was complicated due to a slip-down injury 17 years after the THA, was treated by an open reduction and internal fixation. The dislocation, which was complicated 13 years after THA, was treated by a manual reduction.

Conclusion: Fifteen to twenty year follow-up results of total hip arthroplasty using the CLS femoral stem showed an excellent result without any femoral stem revision.

OSA14-02  Primary Total Hip Arthroplasty with an Cementless Tapered Femoral Component:
Two-Six-Year Results

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This prospective study reports the midterm outcome of total hip arthroplasty performed in a consecutive series of patients using a tapered uncemented femoral component. From Nov. 2001 to Apr. 2006, total hip arthroplasties were performed in 138 patients (150hips). The clinical records and the routine serial radiographs of these patients were monitored closely over a 1-year period. Clinical evaluation was done by Harris hip score before surgery and at last follow-up. Radiological evaluation was done on plain radiographs. The average follow up period was 4.05 years. There was a significant improvement in functional outcome of these patients as measured by Harris hip score. There were no revisions for aseptic loosening of the femoral component in this series, accounting for an overall survivorship of 100%. The study confirms that the midterm outcome of this stem is excellent, with no revisions.
**Total Hip Replacement Arthroplasty with Mallory - Head System**

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**Purpose:** The purpose of this study was to assess the long term clinicoradiological results of a total hip replacement using the double tapered Mallory-Head system.

**Materials and Methods:** The results of a consecutive series of 81 total hip replacements in 75 patients were reviewed three to eleven years (average eight years) postoperatively. The diagnosis were avascular necrosis for 46 hips (57%), osteoarthritis for 12 hips (15%), RA for 9 hips (11%), and others. The clinical result was evaluated on the basis of the modified Harris hip score, modified Merle d’Aubign and Postel score. A detailed radiographic analysis was also performed.

**Results:** The average modified Harris hip score improved from 56 points to 92 points. The average modified Merle d’Aubign and Postel score was 15 points at the latest follow up, and 55 hips (68%) were classified as the clinical grades of excellent or good results. Two acetabular components were revised because of loosening, and one was revised because of recurrent dislocation.

**Conclusion:** The clinical and radiological evaluations of the total hip replacements, using the Mallory-Head system showed good results.

**Key Words:** Mallory-Head, Tapered, Cementless, Total hip replacement (arthroplasty)

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**Effect of Hydroxyapatite and Tricalcium-Phosphate Coating on Fibermetal Porous Coated Femoral Stem -Results at 127 months-**

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For successful long-term result of non-cemented total hip arthroplasty (THA), direct biological bond between bone and implant through bony ingrowth into the implant is essential. To facilitate strong bond between bone and implant, hydroxyapatite (HA) or hydroxyapatite and tricalcium phosphate (HA-TCP) coated implants have been developed. Early clinical results of HA coated implants were reported very satisfactorily. However, the long-term effects of HA or HA-TCP coating on implants were still controversial. We evaluated the effect of hydroxyapatite and tricalcium phosphate (HA-TCP) coating on fibermetal coated femoral stem. 37 cases using fibermetal coated femoral stem with additional HA-TCP coating and 38 cases using fibermetal coated femoral stem without additional HA-TCP coating were included with average follow-up for 127 months. The mean Harris hip score at final follow-up 91.2 in HA-TCP group and 90.5 in porous group. Engh’s score at final follow-up was 19.1 in HA-TCP group and 18.7 in porous group. Six acetabular components (8.0%, 3 cases in each group) were revised for excessive PE liner wear and liner dissociation from locking mechanism. One femoral stem without HA-TCP coating was considered as a loosening and failure. None of the remaining femoral components (98.7%) showed any signs of aseptic loosening. No significant differences between two groups were found in all parameters. A cementless porous coated femoral stem provided good clinical function and survival in the medium term regardless of additional HA-TCP coating.
2 Cementless total hip arthroplasty for hemophilic arthropathy - Minimum 5 years follow-up

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Introduction: The aim of this study is to analyze the mid to long term results of cementless total hip arthroplasty (THA) performed in hemophilic coxarthrosis.

Material & Method: Of 32 hips (28 patients) that underwent cementless THA for hemophilic arthropathy, 28 hips (24 patients) that were followed up for more than 5 years were enrolled. The average age at the time of surgery was 36 years (± 8.3) (range 24 - 52). All the patients had type A hemophilia. In all cases multiple joints were involved. The mean follow-up period was 89.2 months (± 30) (range 60 - 154). For clinical assessment we evaluated the Harris hip score, hip range of motion, amount of transfusion and factor replacement, perioperative bleeding and the problems associated with the use of coagulation factors and the bleeding itself after surgery. For radiographic assessment, we evaluated the stability and fixation of the components, various bone responses around implants and complications such as loosening and osteolysis.

Result: The average Harris hip score improved from 60.7 (± 19.3) (range 30 - 89) before surgery to 95.2 (± 3) (range 90 - 100) at the final follow-up. The hip range of motion in all planes increased after the operation. During and after the surgery, an average of 3.2 units of packed RBC was transfused and an average of 46000 units of coagulation factors were injected. The episode of re-bleeding was observed in 4 cases. In one of them, severe osteolysis around the pelvis and femoral stem was noted due to a huge pseudotumor. Radiographically, except 1 loosened cup, the fixation was stable in all cases at the latest follow-up. Heterotopic ossification was noted in two hips. The osteolysis was noted in 4 cups and 5 stems. In one case of severe osteolysis around the stem, morsellized bone graft was performed at 144 months after the index operation. One case of pseudotumor was waiting for surgery. One loosened acetabular cup was revised into a cemented cup.

Conclusion: Unlike the worrisome results of cemented THA, meticulously performed cementless THA for the moderate or severe hemophilic arthropathy is safe and greatly effective in reducing pain, increasing the range of motion and improving walking ability. However, special attention should be paid to the possible complications associated with re-bleeding such as pseudotumor around the hip. To obtain the best results multidisciplinary team which is composed of a pediatrician, a hematologist, a rehabilitation therapist and an orthopaedic surgeon should be assembled.
TOTAL HIP ARTHROPLASTY AS A SALVAGE PROCEDURE FOR FAILED INFECTED INTERNAL FIXATION OF HIP FRACTURES

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Failed internal fixation of hip fracture is a problem with varied aetiology. This becomes more complex when associated with infection. Total hip arthroplasty (THA) remains the only option to restore hip biomechanics when there is partial/complete head destruction associated with it.

A retrospective review was performed for 22 consecutive patients of THA following failed infected internal fixation between Sept. 2001 and Nov. 2007. There were 11 dynamic hip screw failures for intertrochanteric fractures, 6 failed osteotomies following proximal femoral fractures, and 5 failed screw fixations for transcervical fractures. The average age of the patients were 48.5 years and average follow up period was 3.5 years (5months - 7.5years). All the patients have undergone two stage revision surgeries. The average Harris Hip Score improved from 35.5 to 82.8 at the latest follow up. None of the patients had recurrence of infection. One patient developed sciatic nerve palsy, recovered partially at 1 year following surgery. The results were comparable to primary arthroplasty in femoral neck fractures. THA is a useful salvage procedure for failed infected internal fixation of hip fractures. Extreme care must be taken to avoid fracture and penetration of femoral shaft in such cases. Auto graft, allograft and special components like multihole cup, narrow stem should be available for reconstruction in difficult cases.

Level of Evidence: Therapeutic Level IV

CEMENTLESS BIPOLAR HEMIARTHROPLASTY FOR FEMORAL NECK FRACTURE IN PATIENTS OLDER THAN SEVENTY YEARS USING TAPERED RECTANGULAR STEM

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Purpose: The purpose of this study was to evaluate clinical and radiological outcomes after cementless bipolar hemiarthroplasty in elderly patients with femoral neck fractures.

Materials and Methods: Eighty hips-all in patients greater than 70 years of age-were followed for more than 2 years after undergoing cementless bipolar hemiarthroplasty with a tapered rectangular cementless stem (Lima SPH-C2°). The mean age was 76 years, and the mean follow-up period was 37 months. The Harris hip score and postoperative hip pain were analyzed clinically. Femoral bone types were classified according to Dorr method. The radiological results were assessed using various radiological indices.

Results: At last follow-up, the mean Harris hip score was 80.2 points. There were 5 cases of groin pain, 4 (5.0%) mild and 1 (1.3%) moderate and 7 cases of thigh pain, 6 (7.5%) mild and 1 (1.3%) moderate. Fifty-five cases (68.7%) showed no decrease in ambulation capacity postoperatively. Patients have type A bone types in 13 cases (16.2%), type B in 51 cases (63.7%) and type C in 16 cases (20.0%). Radiologically, there were 47 cases (58.7%) of bone ingrowth and 33 cases (41.3%) of stable fibrous fixation. There were no cases of osteolysis, and 30 cases (37.5%) exhibited new bone formation around the stem. All stems were stable without significant alignment change or progressive subsidence.

Conclusion: Short-term outcomes proved to be satisfactory in elderly patients undergoing cementless bipolar hemiarthroplasty for femoral neck fractures. Tapered rectangular stem showed satisfactory results with all bone morphology.
Dislocation remains a common complication following total hip arthroplasty, second only to aseptic loosening as a cause of revision. Factors thought to play a role in dislocation include cup and stem alignment, soft tissue tension, surgical approach, patient factors, and design features of the prosthesis, including femoral head size.

We analysed all consecutive total hip replacements at one institution over a 17 year period. Criteria for study inclusion were hips replaced due to primary osteoarthritis with no previous surgery, femoral head sizes of 28mm and 32mm only, and at least one year from date of surgery. 3682 hips fulfilled these criteria. All procedures were carried out using a posterolateral approach with enhanced posterior repair, and a standard method of intraoperative soft tissue balance assessment.

The rate of dislocation was 1.6%. 32mm femoral head size was associated with a statistically significant lower rate of dislocation. However, after controlling for different follow-up times between 28mm and 32mm heads, this difference was no longer observed. Older age at time of surgery and decreased cup anteversion were shown to be significantly associated with an increased risk of dislocation. Ceramic on ceramic bearing surface was significantly associated with a decreased risk of dislocation, after controlling for age, bearing wear and time from surgery. Cup inclination, gender, BMI, and preoperative hip score were not related to dislocation risk.

Our dislocation rate may reflect current dislocation rates of surgeons using the posterolateral approach with posterior capsule and external rotator repair. The risk factors identified and excluded in this study are likely to be relevant to all surgeons who utilise this approach in total hip arthroplasty.
PROSTHESIS POSITIONING AND DISLOCATION IN THR: CT STUDY ASSESSING CUP AND STEM POSITIONING IN A SERIES OF 152 PRIMARY TOTAL HIP ARTHROPLASTY AND ITS INFLUENCE ON DISLOCATION

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Introduction: Dislocation is the most relevant early complication after primary total hip replacement (THR) in literature. Many factors have been advocated for dislocation, either surgeon-related either patient-related. Component positioning seems to be of major importance in determining dislocation. We evaluated 152 randomised THR with a CT study between 985 THR done at our institute since November 2004 to November 2006.

Materials: 152 randomised primary THR on a total of 985. The same prosthetic pattern (head size, stem, cup). Lateral approach with total capsulectomy and external rotator section. All 152 patients underwent a standardized CT study assessing cup antversion and inclination angles and stem antversion angle. Dislocated patients where furthermore analysed for any detail concerning their procedure and follow-up. A safe zone was then deduced for safer positioning.

Results: During the follow-up period dislocation occurred in 5 hips (only one in the randomised group) assessing our rate of dislocation at 0.5%. All dislocation were managed with closed reduction and an articulated hip brace. No open reduction or revision surgery were further needed. The mean cup abduction was 47° in the dislocated hips and 49° in the control group. Mean cup antversion was 29° in both groups. The mean stem antversion was 8.2° in the dislocated group and 3.1° in the control group.

No statistical difference could be reached between dislocation and cup positioning. A correlation between hip dysplasia (Crowe II) as primitive diagnosis and dislocation could be reached.

Discussion: In THR inappropriate cup and stem positioning is considered an important risk factor of postoperative dislocation. Accurate and reproducible measurement is mandatory for implant positioning evaluation. Conventional radiographs cannot provide accurate and reproducible measurement. CT can provide a precise measurement of prosthetic components. Several studies failed to demonstrating a correlation between component positioning and dislocation often because of small number of patients and many bias. We tried to reduce bias using the same prosthetic pattern and the same surgical approach. Notwithstanding we could not reach a statistical difference in term of prosthetic positioning between dislocated and control group. Perhaps the dislocated group was too small to have a statistical meaning.

We could determine a Safe Zone of cup and stem positioning for our patients: cup antversion between 24° and 33°, cup inclination between 42° and 50°, stem antversion between -3° and 10°.

Conclusion: Dislocation is the main early complication after THR. Its etiology depends on many factors. Sometimes the cause can’t be identified. Orientation of prosthetic components may be responsible for dislocation but its truly correlation can be hard to be assessed. In this study we found no correlation between implant positioning and occurrence of dislocation, but we defined a tighter Safe Zone than previous reported, in which the risk of dislocation is nought. A correlation between hip dysplasia (Crowe II) as primitive diagnosis and dislocation could be reached.
INTRA-OPERATIVE FRACTURES OF THE GREATER TROCHANTER AND CALCAR DURING HIP ARTHROPLASTY: AN OUTCOME STUDY

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Total hip arthroplasty (THA) allows patients to return to an active lifestyle. Unfortunately one of the more common complications of cementless THA is a fracture of the greater trochanter (GT) or the calcar. These may compromise the outcomes of THA, but there are no large studies looking into this hypothesis.

Between September 1998 and August 2005 the Hamilton Arthroplasty group performed 2282 THA operations. Demographic and outcome data on these patients was collected and tabulated in a prospective database. Radiographs were available on a PACS system for 1075 of the patients, 85% of which were primary THAs. GT and calcar fractures were identified. Statistical comparisons on the normal distributed outcome data were made using the Student’s T-test comparing repaired and missed fractures.

A total of 60 GT fractures were found in the review of 1075 radiographs, giving an incidence of 5.6%. This included 19 isolated GT fractures and 10 GT fractures with associated calcar fractures that were found in primary hip arthroplasties, 48% of the total. Revision hip surgeries had 14 isolated GT fractures and 17 GT fractures with associated calcar fracture. We found that 23 (40%) of all GT fractures were missed intra-operatively and did not receive any fixation. All calcar fractures were noted and repaired, even if the associated GT fracture was not.

106 isolated calcar fractures were noted, 10% of all arthroplasties, only one of which did not receive fixation. Of this, 85 (80%) were from primary total hip arthroplasty and 21 (20%) from revision hip arthroplasty.

Evaluation of the outcome data showed no significant difference between repaired and missed GT fractures. Reported outcomes compared favourably with the average for all THA in that time period.

Adoption of cementless total hip arthroplasty in North America undoubtedly increases the rate of GT and calcar fractures. Most calcar fractures were noted and fixed but only 50% of GT fractures were discovered intraoperatively, an area of potential improvement. Greater trochanter and recognized calcar fractures may not have long-term detrimental effects.
RECOVERY AFTER THREE DIFFERENT TECHNIQUES IN MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY

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This research was done in the Teikyo University Hospital, Nissan Tamagawa Hospital, and Shonan Kamakura Joint Reconstruction Center. There are several techniques in minimally invasive total hip arthroplasty. One of the possible advantages of these techniques is early functional recovery. The purpose of the study was to evaluate possible differences in functional recovery patterns after three different techniques of minimally invasive total hip arthroplasty.

**Patients and methods:** Two hundreds and eighty-eight hips were recruited for this study. All operations were done without cement in all institutes. Acetabular components were Trilogy and femoral components were VerSys (Zimmer, Indiana, USA) in all hips. Mini-incision antero-lateral approach was used for 112 hips (Mini-AL group), mini-incision postero-lateral approach for 53 (Mini-PL group), and muscle sparing antero-lateral approach was used for 123 hips (MIS-AL group). There were no significant differences among the three groups for body-mass index. All patients were encouraged to walk with full weight-bearing as soon as possible. Recovery of the hip function for walking with a cane (100 meters) and putting on socks was analyzed. We also analyzed pain during resting and walking, and evaluated muscle strength for abduction before surgery, at one, three, five, seven and 14 days after surgery. Pain was assessed using a visual analog scale. Muscle strength was assessed using a hand held dynamometer (MicroFET-2) in supine position. The data among the three groups was compared using a Wilcoxon non-parametric test (level of significance set at $p<0.05$).

**Results:** Mean of the postoperative days until able to walk longer than 100 meters with a cane was 4.09 days for MIS-AL group, 4.82 for Mini-AL group, and 5.57 for Mini-PL group. MIS-AL group showed a significantly earlier recovery than Mini-AL and Mini-PL groups. Mean of the postoperative days until able to put on socks was 5.86 days for MIS-AL group, 7.37 for Mini-AL group, and 9.9 for Mini-PL group. MIS-AL group showed a significantly earlier recovery than Mini-AL and Mini-PL groups. There were no differences at any days among the three groups. In the recovery of muscle strength for abduction, there were no differences at one and three days after surgery. At five, seven and 14 days after surgery, Mini-PL and MIS-AL groups showed a significantly earlier recovery of muscle strength for abduction than Mini-AL group.

**Conclusion:** Muscle sparing antero-lateral technique showed earlier recovery for walking and putting on socks than those using mini-incision techniques. For abductor muscle strength, mini-incision postero-lateral technique and muscle sparing antero-lateral technique showed earlier recovery than mini-incision anterior-lateral technique.
Modified posterior approach of THRA to enhance the joint stability in patients with osteonecrosis

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Modified posterior approach preserving short external rotators would be able to contribute greatly to prevent dislocation after total hip arthroplasty.

We modified the posterior approach to the hip by preserving the external rotator muscles in order to enhance joint stability after total hip arthroplasty in patients with osteonecrosis of the femoral head. The aim of the this study was to determine the influence of external rotator preserving posterior approach in primary total hip replacement on early dislocation and clinical outcome.

Three hundred sixty-four primary total hip replacements were divided into two groups based on how the external rotators were treated at surgery. External rotator preservation (Group 1, 165 hips) group was compared with reattachment (Group 2, 199 hips) group by evaluating the clinical and radiographic outcome at one year postoperative. Anteversion was significantly less in Group 1 as compared to Group 2 (P < 0.001). There was no significant difference in inclination between the groups (P > 0.05 in all comparisons). No dislocations were found in 165 hips with external rotator preservation whereas dislocations was noted in 11 (3.9%) in Groups 2, respectively. Group 1 had the higher mean Harris hip score (97.2 ± 2.9 points) as compared with Group 2 (94.9 ± 3.4).

The results of this study showed that external rotators could play an important role in preserving joint stability after total hip arthroplasty in patients with osteonecrosis of the femoral head. It can be implied that this modified posterior approach would be able to contribute greatly to prevention of dislocation, and improve clinical outcome after total hip arthroplasty.

COMPARISON OF MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY VIA A POSTEROLATERAL APPROACH VERSUS AN ANTEROLATERAL APPROACH.

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PURPOSE: The interest in minimally invasive surgery (MIS) for total hip arthroplasty has not waned in anyway (THA). Different surgical approaches have been used to do MIS-THA. The purpose of this study was to compare the outcome of the THA using the minimally invasive postero-lateral approach (MIS-PL) and minimally invasive antero-lateral approach (MIS-AL).

PATIENTS AND METHODS: Fifty randomly assigned patients with MIS-PL and 32 patients with MIS-AL were included in the study. There were no significant differences in age, sex, diagnosis, JOA score or body mass index in each group. The operation time, length of incision, blood loss, implant position, muscle recovery and complication were observed.

RESULTS: Total blood loss and pain was significantly less in patients undergoing THA via MIS postero-lateral approach. In addition, the MIS-PL had improved recovery of muscle strength (hip flexion and abduction) which was statistically significant. Median cup inclination was 42.3 degrees (MIS-AL) and 41.7 degrees (MIS-PL). Median cup anteversion was 18.3 degrees (MIS-AL) and 15.9 degrees (MIS-PL), respectively. Roentgenographic evaluation of femoral component positioning showed no significant difference. Other postoperative data (length of hospital stay, operation time, complication) were comparable.

CONCLUSION: The MIS antero-lateral approach have often been selected to decrease the risk of dislocation, but this approach needs to release the one third of the gluteus medius from the greater trochanter. MIS postero-lateral approach caused less pain and improve recovery time, postero-lateral approach is more suitable for minimally invasive total hip arthroplasty.
A consecutive series of patients who underwent 113 total hip arthroplasty (THA) with minimally invasive surgery (MIS) (63 one-, 50 two-incision cases) were studied. One-incision THA was performed with a posterolateral approach. For the two-incision, the first incision for cup insertion was made over the anterolateral side of the hip and intermuscular dissection was performed between the gluteus medius and the tensor fascia lata. The second incision for stem insertion was made on the posterolateral side along the fiber of the gluteus maximus and intermuscular dissection was made between the gluteus medius and the piriformis.

The average length of the skin incision and standard deviation (SD) in the one- and two-incision group was 7.5 ± 0.54 cm and 12.1 ± 0.93 cm (p<0.001). Average surgical time for the two groups (and SD) was 52 ± 8.5 minutes and 70 ± 10.2 minutes (p=0.042) in the one and two incision groups respectively. Fluoroscopy was used in the two-incision group for an average 6.0 ± 5.3 seconds. In the one-incision group, the average time was 1.3 ± 2.1 seconds. The patients in the one-incision group could walk on crutches at postoperative 3.7 days on average, and in the two-incision group at 1.6 days on average (p<0.000). In the one-incision group, patients used crutches for six weeks on average, and in the two-incision group, patients used crutches for three weeks on average (p=0.042).

Complications that developed within one month of surgery in the one-incision group were: one case of DVT, one case of intra-operative fracture and one case of dislocation; for the two incision group there were: one case of DVT, one case of intra-operative fracture and one case of femoral nerve entrapment.

Before surgery, the HHS for the one-incision group was 49.8 points, and for the two-incision group it was 49.6 points (p>0.05). At the time of the follow up review conducted postoperatively one year, the average HHS was not significantly different (p>0.05). However, the average function score in HSS for the two-incision group was superior to that of the one-incision group (p=0.045). Preoperative WOMAC scores were not different for the two groups (68.7 in one-incision group and 70.9 in two-incision group, respectively, p>0.05). However, the average WOMAC score for the two-incision group was better, especially for the function score (p=0.001). The other hip functions, common in oriental persons, were also better in the two-incision group compared to the one-incision group.

On the radiographs, the location of the femoral prosthesis inserted in the medullary cavity was usually central in both groups; only four cases showed varus in the one-incision group and two cases in the two-incision group. The opening angle of the acetabular component was 38.1° in the one-incision group and 39.2° in the two-incision group (p>0.05). The anteversion of the acetabular component was 21.0° in the one-incision group and 22.2° in two-incision group (p>0.05).

As compared with one-incision MIS-THA, two-incision MIS-THA, although it is a more difficult procedure, produces superior results, recovery was faster and patient satisfaction was higher due to early rehabilitation and reduced soft tissue damage without increasing the complication frequency.
FEMORAL EXPOSURE THOUGH MEDIAL GLUTEUS MUSCLE ON TOTAL HIP ARTHROPLASTY AND HEMIARTHROPLASTY

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Purpose: Minimally invasive surgery (MIS) for total hip arthroplasty and hemiarthroplasty is performed through anterior or anterolateral approach from April 2006. Appropriate stem insertion is often difficult by conventional approach. Retractor for MIS stem insertion is used from February 2007 and initial stem position is measured.

Material and Method: 44 hemiarthroplasty and total hip arthroplasty were performed from April 2006 until December 2007 with mean age of 79.7. Retractor for MIS stem insertion has been used for hips from February 2007. Stem was cemented for more than 13mm at femoral isthmus. Stem position was measured in rentegenographs of hip after operation about adduction or abduction, extension or flexion, and anteversion of stem in proximal femur.

Results: The average abduction/adduction was 1.75 degree abduction in conventional method and 1.38 degree abduction from February 2007. The average extension/flexion was 1.10 degree flexion in conventional method and 0.25 degree flexion from February 2007. The average anteversion was 30.3 degree in conventional method and 28.4 degree from February 2007.

2 cases in conventional method and 1 case from February 2007 complicated femoral fracture during operation. In conventional method, cement cap of 1 case was undersized and proximal major trochanteric fracture was happened in 1 case. Ectopic ossification at medial gluteal muscle in 1 case was observed and 1 case was dislocated among conventionally operated cases during follow-up period.

Conclusion: Care of femoral exposure though gluteal muscles is needed in anterior and anterolateral MIS. More exact and safe stem insertion procedure is available by using retractor for MIS of the hip.
PATIENT FEMOROACETABULAR MORPHOLOGY SIGNIFICANTLY AFFECTS HIP RANGE OF MOTION AFTER TOTAL HIP ARTHROPLASTY

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Introduction: Dislocation remains a major early complication after total hip arthroplasty (THA), and range of motion (ROM) before impingement is important in joint stability. Factors contributing to dislocation include design specific factors such as head-neck ratio, surgeon-related factors such as component placement, and patient-related factors such as bony anatomy. To study the relative importance of these factors, we analyzed the effects of patient anatomy, implant design, and component orientation on hip ROM.

Methods: Femoral and acetabular geometry was extracted from CT scans of 20 hips. CAD models of four different total hip arthroplasty component designs were virtually implanted in the 3D CT reconstructed anatomic models. The major design differences were in head-neck ratio and neck-stem angle. A previously reported contact detection model (D Lima, J Orthop Research, 2008) was used to measure restriction in hip ROM due to prosthetic or bony impingement. The following patient parameters were measured on plain AP radiographs: acetabular inclination, acetabular depth ratio, the arc-length between the tip of greater trochanter and ilium, and the arc-length between lesser trochanter and ischium. Multiple linear regression was used to determine correlation between radiographic parameters and hip ROM in flexion, extension, adduction, abduction, and external rotation.

Results: Mean anatomic acetabular inclination was 53° ± 5, mean anteversion was 22° ± 6 and mean acetabular depth ratio was 497 ± 146. When the cup and stem were implanted for best fit to the anatomy, mean hip ROM was 124° ± 17 (flexion), 57° ± 13 (extension), 32° ± 14 (adduction), 69° ± 11 (abduction), and 45° ± 17 (external rotation). Implanting the cup in optimal surgical alignment of 45° abduction and 20° anteversion reduced mean hip flexion, extension and abduction and increased adduction. Subject-to-subject variation was substantially greater than variation between CAD designs (differences in head-neck ratio) or component orientation (between ideal and anatomic). Hip morphologic parameters measured on radiographs correlated strongly with abduction ($R^2 = 0.98$), adduction ($R^2 = 94$), external rotation ($R^2 = 0.85$), and extension ($R^2 = 0.70$) but weakly with flexion ($R^2 = 34$).

Discussion & Conclusion: A universal cup position that permits optimal range of motion in all patients may not be valid. Since patient-related factors overshadowed implant design, cup position should be tailored to the individual patient. Preoperative radiographs can help predict postoperative hip ROM although not as accurately as 3D CT reconstructions. These results may lead to enhancements in surgical navigation techniques.
HipMatch: A 2D-3D Matching Software - Accurate and Reliable

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The long-term results after a total hip arthroplasty (THA) strongly depends on the correct component positioning of the acetabular cup and stem. Surgical navigation has been established for THA to achieve more precise component placement. The postoperative measurement of the cup orientation on antero-posterior (AP) pelvic radiographs for verification of the accuracy of this technique is subject to substantial error if the individual pelvic tilt and rotation is not taken into consideration. Therefore, we developed and validated a software (HipMatch) to determine the exact postoperative cup orientation (anteversion and inclination) out of a standard AP pelvic radiograph with the help of a preoperative CT-scan. The software matches the 3D-shape of the pelvis from the CT-scan with the projected pelvis contours on the radiograph to correct the measured angles regarding the individual pelvic orientation. The purpose of this study was to validate the accuracy and intra- and interobserver reliability of this software using a cadaver trial and a clinical patients series.

For the cadaver validation 10 human pelves (20 hips) were used. From each pelvis 2 CT scans, one with and one without an inserted cup were acquired. The CT scan with the cup was used as the ground truth. With the cup inserted 4 AP pelvic radiographs with the pelvis in an unknown arbitrary position during acquisition were performed resulting in 80 measurements for accuracy and consistency. These measurements were performed by 2 observers at 2 different occasions resulting in a total of 320 measurements for reproducibility/reliability. For the clinical validation 46 patients with a pre- and a postoperative CT scan and 2 postoperative radiographs were used to test the accuracy in the clinical setup.

In the cadaver validation the cup orientation measured on the CT (ground truth) ranged for the inclination from 34° - 57° and for the anteversion from 1° - 24°. The accuracy of the software for the inclination was 0.9° ± 1.6° (-3.2° - 4.0°) and for anteversion 1.2° ± 2.4° (-5.3° - 5.6°). For the intraobserver reliability the intraclass correlation coefficient (ICC) ranged from 0.96 to 0.99 and for the interobserver reliability the ICC ranged from 0.95 to 0.98. No relevant systematic error was detected in the Bland-Altman analysis. In the clinical validation the cup orientation measured on the postoperative CT ranged for the inclination from 22° - 57° and for the anteversion from 7° - 35°. The accuracy of the software for the inclination was 2.1° ± 1.5° (-1.5° - 5.0°) and for anteversion 0.4° ± 2.4° (-5.6° - 5.7°).

The software HipMatch appears to have a good accuracy to calculate cup inclination and abduction with a very good intra- and interobserver reliability. This allows to measure the exact up orientation out of a AP pelvic radiograph with the help of a preoperative CT with correction of the parameters to the individual pelvic orientation. HipMatch is a powerful tool to test the accuracy of CT-based computer-navigated cup placement in a large clinical series.
Tilting of femoral canal in the axial plane - Can it be a factor for surgeon’s consideration during planning a robotic THA?

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Radiographic evaluation after THA usually contains plane AP and translateral projections. Of the various parameters, fitting of a femoral stem is one of the most important one. We sometimes encountered undersized femoral stem in postoperative AP radiograph, even though it was well-fitted during the surgery. This phenomenon was more frequent when we use a straight, tapered stem with relatively round axial geometry. Was it technical pitfalls or just a matter of the viewpoints? To solve this question, we measured the geometry of the femoral canal and canal filling of the stem in Orthodoc system (ISS, USA), which was used in preoperative planning for robotic THA, and compared with that in the postoperative AP radiograph.

From June 2007 to May 2008, thirty ROBODOC (ISS, USA) THAs were performed. The used implant was VerSys Fiber Metal Taper (Zimmer, USA). With the saved data at Orthodoc (preoperative planning) system, we measured the geographic dimension of femoral canal at the axial cut at the mid-point of femoral stem. The measurement was made with the built-in tool in the Orthodoc and digital imaging system using PiView (Infinitt, Korea). We measured the femoral anteversion, tilting angle at the corresponding point, the longest and shortest diameters of the femoral canal and their ratio, and canal filling of the stem in AP and lateral sections in preoperative data. In postoperative radiographs, we measured the canal filling in both projections.

The mean femoral anteversion was 21.1° ± 10.2°. The canal tilting angle (in axial plane) was 39.3° ± 7.9° and they were statistically different. The mean diameters at the corresponding point were 19.3° ± 2.6° and 14.3° ± 1.8°, respectively. The mean ratio of the two diameters were 0.8° ± 0.08°. Canal filling at the AP and lateral dimension in Orthodoc were 88.25° ± 9.8% and 85.7° ± 6.9%. In postoperative X-rays, canal fillings were 85.4° ± 7.3% and 88.0° ± 6.1%. The canal filling at the AP projections were statistically different (p=0.04). In lateral view, it showed some tendency (p=0.06).

This result suggests that the elliptical femoral canal at this particular level tilts (in axial plane) to the same direction but not the degrees with the femoral anteversion. Although the direction of it is not the same, the ratio of the shortest to the longest diameter is relatively constant. It means the round stem cannot match the shape of femoral canal. In other words, the stem can never be completely filled without milling or reaming of the cortical bone. Because of this tilt, relatively round femoral stem can be considered as undersized in plane AP radiograph, although it really fills almost entire femoral canal. This inaccuracy can be exaggerated when an uncontrolled rotation of femoral shaft occurred during taking a radiograph. Therefore, using a plane radiograph alone for postoperative evaluation would not be enough. Postoperative CT may provide appropriate accuracy for evaluating canal filling of the stem.
IMPROVEMENT OF ACCURACY OF IMAGELESS NAVIGATION USING GENERALIZED ESTIMATION MODEL OF SOFT TISSUE THICKNESS IN THR

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Typical navigation system to insert hip implants in the accurate position consists of a 3D position measurement device and a computer. These navigation systems are classified into two categories according to the method of identifying the anterior pelvic plane that works as the reference of the orientation of the acetabulum cup. The preparation process for imageless navigation system is very easy because it uses three anatomical bony markers to define the anterior pelvic plane. When these anatomical bony markers are hard to locate, especially at the pubic symphysis due to the thick soft tissue, the accurate direction of the cup cannot be secured. The aim of this study is to estimate the soft tissue thickness without using the patient’s specific data such as the A-mode ultrasound image or C-arm image.

In our previous study, it was pointed out that the thickness of the hypodermic fat obtained through an ultrasound image could be estimated using the patient’s BMI and the displacement created by a specific force. Considering the probe shape, the soft-tissue thickness estimation formula is expressed as follows:

\[ Y_{\text{estimated, thickness}} = k (b_0 + b_1 \times \text{BMI} + b_2 \times \delta) \]

\( k \): constant for the shape of the probe end

Only two kinds of the probe end shapes (flat-ended probe and spherical-ended probe) were considered, and the change in the \( k \) value corresponding to the radius was calculated using the FE model of the soft tissue for each subject. The finite-element model was constructed as axisymmetric.

The simulation result of the initially assumed variables and the measured result were compared, and the optimization method was used to minimize the error: The RMS difference between the result of the experiment and that of the analysis was taken as the objective function. With the FE analysis for the two kinds of probe shapes with one subject, we determined the shape variable (\( k \)).

From the formula composed by a model with data from 28 people, the average error was 3 mm equivalent to the angle error of less than 1°. Therefore, the use of the method suggested in this study will help to improve the acetabulum cup navigation in THA, when we use only the surface points on the soft tissue. In addition, it seems that the soft-tissue thickness estimation formula suggested in this study may be generally used.
Anterior pelvic plane may mislead cup orientation in a case with sagittal tilting of the pelvis

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Anterior pelvic plane (APP) through the bilateral anterior superior iliac spines (ASIS) and pubic tuberosities is often used as a pelvic reference in measuring orientation of the acetabular cup in total hip arthroplasty. Apophyses such as ASIS is, however, anatomically variable among patients and APP does not always represent the functional pelvic tilt in the sagittal plane in each patient. Therefore, malposition of the cup and recurrent dislocation may occur even though the cup is placed in a safe zone against APP. We analyzed dynamic pelvic tilt angle in the sagittal plane using a motion analysis system after THA and we found a case of recurrent dislocation due to an unusual APP tilt.

A 77-year-old woman underwent primary THA 3 years ago and cup re-implantation was done with the use of a 10-degree elevated liner and the head diameter was increased from 26mm to 28 mm after twice anterior dislocation. However, posterior dislocation occurred 11 times after this. Then second revision was performed with a 36 mm head and cup anteversion was optimized against APP. Further posterior dislocation occurred twice again. To probe the cause of recurrent dislocation, we performed motion analysis using a 6-camera VICON system and the markers were registered to the bone and implant models based on the postoperative CT images. This system visually represents four-dimensional dynamic motions that include the time sequential transitions of components and their posture. In results the cup was placed 6 degrees of the radiographic anteversion against APP, while -13 degrees radiographic retroversion in supine (FPP), because the pelvic flexion angle in supine was 17.6 degrees. Furthermore, when standing, the pelvic flexion angle increased 10 degrees.

Malposition of the acetabular cup in THA is the most common cause of dislocation. To avoid the errors in cup placement, computer navigation systems have been introduced and most of the navigation systems refer APP to measure cup orientation. There are two drawbacks in using APP reference. One is that apophyses such as ASIS are developed variably in each patient with resulting variable APP tilt in the sagittal plane in supine. The other is significant changes in pelvis tilt during various activities of daily living such as standing, walking, and sitting. Therefore, if we make a component positioning based on APP, it can lead to malposition of the cup in a functional position of the pelvis like this case which showed a proper anteversion against APP but retroversion in supine.

In conclusion, we revealed that there exists a case in which APP is not a suitable pelvic reference in determining orientation of the cup.
INTRODUCTION: Malposition of the pelvis at the time of acetabular component insertion can contribute to malpositioning of the acetabular component. This study measures the variation in intraoperative positioning of the pelvis on the operating table during surgery by matching intraoperative radiographs with pre-operative computed tomograms (CT) using 2D-3D matching.

METHODS: This prospective study was comprised of a random sample of 45 patients (n = 45, 26 female, 19 male) who had received a total hip arthroplasty (THA) from a single surgeon from 10/21/2003 to 9/6/2007. No THA candidate was excluded for any reason, including body habitus (mean BMI = 27.7, range 17.5 - 42.3), underlying disease process, age (mean age at surgery = 57, range 27 - 80), sex or side of surgery (21 left THAs, 24 right THAs).

According to our standard clinical treatment protocol, each patient had a pre-operative CT scan for CT-based surgical navigation of the hip arthroplasty and each patient had an intraoperative radiograph taken to assess component positioning. All THAs were performed in the lateral decubitus position on a radiolucent peg-board positioning device. Each patient’s intraoperative pelvic radiograph was taken after acetabular component and trial femoral component insertion with the leg placed in a neutral position on the operating table and with the x-ray plate aligned squarely with the operating table. The orientation of the pelvis on the operating table was calculated by comparing the intraoperative 2D projection to the 3D CT dataset using software that can perform 2D-3D matching (XAlign). This software has been validated previously. By matching the 3D CT dataset to the magnification and orientation of the plain radiograph, the position of the anterior pelvic plane relative to the operating table could be calculated.

RESULTS: The mean pelvic tilt (rotation around the medial-lateral axis) was 6.84 degrees of anterior pelvic tilt (lordosis) with a standard deviation of 7.95 degrees and a range from 27.24 degrees of lordosis to 4.96 degrees of kyphosis. The mean pelvic obliquity (rotation around the longitudinal axis) was 2.89 degrees anterior from neutral with a standard deviation of 9.44 degrees and a range from 29.36 anterior to 16.59 posterior from neutral. The mean pelvic rotation (rotation around the anterior-posterior axis) was 2.56 degrees cephalad, with a standard deviation of 4.10 degrees and a range from 10.88 degrees cephalad to 5.97 degrees caudad. Pearson correlation statistics showed no relation among pelvic position and body mass index or age. A correlation was seen between pelvic obliquity and pelvic rotation.

CONCLUSION: This study shows a high variability of intraoperative pelvic positioning in the clinical setting using accurate measurement tools. The greatest variation was seen in pelvic obliquity which has the greatest influence on anteversion/retroversion of the acetabular component. Additionally, pelvic obliquity and rotation appear related in our series. Since all of our intraoperative radiographs were taken with the leg in a neutral position, it is likely that the pelvis is even more greatly malpositioned at other times during the surgery when forces applied by retractors or upon the leg may be greater.
Laser guided instrumentation for acetabular cup placement in hip arthroplasty

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Acetabular cup orientation in hip arthroplasty is critical to prevent edge loading and impingement. Aerial alignment guides position the cup at a specified angle to the orthogonal planes, but only if the pelvis is in strict lateral-decubitus. Computer navigation can also be used to position the acetabular cup, but there are limitations associated with defining the pelvic reference plane. It can also be postulated that a fixed angle of inclination and anteversion is not suitable for every patient and every cup design. This paper describes the development and testing of instrumentation that allows patient specific acetabular cup placement without knowing the exact pelvic orientation.

**Stage 1** determines the cup position during a trial reduction. A Judd nail retractor is left in the pelvis during the trial reduction. A single-use laser pointer is attached to the top of this nail, is free to move and can be locked in position. The trial acetabular cup has a handle protruding at a fixed angle from the face of the cup. At the end of this handle is another single-use laser pointer that projects a laser beam parallel to the axis of the cup onto the wall/ceiling. Keeping the handle parallel to the medio-lateral axis to control inclination angle, the leg is moved through a range of motion (ROM). The anteversion of the trial cup is adjusted until a position is found where flexion extension ROM is possible without impingement and satisfactory abduction-adduction! is achieved with stability. Once this position is found, the Judd nail laser (fixed to the pelvis) is adjusted until its projected point, on the wall/ceiling, coincides with that from the trial handle. The Judd nail laser is then fixed in position, the hip dislocated and trial components removed.

**Stage 2** aligns the definitive acetabular cup. The introducer has a laser pointer pointing parallel to its axis (away from the patient) and is attached to the definitive cup. The definitive cup is placed in the acetabulum and the introducer adjusted until its projected laser coincides with that from the Judd nail. The cup is then in the same orientation as determined during the trial reduction and can be impacted. To demonstrate the accuracy of the laser alignment method, the position of the definitive cup was compared to that of the trial cup in polyurethane foam models. With the laser points projected onto an object >2m away, the accuracy was ±2°.

To compare the laser guided instrumentation with the conventional aerial device, the ROM of the definitive cup was assessed in Sawbones resurfaced pelvis/femur models. The pelvis orientation was rotated by ±10° about the medio-lateral axis and the superio-inferior axis to investigate the effect of the pelvis being unknowingly out of lateral-decubitus. In the worst case of pelvis position, the aerial halved the required flexion and allowed double the required extension. The laser guided instrumentation maintained the physiological range of flexion/extension regardless of pelvis position and is therefore considered an improvement on current technology and a viable alternative to computer navigation.
Computer-assisted fluoroscopic navigation system for removal of distal femoral bone cement in revision total hip arthroplasty

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Removal of femoral bone cement is required for preparation of proper implant bed for reimplantation of a new femoral component in revision total hip arthroplasty. Several devices and procedures have been developed for cement removal, including an extracorporal shock-wave lithotripter and YAG laser, as well as a high-powered drill or burr under the control of conventional fluoroscopic images and an intrafemoral endoscopy. Ultrasonic tools are efficient for removal of bone cement with minimal damage to bone. We use a high-powered burr to remove the deep femoral bone cement under the control of conventional fluoroscopic images, although the problem of this procedure is large exposure of X-ray and two dimensional viewing of burr position which can result in perforation in the third plane.

Computer-assisted fluoroscopic navigation system allows the surgeons to provide positional information about surgical instrument to target bones during operations. Two-dimensional image data are obtained using the fluoroscope with a reference frame and stored on a computer workstation. A camera interfaced with the computer then tracks the position of the patient and registered surgical instruments during the procedure. Taking advantage of the real-time guidance of computer-assisted fluoroscopic navigation system, we introduce a valuable technique using computer-assisted fluoroscopic navigation system for performing removal of the cement of the femoral canal in revision cemented total hip arthroplasty.

UNCEMENTED FEMORAL REVISION

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Goals of femoral revision arthroplasty are to achieve stability of the femoral component, to restore biomechanical function of the hip joint and to restore the femoral bone stock. In order to accomplish such an ideal revision arthroplasty, several points should be reminded before and during the revision arthroplasty such as exposure, removal of the failed component, restoration of bone loss, placement of the new component and hip stability. Appropriate options of femoral components for revision depend on the degree of femoral bone loss. When the bone loss is minimum, a standard length component can be used like in primary total hip arthroplasty (THA). When it is moderate or severe, special components and techniques would be necessary.

Loss of bone stock is the most difficult problem in femoral revision surgery. It increases a risk of complications during operation such as fracture or perforation, and also results in difficulty to achieve stability of the component. Even when the bone defect is moderate or severe, immediate fixation of the femoral component should be mainly supported by native bone. Additionally, in the remaining bone loss, bone tissue is grafted as much as possible.

Survival rate of revision arthroplasty is low comparing with that of primary THA. In addition to the present revision, a possible next operation in the future should be considered when we plan revision surgery.

Cemented femoral revision has a disadvantage of removal of the prosthesis when it is failed. Removal of cemented component has a high possibility of complications including perforation and fracture. During revision arthroplasty of a cemented femoral component using a modern cement technique, removal of the cement mantle is difficult, time-consuming and hazardous. The cement mass distal to the tip of the femoral component is the most difficult to be removed since it is often well fixed. The removal procedure has a high risk of causing femoral perforation or fracture. Furthermore, in re-revision, the cement fixation will be often beyond the isthmus and into distal bone defect. And revised cemented femoral components would be more difficult to be removed. On the contrary, loosened uncemented components will be removed relatively easily.

Uncemented femoral stem has the advantage of bone stock restoration. Simultaneous bone graft induces restoration of bone stock. Restored bone tissue will support the component, and this improvement of the bone stock would be beneficial when it is failed again in the future.

According to these principles, we prefer uncemented femoral revisions rather than cemented revisions. This paper will show the clinical results of femoral revisions in our department mainly using an uncemented femoral component.
Abductor Reattachment to Structural Femoral Allograft Utilizing Porous Tantalum in Revision THA

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The complications of infection, mechanical loosening and osteolysis may lead to segmental deficiency of the proximal femur that can be substantial in revision total hip arthroplasty. More problematic is the circumstance where avulsion or detachment of the abductors has occurred without the presence of any residual attached trochanteric bone for host-to-allograft bone-to-bone healing. This report describes the surgical technique as well as radiographic and functional outcomes of two patients who were successfully managed with the use porous tantalum to achieve abductor tendon reattachment to a massive structural graft of the proximal femur. 

Between August and October 2001, two patients requiring revision total hip arthroplasty with segmental deficiency of the proximal femur were treated with the use of a proximal femoral allograft. In each case, a segment of porous tantalum with trapezoidal cross section was fixed to a dovetail joint of complementary geometry cut into the lateral aspect of the greater trochanter with a reciprocating saw. Fixation of the porous tantalum was supplemented with the use of polymethylmethacrylate cement. Residual abductors were mobilized from the surrounding soft tissues to reach the greater trochanter. A short greater trochanteric reattachment device with two 1.7 mm braided steel cables was used to secure and compress the residual abductors against the porous tantalum segment. Post-operatively, both patients were advanced to full weight bearing over a four-month period. Following routine post-op follow-up, both patients were followed annually up to most recent follow-up at six years.

Case 1. The pre-operative Harris Hip Score (HHS) was 42. Three months post-op, as a result of refractory mechanical irritation, she was taken back to surgery for removal of the trochanteric reattachment device. At surgery, the abductors were observed to have adherence to the porous tantalum insert. By follow-up 73 months post surgery, she was found to have an HHS of 90, with no radiographic evidence of prosthetic loosening. The patient experienced no sensation of hip instability and realized resolution of her pre-op recurrent hip dislocations. She ambulated without support and with no limp. Trendelenberg sign was negative. The patient expressed great satisfaction with the clinical outcome.

Case 2. The patient was found to have a pre-operative HHS of 68. By last follow-up at 80 months postop, his HHS was 92. The patient is an unlimited community ambulator without support. Radiographs revealed no evidence of implant loosening. The trochanteric grip and cable were in place with no evidence of cable failure or fraying. Trendelenberg sign was negative. The patient felt very satisfied with his clinical result.

These two case reports demonstrate clinical evidence of abductor reattachment to porous tantalum. This preliminary experience suggests that porous tantalum has the potential to be utilized in such cases of severe proximal femoral bone loss and other complex reconstructions involving abductor deficiency.
THE USE OF ALLOGRAFT-PROSTHESIS COMPOSITE FOR EXTENSIVE PROXIMAL FEMORAL BONE DEFICIENCIES

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Introduction: Extensive bone deficiencies in proximal femur remains a significant challenge in hip surgery. In such a situation, one alternative is to use a proximal femoral allograft-prosthesis composite (APC) to restore the mechanical integrity and bone stock. The current study was performed to analyze the results of APC in the treatment of femoral bone deficiency.

Material and Methods: From January 1996 to June 2006, 12 patients who received 15 APC (3 of them received repeated APC), were followed for an mean of 4.2 years (range 2.0 to 9.8 years) by one surgeon. 5 were males and 7 were females and the mean age of the patients was 60.9 years (range 32 to 84 years). 6 patients were diagnosed with septic loosening, 5 were with aseptic loosening, 4 were with re-revision arthroplasty, and 1 was with limb salvage procedure due to malignancy and all were treated with fresh-frozen allograft. The surgical technique was used to cement the femoral component into the allograft but not into the host bone except 1 case.

Results: The average Harris hip score improved from 21.8, preoperatively, to 83.2, the latest follow-up, and the all stems showed good stability except 3 cases of aseptic loosening. These 3 cases went through a repeated operation with another APC after mean 83.7 months (51,92,108 months) and their results showed good stability. 11 APC had a good junctional union. One case was showed junctional nonunion that needed onlay graft at 3.3 years after APC. There were no infections (or septic loosening), dislocations and allograft fractures (except one great trochanter avulsion fracture, neither clinical symptoms nor went a surgical treatment).

Conclusion: This study demonstrated that the use of APC for extensive proximal femoral bone deficiencies showed a clinically, functionally and radiologically good results, Therefore it is considered as a good options.

The Analysis of well fixed Femoral Components retained during Revision Total Hip Arthroplasty

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There are some unsettled controversies about the need for revision of well fixed femoral stem during the revision total hip arthroplasty. The purpose of this study is to evaluate the state of unretrieved femoral stem, in revision total hip arthroplasty where only acetabular component was revised.

From January 1998 to December 2004, thirty-one patients underwent revision total hip arthroplasty whose well fixed femoral stem was retained anda revision and acetabular components revised. Twenty-six patients(29 hips) with a minimum follow-up of three years were included in this study. Out of those twenty-six patients, sixteen patients (18 hips) were male and ten patients (11 hips ) were female with an average age of 54.3 years for the study group. The average time from the primary operation until the revision surgery was 9.2 years and the average follow-up period after the revision was 5 years.

The femoral head component was exchanged in all cases and same size femoral head component was used in eleven hips. The clinical results were analyzed using Harris Hip Score, and the radiographs were reviewed for stability of acetabular components, femoral stem, and degree of osteolysis and radiolucent lines.

The average Harris Hip Score improved from 56.3 points preoperatively to 89.8 points postoperatively. Femoral stems were found to be stable in all hips. Sixteen hips (55.2%) showed evidence of osteolysis and seven hips (27.6%) showed non-progressive radiolucent lines. The osteolysis was detected at Gruen Zone I and VII in most of the affected hips except for two hips which showed distal osteolysis.

The average life of femoral stem from primary operation until the final follow up varied from 10.8 years to 18.2 years, with the average being 14.2 years.

In conclusion, we recommend that well fixed, stable femoral components can be retained at the time of revision total hip arthroplasty.

Key Words: revision THR, well fixed femoral stem, acetabular revision
**Fate of Femoral Osteolysis in the Unrevised Femoral Component During Isolated Acetabular Revision**

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**Background:** Although several investigators have reported favorable results with a retained femoral component in isolated acetabular revision, it is still unclear whether it is best, when revision surgery is required for replacement of an acetabular component, to treat femoral focal osteolysis with bone-grafting or instead to leave it untreated because the defect is too small and uncontained; the concern is to prevent bone graft from escaping into the hip joint. We hypothesized that progression of osteolysis can halted if the cause of particulate generation is removed and the femoral component is well osseointegrated.

**Methods:** Between August 2000 and December 2004, we performed twenty-eight consecutive revision total hip arthroplasties (in twenty-five patients) with retention of a femoral stem with a proximal focal osteolysis and with revision of a cementless acetabular component for polyethylene liner failure and extensive periacetabular osteolysis. These patients were monitored prospectively and evaluated at a minimum of three years after surgery. Two patients (two hips) died and two patients (two hips) were lost to follow-up monitoring. The remaining twenty-one patients (twenty-four hips) had a mean of 4.3 years (range, 3 to 7.4 years) of clinical and radiographic follow-up.

**Results:** All hips demonstrated focal osteolysis proximal to the lesser trochanter around the femoral stem at the time of the revision. At the time of the latest follow-up examination, all hips were judged to be stable and to have well-fixed acetabular cups and femoral stems. No hips had significant progression of the osteolytic defect through the follow-up period and none demonstrated any new osteolytic lesion.

**Conclusions:** Provided that a femoral component is bone ingrown with osseointegration sufficient to provide long-term stability, that the osteolytic defect is in the proximal aspect of the femur, and that the defect is uncontained, simple curettage is an effective alternative to additional bone-grafting.

**Level of Evidence:** Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

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**Experiential radiological outcomes of femoral revision using cement-within-cement technique**

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**Background:** At the revision surgery of the cemented Total hip arthroplasty (THA), complete removal of an old cement mantle of the femur without loosening is very difficult. It can be associated with complications, such as femoral fracture, perforation and femoral bone loss. Cement-within-cement technique (CWCT) of femoral revision is very useful and advantageous without those complications for special cases.

**Patients and Methods:** We reviewed the experiential radiological outcomes using CWCT for the cemented femoral revision. Between 1999 and 2006, we performed seventeen of revision THA using CWCT in 17 patients. There were four men and 13 women, with an average age of 75 years (range 68 to 87), with an average follow up of 39 months (range 12 to 87). The seasons for revision surgery were eleven for cup loosening, 5 for recurrent dislocation and one technical failure of stem insertion intra-operatively. An original Charnley stem (Depuy, Leeds, England) was implanted in six cases, an Exeter femoral component (Stryker Benoist Girard, Herouville, Saint-Clair, France) was in 10 and another stem in one. Posterolateral approach without trochanteric osteotomy was performing for all patients. After the femoral component was removed, the cement mantle was examined in detail, to confirm cement-bone interface and cement fracture. The cement mantle was washed with a pulsatile lavage to clean and to be dried. If necessary, the surface of the cement mantle was reamed. A double mix of Simplex P cement (Stryker Limerick, Limerick, Ireland) in liquid phase was inserted within the cement mantle by a cement gun with a thin nozzle(Stryker Instruments Kalamazoo, US). Thereafter suction and pressuriser were used, and a femoral component was inserted.

**Results:** The intra-operative complication was two fractures of the greater trochanter at the stem removed and was one shaft perforation at a new original Charnley stem inserted. The stem position was one valgus and 3 varus stem position of more than 2 degrees. Radiographic outcomes showed no stem loosening, no radiolucent line at the bone-cement interface, nor any osteolysis in the patients at final follow-up.

**Conclusion:** Though we have one of femoral perforation using same size of femoral component, we propose that this cement-within-cement technique should be used with the femoral component which is thinner and smaller than the previous.
Clinical and radiographic evaluation of revision hip arthroplasty using the in-cement technique

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Aseptic loosening is the major cause of failure of total hip arthroplasty, and in many cases an acetabular component is loose in the presence of a well-fixed cemented femoral component. The in-cement technique provides an option for revision of a well-fixed cemented stem. The purpose of this study was to review a series of revision hip arthroplasties performed in our institution using the in-cement technique, focusing on radiographic changes of the cement-bone interface.

Forty-four consecutive revision hip arthroplasties were performed using the in-cement technique in our hospital. All the patients were followed up over two years and reviewed retrospectively. Previous operations were 40 THA and 4 bipolar arthroplasty, and the reasons for revision surgery were socket loosening (40) and bipolar cup migration (4). The mean follow-up period was 5.1 years (2-10.1 years). The average operation time, including both acetabular and femoral revision procedures, was 210 minutes and the average blood loss during surgery was 661 g. Radiolucency around the stem was evaluated in the zones described by Gruen et al. Radiographic loosening was assessed according to the criteria of Harris et al. Hip function was evaluated using the Japanese orthopaedic association (JOA) score. Kaplan-Meier analysis was performed to evaluate the time to the appearance of a radiolucent line over 1 mm.

Perioperative complications included proximal femoral crack in two cases (4.5%), crack or fracture of the greater trochanter in 7 cases (15.9%), and perforation of the distal femur in one case (2.3%). Five cases required circular wiring and all required no further augmentation. Early postoperative complications included dislocation in three hips (6.8%), which required closed reduction, and one recurrent dislocation that became stable in a year. There were no cases with periprosthetic infection or deep venous thrombosis. The average JOA score improved from 55.5 preoperatively to 78.8 at 1 year postoperatively, 80.4 at 2 years postoperatively, and 77.8 at final follow-up. Radiological analysis at final follow-up indicated no definite, probable or possible loosening of the femoral stem, except for one case with possible loosening radiologically that required further stem revision due to periprosthetic fracture. The patient in this case was a 56-year old woman who required a second revision 7 years after the initial revision surgery. Other than this case, there was no radiolucent line or osteolysis beyond zone 1 or 7 at final follow-up. Kaplan-Meier analysis using appearance of a radiolucent line over 1 mm in any area as the endpoint indicated rates of 71.5% at 5 years and 53.5% at 10 years.

To revise a well-fixed, cemented femoral component, complete removal of cement is often considered to avoid future femoral problems arising from older cement. However, removal of a distal cement mantle with an intact bone-cement interface is time-consuming and vulnerable to intraoperative complications such as femoral fractures and perforation. Our results suggest that the in-cement technique is appropriate for revision surgery in selected cases because it can minimize significant femoral complications, operation time and blood loss, and can be performed safely.
Femoral component revision with use of impaction bone grafting

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Revision of the femur component in total hip arthroplasty using impaction bone grafting (IBG) was performed in 140 hips of 136 patients in our hospital. The mean age of the patients at the time of the femoral component revision was 72 years. The median of follow-up time was 80 months. 140 hips were operated with use of YU stem (Yamagata university stem, collared, not polished) 104, Exeter stem 2, CPT 2, Restraction 5, and others 27.

The length of the stem was a regular stem114, a long stem26. The complications related to the revised hip consist of infection5, dislocation8, DVT9, fracture during operation 11. Four stems were revised due to infection and two due to loosening.

YU stem is made of titanium alloy with collar, the surface of that stem is not polished and Ra is 0.27 μm. We started to apply IBG in 1994, there were no IBG instrument set and system available such as Exeter, CPT in Japan, so we had used YU stem. However, the result with YU stem was preferable and the implant was stable. Thus, we have been using YU stem. In the process, there have been a number of improvements in IBG instrument and system since we started using them. At first, all medullar cavity is filled with grafted bone up to proximal entry with moderate impaction. Along with guide pin, new medullar canal is made by drilling and insert stem tamper into the space to tighten the layer of impaction, then cement fixation of the stem is performed. This method made the operative time short and operative technique easy.

There are several advantages of IBG technique we used. In revision THA, we can revise the stem with the same length of previous one again and exchange also a long stem to a regular length stem. In addition, the system make it possible to re-construct the case of distal medullar canal excessively filled with bone cement below stem, by digging about 2 cm distally without need to remove all the cement. Severe bone atrophy and fragile of femur is also reconstructed by IBG.

Impaction bone grafting technique with modified system has great merit to recover bone stock and to obtain implant stability after femoral reconstruction of revision surgery.

Femoral Revision Hip Arthroplasty with the Use of Impacted Cancellous Allograft and Cement

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Purpose: To evaluate the radiographic mid-to long-term result of femoral revision hip arthroplasty using impacted cancellous allograft combined with cemented, collarless, polished and tapered stem.

Materials and Methods: Among 27 patients with impacted cancellous allograft with a cemented stem, 28 hips from 26 consecutive patients were analyzed retrospectively. The average patient age was 59 years. The follow-up period ranged 36 months to 10 years, 3 months (mean, 76.6 months). Radiographic parameters analyzed in this study included subsidence of the stem in the cement, subsidence of the cement mantle in the femur, bone remodeling of the femur, radiolucency line, and osteolysis.

Results: Radiographic analysis showed very stable stem initially. 27 stems showed minimal subsidence (less than 5mm) and 1 stem showed moderate subsidence (about 8mm) in the cement. But there was no mechanical failure and subsidence at the composit-femur interface. Evidence of cortical and trabecular remodeling were observed in all cases. No radiolucent line or osteolysis were found in the follow-up period. There were 4 proximal femoral cracks and 1 distal femoral splitting during operation.

Conclusion: The result of cemented stem revision with the use of impacted cancellous allograft was good mid-to long-term. And femoral bone stock deficiency may be reconstructed successfully.

Key Words: Revision total hip arthroplasty, Impacted cancellous allograft
Use of hMSCs during hip replacement and hip revision surgery

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Long-term stability of total hip arthroplasty (THA) depends on the integration between osseous tissue and the biomaterial implant. Integrity of the osseous tissue requires the contribution of mesenchymal stem cells and their continuous differentiation into an osteoblastic phenotype.

Some studies, like Wang ML et al., show that chronic exposure to titanium and zirconium oxide wear debris may contribute to decreased bone formation at the bone/implant interface by reducing the population of viable human mesenchymal stem cells (hMSCs) and compromising their differentiation into functional osteoblasts.

On the basis of our good experience in the use of Exeter technique in revision surgery of THA (GIR II-III), 2 years ago we started to utilize bone grafts mixed with growth factors in order to improve grafts incorporation and implant fixation. At the moment we are studying the use of hMSCs during hip revision surgery, employing polyethylene cup to reduce the possible titanium and zirconium oxide debris. hMSCs are obtained with MarrowsStim Concentration Kit (Biomet Biologics Europe) by 60 ml of patient’s bone marrow.

Clinical outcomes and quality of life are evaluated on the basis of Harris Hip Score, Womac score and SF-36 score, while bone graft incorporation features are assessed with post operative computed tomography (CT) examination and further CT controls at 2-4-8 months after surgery.

THR revisions using Delta alumina sleeved heads: a prospective study

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The new technology using femoral heads with sleeves allows conservative procedures for revision hip arthroplasty. The implantation of classical ceramic heads on a previously used femoral taper is not recommended. When there is no loosening of the femoral implant, the use of sleeves is a good solution for using an alumine on alumine couple, specially in young and active patients.

Material and methods: 25 hips in 25 patients were included. In 12 cases the cause of revision was an acetalubar osteolysis with or without loosening in metal on metal cimented THR.
In 13 patients the revision was performed for a loosening and a wear of the PHE cup with osteolysis (4 zyrcon and 9 chrome-cobalt heads).
The mean age was 49 years for the metal on metal revisions (36 to 75) and 54 years for the prosthesis using a polyethylene socket.
Cementless cups were implanted using XLW delta alumina inserts. The 32 mm delta alumina sleeved heads were adjusted on the existing femoral 12-14 tapers. Patients were evaluated preoperatively and followed-up with clinical and radiological examinations.

Results: At 2 years mean follow-up, average Harris Hip Score was significantly improved (97 vs 54, p<0.05). We did not observe ceramic fracture or squeaking. The radiographic results did not demonstrate acetalubar loosening, osteolysis, or femoral abnormalities.
Concerning the metal on metal revisions, the aseptic loosening of the socket was considered with high rates of cobalt and chromium serum levels. Mean delay before revision was 4 years (2 to 11). Unipolar acetalubar revisions were only decided after a careful inspection of the remaining stems to detect any taper alteration or impingement lesions.
Postoperative cobalt and chromium serum levels significantly decreased postoperatively.
Concerning the metal on PHE and the zircon on PHE revisions, the mean delay before revision was 11 years (4 to 21).
At this short follow up, we did not notice any parasitic impingement due to the additional sleeve or any ceramic fracture or squeaking.
The radiographic results did not demonstrate acetalubar loosening, osteolysis, or femoral abnormalities.
Discussion: Failures of metal-on-metal or metal on PHE hip arthroplasties raise new technical problems. Conversion to ceramic on ceramic has been suggested in case of hypersensibility reactions or high rate of serum metal ions, and in case of osteolysis in young population.
This prospective study evaluates a revision strategy using ceramic cups and delta ceramic heads with titanium adapter sleeves when a femoral revision is not required.
Despite the limitation due to short follow-up, this technical option should be considered when wear surfaces exchange is decided.
Custom made Jumbo Socket for reconstruction of Large bone defect in Revision Total Hip Arthroplasty

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Patient and Methods: A seventy-one years old, female, has been treated by hemodialysis from 1977 due to renal failure. In April 19, 1985, she had Charnley Low Friction Arthroplasty for right hip joint. She often felt mild pain on the joint from 2000. Radiograph showed central migration of the socket and huge cystic bone defect of the acetabulum surrounded by thin cortical bone like an egg-shell form. Tear drop (acetabular floor) was diminished due to massive bone destruction or severe Osteolysis. CT showed that the diameter of the cavity was approximately 10 cm. In March 1, 2002, the socket was upside down and moving freely in the cavity. The patient could not weight-bear on right lower extremity but walk without two crutches. However, she suffered femoral neck fracture in June 26, 2006. Left hemiarthroplasty of the hip joint was done. Because of pain and walking disturbance, she underwent revision surgery in May 2008. At the surgery, the cavity was empty except for the socket and fibrous tissue. Impaction grafting by using morselized allograft including porous and solid hydroxyapatite granules (100 g and 40 g) was done after the socket and the tissue were extracted. A custom made all polyethylene socket (73 x 68 mm in diameter) was fixed by polymethylmetacrylate bone cement. Postoperative course was uneventful. She can walk with two crutches.

Discussion: It is often difficult to reconstruct acetabulum with large bone defect in revision total hip arthroplasty. Especially, almost of support rings with hook cannot be applied in the case that the tear drop is destructive and absorbed. Impaction bone grafting is commonly used for reconstruction of bone defect in revision surgery. However, the extremely thick graft is at risk of collapsing lead to implant migration. The socket used in the case was custom made jumbo type to reduce the thickness of impaction grafting. It is one of resolution to use the custom made jumbo socket for the case with large defect of acetabulum in revision total hip Arthroplasty.
IMPACTION BONE GRAFTING FOR ACETABULAR RECONSTRUCTION: AVERAGE 5.5-YEAR RESULTS

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Purpose: Impaction bone grafting is technical demanding option for acetabular reconstruction. Though over ten-year follow-up results from European countries are available in literatures, clinical reports from Asian countries are rare. The purpose of the present study is to assess mid-term clinical and radiographic follow-up results at least three years after acetabular reconstruction with impaction bone grafting technique by single surgeon in Japanese cohort.

Patients and methods: The senior author performed 24 acetabular revisions with impaction bone grafting technique in 24 patients from February 2001 to June 2005. The average age of the patients at the revision was 67.5 years (36-82 years), and 21 patients were female and 3 were male. The average follow-up period was 5 years and 5 months (3-7.3 years). The reasons for the operation were aseptic loosening of sockets in 17 hips and migration of bipolar heads in seven. The acetabular bone defects were classified as cavitary in 3 hips and as combined segmental-cavitary in 21 hips according to AAOS classification. Segmental wall defects were contained using metal wire mesh, and ultra high molecular weight polyethylene socket was cemented after morcellised allograft bone was tightly impacted into the contained acetabular cavity. For clinical assessment, Merle d’Aubigné and Postel hip score was assessed. Peri-operative complications were recorded. For radiological assessment, antero-posterior hip radiograph was analyzed pre-operatively, and post-operatively at one month, 6 months and every 6 months thereafter. Clear lines more than 2 mm around the sockets using DeLee and Charnley zone classification, and migration of the sockets were assessed. Hodgikinson’s type 3 (complete demarcation line) and type 4 (migration more than 5 mm or change of the angle more than 5 degrees) were classified as loosening. Kaplan-Meier survival analysis was performed with radiographic loosening and any re-operation (including recommendation for the re-operation) for the sockets as the end point, respectively.

Results: The mean Merle d’Aubigné and Postel hip score improved from 11.5 points before operation to 15.7 points at the final follow-up. Though, intra-operative blow-out fracture of the acetabular floor was detected in 3 hips, re-containment had been achieved by adding metal mesh or bone graft. Clear lines at cement-bone interface were detected at zone 3 in 2 hips. Migration more than 5 mm was detected in 2 hips of type III defect at 2 years and 6 months. Re-revision was recommended for one migrated hip at 3 years and 6 months after the operation, and the other hip was stable with no clinical symptom without progressive migration at the final follow-up of 5 years. The Kaplan-Meier survival analysis, with loosening and re-operation as the end point, predicted a rate of survival of the socket of 91.7% and 95.2% at 5 years, respectively.

Conclusion: Acetabular reconstruction with impaction bone grafting is attractive, but technical demanding procedure. The survival rate of the present series was compatible with the results of previous literatures. However, careful follow-up is essential, especially for the cases with massive bone defect.
THP revision using anterior approach in lateral position: prospective Feasibility Evaluation

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Introduction: Anterior approaches have been suggested for THP revision in order to reduce dislocation rate. However, the exposure is considered to be more strenuous. The goal of the study was to evaluate if anterior approach in lateral position may improve the exposure.

Material and method: From 2005 to 2007, 47 patients underwent THP revision, 34 times on the acetabular side, 2 times on the femoral side and 11 patients had a bipolar revision. The cohort was composed of 32 males and 15 females with a mean age of 65 years and a mean BMI of 23. Patients were positioned on the lateral side and had an antero-lateral approach. During the femoral procedure, the leg was placed in a sterile bag stuck on the lateral side in order to optimize the exposure by positioning the femur in adduction and posterior translation.

Results: Acetabular and femoral exposures were achieved correctly in all the cases allowing to perform all the revisions using this technique and no additional approach was needed in any patient. Antero-posterior femorotomies were performed in 7 patients for stem replacement and cement extraction, without any specific complication. Early post-operative anterior dislocations occurred in 2 patients who underwent monopolar cup revision. Dislocation was explained by an excessive anteversion of the remaining stems. 2 patients had an incomplete transitory sciatic deficiency.

Discussion: The lateral position allowed improving the exposure when using an anterior approach. Using this technique, THP revision seems to be achievable even in complicated cases requiring stem revision and femorotomy. Dislocation rate was low (4%), however a larger cohort is needed to confirm these preliminary results.
INFLUENTIAL FACTORS IN REVISION TOTAL HIP REPLACEMENT WITH ANTIBIOTIC-LOADED CEMENT FOR DEEP INFECTION; 5 TO 27 YEARS FOLLOW-UP STUDY

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Background: Since Sir John Charnley introduced bio-clean air operating techniques such as the "body exhausting" system and a bio-clean air operating theatre to reduce the risk of infection, total hip replacement has become one of the safest and most successful procedures in orthopaedic surgery and has benefited numerous people suffering from arthritis all over the world. However, deep infection is still undoubtedly one of the most serious complications after total hip arthroplasty (THA). It is still controversial whether one or two stage revision should be indicated for deeply infected hip replacement.

Purpose: The aim of this study was to identify the influential factors in one stage revision THA for deep infection with a long-term follow-up.

Methods: One stage revision THA for deep infection was carried out in 273 joints on 262 patients by the senior author between 1974 and 2000. All infected hip replacements were primarily treated with one stage revision THA regardless of microorganisms at the authors’ unit as far as sufficient bone stock for socket fixation was available in the acetabulum. This study included 162 revisions in 154 patients for which a minimum follow-up of five years (range 5 to 28 years; average 12.3 years) had been done. Fifty-two cases (32.1 %) had had discharging sinus by the time of revision surgery for infection.

Results: One hundred and thirty eight (85.2 %) hips were free of infection at the time of the latest follow-up. Twenty cases (12.3 %) had reoperation for recurrent infection. Four hips (2.5 %) maintained their implants with the evidence of infection. Twenty-two cases (13.6 %) showed radiological loosening. Thirteen cases (8.0 %) were revised again for reasons other than infection (12 for aseptic loosening and one for dislocation). Bone stock did not have significant influence on infection control while it did affect mechanical outcome. The cement-bone interface was an affecting factor for not only the mechanical survival of implants but also the cure of infection. Neither discharging sinus nor gram-negative microorganism was considered as a contraindication.

Conclusion: This study presented the longest follow-up with a large number of cases in revision THA for deep infection. The results suggested that shielding medullary space with antibiotic-loaded cement was important for treatment of infected THA.
TWO-STAGE REVISION WITH CEMENT SPACER MOLD FOR INFECTED TOTAL HIP ARTHROPLASTY

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Background: Implant-related infection has been one of the serious complications after total hip arthroplasty (THA). It forces physical and mental stress to the patients. We have routinely applied two-stage revision for infected replaced hip joint. Before 2002, hand made antibiotic-loaded cement beads technique was used in the first-stage operation. Cement spacer mold technique has been used for the purpose since 2002. This study focused on analysis of perioperative status and functional outcome of the patients underwent the revision procedure.

Materials and Methods: Nine joints of the eight patients who received THA were included in the study. One patient suffered from infection in both hips. Seven was female and one was male and its average age was 64 years (55-81 years). After removal of implant, antibiotic-loaded cement spacer prosthesis, made by the cement spacer mold (Biomet, Warsaw, USA), was inserted. The spacers were fixed on acetabulum in seven cases to maintain leg length and to prevent dislocation of femoral cement spacer. The change of leg length, range of motion, walking ability and complications after first-stage operation were evaluated before second stage operations. The study protocol was approved by the institutional review board (IRB).

Results: The change of leg length after first stage operation was maintained within 20 mm (ranging from -18 mm to +13 mm). Average range of hip flexion was 70° (40-90°). Patients were permitted to walk with crutches after first-stage operation. Complications after first stage operation were found in two cases; fracture of femoral cement spacer prosthesis and dislocation of the spacer after cement spacer fracture on acetabulum. Average interval between first-stage operation and second-stage operation was 14 weeks (12-22 weeks). There was no case who had a recurrence of infection after second-stage operation.

Discussion: The efficacy of antibiotic-loaded cement to infection after total hip arthroplasty were reported in the 1970’s. The utility of the antibiotic-loaded cement spacer prosthesis was reported in the latter 1980’s. This method made it easy to keep the leg length, the range of motion and working ability. Cement spacer was also fixed on acetabulum to keep leg length and joint stability when there are much bone loss such as a case of infection after revision total hip arthroplasty. There were seven cases that cement spacer was fixed on acetabulum. The spacer was shaped roundly and smoothly using the cup gauge. It seems important not to apply the cup gauge excessively during surgery to make thick spacer. The change of leg length and the instability of the joint was minimal. In addition, favorable joint function was maintained except two case that cement spacer was failed.

Conclusion: Clinical assessment of two-stage revision for infected replaced hip joint with cement spacer mold showed satisfactory short-term outcome with favorable functional outcomes and a few complications. However there seems still concerns how to improve patient’s quality of life during the waiting period for second-stage operation after the spacer is inserted.
OSA22-03

**Treatment of infected total hip arthroplasty with PROSTALAC articulating Spacer - technical tips and advantages**

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We evaluated the effects on infection control and clinical feasibility of a prosthesis with antibiotic-loaded acrylic cement (PROSTALAC) which was designed for treatment of infected total hip arthroplasty. Thirty patients underwent two-staged exchange arthroplasty using the PROSTALAC for treatment of the infected total hip arthroplasty were analysed from March 1995 to February 2007. For shaping of the stem spacer, cement containing antibiotics were appropriately coated on stem spacer and push and pull movement was carried out within the medullary cavity of proximal femur until cement hardened. Also, for prevent of post surgical dislocation, a specially designed polyethylene liner was used. Postoperatively, antibiotics were administered for at least 6 weeks according to the results of erythrocyte sedimentation rate and C-reactive protein assessment Infection cure rated 83.3% (20 cases) and C-reactive protein normalized in an average of 5.6weeks (2wks-26wks) but ESR showed very variable score. Partial weight bearing with crutch was possible after 2 weeks postoperatively and lower-limb shortening averaged to 1.43 cm (0.5~3) with a mean bending range of 63.6 degrees (40~90). There were neither dislocations nor fractures during patient mobilization and 5 cases, especially in old age showed satisfactory results even without second staged revision. Recurred infection after PROSTALAC insertion occurred in 5 cases (15%). Appropriate techniques of PROSTALAC insertion for stability allows us to adjust the reimplantation timing to the course of infection control.

OSA22-04

**Direct exchange endoprosthetic reconstruction for periprosthetic infection with segmental bone defects**

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**Introduction:** Periprosthetic infection with extensive bone loss is a complex situation. The appropriate management of large bone defects has not been established. Without reconstruction amputation/disarticulation is the likely outcome.

**Aim:** To Analyse preliminary results of direct exchange endoprosthetic reconstruction for periprosthetic infection associated with segmental bone defects.

**Methods:** Study of patients with periprosthetic infection and severe osteolysis treated by direct exchange tumour prostheses between June, 2005 and May, 2008 (4 - Distal femoral & 2 - Total femoral Replacements). Microbiological evidence of infection was confirmed with regular monitoring of radiograph, crp, esr and wcc. Community based antibiotic therapy was provided by infectious disease team based in our institution.

**Results:** The mean age and follow up were 74.2 years and 26.5 months respectively. Mean duration of antibiotics was 6 weeks intravenous (community based) and 3.5 months oral. 1 patient required intervention by plastic surgeons at index procedure. Radiographs at 6, 12 & 24 months showed no changes from immediate post-op. CRP,ESR and WBC count were within normal limits at the end of antibiotic therapy. One patient required prolonged pain relief with poor mobility due to instability in the opposite knee. One patient had infection recurrence. Knee range of movements averaged full extension to 95 degrees. The mean oxford knee scores pre and post operatively were 58 and 39.4 respectively.

**Conclusion:** Salvage endoprosthetic reconstruction has provided effective pain relief, stability and improved mobility in our experience. It has provided an opportunity to avoid amputation. Multidisciplinary support from plastic surgeons and specialist microbiologists is essential.
CABLE TENSION FOR PERIPROSTHETIC FRACTURE OF THE FEMUR

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Introduction: The amount of tension which surgeons apply to a two-side Dall-Miles cable during the fixation of periprosthetic fracture has not been reported. Current study is the first report that reveals the real cable tension data which was intraoperatively measured.

Methods: In vivo data of tightening torque was measured intraoperatively during Dall-Miles cable fixation surgeries for periprosthetic fracture of the femur. And the numerical relationship between torque and cable tension was assessed through mechanical tests. Using the torque vs. cable tension relationship, intraoperatively measured tightening torque was converted into a cable tension.

Intraoperative measurement of tightening torque: In vivo data of the maximal torque which was applied by an experienced surgeon was measured using a torquemeter. Total 11 cases of periprosthetic femoral fractures from 11 patients were participated with their agreement. A two-side Dall-Miles cable tightener (Stryker Co., USA) was used. To measure the torque of Dall-Miles tightener applied by a surgeon, a torquemeter (Torque driver 80FTD2-N-S, TOHNICHI, JAPAN) was connected to the Dall-Miles tightener through a square groove. The groove was machined with 1cm x 1cm x 1cm in dimension on the proximal end of the rotational shaft of the Dall-Miles tightener.

Laboratory measurement of torque and tension: To reveal the relationship between the torque of Dall-Miles cable tensioner and the tension of the cable, mechanical tests were done. A two-side Dall-Miles cable tightener were mounted to INSTRON (INSTRON, Norwood, MA, USA) using a customized fixation jig. One cable of 2 mm in diameter was connected to the upper head of INSTRON, and another to the lower head. A preload was slowly applied to the cables up to 10 N so that the initially loose interaction among a tightener, two cables, and two loading heads of INSTRON became tight. Once the preloading finished, tightening torque and cable tension were simultaneously measured. The tightening torque was increased in increment of 1 N-m; accordingly, at each torque the tension hung to Dall-Miles cable was measured by reading loadcell data of INSTRON.

Results:

Intraoperative tightening torque

Intraoperatively measured maximal torque applied to the Dall-Miles cable tensioner was 5.7 ± 0.5 N-m.

Numerical expression of torque-tension relationship

Based on the data of tightening torque and cable tension measured from mechanical tests, the relationship between the torque (T) and tension (P) of Dall-Miles cable fixation system was numerically expressed. Total range of measured tightening torques and cable tensions was linearized. The linear expression was $T = 106.8 \times P$.

Based on this numerical relationship, the amount of cable tension applied to the cable was calculated as 606.6 ± 58 N.

Discussion: This study revealed that 606.6 ± 58 N of cable tension has been applied when an experienced surgeon does cable fixation of periprosthetic fracture. Authors believe that the torque-tension relationship will provide a key biomechanical clue for biomechanics scientists, and the amount of intraoperative cable tension measured at the time of Dall-Miles cable fixation for periprosthetic fracture will provide an important surgical key reference for the surgeons who use the cable fixation system.
Curative Effect Observation of Sodium Hyaluronate Injection plus Herbal Fumigation in Treating Knee Osteoarthritis

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Abstract
Objective: To observe the clinical effects of sodium hyaluronate injection plus herbal fumigation in the treatment of knee osteoarthritis.

Methods: 58 patients (73 knees) were treated by sodium hyaluronate injection plus herbal fumigation with a treatment course of five weeks and after a follow-up of 6-36 months, average follow-up time was 12.1 month, the curative effect show excellent 39 patients (52 knees), fine 11 patients (15 knees), midst 4 patients (5 knees), bad 1 patient (1 knee), and the total fineness rate was 91.78%.

Conclusion: sodium hyaluronate injection plus herbal fumigation in the treatment of early metaphase knee osteoarthritis, which had a better curative effect, less adverse reaction, and worth to to extend clinical application

Key words Knee Osteoarthritis; Herbal Fumigation; Sodium Hyaluronate Injection; Curative Effect Observation
A New Tourniquet System that Determines Pressures in Synchrony with Systolic Blood Pressure in TKA

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**Objectives:** This study compared the clinical use of a new tourniquet system for total knee arthroplasty (TKA) that can determine the tourniquet pressure in synchrony with the systolic blood pressure (SBP) with a conventional tourniquet, which maintains the initial pressure.

**Materials and Methods:** We prospectively applied an additional pressure of 100 mmHg, based on the SBP recorded before skin incision, to 72 consecutive procedures. A conventional tourniquet was used for the first 36 knees, and the new system for the subsequent 36 knees. After surgery began, the pressure with the new tourniquet was kept at SBP + 100 mmHg throughout surgery. The blood pressure was measured every 2.5 minutes in both groups. All surgeries were performed under general anesthesia with epidural anesthesia by a single surgeon.

**Results:** The average initial tourniquet pressure was 201 mm Hg with the conventional and 207 mm Hg with the new tourniquet. There was no significant difference in the perioperative blood loss (conventional group: 523 ± 282 ml, new group: 521 ± 264 ml, \( p=0.9865 \)) and no postoperative complications in either group. There was oozing blood in the surgical field after a sharp rise (over 40 mmHg) in SBP in six cases with the conventional tourniquet and no cases with the new tourniquet. Thirty-two cases (89%) with the new tourniquet had an intra-operative tourniquet pressure lower than the initial value.

**Discussion:** Since the blood pressure can vary with conditions, and the new system responds to blood pressure changes, it appears to be much practical and reasonable for maintaining a bloodless surgical field than the conventional tourniquets, which maintain the initial pressure between 300 and 350 mmHg in TKA surgeries.
ASSESSMENT OF TKA FROM FLUOROSCOPIC IMAGES

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To obtain correct soft tissue balance during TKA is an important operative technique for successful clinical outcome. The soft tissue balancing has been assessed by the tibiofemoral joint gap in full extension, and at 90°. Since recent advancements in the design of femoral components, tibial articular surface and operative techniques have enabled a prosthetic deep knee flexion, the joint gap measurement in such a condition became necessary. Also it should be noted that the joint gap directly reflects on the clinical outcomes such as range of motion, laxity and instability.

In recent years, many in-vivo kinematic measurement methods were developed, which measure the 3D position and orientation from the 2D X-ray image. Among them a pattern-matching method is representative, which is the method by comparing the contour shape from the X-ray image with a predicted contour to seek the 3D position and orientation.

The objective of this study is to measure the range of motion of knee prostheses from their X-ray fluoroscopic images by using the pattern-matching method.

We analyzed 7 knee prostheses of 7 female patients, age of 59 to 77 years, height of 149.5 to 159 cm, weight of 43 kg to 72 kg. Their knee prostheses were all NRG-PS type (Striker Co., USA) with various sizes. During the fluoroscopy measurement, the patient was lying supine on a bed with her both legs free. First the patients were asked to make flexion-extension with their prosthetic knees by themselves and their fluoroscopic images were recorded for analysis.

Next the following motions were done passively. Starting with 0°, the knee angle was gradually increased and fixed at 30°, 60°, 90° and up to 120° respectively. At each flexion angle, the knee was internally rotated as possible as the maximum limit of the patient capacity and then externally rotated in the same way. Similarly, the knee was made varusly and then valgusly at each flexion angle respectively.

The results of kinematic analyses were arranged by the tibial orientations relative to the femur. The range of flexion-extension angles were from 113.9° (SD=8.3°) to 5.2° (SD=8.2°). At maximum flexion for each patient, the orientation in terms of internal-external rotation and varus-valgus was measured and averaged; they were internally rotated by 6.0° (SD=0.6°) and varusly inclined by 1.2° (SD=1.0°). At full extension (minimum flexion), they were externally rotated by 4.3° (SD=1.9°) and varusly inclined by 0.1° (SD=0.7°) respectively. The maximum value of internal-external rotation range was recorded at 89.4° (SD=2.4°) of knee flexion and they were from 5.4° (SD=1.3°) of internal rotation to 12.9° (SD=6.0) of external rotation. The varus-valgus motion was small, from 1.7° (SD=1.6°) of varus to 0.1° (SD=2.2°) of valgus through the whole range of knee flexion.

Important findings were that the range of varus-valgus was smallest for the prosthesis with the thickest insert, and the knee whose collateral ligaments were loose tended to incline varusly.
A new radiographic view for the precise setting of femoral component in total knee arthroplasty

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Introduction: Recent studies suggested that trans-epicondylar axis (TEA) as the origin of collateral ligament was valuable axis for the parallel cut of the posterior condyle. An alternative landmark of the angle between the TEA and anterior trochlear line of the lateral and medial femoral condyles (trochleo-epicondylar angle) for determining the rotational positioning of the femoral component could be considered. We here report a simple radiographic view with a landmark of the anterior and posterior femoral condyle for determining the rotational alignment of the femoral component in TKA.

Subjects and methods: Our new radiograph presented an axial view of distal femur of a patient. The patient lay in the supine position and flexed the knee about 120 to 130 degrees. An x-ray beam was applied to the knee at the angle of 20 degrees to the ground surface. We measured the external rotational angle between posterior condylar (PC) line and clinical TEA that was condylar twist angle, and the internal rotational angle between the anterior trochlear line (AT line) and clinical TEA. This study involved 122 knees in 82 patients with osteoarthritis of the knee, an average age of 67.3 years. And we compared our measured angle with the angle from 3D reconstructed images with 3-dimensional helical CT system (n=35).

Results: The former angle was $5.7^\circ \pm 3.2^\circ$ and the latter was $-5.6^\circ \pm 2.9^\circ$. There was a variation by individual patients, the condylar twist angle was negative correlation with tibio-femoral angle. The internal rotation angle of the trochlear line and clinical TEA (trochleo-epicondylar angle) was $4.9^\circ \pm 2.1^\circ$. The tibio-femoral angle was positively correlated with the trochlear line angle. The trochlear line angle from 3D-CT was $5.4^\circ \pm 1.9^\circ$. The average of the difference between our view and the 3D-CT was $0.5^\circ \pm 1.0^\circ$, R=0.87 with a Spearman's rank test.

Discussion and conclusion: We improved the simple radiographic view in order to evaluate the TEA and PC line, and also the anterior trochlear line, for assessing the rotational alignment of the distal femur in total knee arthroplasty (TKA). We are able to measure and evaluate both angles and do double-checking the condylar twist angle and trochlear line angle. Our new radiographic technique is easy to measure the condylar twist angle, and the angle between AT line and clinical TEA (trochleo-epicondylar angle), simple and reliable, and may be an alternative method for the assessment of TEA of the femur in TKA as preoperative planning.
INTRODUCTION: The natural synovial joints with very low friction and low wear are likely to operate in the adaptive multimode lubrication mechanism, in which various lubrication modes become effective in various daily activities. On the contrary, in the artificial joints composed of ultra-high molecular weight polyethylene (UHMWPE) and metallic or ceramic components, it is difficult to expect the sufficient fluid film formation to prevent the direct contact between rubbing surfaces, and thus considerable wear of UHMWPE occurs. To improve the longevity of joint prostheses by reduction of wear and friction, it is effective to improve the lubrication mode to fluid film lubrication by the application of compliant materials (1). In this paper, the effectiveness of the compliant artificial cartilage of poly(vinyl alcohol) (PVA) hydrogel of high water content and the existence of the optimum adsorbed films were examined.

MATERIALS AND METHODS: The reciprocating friction apparatus was used to investigate the influence of the lubricants containing proteins on the wear properties. The sliding surfaces are composed of PVA hydrogel and itself or a glass plate. PVA hydrogel was prepared by repeated freezing thawing method. The elastic modulus of PVA hydrogel is 1.2 MPa and equivalent water content is 79%. PVA hydrogel stationary upper specimen have elliptical geometry with diameters of 25mm and 40mm. Lubricants as sodium hyaluronate (HA) or saline solutions with or without serum protein were used. For distinction between albumin and $\gamma$-globulin in fluorescent observation for adsorbed film formed on glass plate after tests, albumin and $\gamma$-globulin were labeled with Rhodamine-B-isothiocyanate and Fluorescein isothiocyanate isomer I, respectively. Next, to conduct in situ observation of adsorbed film formation, the reciprocating apparatus was constructed on the stage in inverted fluorescent microscope. A sliding pair of a spherical reciprocating upper specimen of PVA hydrogel and flat stationary lower specimen of cover glass was used.

RESULTS AND DISCUSSION: It is noticed in solutions of single protein that an increase in protein concentration increased wear grade. In contrast, in binary protein solution the minimum wear is found at optimum composition such as total content of 2.1wt% and A/G ratio of 1/2 or 2/1 (A:albumin, G:$\gamma$-globulin). The fluorescence images of adsorbed film on rubbed glass plate showed that the adsorbed films formed a layered structure composed of albumin and $\gamma$-globulin. On the contrary, in high wear case for higher protein concentration, the adsorbed film was formed as a heterogeneous separated structure. Furthermore, in situ observation of lubricated conjunction clearly indicated that the formation of layered films or heterogeneous films corresponded to lubricant constituents.

In this study, it was shown that the layered adsorbed film formation originated from the optimum composition of proteins in lubricants is effective to maintain low wear and low friction for PVA hydrogel artificial cartilage.

Early Clinical Success of Novel Tactile Guided UKA Technique

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Introduction: While novel surgical technologies offer potential for improved outcomes, the new techniques they require create concerns regarding the acquisition of new skills and clinical outcomes during the initial period of relative inexperience. The purpose of this study was to compare short-term clinical outcomes of medial unicompartmental knee arthroplasty (UKA) performed with a conventional technique versus a novel tactile-guided robotic technique.

Materials and Methods: 81 medial UKA s were performed by a single surgeon for isolated medial compartment osteoarthritis, 45 with a standard minimally invasive technique using an implant system with which the surgeon had significant prior experience. The other 36 were performed using a new haptic-guided technique with which the surgeon had no prior experience. Knee society scores (KSS) were collected preoperatively and at three, six, and twelve week follow-ups. Marmor ratings were also determined for each follow-up.

Results: There was no significant difference in terms of average KSS, change in KSS, or Marmor rating between the two groups at any of the three follow-ups. At twelve weeks, for example, the average increase in the combined KSS was 83.6 in the conventional group and 79.7 in the haptic-guided group (p = 0.66). Furthermore, there were no significant differences in the measures that comprise these scores, such as range of motion, pain, and use of assist devices (p > 0.05).

Conclusion: Clinical results of an initial series of UKA s using a new haptic-guided surgical technique are comparable to those using established techniques, thus alleviating concerns regarding the acquisition of a new skill set and inferior outcomes at the beginning of the learning curve.

Treatment of Spontaneous Osteonecrosis of the Knee Using Oxford Unicompartmental Knee Arthroplasty

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Introduction: Spontaneous osteonecrosis of the knee (SONK) is a distinct clinical condition occurring in patients without any associated risk factors. There is controversy as to the best method of treatment, and the available literature would suggest that patients with SONK have a worse outcome. We evaluated the clinical and radiographic outcomes of unicompartmental knee arthroplasty using Oxford prosthesis in patients with spontaneous osteonecrosis.

Materials and Methods: Between September 2002 and March 2008, 20 knees (18 patients) with SONK were treated with Oxford unicompartmental knee arthroplasty. There were fifteen women and three men with a mean age of 61.1 years old. The mean follow up was 37 months. The clinical assessment was performed using the American knee society score rating system. The preoperative radiography and MRI were analyzed according to size and stage of the osteonecrotic lesion and the osteoarthritic changes. Postoperatively, new osteonecrotic lesion, loosening of implant, subsidence, arthritic changes of other compartment were recorded.

Results: The mean preoperative knee score and the knee function score were 52.5 and 56.0 points, respectively. The knee score was improved to 89.2 points and the knee function score was also improved to 85.2 at last follow up. There were no implant failures. There was no new necrotic lesion in the lateral compartment, loosening, subsidence and arthritic change.

Conclusion: The Oxford Unicompartmental knee arthroplasty for spontaneous osteonecrosis of the knee provided satisfactory clinical and radiological results in a short to medium term. However, a longer term follow up will be needed.
OSB03-02

MID-TERM RESULTS OF OXFORD MEDIAL UNICOMPARTMENTAL KNEE ARTHROPLASTY

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Purpose: To analyze the clinical and radiographic results of patients treated by Oxford minimally invasive unicompartmental knee arthroplasty.

Materials and Methods: We have operated 166 patients 188 knees of minimally invasive unicompartmental knee arthroplasty (Oxford Uni’y) from January 2002 to December 2005. The mean ages was 65.3 (44-82) years and 16 cases of male and 150 cases of female. The mean follow-up period was 57 (36-77) months. Preoperative diagnosis were osteoarthritis in 166 cases, avascular necrosis of medial femoral condyle in 20 cases and chondrocalcinosis in 2 cases. The clinical results were evaluated using the HSS knee score and the range of motion of knee preoperatively and at the final follow up. At the final follow up, the ability of the patient to assume the squatting and cross-leg position were checked. The tibiofemoral angle was measured preoperatively and postoperatively. Component loosening, radiolucent lines were checked.

Result: The HSS knee score was 67.5 (52-86) preoperatively and 89.9 (59-100) at the final follow up. The mean preoperative flexion contracture was 6.5° (0-20) and 0.81 (0-5) at the final follow up. Active full flexion was possible within postoperative 2 months. The squatting position was possible in 133 patients (80.1%) and the cross-leg position was possible in 152 patients (91.6%). The tibiofemoral angle was improved varus 1.5° to valgus 4.8°. Complication occurred in 14 cases (7.4%). Meniscal bearing dislocation in 8 cases (4.3%). Tibial components loosening in 3 cases (1.6%). Femoral components loosening in 2 cases (1.1%). The average time of meniscal bearing dislocation was 11.3 (3-24) months postoperatively. Six cases returned to the predislocation level of activity with the insertion of thicker bearings and 2 cases required TKR conversion.

Conclusion: Minimally invasive unicompartmental knee arthroplasty (Oxford Uni’y) provides rapid recovery, good pain relief and excellent function quite suitable to Korean life-style. But given the high complicate rate in mid-term results. Oxford Uni’y gives less reliability compared with TKR.

OSB03-03

A KNEE SIMULATOR WEAR STUDY OF MOBILE AND FIXED UNICOMPARTMENTAL KNEE IMPLANTS.

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Introduction: The introduction of mobile bearings for unicompartmental knee implants resulted in heightened interest in this implant design in the field of orthopaedics. This study aims to determine the effect of the mobile and fixed design concepts on the wear progression in unicompartmental knee implants using a knee simulator.

Methods: An unicompartmental knee implant design, which is available in a fixed and mobile version, was tested using a knee simulator. For the wear test, the medial and lateral compartments were implemented in the simulator. To account for the physiologically higher medial load compared to the lateral compartment, a medially-biased load distribution was implemented. The wear test was performed force controlled according to ISO 14243. Wear was measured gravimetrically separately for the medial and lateral compartments. To evaluate implant kinematics, AP-translation and IE-rotation were measured during the simulation.

Results: Gravimetric wear was higher medially than laterally for both designs. The mean wear rate of the medial mobile compartment was found to be 10.70mg/106cycles, whereas a mean wear rate of 6.05mg/106cycles was found for the medial compartment of the fixed design. Lateral wear rates, which were about 50% lower than medial wear rates, were found to be 5.38mg/106cycles in the mobile design and 3.23mg/106cycles in the lateral design. Wear of the mobile design was higher compared to the fixed design, both medially and laterally. Surprisingly the kinematics of both designs were very similar. A low AP-translation of 2.7mm in the mobile and 2.4mm in the fixed design was documented. High IE-rotations of 6.5° and 6.7° for the mobile and the fixed design, respectively, were observed.

Conclusion: In bicondylar bearing knee designs, reduced wear has been reported for mobile polyethylene inlays. This study showed that the wear behaviour of unicompartmental knee implants differs from bicondylar implants and that the introduction of the mobile concept may lead to increased wear.
Does Conversion of a UKA to a TKA Require Medial Augmentation?

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Introduction: Renewed interest in UKA necessitates further investigation into the ramifications of conversion to TKA due to either implant failure or progressive joint disease. The purpose of this study was to compare the depth of tibial resection at UKA and the resulting implications for conversion to TKA using two different UKA techniques and implant designs.

Materials and Methods: A radiographic review of 42 UKA s from a single surgeon was performed. Sixteen cases utilized a standard all-polyethylene tibial onlay UKA marketed as a minimally invasive resurfacing implant. The other 26 employed a novel robotically assisted technique and a tibial inlay implant design. Measurement techniques were developed to determine the depth of medial tibial plateau resection at initial UKA as well as potential tibial cuts and implant components required at conversion.

Results: Average depth of bony medial plateau resection was significantly greater in the standard technique onlay design group (8.5 ± 2.26 mm) compared to the robotically assisted inlay group (4.4 ± 0.93 mm) (p<.0001). At conversion to a standard TKA, the proposed tibial osteotomy would require medial augmentation/revision components in 75% of the onlay group as compared to 4% of the robotically assisted inlay group (p<.0001).

Conclusion: Robotic-assisted UKA using a tibial inlay design appears to be a truly resurfacing procedure with respect to the tibia, resulting in significantly less tibial bone resection at UKA as well as simpler conversion to TKA when compared to conventional onlay techniques.
Progresses and long-term results with the HINTERGRA-ankle prosthesis - analysis of a new anatomical and biomechanical concept in the clinical application

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History and Background: The HINTERGRA® Total Ankle Prosthesis was designed in 2000 by Dr. B. Hintermann (Basel, Switzerland); Dr. G. Dereymaeker (Pellenberg, Belgium); Dr. R. Viladot (Barcelona/Spain); and Dr. P. Diebold (Maxeville, France), and is manufactured by Newdeal SA in Lyon, France.

Design Features: The HINTERGRA® Total Ankle Prosthesis is a non-constrained, three-component system that provides inversion/eversion stability. Axial rotation and normal flexion/extension mobility are provided by a mobile bearing element. Limits of motion are dependent on natural soft-tissue constraints: no mechanical prosthetic motion constraints are imposed for any ankle movement with this device. The HINTERGRA® ankle uses all available bone surface for support. The anatomically shaped, flat tibial and talus components essentially resurface the tibia and talus dome, respectively, and wings hemprosthetically replace degenerate medial and lateral facets (a potential source of pain and impingement). No more than 2 to 3 mm of bone removal on each side of the joint is necessary to insert the tibial and talus components. On the tibial side, most importantly, the bony architecture remains intact, and in particular, the anterior cortex is preserved. Perfect apposition with the hard subchondral bone is achieved by the flat resection of the bone and the flat surface of the component. Primary stability for coronal plane motion is provided by two screws inserted into the anterior shield, in the upper part of oval holes so that the settling process of the component is not hindered by axial loading. On the talus side, additional anterior support is provided by a shield, and pressfit is provided by the slightly curved wings. Two pegs facilitate the insertion of the talar component and provide additional stability, particularly against anterior-posterior translation. Another advantage of this concept is the instrumentation that allows reliable implantation of components.

Technique: The prosthesis is implanted through an anterior approach. In the case of malalignment, ligamentous instability, and concomitant osteoarthrosis of the distal joints, additional surgeries are considered before prosthetic implantation.

Complications: In the beginning, a major concern was the positioning of the talar component, which tended to slide too posteriorly while impacting and press fitting. With the addition of two talar pegs, the current design may resist such translational forces during press fitting. There is evidence that positioning of the talar component too posteriorly may cause pain and limit dorsiflexion of the foot (probably because the posterior aspects of the deltoid ligament are over-tensioned), thereby the intrinsic forces are also increased which may cause unacceptable high shear forces at the bone-implant interface and/or component instability. In all but one of the seven revised talar components (out of the author s first 400 cases), the component was positioned too posteriorly.

There is a potential risk for dislocation of the meniscal component either laterally or medially as long as no appropriate alignment and/or ligament balancing have been achieved during surgery. The author encountered this problem only in two of the first twenty cases; thereafter, no such complications occurred probably because of better understanding alignment and balancing the ankle.

A potential concern in uncemented resurfacing prostheses is the use of screws that may create stress shielding. The HINTERGRA® ankle, however, uses oval holes on the tibial side so that some settling of the component during osteointegration is possible. As screw fixation is located eccentric to the load transfer area, the potential for stress shielding is in addition minimized.

Salvage of Complications: Special revision implants are available for salvage of failed components. On tibial side, components with a thicker plateau may serve to replace loosed bone stock and to get firm bony support more proximally, thereby preserving the original joint line (that means, the ankle ligaments are supposed to be properly used for stabilizing and guidance of the joint). On talar side, components with a flat undersurface allow flat resection of the talus, thus providing a wide area of bone support to the revision component.

Results: Between 05/2000 and 12/2006, 340 primary TAA were performed in 322 patients (females, 165; males, 157, age 57.3 ± 13.4 years). Underlying diagnosis was posttraumatic osteoarthritis in 272 ankles, primary osteoarthritis in 26 ankles and inflammatory arthritis in 42 ankles. All patients were clinically and radiologically assessed after 6.2 (1.1 - 7.5) years, and survivorship analysis was calculated. Revision of a metallic implant or conversion into ankle arthrodesis was taken as the endpoint.
The AOFAS Hindfoot Score improved from 42.1 (14–61) points preoperatively to 78.6 (44–100) points at follow-up. 205 ankles (60.5%) were completely pain free. The average range of motion was clinically 32.2° (range, 15° to 55°), and under fluoroscopy (that is, true ankle motion) 30.4° (range, 7° to 62°). Four ankles were revised to TAA (component loosening, 3; pain, 1), and 2 ankles (component loosening and recurrent misalignment, 1; pain, 1) were revised to ankle arthrodesis. Overall survivorship at 6 years was 98.2%, being 97.9% for the talar component and 98.8% for the tibial component.

Four ankles (1.2%) were successfully revised, and the obtained result at latest follow-up did not differ from those ankles without complications. Whereas, 2 ankles (0.6%) were revised to ankle arthrodesis.

In another series of 37 patients (37 ankles: STAR, 26 ankles; HINTEGRA, 3 ankles; AGILITY, 3 ankles, B chel-Pappas, 2 ankles; MOBILITY, 2 ankles; SALTO, 1 ankle) with failed total ankle arthroplasty, revision arthroplasty was performed with the HINTEGRA® ankle. All but one surgery were successful. At a mean follow-up of 3.6 (1.2-6.4) years, 29 patients (78.4%) were satisfied with the obtained result. The AOFAS Hindfoot Score improved from 39.2 (23–58) points preoperatively to 72.8 (54–95) points. All but on implants were radiographically stable; in one case, the tibial component showed, at one year, still a radiolucency which may be considered as loosening. As the patient is completely pain free, no revision surgery was done.

In another series of 29 patients (30 ankles), a painful ankle fusion was taken down and ankle arthroplasty was performed with the HINTEGRA® ankle. All surgeries were successful. At a mean follow-up of 3.4 (2-7.6) years, 24 patients (80%) were satisfied with the obtained result. The AOFAS Hindfoot Score improved from 34.1 (18-47) points preoperatively to 69.4 (48-90) points. The obtained motion for dorsi-/plantar flexion was clinically 23.5° (10° - 40°) [52.6% of contra lateral ankle], and radiographically (true ankle motion) 24.5° (8°-24°) [54.4% of contra lateral ankle].

The author’s overall experience: more than 750 replacements with the HINTEGRA® ankle in the last 8 years. The learning curve was rather long as some adjustments had to be performed, and there was need of some time to understand ligament balancing in ankle replacement in more detail. However, since then, an extremely high satisfaction rate was obtained, and most patients are doing very well. The revision rate has also turned down to < 2% despite, with increased experience, more complex cases may have been considered for ankle replacement.

**Conclusion:** Obviously, TAA using a current anatomic design of 3-component prosthesis (HINTEGRA) have evolved to a safe procedure with reliable results at mid- to long-term. These encouraging results support our belief that TAA has become a viable alternative to ankle arthrodesis even for younger patients and more difficult conditions, as often the case in posttraumatic osteoarthritis.
THE RESULTS AND FUTURE PROSPECTS OF TOTAL ANKLE ARTHROPLASTY

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Since the first total ankle prostheses were published in 1973, many prostheses were developed and applied clinically in our country as well as U.S.A. However, for generally poor results based on loosening and sinking of prostheses, some surgeons recommended arthrodesis as the treatment of choice for painful osteoarthritis (OA) and rheumatoid arthritis (RA). Because the results improve by development of artificial material and operative method of late years, we want to describe the indication, follow-up results, durability and future prospects of total ankle arthroplasty.

From 1975 to 80, total arthroplasty was done using metal and polyethylene prosthesis on 30 ankles in 28 cases in our clinic. However, loosening and sinking of the prosthesis were significant in some cases. Then, an alumina ceramic total prosthesis was designed in 1980. Between 1980 and 91, 60 ankles in 56 cases with painful arthritis were replaced using the ceramic prosthesis with or without cement. But, the loosening and sinking in cases of 40% over 5 years after arthroplasty were recognized.

Then, we have replaced on 159 ankles in 146 cases using beads-formed alumina ceramic prostheses coated hydroxyapatite from 1991 to 2006. The follow-up periods were ranged from 2 to 16 years, with an average 6.1 years. Revision was performed for 13 cases (arthrodesis, 3; re-replacement by artificial talus, 10) with infection, talar necrosis and severe loosening and sinking. Verall results of new prostheses for OA were excellent in 48, good in 31, fair in 10, and poor in 9. On the other hand, the results for RA were excellent in 14, good in 31, fair in 6, and poor in 6. Finally, satisfactory of results with OA was 88%, and RA was 74%. Results of OA were better than RA. Furthermore, we are trying clinical application of prostheses (33 joints) cultured mesenchymal stem cells from patient s bone marrow. Furthermore, we have re-replaced using ceramic talar whole body for 10 revision cases. These results until present have been good.

It is convinced that total ankle prostheses of three components with mobile-bearing or talar whole body to get good results and range of motion becomes the mainstream in the mark in the future.
CLINICAL OUTCOMES OF TOTAL ANKLE ARTHROPLASTY USING HINTEGRA®: EARLY RESULTS IN 55 ANKLES

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The purpose of this study was to review the total ankle arthroplasties performed in consecutive series of 78 ankles and to determine the short-term results in cases with over 12 months follow-up. Preoperative diagnoses were posttraumatic osteoarthritis in 40 ankles (51.3%), primary osteoarthritis in 32 ankles (41.0%), and systemic arthritis in six ankles (7.7%). HINTEGRA® (Newdeal SA, Lyon, France) total ankle system was used in all cases.

Fifty-five total ankle arthroplasties including four revision cases, followed up for over 12 months (range, 13~49 months) were included in this study. Ankles were divided into three groups according to the coronal plane deformity in preoperative standing ankle AP radiograph; Varus (≥10°; 20 ankles (39.2%)), neutral (<10° valgus or varus; 25 ankles (49%)), and valgus (≥ 10° valgus; 6 ankles (11.8%)). Various additional surgeries were performed simultaneously with the arthroplasty to correct the deformities; deltoid ligament release (25 cases), posterior tibialis tendon lengthening (2 cases), peroneus longus tendon transfer to brevis (5 cases), lateral ankle reconstruction with modified Broström procedure (4 cases), lateral closed-wedge calcaneal osteotomy (3 cases), percutaneous heel cord lengthening (19 cases), and gastrocnemius recession (1 case). In one patient with severe valgus deformity, staged total ankle arthroplasty was conducted after primary triple arthrodesis.

Preoperative and postoperative visual analogue scale (VAS), American Orthopaedic Foot and Ankle Society (AOFAS) score, range of motion (ROM), as well as patient’s satisfaction and willingness to receive the operation again were evaluated. The results were compared among the three groups. Serial radiographs were reviewed for any radiological changes.

AOFAS score has improved from 54.3 ± 11.4 preoperatively to 79.2 ± 11.4 at last follow-up. VAS has decreased from 6.8 ± 1.6 to 3.2 ± 1.6. Mean improvement in ROM was 15.6 ± 16.2 degrees. Forty-eight cases (87.3%) were satisfied with excellent or good results and 49 cases (89.1%) were willing to receive the operation again. No significant differences in the postoperative VAS (p=0.14), AOFAS score (p=0.79), and ROM (p=0.06) were found among the three groups. Heterotopic ossifications were observed in 12 cases (23.5%) and periosteal reactions proximal to medial malleolus occurred in four cases (7.8%).

Perioperative complications include one intraoperative medial malleolus fracture which was successfully managed with two cannulated-screws, and one medial malleolar stress fracture at six weeks after surgery which has healed spontaneously. One case with osteolysis around tibial screws was managed with bone graft. One case with deep fungal infection was converted to arthrodesis after infection control. Four ankles had to be revised including three cases of polyethylene bearing change due to dislocation, and one case of tibial component and bearing change due to loosening.

The short term clinical results of HINTEGRA ankles showed favorable results. No significant differences were observed among different groups of coronal plane deformities when adequate additional surgeries were performed simultaneously. Long term follow-up study is required.
**Perioperative Complications of Hintegra Total Ankle Replacement for the Initial 50 Consecutive Cases**

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**Background:** The purpose of the present study was to report the perioperative complications that occurred among the initial 50 consecutive cases of HINTEGRA total ankle replacement.

**Methods:** This was a retrospective study of 50 cases composed of 30 men and 18 women of average age 57 years. Perioperative complications were used to compare the first 25 cases (Group A) with the subsequent 25 (Group B).

**Results:** Perioperative complications occurred in 15 cases (60%) in Group A but in only five (20%) in Group B. No major wound complications requiring a soft-tissue coverage procedure were encountered. Minor wound complications occurred in three cases in each group, and resolved with skin grafting or topical dressing changes. One deep infection occurred in Group A, which required implant removal and antibiotic impregnated spacer prior to revision TAR. Four patients sustained intraoperative malleolus fractures in Group A, but only one in Group B. Coronal malposition of the tibial component occurred in three cases in Group A and in two in Group B. Sagittally increased slope of the tibial component occurred in two cases in only Group B and sagittal malposition of the talar component occurred in two cases in only Group A. There were 7 instances of anterior translation of the talar component with respect to the tibial component; four in Group A and three in Group B.

**Conclusions:** The results of the present study suggest that TAR has a steep learning curve. Moreover, knowledge of the perioperative complications of TAR may reduce the incidence of potential complications.

**Key Words:** Total Ankle Replacement, Perioperative Complications

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**Complications after Total Ankle Arthroplasty**

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We evaluated the complications and failures after total ankle arthroplasty during 1 year short term follow up. There were 11 cases of Agility™ (DePuy, Warsaw, Indiana, USA) total ankle arthroplasty and 21 cases of HINTEGRA™ (Newdeal SA, Lyon, France) model from May 2003 to September 2005. Follow up averaged at least 1 year. We evaluated the complications and analyzed the cause of the failures.

Total complication was 19 cases. Delayed healing of the wound were 4 cases, medial impingement syndrome were 4 cases, varus malposition were 3 cases, peroneal nerve problem were 3 cases, medial malleolous fracture, lateral malleolous fracture, talus fracture, post-operative deep infection and gouty arthritis pain was each by one case.

Total ankle arthroplasty had more complication rate than other joint arthroplasty, so we need more meticulous preoperative and peri-operative care.
SURGICAL OUTCOME OF TOTAL ANKLE ARTHROPLASTY FOR END-STAGE ARTHRITIS WITH SEVERE VARUS TILT OF TALUS

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Introduction: With the recent advancement, total ankle arthroplasty has been performed more frequently for painful end-stage ankle arthritis. However the indications of total ankle arthroplasty have yet to be determined. There is no clear consensus regarding the use of total ankle arthroplasty in end-stage arthritis with severe varus talar tilt. The present study evaluated the surgical outcome of total ankle arthroplasty performed in the cases with varus talar tilt of more than 20 degrees within the mortise.

Material and Method: Among 33 TAAs that were performed at our institution by single surgeon between August 2006 and February 2008, 4 cases showed varus talar tilt of more than 20 degrees determined by tibio-talar angle on preoperative standing ankle AP radiograph. There were 2 males and females, their ages were 60, 74, 75 and 76 years old. All the patients were not able to walk more than 10 minutes. Preoperative AOFAS ankle/hindfoot scale were rated as 28, 57, 60 and 50. The degree of varus talar tilt for each patient was 23, 25, 29 and 27. In 2 cases only TAA was performed, while a calcaneal osteotomy and peroneus longus transfer to peroneus brevis was added for one case, and a dorsiflexion osteotomy of the first metatarsus for the other case to address combined or remaining deformity and instability.

Result: There was no postoperative surgical complication such as wound problems or surgical infection. The tibio-talar angle measured at sixth month postoperatively was 4, 4, 2 and 3 degree for each patient. Neither instability nor loosening was shown for all the patients. Postoperative AOFAS score improved to 72, 86, 87 and 98 at sixth month after the surgery.

Conclusion: Total ankle arthroplasty could be performed safely in the cases with varus talar tilt of more than 20 degrees within the mortise, of which results were satisfactory. For successful surgery, preoperative and intraoperative evaluation of the deformed ankle should be done, and if necessary additional surgeries should be performed to address combined or remaining deformity and instability.

ANTHROPOMETRIC MEASUREMENTS OF KNEE JOINT IN INDIAN POPULATION: CO-RELATION WITH CURRENT KNEE ARTHROPLASTY SYSTEMS

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Introduction: There is no data concerning morphological dimensions of distal femur, proximal tibia and patella in Indian population. The objective was to analyse the anthropometric data in Indian knees and to co-relate them with existing knee arthroplasty systems.

Methods: MRI scans of 25 patients (15 males & 10 females) who underwent bilateral knee scans for ligamental injuries were collected. Patients with arthritis, bone loss, varus/varus deformity of >15 degrees and those with immature skeleton were excluded. The mean age was 32 yrs (18-53 yrs). Three surgeons independently measured medio-lateral(ML), antero-posterior(AP) dimensions & aspect ratio(AR) of distal femur, proximal tibia and unresected patellar thickness(PT) on three occasions one week apart to account for intra & inter-observer variability. The resultant data of 50 knees was analysed using SPSS v14.0 and compared with five prosthesis knee systems (PFC sigma, NexGen, Scorpion, IB-II & Gender specific knee).

Results: The mean ML & AP for proximal tibia was $73.3 \pm 5.3$ & $47.8 \pm 4.3$ mm. The mean ML & AP (lateral condyle) for distal femur was $74.3 \pm 5.9$ & $65.4 \pm 5.0$ mm. The mean PT was $24.7$ & $21.8$ mm in males & females respectively. The ML & AP showed a statistically significant positive correlation with the height of the person (ML $r=0.55$; AP $r=0.50$ & $p=0.01$). The tibial and femoral AR showed higher ratio for smaller knees & smaller ratio for larger knees i.e. decline in AR for increasing AP dimension. None of the prosthesis designs mimicked this decrease in AR and NexGen prosthesis infact showed an increase in AR. Gender differences in the morphological data were shown by variable tibial AR.

Conclusion: Most of the available TKR prosthesis designs differ from actual knee morphometry of Indian population. These data provides the basis for designing optimal prosthesis for people of Indian/Asian origin in UK and overseas.
GENDER DIFFERENCES IN FEMORAL ANATOMY CAN BE ADDRESSED WITH A COMMON PROSTHESIS

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Femoral component sizing can play a critical role in the clinical outcome and success of a TKR prosthesis. In particular, achieving the correct AP dimension for the femur is important to ensure correct balancing and to maintain flexion/extension spacing and the ML width dictates bone coverage which, if insufficient, can cause complications or affect long-term outcomes.

There has been some discussion in the literature about the optimal femoral component shape and size with reports of differences in anatomy between male and female patients or those of larger or smaller stature. The majority of these publications have been conducted on normal anatomy with un-cut bone, reporting on the epicondylar width of the femur which is difficult to relate back to the dimensions of a prosthesis. Some studies have measured resected bone, however, the prosthesis and instruments used to make the cuts dictate the amount of bone removed anteriorly and posteriorly which, in turn affect the footprint of exposed bone that is measured.

Data was gathered to assess whether a generic prosthesis with a standard AP/ML sizing ratio could be used to cover the range of femoral sizes dictated by a Caucasian population of 26 male and 26 female patients. MRI scans were obtained for these patients, all between 20 and 45 years of age and diagnosed with a meniscal tear. A theoretical size range for a prosthesis was determined from an analysis of literature data and a review of currently available devices. This consisted of 8 femoral sizes ranging from 50 - 74.5 mm in AP dimension with a constant AP/ML ratio of 0.9.

Each MRI scan was viewed in the sagittal plane and the maximum AP dimension was measured. This was sized to the closest available femoral component using the criteria of matching the existing articulating geometry as closely as possible. A virtual distal condyle cut was made on the scan relating to the component size and the ML dimension of the resected bone was taken. The measured ML data was then compared to the implant dimension for each subject and component overhang/underhang was determined.

An appropriate femoral component match was found in all cases with a mean AP dimensional undersize of 1.71 mm across all patients (range: 0.16 - 3.77 mm). The mean ML femoral component overhang was 0.34 mm for the male population, 1.52 mm for the female population and 0.89 mm for all 52 patients. These values were all considered to be well within an acceptable range and not be significant in terms of clinical outcome. No patient was too large for the largest component, however no patient in the population that was assessed matched the smallest of the 8 components.

This simple dimensional assessment has shown that using a prosthesis with a standard AP/ML ratio, it is possible to accommodate a mixed gender population. The data reported here suggests that the anatomical differences between men and women femora is not hugely significant and can be covered with a common implant provided a sufficient size range is used.

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MORPHOLOGICAL DIFFERENCE OF LATERAL AND MEDIAL FEMORAL CONDYLES BETWEEN AMERICAN AND JAPANESE WOMEN, EVALUATED BY MRI IN SAGITTAL PLANE

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Background: It is known that not only the size but also the shape was different between races. We previously compared the distal femur shapes between the American and the Japanese by lateral radiograph and demonstrated the morphological difference in detail. In this study we evaluated the morphologic feature of the lateral and medial condyles separately between the American and the Japanese using MRI in the sagittal plane.

Patients and methods: The subjects were 99 American and 41 Japanese adult women. MRI scan of sagittal section through the distal half of the femur was taken with the slice thickness about 4.0mm. The envelope curve of each condyle was superimposed to be approximated to an ellipse. The length and inclination of two axes of the ellipse were estimated as the parameters of the statistical comparison.

Results: The ratio major axis/minor axis of the lateral condyles in American women was significantly larger than that in Japanese, while the ratio of the medial condyles in American was significantly smaller. The inclination of the major axis to the anatomical axis of the distal femur in the American lateral condyles were significantly more than that in Japanese lateral condyles, while both the American and Japanese medial condyles showed similar inclination.

Discussion: The morphological feature of both the lateral and medial condyles in American women was significantly different from that in Japanese. The ratio major axis/minor axis and inclination of lateral condyle in American women were different from those in Japanese, while only the ratio was different between the American and Japanese medial condyles. Understanding of these morphological differences between American and Japanese women is beneficial in elucidating discrepancies in normal knee kinematics and in tailoring the design and procedure for successful total knee arthroplasty.

INTRODUCTION: The aim of this study was to evaluate passive kinematics of a mobile-bearing, ultracongruent (UC) total knee design compared with a mobile-bearing, posterior stabilised (PS) design intraoperatively using navigation system.

MATERIALS AND METHODS: Thirty-four knees of 24 patients which had undergone total knee arthroplasty with UC prosthesis (E-motion®, Aesculap, Tuttingen, Germany) for primary osteoarthritis and fifteen knees of 14 patients with PS prosthesis (E-motion®) were included in this study. Thirty-one female and seven male patients were included and the mean age was 70.4 years. Patients were followed up for 7.26 months (6 to 12 months). Intraoperative kinematics including valgus/varus rotation, internal/external rotation, and anterior/posterior translation was assessed from 10° to 120° of passive flexion before and after total knee replacement using a surgical navigation system (Orthopilot®, Aesculap). The range of motion (ROM) was measured preoperatively and at the final follow up.

RESULTS: The tibiofemoral alignment in 10° flexion changed from varus 5.85° to valgus 0.38° in UC group and changed from varus 7.45° to valgus 1.08° in PS group (p<0.05), the magnitude of varus rotation during flexion was 0.01° in UC group and 4.08° in PS group (p<0.05). PS knee showed the tendency to slight varus alignment during flexion but UC knee showed the tendency toward varus alignment after flexion. The mean internal rotation during flexion was 10.3° in UC group and 13.2° in PS group (p<0.05). The translation of the femur was 4.99mm posteriorly in UC group and 3.24mm posteriorly in PS group at 120° flexion (p<0.05). The maximum flexion angle at the final follow up was 123° in UC group and 118° in PS group (p<0.05)

CONCLUSIONS: UC total knee design showed less varus rotation during flexion, more valgus pattern in higher flexion angle than PS design, similar internal rotation angle and pattern, and similar posterior translation at 120° flexion with PS design.
IN VIVO KINEMATICS OF AN ACL-SUBSTITUTING KNEE ARTHROPLASTY DURING GAIT AND STAIR ACTIVITIES

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Numerous fluoroscopic studies of total knee arthroplasty (TKA) kinematics have shown that many contemporary TKA designs exhibit abnormal tibiofemoral translations during activities like gait and stair climbing. One reason for these abnormal motions is the absence of the anterior cruciate ligament (ACL) in the vast majority of knees with TKA. The purpose of this study was to analyze knee kinematics during gait and stair activities in patients with a new design of TKA, incorporating a lateral compartment which is fully congruent in extension, but lax in flexion - approximating the function of the anterior cruciate ligament. Our goal was to determine if such ACL-substitution results in more normal weight-bearing kinematics during gait and stair activities.

Twelve ACL-substituting TKAs (AS knees) in 8 patients were observed using fluoroscopy during treadmill gait (1m/s) and stair stepping. Model-image registration was used to determine the 3D knee kinematics. These kinematics were compared with those from knees with posterior cruciate preserving TKA (PCL Group) and ACL-intact medial unicompartmental arthroplasties (UNI Group). AS Group subjects averaged 71 ± 9 years and were 12 ± 6 months post-op. Control groups (PCL Group / UNI Group) subjects averaged 70 ± 6 to 73 ± 8 years and were 72 ± 6/15 ± 6 months post-op.

During gait, the AS knees showed 1.6 ± 0.4mm medial condyle anterior translation from heel strike to the middle of stance phase and 2.6 ± 0.3mm posterior translation during swing phase. A similar pattern was observed in the UNI knees. The lateral condyle translated posteriorly 2.1 ± 0.2mm from heel strike to terminal stance phase, similar to the PCL knees. The center of rotation was predominantly lateral (19% lateral) from heel strike to mid-stance and then moved medially (16% medial) in swing phase. AS knees showed 3.4° ± 2.4° of internal tibial rotation from mid-stance to terminal stance, similar to the UNI knees. During the stair activity, medial/lateral condylar AP translation in the AS Group was 1.6 ± 0.1mm/2.0 ± 0.3mm from extension to flexion, similar to PCL knees. The AS knees showed 5.9° ± 2.4° of internal tibial rotation from 20° to 80° during stair activity, similar to UNI knees.

Substitution of the ACL by a lateral compartment which is conforming in extension may provide more natural stability and function with knee arthroplasty. Medial condylar translations and axial rotations were similar to those observed in ACL-intact medial unicompartmental knees. Gait kinematics were similar to those reported for healthy natural knees [Koo S and Andriacchi TP, J Biomechancs, 2008]. The long-term success of TKA depends not only on kinematic factors, such as those reported here, but also on polyethylene wear and patellar complications. A longer-term clinical study will be required to determine if ACL-substituting TKA represents an overall functional and clinical improvement compared to more traditional designs.
IN VIVO KINEMATICS OF MOBILE-BEARING TOTAL KNEE ARTHROPLASTY INCLUDING POLYETHYLENE INSERT

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Background: Mobile-bearing (MB) total knee prostheses have been developed to achieve lower contact stress and higher conformity than fixed-bearing total knee prostheses. However, little is known about the in vivo kinematics of MB prostheses especially about the motion of polyethylene insert (PE). And the in vivo motion of PE during deep knee bending under weight-bearing conditions has not been clarified. The objective of this study is to clarify the in vivo motion of MB total knee arthroplasty including PE during weight-bearing deep knee bend motion.

Patients and methods: We investigated the in vivo knee kinematics of 9 knees (9 patients) implanted with PFC-Sigma RPF (DePuy). Under fluoroscopic surveillance, each patient did a weight-bearing deep knee bending motion. And motion between each component was analyzed using two- to three-dimensional registration technique, which uses computer-assisted design (CAD) models to reproduce the spatial position of the femoral, tibial components, and PE (implanted with four tantalum beads intra-operatively) from single-view fluoroscopic images. We evaluated the range of motion between the femoral and tibial components, axial rotation between the femoral component and PE, the femoral and tibial component, and AP translation of the nearest point between the femoral and tibial component and between the femoral component and PE.

Results: The mean range of hyper-extension was 2.1° and the mean range of flexion of 121.2°. The femoral component relative to the tibial component demonstrated 13.0° external rotation for 0-120 degrees flexion. The tibial component rotated 12.1° externally relative to the PE and the femoral component minimally rotated relative to the PE within ± 5 degrees. In upright standing position, the femoral component already rotated externally relative to the tibial component in 7.8°, and the PE also rotated on average 8.2° externally on the tibial tray. Typically the femoral component relative to the tibial component exhibited a central pivot pattern external rotation from extension to 80° knee flexion. Subsequently from 80 to 120°, bilateral condyles moved backward. In a similar fashion, the femoral component relative to the PE exhibited a central pivot pattern external rotation from extension to 70° knee flexion and subsequently bicondylar rollback from 70 to 120° knee flexion.

Discussion and conclusion: In this study, we evaluated the in vivo motion of PE during deep knee bend motion under weight-bearing condition. About this total knee prosthesis, the mobile-bearing mechanism which advantages over fixed-bearing prosthesis to reduce contact stress and keep high conformity might work well, and arc of range of motion was maintained. Furthermore, in upright standing position, the femoral component and tibial component already rotated externally relative to the PE in almost equal measure. This indicated that, self-aligning mechanism, another characteristic of the MB prosthesis might also work well.
Comparison of in vivo kinematics during deep knee bending between fixed bearing and mobile bearing posterior stabilized total knee arthroplasty

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Recently mobile-bearing total knee arthroplasty (TKA) has become more popular. However, the advantages of mobile bearing (MB) PS TKA still remain unclear especially from a kinematic point of view. The objective of this study was to investigate the difference and advantage in kinematics of mobile baring PS TKA compared with fixed bearing (FB) PS TKA. Femorotibial nearest positions for 20 subjects (20 knees), 10 knees implanted with NexGen Legacy flex with mobile bearing PS TKA, and 10 knees implanted with NexGen Legacy flex with fixed bearing PS TKA were analyzed using the sagittal plane fluoroscopy images. All the knees were implanted by a single surgeon. All the subjects performed weight bearing deep knee bending motion. The average range of motion between femoral component and tibial component was $122^\circ \pm 10^\circ$ in MB and $119^\circ \pm 18^\circ$ in FB. The axial rotation of the femoral component was $11.8^\circ \pm 6.2^\circ$ in MB and $11.8^\circ \pm 4.9^\circ$ in FB. There was no significant difference both in range of motion and axial rotation between BM and FB. The kinematic pathway pattern was externally rotated due to a lateral pivot pattern in both MB and FB. In four subjects, more than $12^\circ$ axial rotation was observed in knees implanted with FB TKA which allows only $12^\circ$ axial rotation.

The data in this study demonstrates that there was no significant difference in kinematics of weight bearing deep knee bending motion. The advantage of MB is allowance of axial rotation which restricted until $12^\circ$ in FB NexGen Legacy flex PS TKA.
INTRA OPERATIVE TKA KINEMATIC ANALYSIS USING NAVIGATION SYSTEM

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Introduction: It is difficult to measure the knee kinematics after TKA, navigation system can measure the knee kinematics during TKA operation. The purpose of this study is to describe the knee kinematic analysis in TKA using navigation system.

Patients and methods: TKA kinematics were measured in 24 patients (7 men and 17 women) 27 knees (7 rheumatoid arthritides knees and 20 osteoarthritis knees) in this study. Mean age was 72.8 (55-81). The TKA implant was Vanguard PS (Biomet, Warsaw) and navigation system was Vector Vision Knee ver. 1.6 (BrainLab Inc). All patients were operated using navigation system. This system was CT-based navigation system. We cut the bone independently and released medial collateral ligament, joint capsule and other tight structures to equal the joint balance. Femoral component was implanted parallel to clinical epicondylar line.

Kinematic Analysis: We measured the joint gap (mm), coronal alignment (degree), antero-posterior translation (mm) and femoral rotation angle (degree) using navigation workstation just after all prostheses implantation and closure of joint capsule. The patient’s leg was held by operator and moved passively. All joint kinematic data were recorded at every 10 degrees in full range of motion (0 to 130 degrees). The joint gap is the distance between proximal tibial cut surface and that of distal femur (extension range: 0- 40) and posterior femur (flexion range: 50-130). Medial and lateral distances were measured.

Results: In extension range, medial joint gap was 21.7mm at 0 degrees and decreased to 15.2mm with knee flexion. Lateral joint gap was 22.1mm at 0 knee extension, slightly decreased up to 40 degrees. Coronal alignment was 0.47 varus at 0 deg. and increased to 6.64 varus at 40 flexion. In flexion range, medial and lateral joint gap were increased 20.7 to 25.3, 17.2 to 31.2mm. Coronal alignment was c hanged from 4.94 valgus (60 flexion) to 8.94 varus (130 full flexion). Regarding to AP translation, femoral component was once moved 7.4 mm forward in early knee flexion and 15.2mm backward with flexion. Femoral components were rotated internally to 50 degrees flexion and then rotated externally with flexion.

Conclusion: The balance of TKA was still varus alignment after soft tissue release. Femoral components were moved backward and external rotation. Our results demonstrated that femoral rollback movement and medial pivot knee motion were recognized. The limitation of this study was the situation of under anesthesia and no muscle strain were loaded during the measurement of knee kinematics. However navigation system is available not only for the accurate implantation but also the measurement of intra operative knee kinematics.
Purpose of the study: Synthesis and hemi-prosthesis give well known radiological results for acute proximal complex humeral fractures in elderly population. We wanted to expose the radiological outcome of the reverse concept in this indication.

Material and methods: From 1993 to 2007, forty one DELTA III were implanted for thirty two three-part and four-part displacements and nine fracture-dislocations, in 3 males for 38 females, with an average age of seventy five years. The results were estimated with AP and LAMY profile X-rays.

Results: Because of nine deceases and two moving, thirty cases were reviewed with a mean follow-up of 6.5 years, range 1 to 14. The radiographs showed: two 2-mm thick borders on the glenoid at four and eight years with a scapular notch at 11 years and an aseptic loosening of the base plate at 12 years with a broken polar inferior screw. The patient underwent an easy surgical revision because of a fair bone stock. There was no wear of the polyethylene. According to the NEROT classification, seventeen inferior scapular notching were observed. The mean occurrence time of the seven type-1 notches (41%) was 2 years, of the five type-2 notches (30%) was 4 years, of the three type-3 notches (17%) was 5 years and of the two type-4 notches (12%) was six years: the longer the follow-up, the more severe the notch. Fourteen inferior spurs, stable after emergence, were reported with a mean occurrence time of 2.5 years (extremes 1 - 6 years). One joint ossification occurred at 6 months and was stable at 6 year follow-up. The humeral results consisted in four medial (5,6,7 and 10 years) proximal bone looses and two bone-cement interface medial borders on the two thirds of the height of the stem at 5 year follow-up. In these six cases, there was a notch associated. We reported one case of septic humeral loosening at 2 year follow-up.

Conclusion: For acute proximal humeral complex fractures in elderly population, when re-fixation of the tubercles on the classical orthopaedics devices is impossible, the use of a DELTA III prosthesis shows, with a mean follow-up of 6.5 years, worrying images in 70% of the cases. These images are on the glenoid in 70% of the cases, appeared before seven years in 86% and are progressive in 50% of the cases. But, we have only one re-intervention for an aseptic loosening of the base plate at a twelve year evolution. New developments in design and bearing surfaces and a more long term results will probably provide more durable utilization of the reverse concept in this indication.
EFFECT OF REVERSE TOTAL SHOULDER ARTHROPLASTY COMPONENT PLACEMENT ON ABDUCTION EFFICIENCY

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Introduction: Reverse TSA (R-TSA) converts the glenohumeral joint into a ball-and-socket articulation by implanting a metallic glenosphere on the glenoid and a concave polyethylene articulation in the humerus. This design increases the stability of the shoulder and is indicated for the treatment of end-stage shoulder arthropathy with significant rotator cuff deficiency. To minimize the risk of loosening, the glenosphere is often medialized (to keep the center of rotation within glenoid bone). Since bone grafting under the glenosphere is recommended as an alternate method to medialization we studied the effect of glenosphere placement on the biomechanical efficiency of the deltoid.

Methods: A musculoskeletal model of the shoulder was constructed using BodySIM (LifeModeler, Inc, San Clemente, CA). The model simulated active dynamic glenohumeral and scapulothoracic abduction in a shoulder implanted with an R-TSA. Muscle forces and glenohumeral contact forces were computed during shoulder abduction. The following conditions were simulated: 1) R-TSA with the center of rotation unchanged; 2) medialization of center of rotation by 16 mm, 3) medialization reduced to 10 mm with a 6 mm bone graft; and 4) inferior placement of R-TSA by 4 mm to preserve soft-tissue tension and prevent scapular notching.

Results: We validated our model by comparing peak glenohumeral contact forces (85% body weight) with previously reported in vivo measurements (Bergmann, J Biomech 2007). Inferior placement of the glenosphere component increased the mechanical advantage of deltoid muscle at 90° abduction by 25%. Medialization of the glenosphere had little effect on deltoid forces. Reducing the medialization (to 10 mm, by simulating the effect of a bone graft under the glenosphere) also did not change the mechanical advantage relative to full medialization (16mm).

Discussion: One disadvantage of R-TSA is that a center of shoulder rotation outside (lateral) to the glenoid increases the tendency for glenosphere loosening. Unfortunately, medialization of the glenosphere reduces the tension on the deltoid, increases the incidence of prosthetic impingement resulting in scapular notching, and produces a shoulder contour that is cosmetically undesirable. To counter these disadvantages, reduced medialization is proposed by bone grafting under the glenosphere and placing the glenosphere inferiorly. Our model indicates that the major mechanical advantage of the R-TSA is provided by the inferior placement of the glenosphere which increases the moment arm of the deltoid muscle. On the other hand, the extent of glenosphere medialization had an insignificant effect. These results support the use of reduced medialization and bone grafting in the presence of other advantages, such as reduced notching and maintenance of infraspinatus tension and improved shoulder contour.
HEMIARTHROPLASTY WITH LOW PROFILE PROSTHESIS AND BONE BLOCK GRAFT FOR PROXIMAL HUMERUS FRACTURES

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Purpose: To evaluate the outcome of hemiarthroplasty with low profile prosthesis (Aequalis® fracture prosthesis) and bone block graft for the comminuted proximal humerus fractures.

Materials and Methods: Sixteen patients were operated with this technique since July 2004, and 11 patients were followed-up for average 19.9 (12-30) months. There were 6 males and 5 females with the mean age of 67.3 (52-78) years. Ten patients were 4-part fractures, and 1 was 3-part fracture. Surgery was performed after 3.8 (1-8) days after trauma in 9 patients, and after 2 months of 1st operation in 2 patients. Postoperative immobilization was maintained for 6 weeks in neutral position. Pain and satisfaction visual analog scale (VAS), range of motion, and modified UCLA score for hemiarthroplasty were evaluated at every visit. Radiography was also checked for stem position, loosening, and tuberosity union.

Results: Mean pain VAS was 2.7 (0-5), and mean satisfaction VAS was 8.4 (5-10). Mean active forward flexion was 137° (90-170), external rotation at side was 45.5° (25-70), and internal rotation at back was T10 (T7-L1). Modified UCLA score was 19 (12-30) at final visit. Stem was in average 2.6° valgus (center in 4). Head to greater tuberosity distance was below 5mm in 1 patient, 5-10mm in 5, 11-15mm in 3. All stems were stable, and there were no loosening at the final follow-up. All tuberosities were united except one greater tuberosity absorption and one lesser tuberosity absorption.

Conclusion: The outcome of hemiarthroplasty with low profile prosthesis and bone block graft was comparable to other implants for the comminuted proximal humerus fractures. This system had unique advantages for tuberosity union. Further study with more patients and longer follow-up are necessary to clarify the effectiveness of this prosthesis.

Neurologic Complications after Shoulder Arthroplasty

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Introduction: Previous studies report the neurological complication rate for shoulder arthroplasty to be 4.3% to 5.0%. However, these studies were limited to total shoulder arthroplasty (TSA) and did not include hemiarthroplasty (HA) or reverse prosthesis arthroplasty (RPA). Our hypotheses were that the neurological complication incidence after shoulder arthroplasty would vary by type of procedure performed and that the overall incidence would be higher than previously reported in the literature.

Methods: We retrospectively reviewed the charts of 307 consecutive patients who had a total of 349 SA by the same surgeon between June 1995 and August 2007. Only patients with over six months follow up were included. The charts were reviewed for any sensory or motor disturbance postoperatively. Those who had EMG confirmation of nerve injury (NI) were placed into the surgical complication group, with a second group composed of patients with neurological symptoms (NS) who did not require electromyography (Dr Ji or Matt—how many in the NI group did not have EMG?). These two groups were statistically compared to those patients without neurological injury using standard statistics software.

Results: There were 113 HA, 191 TSA and 45 RPA with over 6 month follow up, and there were 10 (10/349; 2.9%) neurological injuries (NI) There was no significant difference in the incidence between the groups (HA: N=3/113, 2.7%; TSA: N=5/191, 2.6%; RPA: N=2/45, 4.4%). There were an additional 34 neurological symptoms (NS) after shoulder arthroplasty, and if included with the NI then the total rate of neurological complaints after shoulder arthroplasty was 12.6% (44/349). If the NI and NS are combined, multivariate analysis showed that there was a statistically significant association between the development of neurological symptoms and revision surgery.

Conclusion: The rate of neurological complications after shoulder arthroplasty was independent of the type of procedure. The incidence of neurological complaints after shoulder arthroplasty is higher than previously reported.
THE POSITION OF FEMORAL COMPONENT TO OBTAIN RECTANGULAR FLEXION GAP IN TOTAL KNEE ARTHROPLASTY

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Introduction: To make rectangular flexion and extension gap is an important goal in total knee arthroplasty (TKA). The purpose of this study was to determine the AP and rotational position of the femora component to obtain rectangular flexion with reference to the anatomical landmarks.

Method: One hundred and twenty seven varus osteoarthritic knees (87 patients) undergoing TKA from June 2004 to March 2006 were included (72 women and 15 men, mean age 74.4 years). All operations were performed with Vanguard PS, Biomet (Warsaw, IN U.S.A.). The position of femoral component was determined using a modified Ranawat block (EquiflexTM Biomet) to obtain the rectangular flexion gap equal to extension gap. This instrument uses the balanced soft tissue sleeve in extension as a guide to create a balanced flexion gap. The flexion gap asymmetry after TKA was evaluated as the angle between the PCL and the tibial cutting line (TCL) by axial radiography of the distal femur. (Tokuhara et. al., JBJS (88-B), 2006). Briefly, axial radiography of the distal femur of flexed knee was obtained with a 1.5kg distraction force in ankle joint. This technique led to clear visualization of the asymmetry of the flexion gap. Femoral component rotation was evaluated using pre- and post-operative axial radiography of the distal femur (Kanekasu et. al., CORR (434), 2005). Condylar twist angle (CTA) is the angle between the CEA and the posterior condylar line (PCL). The rotational position femoral component relative to the PCL was calculated by subtracting post-operative CTA from pre-operative CTA. In addition, the thicknesses of resected bone from the lateral and medial posterior femoral condyles were measured.

Result: The asymmetry of the flexion gap was 1.6 ± 2.4° with slight laxity in the lateral side. The average amount of external rotation of the femoral component relative PCL was on 6.2 ± 2.5° . The thickness of resected bone from the posterior lateral and medial condyles were 4.7 ± 2.1 mm and 8.6 ± 2.1 mm respectively.

Discussion: The results of this study have shown that, for a well-balanced flexion gap, femoral component should be excessively rotated by 3 degrees compared to current recommendation (Parallel to SEA) As for the AP position, the average amount of medial bone resection is equal to the implant thickness (9 mm). This information is useful for the modification of measured resection technique to obtain rectangular flexion gap.

Rotational alignment the tibial component in total knee arthroplasty

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Improper rotation of the femoral and tibial components in total knee arthroplasty may leads to various patellofemoral(PF) complications. As for the femoral component, alignment it to the epicondylar axis of the femur has been a widely used method. The tibial component traditionally has been aligned to the medial 1/3 of the tibial tuberosity. However, there is no consensus concerning how to determine the tibial component rotation. The purpose of the current study is to evaluate the influence rotational alignment of tibial component upon PF joint.

Materials and Methods: We divided the cases to two groups. Group A: 41cases50knees (OA 34cases, RA16cases). The average age was 69.5(35~84). Group B: 30cases30knees (OA 25 cases, RA 5cases).The average age was 72.6(59~86). In group A, the anteroposterior (AP) axis was defined as the line connecting the medial 1/3 of tibial tuberosity and the center of PCL attachment. In group B, the line connecting the medial edge of patellar tendon attachment and the center of PCL attachment was defined as AP axis. We measured the PF alignment on postoperative X-rays. Tangential radiographs were used to measure the amount of patellar tilt (tilting angle: TA), subluxation and patellar lateral shift (LS).

Results: Group A showed that tilting angle 14 ± 4°, lateral shift 0.3 ± 0.1. These values of group B were 12 ± 5°,0.2 ± 0.1, respectively.

Discussion: In rotation of tibial component, Insall reported that the landmark in front of tibia was medial 1/3 tibial tuberosity. Akagi et.al reported that the landmark was midial edge of patellar tendon attachment. This study indicated that the latter had better alignment in patellofemoral joint.
VARIABILITY OF ROTATIONAL POSITION OF THE TIBIA AND POSTOPERATIVE CORONAL ALIGNMENT IN NAVIGATED TKR

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Introduction: The aim of this study was to evaluate the rotational axis of the tibia and the association of its axis to tibial coronal alignment after TKR.

Materials and Methods: TKRs were performed using navigated mobile bearing system (40 knees), conventional mobile bearing (48 knees) and conventional fixed bearing (40 knees) and preoperative and postoperative CT scans were assessed using 3D image reconstruction-analysis program. The tibial AP axis which was defined as the line connecting the middle of the PCL and the medial edge of the patellar tendon attachment was measured relative to the AP axis of distal femur preoperatively and postoperatively, as well as the coronal angle of the tibia and posterior slope. The tibial coronal alignments in navigation, postoperative plain radiograph and CT were compared.

Results: The AP axis of the tibia was in 2.10° internally rotated position relative to the AP axis of the femur preoperatively and 3.54° postoperatively (range, 19.5° internal rotation to 16.8° external rotation). The coronal angle of the tibia was 0.46° varus on plain radiograph, 0.72° varus on CT, 0.37° valgus in navigation (p=0.005). Posterior slope was 2.53° on plain radiograph and 0.67° in navigation (p<0.001). There was no correlation between postoperative rotational position of the tibia relative to the femur and the difference in the tibial coronal angle between navigation data and CT.

Conclusion: The proposed anteroposterior axis of the tibia centered between 0 to 5 degrees internally rotated position relative to the femur but showed wide range of deviation. The rotation angle of the tibial cutting in navigated TKR did not influence on the postoperative measurement discrepancy between navigation and CT.
The Placement of the Tibial Component Affecting the Postoperative Mechanical Axis in Total Knee Arthroplasty

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Purpose: In the anatomical studies for Caucasian, it has been reported that the center of plateau tends to be located central or lateral from the tibial canal axis1,2. However, in the three dimensional analysis of author3, the center of plateau was located on average 4.4 mm medial from the point of tibial canal axis passing through the plateau. The purpose of this study is to examine the placement of the tibial component in relation to the anatomical axis of the tibia in total knee arthroplasties for Korean patients and to identify the effect of this mismatch for postoperative mechanical axis.

Material and method: Measurements were performed on the pre- and post-operative radiographs of 60 osteoarthritic knees with varus deformity replaced between October 2005 and May 2008 using PFC. The mean age was 66.6 years (range, 54 to 79), and the body mass index was 27.0 kg/m² (range, 20.7 to 37.7). The cases with accurate coronal alignment of component were selectively included, in which α angle ranged from 95 to 96° and β angle ranged from 89 to 91°.

Radiological measurements were performed using an orthoreontgenogram. Preoperatively, 30 patients with varus deformity lesser than varus 10° were classified to group A and 30 patients greater than varus 10° were classified to group B. Post-operatively, the distance between the midline of the stem and anatomical axis (medial offset) was measured at the level of tibial resection. These distances were compared between the group A and B. The postoperative mechanical axes were compared between the group A and B.

The intra- and inter-observer reliabilities were assessed. In this study, intraclass correlation coefficient values of all measurements were greater than 0.8.

Result: The mean preoperative mechanical axes were varus 7.4°±2.3° in group A and varus 17.0°±3.9° in group B (p=0.000). The mean medial offsets were 2.6°±2.0mm (range, -3.6 to 5.9) in group A and 4.0°±2.8mm (range, -1.1 to 10.2) in group B (p=0.022). The tibial stems were located medial to anatomical axis in 22 knees (73.3%) of group A and 26 knees (86.7%) of group B. The mean postoperative mechanical axis were varus 1.5°±1.2° (range, varus 3.0 to valgus 0.3°) in group A and varus 2.8°±2.0° (range, varus 5.0 to valgus 1.3°) in group B (p=0.003).

Conclusion: In this study of TKA, the tibial component in relation to anatomical axis tends to be located medial. The varus deformity was sustained in spite of the accurate coronal alignment of the component as the preoperative varus deformity was more severe. This study suggests that the radiographic measurement of postoperative mechanical axis using a line passing the component center has the limitation.

Key words: knee, osteoarthritis, total knee arthroplasty, mechanical axis, anatomical axis, tibial component, location
MODEL ANALYSIS OF LOWER LIMB AT ASCENDING FROM DEEP KNEE FLEXION

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A new type of knee prosthesis capable of making deep knee flexion has been long awaited for Asian and Muslim people. Our research group has developed such a prosthesis and designated it as CFK (Complete Flexion Knee). In order to assess the performance of CFK, we have set up various kinds of simulation/experimental projects, such as a cadaveric study, a mathematical model analysis, a photoelastic analysis and FEM analysis. For carrying out the above-mentioned projects, we faced the most fundamental problem; the information about the muscles’ forces and the forces acting on the joints is limited to that for ambulatory activities but not for squatting or sedentary sitting.

The objective of this study is to introduce the force acting on the knee joint and the lower limbs’ muscle forces at deep knee flexion. A 2D mathematical model was used. The model was composed with three segments: upper leg, lower leg, and foot. The muscle groups incorporated into our model were gluteal muscles, quadriceps including rectus femoris and the vasti, hamstrings, and calf muscles including gastrocnemius and soleus. And thigh-calf contact was assumed to take place at 130° of knee flexion. Three equations were introduced from the moment equilibrium condition about each joint. Since the number of unknowns was six, being surplus to the number of equations, several muscles were grouped into one basing upon the EMG data.

Double leg ascending motions from deep squatting with heel rising were studied for 10 healthy male subjects age of 24±2 years, height of 172±5.8 cm, weight of 66.5±8.7 Kg. The data of ground reaction force and angle of each joint during the motion were collected using a force plate and video recording system respectively. The length of each segment for each subject was directly measured. The mass of each segment and center of gravity was determined by referring to the literature.

The results demonstrated that both the normal force acting on the knee joint and the quadriceps force became maximum when knee flexion angle became 130° (the angle at which the thigh-calf contact diminished), then decreased according as the knees extended. Both of their maximum value were proportional to the subject’s body weight and about seven times larger than that. Therefore it was justified that the joint force and quadriceps force were normalized by dividing them by the body weight. Ascending speeds did not affect the values of joint and quadriceps forces unless the motion was jumping.
EFFECT OF IMPLANT MALALIGNMENT ON FAILURE RISK IN POSTERIOR STABILISED TOTAL KNEE REPLACEMENT

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Recently, it has been reported that the posterior stabilised implant clinically used for the TKR may have a risk of failures caused by pressure and stress concentrated on the tibial post. Malalignment of the implant or variable loading applied to the implant are one of the major causes of the failure in posterior stabilised TKR. The purpose of this study is to biomechanically analyse the effect of implant malalignment on the failure risk of the implant in posterior stabilised TKR by estimating von-Mises stress on the implant.

Finite element models of a knee joint and a posterior stabilised implant were developed from 1mm slices of CT images and 3D CAD software, respectively. The posterior stabilised implant consists of a femoral component, a tibial post, and a tibial tray. The finite element models of TKR for the neutral alignment case as well as the different malalignment cases (3° and 5° of valgus and varus angulations, 2° and 4° of anterior and posterior tilts, and 3° of external rotation) were developed. Then, the von-Mises stress, which is which was chosen as the fracture risk parameter, acting on the implant were analysed by using CAE software. Loading condition at the 40% of one whole gait cycle such as 2000N of compressive load, 25N of anterior-posterior load, and 6.5Nm of torque was applied to the TKR models.

The maximum von-Mises stresses were concentrated on the anterior region of the tibial post regardless of the oblique loadings. In the rotationally additional loading (3° of external rotation), excessive stresses occurred in the anterior medial and posterior lateral areas. The maximum stress was 18.3MPa in neutral position. The maximum stress increased by 10% in anterior tilt 2°, 15% in anterior tilt 4°, 25% in posterior tilt 2°, 54% in posterior tilt 4°, 116% in varus 3°, 262% in varus 5°, 318% in valgus 3°, 389% in valgus 5°, 6% in external rotation 3° compared with that in the neutral position case. In addition, 32.0MPa of maximum stress occurred on the posterior lateral area of the base component in rotationally additional loading.

The results showed that the implant malalignment could accelerate the stress concentration on the anterior region of the tibial post as in the result of clinical study. In the case of additional rotation, high stress concentration on the anterior medial and posterior lateral areas as well as on the tibial base surface could generate wear or fracture of tibial post. From the additional rotation case, we can expect that higher conformity implant will generate higher stress concentrations than lower conformity implant even though we did not compare the effect of conformity ratio on the stress concentration in the tibial polyethylene component. This study showed that careful consideration of the implant malalignment would be necessary to improve the clinical outcome in the posterior stabilised TKR.
PHOTOELASTIC STUDY OF CONTACT STRESS ON THE TIBIAL INSERT OF KNEE PROSTHESIS AT DEEP FLEXION

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One third of the world population have a lifestyle to sit sedentary on a floor. Thus far, the patients who had undergone TKA surgery loose deep flexion of the knee, and various designs of artificial knee joint capable of deep knee flexion have been proposed. Among them, Bi-surface knee prosthesis (Kyocera Inc., Japan) is of special interest because of its unique design with a ball-and-socket joint. Although some patients attained a sedentary sitting with this prosthesis, the X-ray studies revealed that the femoral condyles and tibial insert tended to separate at about 150° of knee flexion, indicating a risk of subluxation when standing up.

Thus we have developed CFK (Complete Flexion Knee, Japan Medical Material Co., Japan) by further improving Bi-surface knee to enable the patient to make knee flexion as much as 180°. Our CFK has a ball-and-socket joint and whose socket part is jutted to form a tibial post. Since the ball and the cam become into a single sphere and the ball-socket and post-cam joints form a spherical bearing, CFK can provide high stability and mobility at the same time.

Besides its kinematic performance, CFK has to be assessed with its strength and durability. Since the durability of an artificial knee joint is attributed to wear of the polyethylene insert, it is essential to focus on determining the stress on it. Although the FEM analyses have been most extensive for stress analysis, whose results greatly depend upon the way how to create the meshes. The stress values introduced from the FEM are the Von Misses stresses; while wear is mainly attributed to the shear stresses. For these reasons, we employed a photoelasticity for determining the magnitude and distributions of stresses on the insert.

The models of Bi-surface, CFK and a conventional posterior stabilizer knee, Scorpio NRG (Stryker Co., USA) were used for the experiments. Epoxy resins (Araldite AER 250, 2400, Ciba Geigy Co., Japan) were selected to fabricate the tibial insert models. Special equipment was used to apply 2 kg force on the model by setting knee flexion angle at 0°, 30°, 60°, 90° and 120° respectively. After that the stressed model was sliced along the antero-posterior direction and photoelastic fringes in each slice were observed. The results demonstrated that while knee angle was smaller than 90°, shear stress on the lateral slice became higher in the order, NRG, CFK, and Bi-surface, indicating NRG has high conformity in the condylar surface. After knee angle became larger than 90°, shear stress on the midposterior slice became higher in the order, CFK, Bi-surface and NRG. We may conclude that CFK has optimal configuration at deep knee flexion not only for kinematic but also load bearing viewpoints.
CONTACT ANALYSIS OF COMPLETE FLEXION KNEE USING 2D AND 3D MATHEMATICAL MODELS

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We have developed a new type of knee prosthesis which is capable to make 180° knee flexion, and have designated it as Complete flexion knee (CFK). Since the kinematics and kinetics of knee prosthesis vary depending not only on its articulating surface shapes but also on the stiffness of soft tissues, its performance should be assessed under various kinds of lower limb activities.

The objective of this study is to perform simulation analysis of various lower limb activities to evaluate the performance of CFK using the 2D and the 3D mathematical models. Kinematic analyses using X-ray picture or stress analyses using FEM are extensive however, kinematic analyses can not introduce stresses and FEM can not introduce kinetics. Mathematical model analyses can introduce vital information about kinematics and kinetics at the same time.

First, we carried out an in-vitro experiment using cadaver knee under the condition of passive knee flexion-extension. After that, we performed a simulation using the same parameter variables as the in-vitro experiment in order to assess the validity of our 2D and 3D models by comparing the results about the joint contact forces and kinematics with those from the experiment.

In the in-vitro experiment, the femoral bone of a cadaver knee was fixed on a jig. In order to secure the tibiofemoral contact, each muscle was pulled with constant force respectively. Then the tibia was carried through from 40° to 140° of knee flexion. The contact forces between the femur and the tibia were measured by a load sensor. During the process, fluoroscopic images were taken, and then 3D positions/orientations of the tibia relative to the femur were introduced from the images using the pattern matching method.

Our 2D and 3D models of total knee arthroplastic joint included the tibio-femoral and patello-femoral compartments, incorporating major muscles, patella tendon and primary ligaments. The patella tendon and primary ligaments were represented with non-linear springs, whose mechanical properties were determined from the literature. In our 2D model, thigh and calf contact was taken into account at deep knee flexion.

Using our 3D model, the simulation was performed up to 100° of knee flexion. After that we had to alternate the model from the 3D to the 2D because the patella stacked into the femoral intercondylar, the thigh-calf contact occurred and the 3D model did not introduce the converged solution.

Over all, both the experimental and simulation results were in good agreement with each other. The results from the simulation showed that the contact points were located unusually anteriorly. The post-cam contact occurred at 44° of knee flexion, indicating that the tibia was strongly pulled to the posterior. As for the contact resultant force, large differences between simulation and experiment were found. This may be because the soft tissues of the cadaver were not intact, while we determined their properties from the literature in the simulation.
FINITE ELEMENT ANALYSIS OF THE BIRMINGHAM KNEE REPLACEMENT DURING DEEP KNEE FLEXION

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Introduction: Recently, high-flexion knee implants have been developed to provide for a large range of motion (ROM > 120°) after total knee arthroplasty (TKA). High-flexion knee implants are more likely subjected to large knee loads than conventional implants since knee joint forces increase with larger flexion angles. Highly conforming knee replacements are designed to minimise polyethylene peak stresses during (deep) knee flexion. The Birmingham Knee Replacement (BKR, Jointmedica, UK) is a newly designed knee replacement which combines a high conformity during the complete ROM with the principles of rotating platform and high-flexion TKA. The main objective of this study was to analyze the mechanical performance of the BKR during its full ROM (0°-155°) and investigate whether its high conformity could be maintained during high-flexion. In addition, the BKR polyethylene loading computed in this study was compared with other mobile bearings.

Materials & methods: TKA performance was analyzed using a three-dimensional dynamic finite element (FE) model of the knee joint. The FE knee model consisted of a distal femur, a proximal tibia and fibula, a quadriceps and patella tendon, a non-resurfaced patella and TKA components. Tibio-femoral and patello-femoral contact were defined in the knee model. Three different posterior stabilised rotating platform TKAs were subsequently incorporated: the high-flexion BKR, the high-flexion PFC Sigma RP-F and the standard PFC Sigma RP (Depuy, J&J, USA). The polyethylene insert was modelled as a non-linear elastic-plastic material in each TKA system. Polyethylene loading parameters as well as the tibio-femoral contact point locations were computed during an entire flexion movement (0°-155°).

Results: In the normal flexion range (flexion ≤ 120°) the three knee implants behaved very similar except for the polyethylene loading at the post. At 120° of flexion, the contact stress at the dish was ±45 MPa for all implants whereas the maximal post-cam contact stress came down to 26.7 MPa for the BKR which was half the amount of contact stress experienced by both PFC Sigma implants. During high-flexion (flexion > 120°), the contact stress difference at the post between the BKR and the PFC Sigma RP-F became smaller and came down to 37.9 MPa and 60.7 MPa, respectively. The total amount of plastic deformation at maximal flexion (155°) was smaller for the BKR (577 mm³) in comparison with the Sigma RP-F (2256 mm³). Femoral rollback was negligible for the BKR in the high-flexion range in comparison with the Sigma RP-F (1.9 mm).

Discussion: A comparison between different geometrical models using finite element techniques is jeopardised by differences in element distribution within the various models. These differences may affect calculated parameters such as peak stress values. However, in this study the models were very similar which would indicate that the differences in stress patterns found are due to design differences rather than model artefacts. The current study therefore indicates that the BKR benefits from its high conformity during the full ROM. Hence, the BKR demonstrated relatively low polyethylene stresses. The quadriceps efficiency during deep knee flexion may be lower in case of the BKR since the femoral rollback was negligible at these flexion angles. Whether this phenomenon is of any clinical relevance is unknown.
Inset Patellar Implants Demonstrate Superior Fixation over Onlay Patellar Implants

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INTRODUCTION: Following Total Knee Arthroplasties, patellofemoral complications have shown to be responsible for approximately 50% of re-operations. Contemporary patellar designs employ both onlay and inset configurations. The latter promotes ease of placement, reduced bone removal and a heralded theoretic advantage of increased strength at the fixation interface. However, to date, no reports have compared the disassociation strengths of these two patellar component modes of fixation. The purpose of this study is to quantify the shear disassociation strength for both onlay and inset patellar fixation techniques.

METHODS: Two sets of synthetic solid foam patellae were prepared using standard milling techniques for symmetrical, three-peg onlay and inset polyethylene cylinders of identical dimension. The use of synthetic bones in mechanical testing was validated in the past. The cylinders were cemented to the synthetic patellae, using standard cementing techniques. The fixation resistance of both groups was measured using an Instron Testing Machine. A compressive joint force simulating chair rise was applied perpendicular to the anterior surface of the patellar component model. A shearing displacement was then applied to the composite until patellar component disassociation.

RESULTS: The mean shear strength of the onlay group was 571 lbf SD 53 lbf, (n=7) and 715 lbf SD 41.8 lbf, (n=6) for the inset group. The inset patellae were 25% (144 lbf) stronger than the onlay patellae, (p=0.0002, two-tailed Student t-test).

DISCUSSION/CONCLUSION: The results of the study demonstrated a significantly higher resistance of inset patellar fixation to shear stress compared to onlay patellar fixation. Although further in vivo studies are indicated, the data suggests that the use of inset patella in total knee replacement may offer stronger fixation and consequently decreasing morbidity associated with patella implant loosening.

PATIENTS PREFER THE RESURFACED PATELLA
- A 5 YEAR MINIMUM FOLLOW-UP OF BILATERAL TOTAL KNEE ARTHROPLASTY

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Orthopaedic surgeons vary in their attitude towards resurfacing of the patella in total knee arthroplasty. Few studies are available to assess outcome and patient preference. We evaluated post-operative anterior knee pain and knee preference in patients with bilateral knee replacements and unilateral patellar resurfacing.
We reviewed 30 patients who had undergone bilateral knee replacement with patellar resurfacing on only one side. Follow-up was from 5 to 12 years and the patients were assessed using the Knee Society rating, an anterior knee pain rating and a satisfaction score. Patients were also asked specifically if they had a preference for either knee.
Assessment was performed without knowing which patella had been resurfaced.
14 patients (47%) favoured the resurfaced knee, 6 (20%) the un-resurfaced knee and 10 (33%) had no particular preference. The overall prevalence of anterior knee pain was 50% in the un-resurfaced cases (6 mild, 6 moderate, 3 severe) and 20% in the resurfaced knees (4 mild, 2 moderate). No significant difference was found between knee scores. Three un-resurfaced patellae have been secondarily resurfaced.
This study shows a significant preference for the resurfaced side (p<0.01), with a higher prevalence of anterior knee pain in non-resurfaced patellae (p<0.05)
The aim of our study was to assess lateral tracking of the patella with differing designs of Total Knee Arthroplasty (TKA) and compare to that of the native patella.

Studies have shown that the normal patella tracks laterally with flexion of the knee joint, this is consistent with the findings of Eckhoff et al. that the femoral sulcus is lateral to the midpoint between the 2 femoral condyles. Patellar pain and instability is a known complication of TKA. To date, several studies have identified the effect of femoral and tibial components on complication after TKA. However, there is very little work on how the design of the implant affects patellar tracking. This study compares lateralization of the patella in two different AP stabilized knee implants.

A modified caliper was used to measure the width and position of the patella relative to the femur at different degrees of knee flexion. The relationship of the patella midpoint to that of the femur was subsequently assessed. Group 1 consisted of 25 native knees. Group 2 consisted of 25 patients with antero-posterior stabilized knee implant with a spherical medial condyle and a deep lateralized patellar groove (MRK, Finsbury Orthopaedics, UK). And Group 3 consisted of 25 patients with traditional cam-and-post posterior cruciate-substituting implant with a symmetrical patellar groove (PFC-Sigma, Depuy, UK). The mean follow-up for the 50 TKAs was 28 months.

Lateral tracking corresponded well in all groups, but the mean lateral displacement of the patella in group 2 correlated more closely to that of group 1. At 90 degrees of flexion, the patella was displaced a mean of 7mm laterally in both groups 1 and 2, but a mean of 4mm in group 3. Two-tailed Mann-Whitney U test (95% confidence interval) showed that the difference in lateral patellar displacement between groups 1 and 3, and that between groups 2 and 3 were statistically significant (p<0.05). However, the patellar displacement between groups 1 and 2 was not statistically different.

Our results indicate that lateral patellar displacement in group 2 is similar to that of native knees (group 1). The effect of the underlying lateralized deep patellar groove of the femoral component in group 2 is more able to mimic that of the native femoral sulcus. This intrinsic implant design accommodates the natural tracking of the patella.
A Novel Method to Solve Disparities Between Radiographic and Navigational Measurements of Limb Alignments in Computer Assisted Total Knee Arthroplasty

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Background: Application of computer assisted navigation (CAN) has been documented to improve the accuracy of limb alignment and implant positioning. However, a recent study reported that a great deal of disparities occurred between the radiographic and navigational measurements calling the basic argument for application of CAN to TKA into question. In the authors’ practice using CAN for TKA, we have observed consistent disparities between the preoperative radiographic assessments and intraoperative navigational assessments of limb alignment in the coronal plane. A large disparity between radiographic and navigational assessments of limb alignment would be presenting a challenging question whether or not the surgeon can rely on the information provided by the CAN system. We developed a novel method to measure the coronal limb alignment and have found that the radiographic measurements with the novel method remarkably reduce the disparities between the radiographic and navigational assessments of the coronal limb alignment. This study was conducted to document the existence of the disparities between the radiographic and navigational assessments of the limb alignment and the value of our novel method to perform preoperative radiographic measurements of limb alignment. Methods: In 107 TKAs performed using a CAN system (Orthopilot: B.Braun-Aesculap, Tuttlingen, Germany), radiographic assessments of coronal limb alignment were assessed using preoperative and postoperative whole limb radiographs taken with weight bearing with two different methods: a standard method, angle between the femoral mechanical axis (the line connecting hip center and the top pint of the femoral intercondylar notch) and a tibial mechanical axis (the line connecting the mid-point between the medial and lateral tibial eminences and the mid-point of the talus dome) and a novel method, the angle between the weight loading line (the line connecting the hip center and the mid-point of the talus dome) and the tibial mechanical axis. A negative value was given to a varus alignment and a positive value to the valgus alignment. During surgery, the coronal limb alignment was measured by the navigation system two different time-points: after registration and after implantation of prostheses. The disparity between the radiographic and navigational assessments was calculated with subtracting the radiographic assessments by the navigational assessments. Results: The disparity between the radiographic and navigational assessments was calculated with subtracting the radiographic assessments by the navigational assessments. Results: The disparity between the radiographic and navigational assessments was significantly smaller with the novel method than with the standard method. The mean difference between the radiographic and navigational assessments of preoperative limb alignment was -6.5° (range: -19 ~ 1) with the standard method and -0.9° (range: -8° to 4°) with the novel method. The mean difference between the radiographic and navigational assessments of the postoperative limb alignment was -1.96 (range: -11 ~ 3) with the standard method and -1.3 (range: -6 ~3). Conclusion: This study documents that a wide range of disparities occurs between the radiographic and navigational assessments of limb alignment and the amount of disparity occurs in preoperative assessments. Our findings indicate that our novel method to perform the radiographic assessments of limb alignment can be a useful tool to interpret the information intraoperatively given by the navigation system.
**The Reliability of Navigation-Guided Soft tissue Balancing in Total Knee Arthroplasty**

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The Orthopilot TKA navigation system offers soft wear for optimizing soft tissue balance using gap technique. However, there has been no study about reliability of navigation-guided gap technique. The goal of the present study was to establish the reliability of navigation-guided gap technique. The authors measured flexion and extension gap in medial and lateral side of the knee joint after bone resection to evaluate the reliability of navigation-guided soft tissue balancing. Gap data of 100 cases of navigation-guided total knee arthroplasty were analyzed. We defined trapezoidal gap (unsatisfactory soft tissue balancing) as a gap difference greater than 3 mm between medial and lateral side in extension, and 5 mm difference in 90 degree flexion. And gap difference between flexion and extension gap greater than 3 mm in the medial side, and 5 mm in the lateral side was also considered as a trapezoidal gap. Among 100 cases, 84 cases (84%) showed rectangular (acceptable) gap, but 16 cases (16%) were trapezoidal gap. We also evaluated the correlation between clinical results including range of motion and soft tissue balance as well as affecting factors for trapezoidal gap. This study suggests that navigation-guided gap technique is a reliable method for optimizing soft tissue balance.

**IN VIVO STABILITY OF TOTAL KNEE ARTHROPLASTY USING A NAVIGATION SYSTEM**

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We hypothesized that navigation can help provide a well-balanced knee, through real-time feedback of alignment accuracies and gap sizes in flexion and extension. The purpose of this study was to evaluate in vivo stabilities of mediolateral laxity in full extension and anteroposterior laxities in 90° of flexion after navigation-assisted total knee arthroplasty, and to determine the nature of the correlations between these and range of motion (ROM). Forty-two total knee arthroplasties performed using a navigation system with a minimum two-year follow-up were included. The following were measured at final follow-ups: mediolateral laxities at extension and anteroposterior laxities at 90 degrees of flexion (using stress radiographs and a Telos arthrometer), modified HSS scores (excluding laxity and range of motion), and range of motion (ROM).

At final follow-up the mean modified HSS score was 82% of total points and mean postoperative ROM was 128.1 ± 10.4°. Mean medial laxity was 3.5 ± 1.4 mm, mean lateral laxity 4.4 ± 2.2 mm, and mean anteroposterior laxity 7.1 ± 4.1 mm. We found no significant correlation between mediolateral laxity and postoperative ROM. However, a significant correlation was found between postoperative ROM and anteroposterior laxity. In the present study, the use of a navigation system in total knee arthroplasty was found to improve in vivo stability and produce promising short-term clinical results.

**Summary:** Using a navigation system in total knee arthroplasty, we obtained good *in vivo* stability and found the positive correlation between the range of motion and anteroposterior laxity.
Intermediate Postoperative Outcomes in Computer Assisted Total Knee Arthroplasty: Evaluating 261 Initial Consecutive Cases

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Introduction: Computer assisted surgical techniques in total knee arthroplasty have demonstrated increased accuracy of alignment and decreased risk of outliers. Some studies have also demonstrated improved early functional results and pain scores in comparison to traditional surgical methods. Studies have also shown a slightly increased surgical time for computer assisted surgery. A learning curve for computer assisted surgery is recognized, and there may be different outcomes for cases performed initially during the learning phase. This study reports on a single surgeon's experience with the initial 261 computer assisted total knee arthroplasies.

Methods: A single experienced, fellowship trained surgeon performed computer assisted total knee arthroplasty utilizing either the BrainLab or Ci intraoperative navigation system and either the LCS Complete Mobile Bearing Knee System (DePuy) or Sigma PFC Rotating Platform (DePuy). Preoperative and postoperative data was recorded prospectively (DePuy Captureware) of the initial 261 consecutive cases at minimum of one year follow-up. SAS 9.1 was used to perform univariate and multivariate analyses of four groups of patients: patients 1-77, patients 78-135, patients 136-211 and patients 212-261. Multivariate analyses were performed to control for body mass index, age, sex, implant type, preoperative range of motion, preoperative function and preoperative pain scores.

Results: Multivariate analysis of these four groups demonstrated that there was no statistically significant difference in the improvement of postoperative function (p=0.29) and pain scores (p=0.28) among the patients in the four groups at minimum one year follow-up. There was a statistically significant difference in improvement of postoperative extension (p=0.0022) and flexion (p=0.0139) scores with subsequent surgeries, however the range of improvement for the groups was not clinically significant (extension ranging from 1.97 to 5.92 degrees gained in the four groups, and flexion loss of 0.67 degrees to gain of 6.18 degrees in the four groups). The number of patients requiring a hospitalization greater than two days decreased with each subsequent group which was clinically significant (p=0.021, p=0.001, p<0.0001 for the second, third and fourth groups, respectively).

Summary: For an experienced reconstructive surgeon incorporating computer assisted surgery into his total knee arthroplasty practice, there is no significant learning curve in regards to intermediate term outcomes. Patients undergoing computer assisted total knee arthroplasty have similar intermediate outcomes whether performed earlier in that surgeon's experience or later. Patients did initially have shorter hospitalization stays in subsequent groups. However, at an intermediate follow-up period of one year, there is no significant difference in patients, postoperative improvement in function, pain score, knee flexion and knee extension.

Cost Effectiveness of Computer Navigation in Total Joint Arthroplasty in the Medicare Population

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Computer navigation in total joint arthroplasty has been shown to be effective in improving the radiographic outcome in patients undergoing both hip and knee arthroplasty. However, critics have argued that the required capital equipment and added time to perform the procedure is cost prohibitive. To test this hypothesis, we compared our hospital discharge experience with computer navigation to national standards published by the Agency for Healthcare Research and Quality for the years 2004 and 2005.

In the AHRQ database the average length of stay for DRG 209 in 2004 and 2005 respectively, in the Midwest region was 4.6 days and 4.3 days, with a mean charge of $27,403 and $27,948, with only 40% and 45%, of patients discharged to home with or without home health care. In 2004 and 2005, the senior author performed 125 and 117 Medicare primary hip and knee replacements, respectively, with computer navigation with a mean length of stay of 2.9 days and 2.8 days, with charges of $22,134 and $24,612, and 63% and 71% discharged to home.

On a pure charge basis, the senior author experience a decreased overall charge compared to published data. Even if the entire cost of the navigation system in our system $204,000 was spread equally over only the Medicare patients over the two year period, the additional $842/case still results in a case charge below published data. Based on the senior author's experience with hospitalization cost, length of stay and discharge disposition, computer navigation in total joint replacement is not associated with an increased cost/case and may result in dramatically lower indirect costs due to shorter length of stay and increased number of discharges to home compared to published regional Medicare discharge data.
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Introduction: Computer-assisted TKA improves alignment accuracy; however few articles cite any clinical benefit over conventional TKA. The author’s experience and outcomes with CAS for TKA including ligament balancing with a spring loaded tensioning device is reported.

Methods: This is a retrospective review of prospectively collected data on 1005 TKAs (975 had OA) with 464 cases using Depuy® LCS® Complete™ Rotating Platform and 474 cases using Depuy® P.F.C® Sigma™ Rotating Platform. Seventy-six were conventional TKAs and 929 were CAS TKAs. Average follow up was 17 months. Outcome variables included radiographic alignment, Knee Society Scores, and complications.

Results: Eighty-eight percent of CAS TKAs were placed within three degrees of neutral mechanical axis. Eighty-one percent were placed within three degrees of optimal sagittal tibial component angle. Ninety-two percent were placed within three degrees of optimal coronal tibial component angle.

Mean pain score improved 39.4 points, Knee Score improved 47.8 points, and the functional component improved 17.1 points. The pain score improvement for CAS was 39.2 compared to 33.0 for conventional knees (p<0.002). The Knee Score improvement for CAS was 48.3 compared to 41.4 for conventional knees (p<0.013). The functional component improvement was not significant between CAS and conventional TKA. When CAS is utilized along with the spring loaded tensioning device for ligament balancing, manipulation rates dropped to 7% (p<0.01). There were a total of thirteen infections, three deep infections (0.3%) and ten superficial infections (1%). There were no fractures from the pin sites, and no patients were revised for instability.

Conclusion: Our series showed a statistically significant improvement in pain and Knee Society Scores compared with conventional TKA. In addition, CAS resulted in excellent radiographic alignment and well balanced knees with the spring loaded tensioning device. Furthermore, improved radiographic alignment is likely to increase implant survivorship and provide further cost savings. With continued use of CAS, long term studies may show significant beneficial clinical effects.
Relationship Between Anatomical References and Sagittal Mechanical Axes of Computer Assisted Navigation for Total Knee Arthroplasty

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Background: Whereas the application of computer assisted navigation (CAN) to total knee arthroplasty (TKA) has been documented to improve the coronal alignment of limb and prostheses, varying results have been reported regarding sagittal alignment and even the reference to measure the sagittal alignment has not been universally agreed. Current CAN systems rely on the sagittal mechanical axis calculated from the hip and distal femur centers identified by the system. Two different sagittal mechanical axes are utilized in the current CAN systems, but there is little information of the association between the anatomical (radiographic) landmarks and the sagittal mechanical axes. This study was conducted to determine the relationship between the anatomical landmarks and the two mechanical axes used in CAN-TKA. We also attempted to determine whether the degree of femoral anterior bowing influence the relationships. Methods: In 200 knees of which true lateral radiographs were available, the angles between two anatomical references [anterior cortical line (ACL) and mid-medullary line (MML)] and two sagittal mechanical axes (MA1 and MA2) commonly used in current CAN systems. MA1 was defined as the line from the center of the femoral head to the point 1 cm anterior to the Blumensaat’s line. MA2 was defined as the line from the center of the femoral head to the point 65% posteriorly from anterior cortex of the distal femur to the most prominent medial posterior femoral condyle. A negative value was given to the knee where the mechanical axes were oriented in extended position with reference to the anatomical references. The degree of femoral anterior bowing was represented as the angle between the anterior cortical lines of the distal and proximal femur. Correlation analyses were carried out to determine whether the degree of femoral anterior bowing was associated with the angles between the anatomical references and the mechanical axes. Results: The mean angles between the MA1 and ACL was 1.2° (SD = 1.8) whereas the mean angle between the MA2 and ACL was -1.2° (SD = 1.6). The mean angle between the MA1 and the MML 2.6° (SD = 1.6) and the mean angle between the MA2 and the MML was -0.2° (SD = 1.6). Wide ranges were identified for all angles: MA1 vs. ACL, -2.6° - 6.7; MA2 vs. ACL, -4.9 - 3.7; MA1 vs. MML, -0.6 - 7.3; and MA2 vs. MML, -4.1 - 4.1. There was significant positive correlation between the degree of femoral anterior bowing and the angles between the anatomical references and the sagittal mechanical axes (correlation coefficients = 0.73 - 0.81). Conclusions: This study documents the relationship between the anatomical references and the two sagittal mechanical axes commonly used in the current CAN-TKA systems. We also found that the angles between the anatomical references and the mechanical axes were positively correlated and that wide variations existed in the angles. This information should be used to improve the algorithm of the current CAN systems and to administer the CAN technology optimized for each individual.
Electromagnetic Navigation in Total Knee Arthroplasty
- Comparison of our first 100 cases to our last 100 cases -

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Introduction: Electromagnetic Navigation (EM) system has been introduced in total knee arthroplasty to increase the accuracy of lower limb alignment and positioning of the implant. EM navigation systems offer several potential advantages over their infrared counterparts. To our best knowledge, there have been scarce clinical results reported. In order to obtain optimal results, a certain period of learning curve may be necessary. We have compared our first 100 cases of total knee arthroplasty to our last 100 cases in order to verify the clinical accuracy, efficacy and learning curve.

Methods: From July 2006 to November 2007, 138 patients underwent 200 serial primary TKA operations by a single surgeon with the assistance of Electromagnetic Navigation system. The 200 TKA cases were divided into two groups: the first 100 and the next 100 cases. We have compared the deviation in postoperative mechanical axis and angles of femoral and tibial component position (α, β, and γ) in addition to the outlier percentage of post-mechanical axis between the two groups. We used the independent sample t-test to verify our results.

Results: The deviation in angle of postoperative mechanical axis was significantly lower in the last group than the first group; 2.0633 vs. 2.6944. (p=0.0145) respectively. The deviation of α was significantly lower in the last group than the first group; 1.1597 vs. 1.6778. (p=0.005) respectively. The deviation of β was lower in the last group than the first group; 1.3475 vs. 1.2115, but this value was not significant. (p=0.849). The results of the value γ proved to be more towards extension in the first group and more towards flexion in the last group, yet these values were not significant (p=0.159). The outlier percentages of postop-mechanical axis between two groups were significantly different.

Discussion and Conclusion: The navigation system most often used in studies is an optical system with an infrared camera. Many authors have reported the efficacy of optical navigation system. It has been known to increase the accuracy of lower limb alignment and positioning of the implant while decreasing the outlier percentage of postoperative mechanical axis. The large transmitter, however, for this system requires bicortical pins, which would result in stress fracture through the drill-holes in bone. In addition, another skin incision is needed for the transmitter. A new navigation technique using electromagnetic signals has been introduced with advantages including small transmitter size, although its signal is often distorted by metal devices used in the operative field. Our hypothesis was therefore that the EM system could lead to better alignment of the leg and positioning of implants than traditional method with comparable learning curve. In summary, the EM navigation system can lead to better alignment of the mechanical axis of leg and positioning of femoral implants in coronal view compared to conventional method, although it can’t prevent outliers in all case. And also our experience suggests that in order to obtain such results, however, a certain period of learning curve may be necessary. Several valuable surgical tips specific to this technology were obtained enduring our learning curve and will be presented.
Accuracy of Robotically Assisted UKA

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Introduction: Literature has shown that the outcomes of UKA are significantly improved by correct component alignment. With the desire to minimize the surgical exposure and the limitations of manual instrumentation, this goal has proven difficult to achieve consistently. This study evaluates the accuracy of a new technique that replaces manual instrumentation with a robotically guided cutting instrument designed to implement a three-dimensional pre-operative plan.

Materials and Methods: Forty-three UKAs were implanted using a robotically guided system that creates virtual boundaries defining the depth and volume of bone resection for a specific implant. The boundaries were based on a three-dimensional pre-operative plan. Post-operative lateral and AP radiographs were evaluated for four different aspects of component to host bone alignment for the tibia and four for the femur. Ten patients also underwent a post-operative CT to compare the resultant versus the planned three-dimensional component placements.

Results: Radiographically, we identified an outlier as any specific measurement outside a particular range set by an independent clinical advisory board of orthopedic surgeons. Of the 344 radiographic measurements, only 4 (1%) were identified as outliers, with none of these deemed clinically significant. On average, the components were placed in 0.6° less varus (SD = 1.9°) and 0.1° less posterior slope (SD = 1.8°) compared with the pre-operative plan, with RMS errors of 1.9° in the coronal plane and 1.7° in the sagittal plane.

Conclusions: Robotically assisted implementation of a pre-operative plan for UKA is accurate and precise with very few outliers. This is particularly impressive as these patients were from the inaugural series of patients undergoing a technologically innovative procedure. This technology has great potential to improve accuracy and enhance safety for surgeons with procedures that are less forgiving and technically difficult.

FEMORAL FRACTURE RISK CAUSED BY PIN HOLE IN COMPUTER NAVIGATED TKA FOR HOLE SIZE AND POSITION: A PARAMETRIC STUDY BY FINITE ELEMENT ANALYSIS

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Computer navigation for total knee arthroplasty (TKA) has been increasingly used because it improves the accuracy of implant placement. However, some clinical cases have reported complications caused from pin holes during the computer navigated surgery. The objective of this study is to analyse the femoral fracture risk cause by the pin hole in the computer navigated TKA by using finite element analysis.

Three dimensional finite element model of the human femur was developed from CT images. A parametric investigation was conducted to analyse the femoral fracture risk for the following parameters: hole sizes (3, 4, and 5 mm) and hole position (70, 100, and 130 mm above the distal end). Four different penetrations (unicortical, bicortical, half-bicortical, and transcortical) methods in tubular bone were considered in each model, where the half-bicortical penetration was defined that the pin hole was located between the holes of bicortical and transcortical penetrations.

The finite element model was rigidly fixed to a distance of 25 mm above the distal end. The vertical load of 1500 N and the torsional load of 12 Nm were applied to the femoral head. The maximum von-Mises stress, which was chosen as the fracture risk factor, was then investigated around pin hole.

The maximum von-Mises stress around the pin hole was the highest in the transcortical penetration for different hole sizes: 7.8~8.5, 15.7~16.2, 15.5~16.8, and 25.5~45.3 MPa under the vertical load, and 9.6~10.5, 9.7~11.0, 8.8~10.2, and 14.2~33.8 MPa under the torsional load in unicortical, bicortical, half-bicortical, and transcortical penetrations, respectively. For the different hole position, the maximum von-Mises stress around the pin hole was: 6.0~7.8, 15.7~24.7, 16.3~19.6, and 12.2~22.4 MPa under the vertical load, and 9.6~10.7, 9.7~11.5, 8.7~9.8, and 12.2~16.6 MPa under the torsional load in unicortical, bicortical, half-bicortical, and transcortical penetrations, respectively. For the pin hole size, the maximum stress increased only in the transcortical penetration regardless of the loads as the pin hole size increased. However, there was little meaningful difference between the hole positions for each penetration method. The results of this study suggested that it would be beneficial to avoid using the transcortical penetration and large size of pin with respect to reduction of femoral fracture risk since the high stress may cause the femoral fracture.
15:50-16:40 Oral Session 13

**OSB13-01**

**Short Term Results of Genesis2 TKA With Hi-Flex Insert in Japanese Life Style**

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Hi-flex insert was developed in part for the needs of Asian and Islamic people’s life style, because of the traditional floor sitting style in a daily life. We studied about the short term results of Genesis2 with Hi-flex insert in Japanese life style for 57 knees in 39 patients that were passed more than 2 years post-operation between 2004 and 2006. The mean age at implantation was 72.1. From the patients reviewed the mean pre-operative Japanese Orthopaedic Association score was 51, compared to 81 at last follow up. The mean pre-operative flexion was 113, compared to 124 at last follow up. Almost all patients had changed their life style basically from Japanese (floor sitting) to Western (chair sitting) before operation because of their knee problems. But 30% of the patients sometimes wanted to sit on the floor traditionally before the operation, and 83% of these patients can sit also after the operation. Japanese traditional life styles with the knee flexed deeply can be achieved by Genesis2 with Hi-Flex insert satisfactorily limited to the patients who could do also before the operation. But when the patients sit on the floor, the complicated stress to the implants and insert were unknown. At the present time, we must advice to the patients who can sit on the floor about the motion that can reduce the stress to the implants and insert.

15:50-16:40 Oral Session 13

**OSB13-02**

**THE BISURFACE TOTAL KNEE ARTHROPLASTY: TEN-YEAR FOLLOW-UP STUDY**

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The Bisurface total knee arthroplasty (TKA) was introduced in 1989 to improve knee flexion without affecting the durability of the prosthesis. The prosthesis has a unique ball-and-socket joint in the midposterior portion of the femoral and tibial components, which functions as a posterior stabilizing cam mechanism and causes femoral rollback. The femoral component was made of alumina ceramic. The tibial component was made of alumina ceramic in the type-1 implant and made of titanium alloy in the type-2 implant. The purpose of this study was to review the clinical results of the first 152 arthroplasties performed with this prosthesis.

Between 1989 and 1997, 148 consecutive primary knee replacements were performed in a cohort of 103 patients with this Bisurface knee prosthesis. The preoperative diagnoses included primary osteoarthritis in 85 knees, rheumatoid arthritis in 63. Of the 103 patients, 12 were male and 91 were female. The patients who could be followed over 10 years after surgery formed the basis of the clinical and radiographic evaluation in the present study. The patients were evaluated clinically and radiographically according to the system of the Knee Society. Kaplan-Meier survivorship analysis was performed with revision of the knee as the end point.

Preoperatively, the mean Knee society score and Knee Society functional score was 35 points and 32 points, respectively. At the time of latest follow-up, the mean knee score was 90 points and 58 points, respectively. The mean preoperative and postoperative ranges of flexion were 111 and 112 degrees, respectively. A revision operation was performed in five knees (because of instability in three, infection in one, and wear of the tibial insert in one). Aseptic loosening of the femoral component occurred in one knee but revision surgery was not performed until this study. The rate of survival of the implant was 95 percent at ten years.

These results suggest that the Bisurface TKA gives acceptable clinical results after ten years and the durability of the prosthesis is promising. This good result is caused by the following reasons. One reason is that this unique ball-and-socket joint design might reduce contact pressure. The other is that the femoral component is made of alumina ceramic. However, revision surgery was required because of instability in some cases. For the patients who revealed severe instability, this Bisurface knee prosthesis should be selected carefully.
KINEMATIC ESTIMATION OF BI-SURFACE KNEE PROSTHESIS AT SEDENTARY STATE

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The objective of this study is to determine the in-vivo knee joint kinematics of patients having specially designed knee prosthesis (Bi-surface) at sitting sedentary (seiza) state.

An increase in the demand for TKA has required improvement in the durability and flexibility of knee prostheses. One of the representative cases which has improved knee flexion is Bi-surface knee. Bi-surface knee has two joint surfaces; one for weight bearing and the other for flexion motion which has a unique ball-and-socket joint. This knee prosthesis, having been applied for two decades, has not yet been precisely analyzed how the femoral and tibial components are articulating at deep knee flexion.

Since there is no practical method to measure directly prosthetic kinematics in-vivo; we applied indirect techniques, pattern matching method to the Bi-surface patients. The method has been originated by Banks and Hodge (1964), and we have improved it in order to obtain higher and more reliable accuracies.

The number of subjects examined by X-ray apparatus was 18 knees of 14 patients (3 male and 11 female) who could attain the seiza. Patients were asked to sit at seiza state and their Bi-surface knees were X-ray photographed from lateral side. We focused if the internal rotation was shown at maximum flexion as commonly shown for a normal knee. We also represented the CAD models with the same position/orientation as the data from the pattern matching, thereby investigating the contact states between the ball and socket by viewing them from the desired direction.

The following results were introduced. The mean maximum flexion angle was 144.1° (SD=5.3°), and the mean internal rotation angle at maximum flexion was 15.2° (SD=6.6). The maximum flexion angle among all subjects was 153.3° and internal rotation was 19.5° at that flexion angle. The number of subjects which had (a) contact point(s) on the tibio-femoral and/or ball-socket surface(s) was 5 knees (2 knees had contact point on both the ball-and-socket and the tibio-femoral lateral surfaces, 3 knees had only on either surface) and the other 13 knees had a slight gap between two components.

Correlation was found between the value of the maximum flexion angle and the value of internal rotation angle at that flexion; The subjects of larger maximum flexion angle also demonstrated larger internal rotation angle. This suggest that at deep knee flexion, the tibial internal rotation may play an important role after TKA as a normal knee does. By checking the CAD representations, we found that the tibio-femoral and ball-socket surfaces were separate for most subjects at seiza state. Although serious impingements were not found, it was suggested the risk of subluxation when a patient rises up.

The limitation of our study is that we used simple still X-ray pictures. In order to assess kinematics for ascending from seiza state, kinematic analyses from fluoroscopic images are needed.
A Comparison of the Short-term Results between PCL Substituting Medial Pivot Knee and Nexgen® LPS Total Knee Arthroplasty

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Purpose: To compare the short term follow-up clinical and radiological results after PCL substituting (PS) Medial Pivot Knee and Nexgen® LPS total knee arthroplasty (TKA).

Materials and Methods: Seventy knees in 48 patients after TKA with PS ADVANCE® Medial Pivot Knee (Group I) and sixty seven knees in 45 patients after TKA with Nexgen® LPS (Group II) were evaluated retrospectively from March 2004 to May 2006. The mean follow up period was 31 months (range: 24-43 months) in group I and 32 month (range: 24-46 months) in group II. All the knees were operated by one surgeon. The evaluations included the preoperative and postoperative range of motion (ROM), Knee society score (KSS), tibiofemoral angle, and postoperative complications.

Results: In group I, ROM increased from preoperative mean flexion contracture of 6.3° and further flexion of 116° to postoperative mean flexion contracture 1.9° and further flexion 121°, KS knee score increased from 46 to 87, KS function score increased from 37 to 83, and tibiofemoral angle changed from preoperative varus 4.0° to postoperative valgus 5.5°. In group II, ROM increased from preoperative mean flexion contracture of 13° and further flexion of 118° to postoperative mean flexion contracture 0.9° and further flexion 123°, KS knee score increased from 50 to 87, KS function score increased from 48 to 83, and tibiofemoral angle changed from preoperative varus 4.1° to postoperative valgus 5.3°. The complications were two periprosthetic patellar fracture and one failure of tibial component in group I, and one early failure of femoral component and one arthrofibrosis in group II. There was no statistical difference in radiological and clinical results between the two groups.

Conclusion: Minimum 2-year follow-up result of PS Medial Pivot Knee TKA was comparable to that of Nexgen® LPS TKA and longer term follow-up would be necessary.

Key Words: TKA, PCL substituting, Medial Pivot Knee, Nexgen® LPS

COMPARISON OF THE CLINICAL OUTCOMES AFTER TOTAL KNEE ARTHROPLASTY WITH PFC SIGMA RP-F VERSUS LCS

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Background: The aims of this study were to assess the clinical outcomes especially range of motion of the knee after total knee arthroplasty with sigma RP-F versus LCS RP.

Methods: 110 knees underwent total knee arthroplasty with LCS, and 59 knees with PFC sigma RP-F. We performed a prospective clinical trial. At the time of the one-year follow-up, we compared the clinical outcomes of two groups. In LCS group, LCS AP glide type group was excluded. Range of motion, the knee score, functional score and HSS score etc. were assessed.

Results: 91 knees were available. The mean active non-weight-bearing range of motion at one year was 124 (95% confidence interval) in the fifty-six knees that underwent a LCS and 127(95% confidence interval) in the thirty-six knees that underwent a PFC sigma RP-F (p=0.55). There were no significant differences in the knee score (the mean 94.12 in LCS, 93.54 in RP-F, p=0.05), functional score (the mean 62.58 in LCS, 65.14 in RP-F, p=0.91) and HSS score (the mean 87.73 in LCS, 87.85 in RP-F, p=0.50).

Conclusion: Although PFC sigma RP-F has the design that is advantageous in knee flexion, we found no significant differences between the groups with regard to range of motion or clinical outcomes.
**Functional Disabilities and Patient Satisfaction After Total Knee Arthroplasty in Asian Patients**

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**Background:** In a previous study, we found that pre-TKA patients were severely disabled in high-flexion activities but perceived these disabilities as being no more important than pain relief and the restoration of daily routine activities. This study was conducted to investigate functional disabilities and patient satisfaction in Korean patients after TKA.

**Methods:** Of 387 patients who had undergone TKA with a follow-up longer than 12 months, 270 (69.7%) completed a questionnaire designed to evaluate functional disabilities, perceived importance and patient satisfaction.

**Results:** The top 5 severe functional disabilities were difficulties in kneeling, squatting, sitting with legs crossed, sexual activity, and recreational activities. The top 5 in order of perceived importance were difficulties in walking, using a bathtub, working, climbing stairs, and recreation activities. Severities of functional disabilities were not found to be correlated with perceived importance. The patients (8.5%) dissatisfied with their replaced knees had more severe functional disabilities than the satisfied for most activities. The dissatisfied patients tended to perceive functional disabilities in high-flexion activities to be more important than the satisfied.

**Conclusion:** This study indicates that despite severe disabilities in high-flexion activities, most Korean patients after TKA would not consider high-flexion disability to be more important than other daily routine activities. Moreover, postoperative high-flexion disabilities would not adversely influence satisfaction for most patients. Nevertheless, such disabilities are likely to cause dissatisfaction among those that are not prepared to modify their traditional life-styles.

**Materials and Methods:** Total of eight patients, all female and diagnosed of bilateral knee osteoarthritis, were treated with TKA and reviewed. Mean age was 70 years old (60-74). For prosthesis, we used Scorpio NRG PS, and ADVANCE, with cementation for all. No patella was replaced. Some had unilateral TKA, and some were treated bilaterally as needed. We examined distance factors (step length and step width), gait velocity, and gait barycentric factors (single-support phase and Ratio of center of gravity maximum values). We performed the analysis preoperatively, postoperatively at 1 month, 3 months, and 6 months. We used the floor pressure gauge (NITTA CORPORATION) and the three-dimensional motion analysis device (DITECT Co. Ltd) for the analysis.

**Results:** During the six-month follow-ups, six cases were unilateral TKA and two were treated bilaterally. Increase in step length was seen in the unilateral cases, and it decreased in the bilateral cases. Step width decreased in five cases, two cases showed no change, and increased in one case. Gait velocity had increased in all cases. Single-support phase was close to 1 for all the cases. Ratio of center of gravity maximum values, which indicates the movement of centroid during ambulation, the ratio went up for unilateral cases while it showed no change in the bilateral cases.

**Discussion:** Quantitative studies of gait analysis have reported that gait condition had improved after TKA. However, some reported that the gait impairment had remained. Unilateral TKA group showed gait restoration, whereas gait abnormality in either leg was seen in the bilateral group. Gait analysis is effective in determining whether surgeons should perform unilateral TKA or bilateral TKA to the patients with bilateral knee osteoarthritis. Among the gait analysis factors, we consider that Ratio of center of gravity maximum values shows effectively the improvement of the treated knee, gait, and the condition of contralateral knee.
OBJECTIVE RESULTS AT 1 YEAR OF A NEW ULTRA CONGRUENT POSTERO-STABILIZED TOTAL KNEE ARTHROPLASTY

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Introduction: A new ultra congruent, postero-stabilized total knee arthroplasty (TKA) with a mobile bearing, the FIRST knee prosthesis (Free Insert in Rotation Stabilized in Translation, Symbios SA), was designed and expected to significantly reduce polyethylene wear, to improve the range of motion and the overall stability of the knee while ensuring a physiological ligament balance. Gait analysis has proven to give really objective outcome parameters after lower limb surgery. The goal of our study was to compare the subjective and really objective results of this new TKA with two other widespread models of TKA.

Methods: A clinical prospective monocentric cohort study of 100 consecutive patients (47-88 yrs) undergoing a FIRST TKA for primary osteoarthritis is currently being done. Pre- and post-operative follow-ups (6 weeks, 4 months and 1 year) were done with well-recognized subjective evaluations (EQ-5D and WOMAC scores) and semi-objective questionnaires (KSS score and radiography evaluation) as well as with a really objective evaluation using gait parameters from 6 walking trials, performed at different speeds (slow, normal and fast) with an ambulatory gait analysis system (Physilog®, BioAGM CH). The outcomes of the first 32 new TKA after one year of follow-up were compared to the results after 1 year of a randomized controlled clinical trial comparing 29 NexGen® postero-stabilized TKA (Zimmer Inc) with a fixed bearing and 26 NexGen® TKA with a mobile bearing using the same methods.

Results: Subjective and semi-objective results were similar for the three types of TKA. As for the really objective parameters, the gait cycle time of the FIRST TKA was statistically significantly shorter at normal speed of walk, as well as double-support periods, as compared to both standard models. The extension (in terms of range of motion when walking) of the operated knee was significantly improved for all three types of walk in favour of the FIRST TKAs compared to both NexGen TKAs. The normal walking speed was significantly higher with faster swing speed and stride lengths for the new TKA. Significantly better coordination scores were observed at normal walking speed for the FIRST TKA as compared to the fixed-bearing TKAs.

Conclusion: The FIRST TKAs showed statistically significantly better objective outcomes in terms of gait after one year of follow-up with similar subjective and semi-objective results in comparison with widespread TKA designs. These encouraging short-terms results will have to be confirmed at a 5 years follow-up of the FIRST TKAs.

Results of MIS TKA using Extramedullary Femoral Guide System

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Background: MISTKA resulted earlier recovery of ROM, muscle power and shorter incision. But bleeding after operation did not decrease compared with conventional TKA. We compared MISTKA results between several approach mini arthrotomy, mini midvastus and mini subvastus. There were no difference in these series. We thought extramedullary femoral guide may be less invasive than intramedullary femoral guide system.

Materials & Methods: 34 cases were performed by minisubvastus approach. 17 cases were using intramedullary method. 17 cases were using extramedullary method. We compared JOA score, ROM, muscle power, blood examination, X ray, and operation time. Total protein(TP), albumin(alb), prealbumin(prealb), hemoglobin(Hb), total lymphocyte content(TLC) and CRP were examined.

Results: There was no difference in JOA score, ROM and recovery of muscle power. But there were statistically difference in prealbumin at 1 week after operation and TLC at 2 week after operation. Extramedullary group showed earlier recovery than intramedullary group.

Conclusion: MIS TKA does not discuss about approach but also system of bone cut. Navigation system is very good method but it is very expensive and takes more time at operation. Extramedullary system we developed is simple and low technology method and effective for MISTKA.
**Mid-Term Results of Total Knee Arthroplasty**  
- At least 8-years -

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**Purpose:** To evaluate the clinical and radiographic results of patients who could be followed more than eight years in the Press Fit Condylar total knee arthroplasty  

**Materials and Methods:** Between January 1996 and December 1999, 103 knees in 70 patients after PFC total knee arthroplasty performed by a single-surgeon were analyzed clinically and radiographically. The preoperative diagnosis was degenerative arthritis in all patients. Clinical and radiographic evaluations were performed according to American Knee Society system, American Knee Society Roentgenographic Evaluation and Scoring System. The survival rate was analyzed using the Kaplan-Meier method with the revision arthroplasty cases being counted as a failure.

**Results:** Average ROM was improved from 102.4º preoperatively to 116.4º at last follow-up and average flexion contracture was improved from 8.3º preoperatively to 1.4º at last follow-up. The average knee and functional score of American Knee Society improved 46.3, 43.2 preoperatively to 89.2, 82.2 at last follow-up. Radiolucent lines were present in 27.1%(28 cases) on roentgenographic evaluation. Cumulative radiolucency score was 0.8 points and most radiolucent lines were nonprogressive. There were 8 revision surgery performed due to loosening or infection. The survival rate was 96.1% after 8 years when the endpoint was defined as revision arthroplasty.

**Conclusion:** According to the clinical and radiographic assessments, the mid-term results of PFC total knee arthroplasty were showed excellent results and good survival rate. But the authors considered that more long-term follow-up evaluation should be necessary.

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**Long-term results of total knee arthroplasty in rheumatoid arthritis**  
- at least 10 years follow-up?

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**Purpose:** We reviewed the long-term clinical & radiological results of total knee arthroplasty for rheumatoid arthritis over 10 years.

**Materials and Methods:** We analysed the clinical results of 169 knees in 98 patients with rheumatoid arthritis. The average follow up period was 12.8(10-17.6) years.

**Results:** The flexion contracture was improved from average 25.0 to 2.9 degrees. But the angle of great flexion had decreased from average 128.0 to 114.7 degrees. At the final follow-up, American Knee Society knee score was 87.5 and function score was 76.5 in average. The revision arthroplasty was performed in 20 cases, but only 4 cases were done before 10 years after the primary total knee arthroplasty. The survival rate of the implant was 97.9% at 10 years and 85.3% at 14 years in Kaplan-Meier survivorship analysis.

**Conclusion:** Total knee arthroplasty for rheumatoid arthritis is very effective method of treatment because it relieves pain and converts non-functioning range of knee motion to functional arc which maintained at least 10 years with 97.9% survivor rate. But just after 10 years, some problems are occurred, like increasing osteolysis and periprosthetic fractures. 10 years follow-up results is just the 10 years results only, not long-term or final results of total knee arthroplasty for rheumatoid arthritis.

**Key Words:** rheumatoid arthritis, total knee arthroplasty, long-term result
Total knee arthroplasty for the patients affecting ankylosing knee

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Between the year 1987 to 2005, 45 primary knee replacements were performed for 30 patients affecting ankylosing knee joint. 23 patients were having flexion fused deformities with 38 knee arthroplasty, ten of them were having flexion fused deformities over than 60 degrees. 18 cases were performed ipsilateral THR & TKR. 2 AS patients undergone THR, TKR and total ankle replacement on the same anesthesia. The other 7 patients were having extension ankylosing deformities with 9 primary TKR performed. All patients were post infection deformities with the exception of one Rheumatoid Arthritis and one hemophiliac patient with bilateral extension ankylosing deformities of the knee joint.

(A) Exposure of the knee joint and separation of the fused bones, providing a mobile joint space plays a crucial procedure for the next step of surgery for both flexion and extension ankylosing deformities. The following 2 points are important:

1. First separate the fused bone between the femoral condyles and the patella, pay attention to the thickness of the patella button allowing sufficient bone stock with thickness and strength for patella replacement.
2. Separate the fused bone between the femoral and tibial condyles allowing motion and space, pay attention that: i) the resection plane is 90 degrees perpendicular to the tibial axis and as proximal to the tibial plateau fused with the femoral condyles as possible. ii) release and protect the blood supply and nerve of the posterior resection area avoiding damage to the nerve endings and the blood vessels.

(B) Soft tissue balancing is important, it is difficult to achieve the same flexion and extension gap. Usually the extension gap is narrow than flexion gap with flexion ankylosing deformities, on the contrary the flexion gap is narrow than extension gap with extension ankylosing deformities. Post operative rehabilitation and traction can gradually improve for the patients who less than 20 degrees flexion contracture deformities. For extension ankylosing deformities, post-operative rehabilitation can achieve better results even though the intra-operative ROM is less than 90 degrees but if the patient is stable in extension position.
Evaluation of a Porous Tantalum Cruciate-Retaining Hi-Flex Uncemented Monoblock Tibial Component in MIS Primary Total Knee Arthroplasty. - Clinical and Radiological Results of 108 Knees -

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The purpose of this study was to evaluate a high flex porous tantalum metal monoblock component system implanted through a MIS technique.

A fellowship trained surgeon proficient in MIS surgery performed 109 consecutive TKAs in 95 patients. Patients were implanted with a tantalum monoblock tibia and a fiber-metal cruciate-retaining high flex femur through a MIS midvastus approach. Ninety uncemented porous tantalum monoblock patellae and 19 cemented all polyethylene patellae were implanted.

Knee Society scores and Knee Society radiographic scores were calculated in all patients. Follow-up for a minimum of 2 years was performed in 109 knees. The average follow up was 39 months. Sixty-six percent of the patients were female and 34% male. The average age was 66 years. The average preoperative Knee Society Knee score was 36. The average preop Knee Society Functional Score was 46. Osteoarthritis was the primary diagnosis in 104 knees. Rheumatoid arthritis and Hemophilia was the diagnosis in two knees each.

The average Knee Society Knee Score improved to 89. The average Knee Society Function score improved to 86. 106 of the knees were rated good or excellent and three knees were rated poor. Two patellar revisions were performed for loose components and one for patellar misalignment. One patella fracture occurred that required ORIF. One femoral component was revised for loosening. There were nonprogressive radiographic lucencies demonstrated on 4 tibial components. One tibial component was rated loose. There were radiographic lucencies on 5 femoral components, all nonprogressive. There were two uncemented tantalum patellar components with stable radiolucencies.

Early results in 109 consecutive porous tantalum metal tibial and high flex cruciate-retaining femoral components implanted through an MIS midvastus approach have a high rate of success at a minimum followup of two years.
OSB15-02

Concept of Binary Bearing Surface for Knee Prosthesis to Improve Flexional Motion

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Binary Surface type knee prosthesis (bisurface knee) has successfully been utilized in total knee arthroplasty (TKA) in order to improve flexional motion, especially, deep flexion. Binary surface means that the knee prosthesis has two different bearing structures, that is, normal condylar surfaces and ball-socket structure. The ball and the socket are placed between the condylar surfaces of the femoral component and the tibial insert, respectively. Two different designs of bisurface knee have been proposed so far and only one model called KU has been utilized in clinical applications. The other model called CFK is still under development and characterized to have a post-cam structure to stabilize the knee motion. These bisurface knees are expected to attain deep flexional motion and therefore, it is important to understand their safety and durability at high flexion angles. In the present study, the finite element analysis (FEA) is conducted to characterize the mechanics of the bisurface knees under deep knee flexion. Risk assessment of the bisurface knees are then performed based on the FEA results. Detailed 3D-FEA models are constructed using CAD data and deep knee flexion corresponding to a squatting motion is reproduced by using spring models and proper boundary conditions. The spring models attached to the tibial component are used to express the mechanical effects of soft tissues. Internal rotational motion is also considered with the flexional motion. The femoral and the tibial components are assumed to be rigid and the tibial insert made of UHMWPE is an elastic-plastic solid having a nonlinear constitutive relation determined from experiments. The femoral component is rotated continuously from 0° to 135° to express the flexional motion and the tibial component is also rotated to express internal rotation.

The equivalent stress of the condylar surface of the new CFK model is almost equivalent to that of the KU model during flexion from 0° to 90°, however, the stress values are different at the angles higher than 90°. At higher angles of flexion than 90°, the bearing surface of the KU consists of the condylar and the socket surfaces, while the bearing surface of the CFK consists of the socket surface only. Therefore, the CFK exhibits higher stress than the KU at these high angles. The ball-socket bearing system enables these bisurface knees to be adapted to deep flexional motion. The CFK is trying to achieve higher flexion angles than the KU by employing the modified ball-socket bearing structure, however, higher stress concentration on the socket surface of the CFK may hasten degradation of the tibial insert. It is also found that the stress concentration on the socket surfaces increase with increase of the internal rotation angle and therefore, the risk of damage of the tibial insert becomes higher with internal rotation.

In summary, 3D dynamic FEA is utilized to make a risk assessment of the bisurface knees and the computational results suggest that the design of the ball-socket structure is one of the most important factors to determine the safety and durability of the knees.
Comparative Study of Postoperative Maximal Flexion Angle in PCL-substituting Total Knee Arthroplasty
- High-flex versus Conventional PS TKA-

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Purpose: We have performed this study to compare the postoperative maximal flexion angle (MFA) of high-flex implants with that of conventional implants in PCL-substituted total knee arthroplasty (TKA).

Materials and Methods: The staged sequential bilateral TKAs were performed in Group 1, 35 patients (70 knees) with osteoarthritis of both knee. The conventional implant and the high-flex implant were both used in each patient by randomized method. The postoperative MFA of both type of implants was measured and analyzed at 1 year after surgery. To evaluate unidentified factors that might influence the results, such as the differences derived from personal characteristics during postoperative rehabilitation process achieving the range of motion of knee, we also analyzed the other patient groups, which were composed of Group 2 (10 patients, 20 knees) bilaterally operated with conventional implants, Group 3 (7 patients, 14 knees) bilaterally with high-flex implants, Group 4 (13 patients, 13 knees) unilaterally with conventional implants and Group 5 (17 patients, 17 knees) unilaterally with high-flex implant.

Results: In Group 1, the average postoperative MFA of high-flex implant and that of conventional implant showed no significant difference (131.7 and 131.9 degree each). The average postoperative MFA in Group 1, 2, 3, 4 and 5 showed no significant difference either.

Conclusion: This study indicates that the high-flex implant alone does not seem to improve the MFA as compared to the conventional implant. The status of the contralateral knee and the personal characteristics during rehabilitation seem to be more important factors in increasing the maximal flexion.

EFFECT OF DECREASING TIBIAL SLOPE ON THE EXTENSION GAP DURING POSTERIOR STABILIZED TOTAL KNEE ARTHROPLASTY

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The purpose of this study was to evaluate the effect of decreasing tibial slope on extension gap during posterior stabilized total knee arthroplasty. 110 posterior stabilized total knee arthroplasties were studied for 3 groups; (1) whole, (2) with flexion contracture, (3) without flexion contracture. In each group, we investigated average of tibial slope decrease and frequency of additional distal femoral resections that were done due to insufficient posterior stabilized total knee arthroplasty extension gap in comparison with flexion gap during posterior stabilized total knee arthroplasty. We also compared frequencies of additional distal femoral resections between 2 parts having more and less than average slope decrease. In each group, averages of tibial slope decrease were 7.8 degrees, 8.7 degrees, 7.4 degrees and frequencies of additional resection were 32.7%, 51.4%, 24%. In 2 parts having more and less than average slope decrease in each group, frequencies of additional resection were 27.5% vs 37.3%, 50% vs 52.6%, 14.7% vs 31.7% . Results suggest that more decrease in tibial slope decrease frequency of additional distal femoral resection during posterior stabilized total knee arthroplasty. Decreasing tibial slope can be considered as a factor influencing on extension gap during posterior stabilized total knee arthroplasty. The estimation of predictable tibia slope decrease through preoperative radiologic findings can be beneficial in performing a successful posterior stabilized total knee arthroplasty.
INTRODUCTION: The range of motion (ROM) after total knee arthroplasty (TKA) is one of the most important factors for patient satisfaction, especially in Asian countries. To enhance the knee flexion angle, high-flexion designs have been introduced in total knee prostheses. One of such design was a new design of femoral prosthesis, which increased the posterior cut on the bone by 2 mm and thickened the posterior condyle, allowing the posterior condylar radius to continue further. There were several reports on postoperative ROM of such high-flexion posterior-stabilized (PS) total knee prosthesis. However, there was no report on the postoperative ROM of high-flexion cruciate ligament retaining (CR) total knee prosthesis. The purpose of this study was to compare the ROM associated with standard and high-flexion posterior CR total knee prostheses.

MATERIALS AND METHODS: One hundred and fifty-one consecutive patients (176 knees) had CR total knee prosthesis. 89 knees had standard CR TKA (NexGen CR, Zimmer, Warsaw, IL), and 87 knees had high-flexion CR knee prostheses (NexGen CR-Flex, Zimmer, Warsaw, IL). Differences in the age, diagnosis, preoperative Knee Society Score (KSS), and preoperative ROM of the knee between two groups were not significant. At one year postoperatively, the patients were assessed clinically and radiographically. Student t test and chi square test was performed using computer software. Levels of significance of 95% or better were accepted.

RESULTS: The mean postoperative KSS knee score was 96.2 points for the standard CR prosthesis group and 96.7 points for the high-flexion CR prosthesis group (p=0.464). The mean postoperative KSS function score was 83.4 points for the standard CR prosthesis group and 84.8 points for the high-flexion CR prosthesis group (p=0.446). The mean postoperative ROM was 110.8 degrees in the standard CR prosthesis group, and 114.0 degrees in high-flexion prosthesis group (p=0.236). No knee had aseptic loosening, revision, or osteolysis.

DISCUSSION: Previous report showed that high-flexion PS design did not increase postoperative ROM compared to standard design. However, there was no report on the postoperative ROM of high-flexion CR total knee prosthesis. We found no significant differences between the standard CR group and high-flexion CR group with regard to ROM or clinical and radiographic parameters. However, in the cases which achieved high flexion, high-flexion design, which chamfered posterior femoral edge, can reduce the possibility of deformation from posterior contacts under lord. Therefore, the results of the current study suggested that high-flexion CR design is not the design that increase ROM significantly, but might be the safe design even when the knee achieved deep flexion.
Comparison of Mobile versus Fixed bearing in high - flex Total Knee Arthroplasty

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The purpose of this study was to compare the clinical and radiological results of the PFC flex mobile bearing design with those of the LPS flex fixed bearing design in high-flex total knee arthroplasty. Between January 2005 and November 2006, Forty-six patients who received PFC flex mobile bearing prosthesis in one knee and LPS flex fixed bearing prosthesis in the contralateral knee followed up for a minimum 2 years were evaluated. Clinical results were assessed using the ROM, HSS score, the Knee rating systems of the knee society, WOMAC score and SF-36. Radiological results were evaluated tibio-femoral angle and loosening or osteolysis of components. We subdivided preoperative less 90 degree and more 90 degree in each group.

Mean ROM range of last follow up was increased to 131.1 degree in LPS group and 130.1 degree in PFC group. But there was no significant difference between the two groups. HSS score, knee pain and function score, WOMAC score, SF-36 score didn’t differ significantly between two groups. But descending stairs, rising from sitting, bending to the floor more improved significantly in LPS group. T-F angle was changed from preoperative 8.2 degree varus to a postoperative 4.8 valgus. No knee had aseptic loosening or osteolysis.

Postoperative ROM was increase significantly in both groups. We found no significant differences between the two groups with regard to clinical and radiological parameters excepts descending stairs, rising from sitting, bending to the floor in WOMAC score. There was no aseptic loosening or osteolysis but needed long term observation about these concerns.

Key Words: Total knee arthroplasty, high-flex, fixed & mobile

THE RESULTS OF LEGACY POSTERIOR STABILISED-FLEX TOTAL KNEE REPLACEMENT AT A MINIMUM OF 3 YEARS OF FOLLOW-UP: A PROSPECTIVE STUDY OF 278 CONSECUTIVE KNEES

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This research was done in the Asan Medical Center in Seoul. We performed a prospective study to assess clinical outcomes, complications and survival of prostheses in a consecutive series of 278 knees receiving NexGen legacy posterior stabilised (LPS) - Flex total knee replacement (TKR) between May 2003 and February 2005. The mean follow-up period was 3.8 years (3.0 to 4.8), and 259 knees (93.2%) were followed for an adequate interval. Annual follow-ups showed improvement in the Knee Society scores (paired t-test, P<0.05). At the latest follow-up, the mean maximal flexion was 135° (110° to 150°). Two knees showed radiolucency but revision was not required as there were no significant symptoms. Revision was required in one case due to prosthetic infection, but no prosthesis-related revisions were required. There were no complications such as patellofemoral pain, wound healing problems, dislocation or instability during deep flexion postoperatively. The estimated survival rate at 4 years with revision for any reason and prosthesis-related problems were 99.6% and 100% respectively (life-table method). This relatively large TKR study indicates that LPS-Flex system provides excellent medium-term outcomes and seems to warrant ongoing evaluation to confirm the long-term durability and functioning of the implant afterward.
HIGH FLEXION POSTERIOR STABILIZATION FIXED BEARING TOTAL KNEE ARTHROPLASTY: TWO TO SIX YEARS FOLLOW UP

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INTRODUCTION: Clinical experience has shown the needs for high flexion. The aim of this study was to evaluate the clinical and radiological results of a fixed bearing high flexion posterior stabilized (PS) total knee arthroplasty (TKA).

MATERIALS AND METHODS: Between July 2001 and December 2005, 422 TKAs in 288 patients were performed with high flexion PS prosthesis and 378 knees of 258 patients had been followed up for 2 to 6.5 years (mean: 3 years 11 months). We evaluated range of motion (ROM), Knee rating system of the Hospital for Special Surgery (HSS) and Knee Society (KS) score, and radiological results.

RESULTS: The mean flexion improved from 110.1 degrees to 126.7 degrees at the latest follow-up. 333 knees (88 %) showed more than 120 degrees of flexion, 105 knees (28 %) more than 140 degrees of flexion. The mean KS clinical score improved from 39 to 93 points (p<0.01) and KS function score, from 40 to 85.4 points (p<0.01). The mean HSS score improved from 41.2 to 86.3 points (p<0.01). In 28 knees, radiolucent line of 1-2 mm in width was observed at zone 1 without symptoms. Aseptic loosening in 4 knees, Mid-flexion instability in 2 knees, superficial infection in 3 knees and deep infection in 3 knees were observed.

CONCLUSION: Total knee arthroplasty with high flexion PS prosthesis showed good ROM and satisfactory early clinical results. Complication rate was similar to those of other series. Close observation and serial radiological evaluation are needed for long term results.

THREE TO SIX-YEAR FOLLOW-UP RESULTS AFTER HIGH FLEXION TOTAL KNEE ARTHROPLASTY- CAN WE ALLOW PASSIVE DEEP KNEE BENDING? -

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Purpose: To evaluate the minimum 3 year follow-up clinical and radiological results after Nexgen® LPS-flex total knee arthroplasty (TKA).

Materials and Methods: Two hundred eighteen knees in 166 patients, who could be followed up more than 3 years after Nexgen® LPS-flex TKA from October 2001 to February 2005, were evaluated retrospectively. The average age was 64.2 years. Twenty-two patients were male and 144 patients were female. The mean follow-up period was 51 months (range 36-73 months). The evaluations included the preoperative and postoperative range of motion (ROM), Knee Society (KS) Score, tibiofemoral angle and postoperative complications.

Results: The ROM increased from preoperative mean flexion contracture of 8.7° and further flexion of 117.3° to postoperative mean flexion contracture of 1.8° and further flexion of 131.3°. The KS knee score and function score improved from 52 and 38 before surgery to 87 and 82 after surgery, respectively. The tibiofemoral angle changed from preoperative varus 5.7° to postoperative valgus 5.4°. The complications were 30 knees (13.8%, 27 patients) of early loosening of the femoral component on X-ray, 2 instabilities, 2 periprosthetic fractures and 1 failure of extensor mechanism. Early loosening (30 knees) was found at mean 24 months after operation. Among these cases, 23 knees were able to squat, 5 knees to flex over 130°, 1 knee upto 115° and 1 knee upto 95°. Seven knees (3.2%, 6 patients) were revised at mean 49 months after index operation.

Conclusion: The results after Nexgen® LPS-flex TKA were satisfactory in terms of ROM, but relatively high incidence of early loosening of the femoral components occurred, which might be associated with passive-maximal flexion activity, such as squatting or kneeling.
EVALUATION OF VITAMIN E ADDED ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE IN TOTAL KNEE ARTHROPLASTY
- JOINT FLUID CONCENTRATIONS OF TOCOPHEROL AND MATRIX METALLOPROTEINASE 9 -

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Background: Recent researches have reported that the addition of Vitamin E into UHMWPE improved the mechanical property. The aim of this study was to report a 3 year follow up of vitamin E add polyethylene in total knee arthroplasty.

Methods: UHMWPE powder (GUR1050) was mixed with 0.3% of vitamin E before consolidation by direct compression molding, followed by EOG sterilization. The vitamin E added UHMWPE was applied to the articular surface and patella in 65 patients (mean age, 69.6 years). The femoral and tibial components were made of titanium alloy (Nakashima Medical Co. Ltd., Okayama, Japan). A cruciate-retaining TKA was performed on 43 knees, whereas a posterior-stabilized TKA on 22 knees. The components were fixed without cement in 53 knees, and with cement in 12 knees. The primary diagnosis was osteoarthritis in 44 knees and rheumatoid arthritis in 21 knees. Nine patients were men, and 56 patients were women. The clinical rating system of the Knee Society was applied to evaluate clinical results. Joint fluid concentrations of tocopherol and matrix metalloproteinase 9 (MMP-9) were measured in vitamin E added UHMWPE cases one year after surgery, and were compared to those of conventional UHMWPE cases and osteoarthritis patients (OA). Concentrations of α-tocopherol and γ-tocopherol were measured by using HPLC with ultraviolet-visible wavelength detection. Concentrations of MMP-9 were detected by using enzyme immunoassay.

Results: The Average Knee Society score were 91.7(clinical) and 76.7(functional). There were three failures (1 supracondylar fracture, and 2 skin necrosis). The average concentrations of α-tocopherol were 281.8 ug/dL (10 cases) in the vitamin E group, 371.8 ug/dL (15 cases) in the conventional group, and 317.8 ug/dL (46 cases) in the OA group. There were no significant differences among three groups. The average concentrations of γ-tocopherol were 43.4 ug/dL in the vitamin E group, 52.3 ug/dL in the conventional group, and 49.8 ug/dL in the OA group. There were no significant differences among three groups. The average concentrations of MMP-9 were 83.2 ng/mL in the vitamin E group, 78.4 ng/mL in the conventional group, and 17.4 ng/mL in the OA group. There was no significant difference between the vitamin E group and the conventional group. However, The MMP-9 concentrations of the OA group were significantly lower than others.

Conclusion: No cases exhibited measurable polyethylene wear or osteolysis and also no abnormal values relating to vitamin E on joint fluid examinations. At three year follow-up, vitamin E added polyethylene demonstrated the safe use for the human body.
EFFECT OF CARBON FIBRE ORIENTATION ON THE WEAR OF CFR-PEEK/CFR-PEEK BEARING COUPLES

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Carbon fibre reinforced polyetheretherketone (CFR-PEEK) has been introduced recently as an alternative material to be used in joint prostheses. During injection moulding of the CFR-PEEK the carbon fibres tend to become orientated in the direction of the plastic flow. The direction of these fibres may affect the wear produced by these materials.

MATERIALS AND METHODS: Reciprocation only and reciprocation plus rotation (multi-directional) pin-on-plate wear tests were performed on PAN-based CFR-PEEK against itself. The plates were manufactured with the carbon fibres mainly orientated either longitudinally (in the direction of reciprocation motion) or mainly transversally (perpendicular to the direction of motion) to determine the effect of carbon fibre orientation on the wear of these materials. For each test, four pin and plate samples were tested (two reciprocation only and two reciprocation plus rotation) for 3.5 million cycles at a cycle frequency of 1 Hz under a 40 N load (which resulted in a contact stress of about 2 MPa). The lubricant used was bovine serum diluted with de-ionised water to a protein content of 17 g/l. This was maintained at 37°C. The wear was determined gravimetrically. Soak control specimens were used to account for any weight changes due to lubricant absorption.

RESULTS AND DISCUSSION: The average steady-state wear for the CFR-PEEK samples that underwent reciprocation motion only was found to be 5.41 and 18.7 × 10⁻⁸ mm²N⁻¹m⁻¹ for the longitudinal carbon fibres and the transverse fibres respectively. For the multi-directional tests, the average steady-state wear was 5.88 and 19.9 × 10⁻⁷ mm²N⁻¹m⁻¹ for the longitudinal and transverse fibres respectively. It is clear from these results that for both reciprocation motion only and reciprocation plus rotation the wear was considerably lower with the fibres orientated in the longitudinal direction than the transverse direction. Also, these tests show that reciprocation only gives approximately an order of magnitude lower wear than multi-directional motion.

CONCLUSIONS: It can be concluded that the wear rate of CFR-PEEK is lower when the sliding motion occurs in the same direction as the carbon fibre orientation. Also, in these pin-on-plate tests, the wear produced using reciprocation motion only was an order of magnitude lower than that for the tests using multi-directional motion. The authors wish to thank INVIBIO Ltd. for funding this research.

LOADING EFFECT ON WEAR PRODUCT OF THE DIE DRAWN GUR 1120 UHMWPE AND NITROGEN BASED-ION IMPLANTATION TO COBALT CHROME ALLOY IN KNEE REPLACEMENT APPLICATION

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The combination of UHMWPE as tibiae substitute components and cobalt chrome alloy as femoral substitute components are the most common materials widely used in knee replacement applications. Wear mechanism effect on UHMWPE material is the leading factor that causes failure of this application. In this study, the effect of loading in creating wear product of the die drawn GUR 1120 UHMWPE which was rubbed against nitrogen based-ion implantation on cobalt chrome alloy was investigated using Pin on Plate Unidirectional Reciprocating Movement wear test that employed 25% bovine serum and 75% distillate water as lubricant. The die drawn UHMWPE pin was loaded by 353 N and 462 N of force resulted in 9MPa and 12MPa contact pressure with constant friction velocity of 116.5 mm/s.

After the test application, there was significant difference of wear factor subsequent to the loading process with a total of 35 Km covered distance and average gait length 25 mm. From the 353 N loaded forces there was 1.075 mm³ of wear product volume created and average wear factor observed was 4.4 × 10⁻⁸, while in the 462 N forces application there had been no wear product volume and wear factor resulted during the observation. The result of this study demonstrated that greater load produce lesser wear factor of the die drawn UHMWPE.

Key word: wear factor, load, contact pressure, die drawn UHMWPE, cobalt chrome alloy, nitrogen ion implantation, pin on plate.
THE INFLUENCE OF LUBRICATION ON WEAR MECHANISM OF THE DIE DRAWN ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE (UHMWPE) IN KNEE REPLACEMENT APPLICATION

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Polymerized material (UHMWPE) is commonly used as a bearing cushion, with titanium alloy, austenitic stainless steel, ceramic and cobalt chrome alloy employed for the tibiae and femoral components in knee replacement applications. As a biomaterial product these substances must comprise a wear resistance capacity. This study was conducted to observe the wear mechanism of the die drawn UHMWPE which was rubbed against nitrogen based-ion implantation on cobalt chrome alloy, by irradiation at 100 Kev for 90 minutes and employment of bovine serum in various concentration as a lubricant.

The wear mechanism was tested with the application of bovine calf serum pre conditioned as synovial fluids in human knee. The experiment was tested with a Pin on Plate Unidirectional Reciprocating Movement subsequently as mentioned: the 'A' lubricant is a serum with protein concentration of 19.3 g/L (serum added with distillate water), the 'B' lubricant is a serum with protein concentration of 30 g/L (with supplementation of Sodium Chloride in the distillate water). The load applied for the experiment was 180 N with 116.5 mm/s gait velocity, average gait length 25 mm and total of 35 Km distance covered.

In this study the influence of bovine serum lubrication with the resulted wear mechanism of die drawn UHMWPE GUR 1120 coupled with nitrogen based-ion implantation on cobalt chrome alloy showed that protein concentration augmentation would reduce the wear factor up to 300%. This value was derived by increasing protein concentration of the lubricant (from 19.3 gr/L to 30 gr/L) which altered the wear factor from 5.12x10^-7 mm^3/Nm to 1.71x10^-7 m^3/Nm respectively.

Key word: UHMWPE, Cobalt Chrome Alloy, Implantation of N2 ion, Bovine serum, Synovial fluids

IMPROVED WEAR RESPONSE Mg-stabilized ZrO2 in KNEE SIMULATOR

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Introduction: Suggestions for improved wear performance of total knee replacements have included replacement of standard CoCr femoral components with ceramic. Yttria-stabilized zirconia (y-TZP) was introduced as high-strength and high toughness ceramic as an alternative to alumina ceramic. Since the introduction of zirconia in 1985, the clinical outcomes and successes for hip joint have been controversial. Y-TZP ceramics have been studied both experimentally and clinically. Magnesia-stabilized zirconia (Mg-PSZ) also appears promising for total knee replacements (TKR).

Method: Mg-ZrO2 and CoCr femoral condyles were compared in the Vanguard™ knee configuration (Biomet Inc, IN). Molded tibial inserts (GUR1050) were gamma-irradiation sterilization to 3.2-Mrad under argon. Knee simulation was conducted on a 6 station simulator (Shore Western Manufacturing, Monrovia, CA). Motion included 20 degrees of flexion/extension, 5 degrees of internal/external rotation and 5mm of AP-translation. All knee components were subjected to 3 million cycles of normal walking (2.9 kN max, freq 1.4 Hz). Lubricant was 50% alfa-calf serum diluted to 20mg/ml protein and using EDTA additive. Test duration was 6 million cycles (6-Mc), and wear was measured by weight-loss techniques.

Results: For wear trending of CoCr/PE and MGZ/PE, linear wear trends were apparent from 1 to 6 Mc test duration. The control implants (CoCr /PE) showed excellent linear trending (regression coeff r > 0.99) with wears rate averaging 6.3 mm^3/Mc. These data showed good control of experimental variance (<10%). The ZrO2 / PE combination showed good linear trending (r > 0.86) with wear rate averaging only 0.8 mm/Mc. This set also showed good control of experimental variance (<15%). The MGZ/PE wear was 8-fold reduced from that of CoCr/PE.

Discussion: The laboratory knee wear simulation appeared very supportive of femoral condyles of Mg-stabilized zirconia. Such implants may provide excellent performance for active patients who may risk high wear rates over many years of use.
NEED AND PERSPECTIVE IN SPINE NAVIGATION

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Following orthopaedic reconstruction and cranial neurosurgery, spine surgery is now entering its low invasive period. When, in 90’s, computer went routinely available in the surgical field, the main goal was to help surgeons operate on with more accuracy some difficult but standard procedures. The surgery was “computer aided”. The displayed tools on 2D or 3D images allowed surgeons to avoid permanent intra operative landmarks. Once patient personal anatomy was capture into the machine and the tools calibrated, the surgeon was able to plan and optimised ideal trajectories without direct vision to check tools position. “Navigation” starts to be more obvious to describe this intra operative control.

Anyway, we still needed large exposure to get the full bone surface in order to build a 3D surface based model. This model optically localised was matched using rigid or elastic algorithm with preoperative CT scan model or bone morphing. Ultrasound recognition of the soft tissue/bone interface let think about trans cutaneous palpation.

However, automatic segmentation of the bone surface never lead to commercially available soft. Only X-ray is commonly use during surgery to help surgeon to see tools and bone without surgical exposure. Fluoroscopy allows percutaneous trajectory as iliosacral screwing, vertebroplasty, fracture nailing et caetera. Radiation exposition could therefore be an issue for patient but also for surgeon. Fluoronavigation is a good response to percutaneous surgery. In spine no transversal view could be available. Surgeons should make mental reconstruction of the volume to perform the right trajectory. Industrial proposed intra operative tomography on C-arm with 3D reconstruction. It works well for limbs, but in thoracic and lumbar spine the large amount of surrounding soft tissues leads to low quality images. Flat panel X-ray receptor are a path to get more accurate images. Other perspectives are circular intra CT scan. The cost and the volume of machines stops the spread of such device.

Robots are used by knee surgeons but abandoned by hip surgeons. In spine tool holder robot are available in order to place a pedicular drill guide. Matching with bone is based on fluoroscopy. Spine navigation could be useful to e-learning and simulators too. The training of percutaneous surgery is long, because of mental matching between fluoroscopic 2D projections and the vertebra volume. We need a simulator allowing 3D virtual trajectory checked on AP and lateral view to short the learning curve.
SILICON NITRIDE: A NEW MATERIAL FOR SPINAL IMPLANTS


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Introduction: Implantable grade silicon nitride, like MC²™ from Amedica, is an attractive alternative to the commonly used titanium and PEEK (polyetheretherketone) materials used today for spinal and orthopedic applications. Extensive studies on the mechanical, tribological, and imaging characteristics of MC² have been conducted. As summarized in this paper, MC² silicon nitride intervertebral spacers have demonstrated superior strength, imaging compatibility, and have received US FDA clearance.

Materials and Methods:

Mechanical Testing: MC² intervertebral spacers, of 16x12x35mm size, were tested in static compression per ASTM Standard F2077-03, and for subsidence potential per ASTM F2267-04. All tests were conducted using an INSTRON 8874 Bi-Axial Servohydraulic Testing System (INSTRON, Norwood, MA).

Imaging Compatibility: Imaging compatibility of 11mm dia. x 7mm long cylindrical specimens of the MC² ceramic, PEEK, titanium and trabecular metal was compared under fluoroscopy, MRI and CT was noted. Fluoroscopic images of the spinal spacers, obtained under typical operative conditions, were compared. A cadaveric implantation of a silicon nitride total disc replacement implant was also conducted.

Results and Discussion: In static compression, the maximum compressive load to failure for the intervertebral implants was determined to be 289.87 kN. This can be compared to published values of compressive load to failure for human vertebral implants of ~ 8,000N. (White, Panjabi; Clinical Biomechanics of the spine, 1990). Subsidence testing per ASTM Standard F2267-04 indicated that the subsidence load (Kp) was 763.7 N/mm for the MC2 silicon nitride spacer, and about 853.1 N/mm for a PEEK spacer of identical design. This small difference indicates that material alone is not a predictor for subsidence potential.

The imaging comparison clearly indicates that Ti spacers or cages are visible under fluoroscopy but preclude visualization of the underlying bony tissue, while the PEEK spacers or cages were invisible, and generally require a heavy metal marker to enable surgeons to judge placement of the device in the spinal anatomy. The MC² silicon nitride spacer allowed accurate visualization of intra-operative placement as well as post operative visualization of the bony healing process. The superior strength, and resistance to subsidence of the MC² intervertebral spacer makes it an excellent, non-metallic ceramic for spinal implants. Key benefits for spinal applications include imaging compatibility allowing accurate verification implant placement and post operative monitoring of bony healing, and excellent bony apposition characteristics contributing to implant fixation and long term stability. Additionally, in a separate study, silicon nitride bearings designed for total hip arthroplasty have demonstrated improved mechanical, friction, and wear characteristics when compared to modern bearing materials (B. S. Bal, A. C. Khandkar, R. Lakshminarayanan., I.C. Clarke, A. A. Hoffman,., and M.N. Rahaman, J. Arthroplasty, in print, 2008). Thus, the versatility of the MC2 ceramic may enables its use in total disc replacements owing to its superior wear resistance.

Figure 1. compares the imaging characteristics of the MC² spacer against a titanium and PEEK spacer.

Figure 2. shows the imaging characteristics of the MC² total disc replacement with partially radiolucent keel and porous cancellous structured ceramic pocket.
Radiographic Morphometry of Lumbar Intervertebral Disc Space in Normal Korean

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Study Design: Radiographic measurement of the lumbar disc height

Objectives: To measure the lumbar disc height on radiographs in normal Korean.

Summary of Literature Review: Many reports show good results following procedures, such as inter-vertebral body fusion using cage or total disc replacement, that restore adequate disc height. However, there have been no references regarding the range of normal lumbar disc height in Korean adults which can be used as a standard for the implant size.

Materials and Methods: 132 subjects (age range 20 to 40 years) who had no previous history of low back pain and no significant finding on physical examination were enrolled. Plain lateral lumbar spine radiograph in supine position were taken. Intervertebral disc heights were measured at anterior, middle and posterior portion of each lumbar disc. The average magnification rate was 115%, and the disc heights were corrected by the magnification rate in each segment.

Results: Lumbar disc height showed cranio-caudal pattern in both male and female groups. L4-5 disc heights were highest at anterior, middle and posterior portion in male. L4-5 disc heights were highest at middle and posterior portion in female. L5-S1 disc height was highest at anterior portion in female, but there was no statistically significant difference between L4-5 and L5-S1 disc height at anterior portion. There was no significant difference in disc height between male and female except anterior portion of L1-2 and L2-3 disc. Statistically significant decrease in disc height was not presented in overweight person at all measured site in male and female except posterior portion of L1-2 disc in male.

Conclusion: This research is meaningful in that it is an attempt to provide a reference value of lumbar disc height in Korean adults, and the measured values may also be useful in manufacturing Korean modeled artificial lumbar disc prosthesis or surgical instruments for lumbar interbody fusion.

Key Words: Intervertebral disc, Radiography, Dimension
THE SIGNIFICANCE OF ANGULAR MISMATCHING BETWEEN VERTEBRAL ENDPLATE AND PROSTHETIC ENDPLATE

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Purposes: The prosthesis anchored to the vertebral body by a large central keel has inherent risk of angular mismatching between vertebral endplate and prosthesis endplate at large lordosis angle segment such as L5-S1. Theoretically, these angular mismatching can be considered to cause several problems such as segmental hyperlordosis, anterior positioning of upper prosthesis, posterior prosthetic edge subsidence, decreased ROM and poor clinical outcome.

The purpose of this study is to assess whether angular mismatching between vertebral endplate and prosthesis endplate in lumbar total disc replacement(L-TDR) with ProDisc-L influence on radiological and clinical outcomes.

Materials and Methods: We evaluated 64 levels of 56 patients who were implanted with ProDisc-L from 2002 to 2006. Prosthetic levels were 38 levels of L4-5, and 26 levels of L5-S1(8 patients had 2 level-operations of L4-5 and L5-S1). Mean follow-up was 25.6 (12-49) months.

Angle of mismatching between lower endplate of upper vertebral body and upper prosthetic plate, segmental flexion/extension ROM, segmental lordosis angle at extension, distance from the posterior wall of vertebral body to posterior prosthetic edge were measured in the radiographs. Clinically VAS and ODI were evaluated.

Results: Angular mismatching between upper vertebra and prosthesis of L4-5 and L5-S1 was 1.6° (range, 0-6°) and 5.6° (0-13°) (p<0.001) respectively, at final follow-up. Angular mismatching at immediate postoperative radiographs(2.3° in L4-5 and 4.9° in L5-S1) and at final follow-up was not significantly different(p=0.324 in L4-5, 0.620 in L5-S1). Mean segmental ROM of operated levels was 10.6° (4-22°) in L4-5 and 6.1° (2-13°) in L5-S1(p=0.001). Mean segmental ROM, mean segmental lordosis angle, and mean distance from posterior margin of vertebral body to posterior end of prosthesis in L5-S1 were 6.8° (4-13°), 12.8° (8-17°), 3.8mm (1-6mm) in cases with angular mismatching less than 10°, and 4.6° (2-7°), 21.3° (19-25°), 6.0mm (2-8mm) in that of 10° or more(p=0.024, <0.001, 0.039), respectively. In L4-5 angular mismatching of more than 5° were only 2 cases without statistical significance. Clinical outcomes, VAS and ODI, of L4-5 compared with that of L5-S1 and of angular mismatching less than 10° with that of 10° or more in L5-S1 did not have difference between them(p>0.05).

Conclusion: Angular mismatching between lower endplate of upper vertebra with upper prosthesis endplate is more common in L5-S1 than in L4-5. L-TDR at the most lordotic level, L5-S1, implantation of upper prosthesis with mismatched angle seems to be the causes of lessened segmental ROM, increased segmental lordosis, and anterior positioning of prosthesis.

Key Words: Lumbar total disc replacement, angular mismatching, positioning of artificial disc
BIOMECHANICAL INFLUENCE OF SEMI-CONSTRAINT AND UN-CONSTRAINT TYPE OF ARTIFICIAL DISC ON CERVICAL SPINE

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Spinal fusion has been used as the gold standard to treat some spinal disorders such as degenerative disc or disc herniation of the cervical spine. However, some clinical complications have been reported caused by high stiffness of spinal fusion. Recently, total disc arthroplasty using motion preservation devices such as artificial discs (ADs) have been proposed as an alternative treatment technique. In current study, we analysed biomechanical influences including inter-segmental motion, facet joint forces, and ligament stresses of two different clinical available ADs and compared with those of intact cervical spine in various loading conditions using finite element analysis.

A three dimensional finite element model was developed for C2-C7 spinal motion segment based on CT images and previous anatomical literatures. The finite element models for two different types of ADs, semi-constraint (Prodisc-C®, Synthes, U.S.A) and un-constraint (Mobi-C®, LDR Spine, U.S.A), were developed. Each AD was inserted at C6-C7 segments. Superior and inferior plates of ADs were fixed on inferior plane of C6 and superior plane of C7 vertebrae, respectively. Based on the conventional surgical techniques, anterior longitudinal ligaments and some parts of intervertebral disc in C6-C7 motion segment were removed to insert ADs. Inferior plane of C7 vertebra was constrained in all directions and 1Nm of flexion, extension, lateral bending and torsion were applied on superior plane of C2 vertebra with 50N of compressive load along follower load direction.

Rotation angle in flexion of C5-C6 segment in cases of semi-constraint and un-constraint AD was 3.3° and 3.7°, respectively. Both values were greater than that in case of the intact cervical spine by 18% and 32%, respectively. Rotation angle in extension, lateral bending and torsion were greater than intact model by 45%, 26% and 43% for the case of semi-constraint AD and 55%, 35%, 100% for the case of un-constraint one, respectively. In extension, facet joint forces were about two times higher than intact model in cases of semi-constraint and un-constraint AD. Also in flexion, on average, ligament stresses in cases of semi-constraint and un-constraint AD were higher than intact model by 66% and 116%, respectively.

The results of this study showed that ADs were useful to generate inter-segmental motion at surgical level. And the un-constraint type of AD had higher mobility than semi-constraint one. However, high mobility of ADs would lead not only higher facet joint forces but also ligament stresses than intact cervical spine. Therefore, more careful care must be taken to choose surgical method of total disc arthroplasty.
Comparison of radiographic changes after ACDF versus Bryan disc arthroplasty in single and bi-level cases

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Background: Cervical myelopathy and radiculopathy has been treated commonly with anterior cervical decompression and fusion with autologous bone graft and anterior cervical plating. Long term results have shown excellent pain relief and 73%-90% fusion rates. However, the development of late adjacent-level disease has been reported following anterior cervical arthrodensis which recently have been correlated to clinical findings. The Bryan disc arthroplasty device was developed to preserve the kinematics of the functional spine unit thus preventing adjacent level disease. There have been few studies comparing the incidence of adjacent level changes in patients undergoing ACDF compared to implantation of a Bryan disc arthroplasty device.

Objectives: The object of this study is to compare the clinical results and radiographic outcomes of anterior cervical decompression and fusion versus cervical disc displacement using the Bryan Cervical Disc Prosthesis (Medtronic Sofamor Danek, Memphis, TN) in terms of overall range of motion (ROM) of the cervical spine; ROM, anterior intervertebral height (AIH), posterior intervertebral height (PIH) and radiographic changes at the implanted and adjacent levels.

Methods: The study consisted of 105 patients with symptomatic single or two-level cervical disc disease. Fifty-one received the Bryan Cervical Artificial Disc Prosthesis (Medtronic Sofamor Danek, Memphis, TN). A total of 63 Bryan disc were placed in these 51 patients. A single-level procedure was performed in 39 patients and a two-level procedure in the other twelve. The patient group who underwent ACDF totaled 54 patients which consisted of 26 single level cases and 28 double level cases. The Bryan group had a mean follow-up 19 months (12-38). The mean follow-up for the ACDF group was 20 months (12-40 months). All patients were evaluated using static and dynamic cervical spine radiographs as well as MR imaging. All patients underwent anterior cervical discectomy followed by anterior cervical plating or implantation of the Bryan artificial disc prosthesis, done by one surgeon. Clinical evaluation included the visual analogue scale (VAS), and neck disability index (NDI). Radiographic evaluation included static and dynamic flexion-extension radiographs in an upright position using the computer software (Infinitt PiviewSTAR 5051) program. Range of motion/disc space angle and inter vertebral height were measured at the operative site and adjacent levels. Functional spinal unit (FSU) and overall sagittal alignment (C2-C7) were also measured pre-operatively, postoperatively and at final follow-up. ROM was calculated for all 3 areas and data collected were compared from pre operative to last follow-up as well as between the two groups. Radiographic assessment for adjacent level changes was also done. Radiologic change was analyzed using chi square test (95% confidence interval).

Results: There was clinical improvement within each group in terms of VAS and NDI scores from pre-op to final follow-up for both single (VAS : p=0.8371, NDI : p=0.2872) and double (VAS : p=0.2938, NDI : p=0.6753) level surgeries but not significantly between the two groups. Overall, ROM and intervertebral height was relatively well maintained during the follow-up in the Bryan group compared to ACDF. Comparing the pattern of ROM measurements from pre-op to final follow-up between the two arms regardless of the number of levels operated on, significant differences were noted for overall ROM of the cervical spine (p<.0001) and all other levels except at the upper level for single level surgeries (p=0.2872). In terms of inter vertebral height measurements from pre-op to final follow-up, statistically significant (p<0.0001 and p=0.0172) differences in the pattern between the two groups were noted at all levels except for the AIH of single level surgeries at the upper (p=0.1264) and lower (p=0.7598) levels as well as PIH for double level surgeries at the upper (p=0.8363) level. Radiologic change was 3.5 times more observed for the ACDF group compared to the Bryan group.

Conclusion: Clinical status of both groups, regardless of the number of levels, showed improvement. Although clinical outcomes between the two groups were not significantly different at final follow-up, radiographic parameters, namely ROM and intervertebral heights at the operated site, some adjacent levels as well as FSU and overall sagittal alignment of the cervical spine were relatively well maintained in our Bryan group compared to our ACDF group. We surmise that to a certain degree, the maintenance of these parameters could contribute to reduce development of adjacent level change. Noteworthy is that radiographic change was 3.5 times more observed for ACDF surgeries. A longer period of evaluation is needed, to see if all these radiographic changes will translate to symptomatic adjacent level disease.

Keywords: Bryan, arthroplasty, arthrodesis, adjacent level change
Purpose: Cervical arthroplasty is usually performed for the treatment of soft disc herniation, but not for spondylotic radiculopathy. To our knowledge, there has no study to investigate the clinical and radiological results of cervical arthroplasty for spondylotic radiculopathy. We therefore performed the current study to evaluate clinical and radiological results of cervical arthroplasty for spondylotic radiculopathy with severe narrowing of the intervertebral disc space.

Materials and Methods: Eight patients, who underwent anterior decompression, overdistraction, and implantation of artificial cervical disc for primary, single-level spondylotic radiculopathy with severe narrowing of the disc space (decrease more than 50% of adjacent disc spaces) were included in this study. Four were male and 4 were female with mean age of 49.5 years. The operation level was 7 C5-6 and 1 C6-7. Five Prodisc-C and 3 Prestige LP prostheses were implanted. The clinical and radiological evaluations were performed with minimum one year follow-up (range, 12 - 19 months) after surgery.

Results: VAS of the neck and arm pain improved (79.6 vs. 19.4 points, p < 0.01; 82.5 vs. 22.7 points, p < 0.01) at last follow-up, respectively. According to Odom’s criteria, satisfactory clinical outcome was achieved in 63% (5 out of 8, 3 excellent and 2 good) while fair result was achieved in 37% of the patients (3 out of 8). The disc space (3.0mm vs. 6.4mm, p < 0.01) and range of motion (1.4 vs. 6.3 degrees, p = 0.009) at the operated level increased, respectively. Overall sagittal alignment of the cervical spine was increased after surgery (5.2 vs. 11.3 degrees, p < 0.05). In 5 patients, segmental angle of the operated level was increased (0.2 vs. 5.3 degrees, p = 0.003) after surgery with maintained facet joint articulation overlap. However, in 3 patients, segmental angle of operated level became kyphotic from neutral (0 vs. -10.0 degrees, p = 0.295) with decreased facet joint articulation overlap.

Conclusions: Cervical arthroplasty provided favorable clinical and radiological outcomes in most of the patients with spondylotic radiculopathy and severe narrowing of the disc space at minimum one year follow-up after surgery. However, in some of the patients, postoperative segmental kyphosis developed and clinical outcomes were not satisfactory.
Heterotopic Ossification Following Cervical Total Disc Replacement

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Introduction: Anterior cervical discectomy and fusion (ACDF) has been standard treatment of operative modalities for cervical disc herniation and myelopathy. But since total disc replacement (TDR) introduced with early promising results and its ideal mechanism, it has become an alternative option. The theoretical advantages of TDR are the maintenance of intervertebral motion, prevention of adjacent segment degeneration and quicker return to routine activities. But recently varying degrees of heterotopic ossification (HO) have been reported around these devices. And there is some doubt that mobility of spinal segments may be restricted and clinical outcome worse if HO occurs after TDR.

Purpose of this study is to determine prevalence of HO in patients treated with TDR and to investigate whether HO results in loss of motion and negatively affects clinical outcome.

Material and method: We analyzed 30 levels, 29 patients who were treated with cervical TDR by 2 spine specialists using 4 types of prostheses (Mobi-C:13, ProDisc-C:10, Bryan :5, Prestige LP: 2 levels) consecutively from July 2004 to June 2007. Postoperative mean follow-up period was 21.4 (range, 12-36) months. We assessed occurrence of HO and all subjects were divided into 3 groups, which were group A (no HO, McAfee class 0), group B (class I and II), and group C (class III and IV). And radiological segmental ROM and clinical outcomes by VAS, ODI after 6 weeks, 3, 6 months, and every year postoperatively in principle, then compared with among each group.

Result: HO was detected on 14 levels (46.7%) in the 30 levels (29 patients) at an average of 8.2 (4-18) months after operation. There were 15 levels (53.3%) of group A (no HO, class 0), 7 levels of group B (class I-HO :3, II : 4 levels), and 7 levels of group C (class III : 3, IV : 4 levels). Segmental flexion-extension ROM of group A was 10.1 (5.6-16.2)°, group B is 8.3 (3.5-14.4)°, and C is 3.1 (0.0-6.6)° (p<0.001, multiple comparison test with post hoc Bonferroni correction). And no difference in the clinical outcomes, VAS and ODI, was found compared with each other among group A, B, and C (p>0.05).

Conclusion: The overall prevalence of HO following cervical disc replacement was 46.7% (14 levels in 29 levels), and HO was detected at an average of 8.2 months after cervical TDR. Segmental fusion occurred in 28.6% of patients in our study. Although segmental flexion-extension ROM was decreased in HO-occurred cases, clinical results were not affected by HO until an average of 21.4 months follow-up. Nonetheless, long term follow-up should be performed to investigate whether clinical outcomes would be changed and occur adjacent level degeneration as time goes on. In addition, further study for prevention of HO may be needed as HO in other joint replacement surgery in order to not lose superior mechanism to fusion treatment.

Key words: Heterotopic ossification, Total disc replacement, Clinical outcomes after total disc replacement
SAFTY AND ACCURACY ASPECTS OF ROBOTIC ASSISTED VERTEBROPLASTY: A NOVEL APPROACH TO THE TREATMENT OF VERTEBRAL COMPRESSION FRACTURES.

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Vertebral compression fractures can affect both sexes and constitute a major health care problem, due to negative impact on the patient’s function, quality of life and the costs to the health care system. Patients can be treated conservatively or by conventional fluoroscopic assisted vertebroplasty - injection of polymethylmethacrylate PMMA into the fractured vertebral body. Conventional vertebroplasty imposes technical challenges with possible complications including cement extravasations, nerve root compression, the possibility of breaching the walls of the pedicle by the osteoplasty needle and prolonged fluoroscopic radiation exposure of the surgeon and the medical team at large.

Methods: Retrospective comparative study of 20 cases of thoraco-lumbar vertebral compression fracture, treated with robotic assisted vertebroplasty (research group) versus 30 cases of fractures treated by conventional fluoroscopic vertebroplasty (compared group). All patients were diagnosed as suffering from acute vertebral compression fractures (up to 3 weeks from the traumatic event) and were scored 7 and above in the VAS.

Results: The mean overall operation time of the fluoroscopic assisted vertebroplasty was 35 minutes compared to a mean operation time of 45 minutes at the robotic assisted vertebroplasty. There was a significant difference in the fluoroscopic time and subsequent exposure time to radiation between the groups: in the research group we used only an average of 3 seconds of fluoroscopic exposure (an average of 5 fluoroscopic images) compared to an average of 7 seconds of exposure (an average of 12 fluoroscopic images). No difference was found between the groups in regard with overall admission time or with the time between the operation and physiotherapy.

Conclusions: Robotic assisted vertebroplasty is a new and safe approach aiming to shorten the duration of fluoroscopic exposure and radiogenic dose of the patient and surgeon. This novel procedure, promotes better accuracy with regard to the cement injected thus reducing the potential complication of the operation.
EFFECTIVENESS OF TRANEXAMIC ACID FOR REDUCING BLOOD LOSS IN TOTAL KNEE ARTHROPLASTY
- INTRAVENOUS ADMINISTRATION WITH DRAIN-CLAMPING METHOD -

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PURPOSE: The purpose of this study was to elucidate the hemostatic effects of tranexamic acid (TA) in patients undergoing total knee arthroplasty (TKA) in the different 3 methods.

SUBJECTS & METHODS: The subjects were 89 patients (10 males and 79 females; mean age 74 years old at op.) with TKA for osteoarthritic knee in our department between April 2006 and October 2007. Cemented prosthesis (NexGen LPS flex, Zimmer) had been used in all patients.

They were divided into three groups as follows; In Group A (n=39), intravenous administration of TA (1000 mg) at the time of 15 minutes before tourniquet release and drain-clamping method (DC; joint was filled with a total of 50 ml fluid which was consist of TA (1000 mg, 10 ml) and physiological saline of 40 ml just after surgery) were performed. This procedure was reported by Prof. Otani (Keio Univ., Tokyo, Japan) in 2005. In Group B (n=20), almost the same as Group A except for the way of DC; Joint was filled with a total of 50ml physiological saline alone without TA. In Group C (n=30), DC alone using physiological saline of 50 ml was employed without intravenous administration of TA.

Evaluation items were listed as below, amounts of, a) Intra-operative bleeding, b) Bleeding after 24 hours, c) Total bleeding (intra- and post-operatively), d) Changes in Hb levels between before surgery & 1 week after surgery.

Using these data in each item, statistical analysis was performed using Mann-Whitney U-test, P-value of <.05 was defined as significant.

RESULTS: No differences were observed in the amount of bleeding during the TKA. In contrast, bleeding at 24 hours after surgery and total amounts of bleeding were significantly lower in Group A (281 and 695ml, respectively) than those in Group B (337 and 868 ml, respectively) and those in Group C (650 and 1043ml, respectively) (p< .01). In addition, Hb levels were reduced at 1 week after surgery by 1.8 g/dl in Group A, as compared to 2.3 and 3.0g/dl in Groups B and C, respectively, demonstrating a significantly lower amount of reduction in Group A (p< .01).

DISCUSSIONS: The effect of TA for reducing blood loss in TKA has widely been recognized. In current study, the concomitant use of an intravenous administration and an infiltration into the joint (that is, DC) of TA significantly reduced blood loss during and after TKA. Furthermore, only in this group (Group A), allogenic blood transfusion could be avoided in all patients.

However, according to the previous articles, the use of TA was thought to have the possibility to increase the incidence of venous thrombo-embolic disease, such as deep venous thrombosis, cerebral infarction, pulmonary infarction and cardiac infarction. Even if TA had been used intra-operatively, such as an intravenous administration and an infiltration of TA, no complications had been noticed in our department. When we use TA in the post-operative course, careful attention should be paid to prevent these problems.

In the future, we have to seek the optimal conditions, volume and timing of administration of TA, in order to reduce blood loss during and after TKA.
PREOPERATIVE HBA1C IS A GOOD MARKER FOR PREDICTING WOUND COMPLICATIONS AFTER TKA IN DIABETICS

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Purpose: Wound complication including superficial infection is a concern after total knee arthroplasties (TKA) in diabetics. However, influence of glycoregulation before TKA has not been investigated in relationship to wound healing. Our hypothesis was that glycated hemoglobin (HbA1C), since it reflects long-term regulation of blood glucose, might be associated with incidence of wound complications after TKA in diabetic patients.

Materials and Methods: We retrospectively reviewed 167 TKAs performed in 115 patients with diabetes mellitus between January 2001 and March 2007. All patients were diagnosed as type II DM and osteoarthritis. A wound complication was defined as a hematoma, bulla, drainage or superficial infection. Stepwise multivariate logistic regression was used to identify which variables had a significant effect on the risk of wound complications. Variables considered were age, gender, body mass index, histories of previous knee surgery, comorbidities, duration of diabetes, the methods of diabetes treatment, complications of diabetes, preoperative HbA1c level, operation time, antibiotics-impregnated cement use, the amount of blood transfusion, and postoperative blood glucose level.

Results: The overall incidence of wound complications was 6.6% (n=11) including superficial infection in 1.8% (n=3), hematoma or bullae in 3.6% (n=6), and drainage in 1.8% (n=3). There were seven cases (4.2%) of deep infection. A multivariate logistic regression revealed that independent risk factors for the development of wound complications were preoperative HbA1C $\geq$ 8% (odds ratio 6.074, 95% confidence interval 1.119-32.971) and operation time (odds ratio 1.013, 95% confidence interval 1.000-1.026).

Conclusion: Poorly controlled hyperglycemia before surgery may increase the incidence of wound complications among diabetic patients receiving total knee arthroplasties. The correlation of glycemic control and wound complications may assist in the preoperative evaluation and selection of time for surgery.

Preventing Lateral Skin Numbness after Knee Arthroplasty

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As a result of lateral skin numbness that quite commonly occurs after knee joint operation, injury of the Infrapatellar branch of Saphenous nerve is often underestimated and regarded as a trivial complications. However, there are many complaints and worries from the patients in relation to the injury of this nerve never seems to stop.

The authors wanted to report the results of preserving this nerve during the unicompartmental knee arthroplasty for preventing lateral skin numbness.

The targets of this study were 100 cases of the unicompartmental knee arthroplasty by a single surgeon. All of the cases were medial compartmental osteoarthritis and in which a minimally invasive technique was used, with the average follow up of two years and eight months (range 24 to 42 months). The results were recorded in terms of classification of the nerve by location, preservation after surgery, sensory changes of the lateral skin flap, and complications. The classification by the location of this nerve was observed as either Mochida Type I with 76 people (76%), Type II with 16 people (16%), and unclassified types with eight people(8%). In Type I, this nerve was saved in 62 cases (82%). However in Type II, it could not be preserved in any cases because of the surgical procedure. The results of our study showed that while most of the nerve (76%) on average had a distance of 9.13mm (range 2 to 19mm) from the medial joint line to the nerve and passed inferiorly. This results allowed us to predict ahead of the location of this nerve and careful incision during the operation can preserve this nerve.

The authors discovered in cases of unicompartmental knee arthroplasty, the nerve can be easily preserved, as 62 people(82%) of type I had this nerve completely preserved. Even if five extra minutes is necessary in order to preserve this nerve, when we think of the patient’s satisfaction it is thought of as a meaningful procedure.
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Calcium Phosphate Paste for Treatment of Infected TKA and BHP

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Infection is one of major problems in Total Knee Arthroplasty (TKA) or Bipolar Head Prosthesis (BHP). We have used Calcium Phosphate Paste (CPP) for treatment of infected TKA and BHP, and followed up for minimum one year. CPP is a mixture of alpha Tri-Calcium Phosphate, Tetra-Calcium Phosphate, Calcium Hydrogen Phosphate and Hydroxyapatite. CPP harden in 10 minutes and its stiffness increases to maximum in 3days.

Infected TKA were diagnosed in four osteoarthritis and four rheumatoid arthritis knees , and BHP infection were observed in two femoral neck fracture cases from 2001 to 2007. Two were male and eight were female, average age were 67.3 years old ranged 39 to 80. Follow-up period were one to 7 years. Six cases were MRSA infection, three MSSA, one was unidentified but diagnosed with clinical data. In TKA cases, CPP (10-12g) with vancomycin hydrochloride or tobramycin were filled on the back side of PMMA articulated surface spacers, and in BHP cases, CPP with antibiotics were filled in acetabulum. In all TKA cases, infection ceased in 2 to 4 month and revision TKA ware performed. One recurrence of infection was observed during follow up in BHP infection, and nine patients can walk with/without a cane. No VTE were observed

CPP filled in the space between articulated spacer and bone is gradually crashed and can release antibiotics during walking and ROM exercise. CPP with antibiotics is useful for the treatment after infected TKA and BHP.

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METAL BLOCK AUGMENTATION FOR TIBIAL BONE DEFECT IN PRIMARY TOTAL KNEE ARTHROPLASTY

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Uncontained peripheral bone defect in postero-medial tibial plateau is not an infrequent problem even in primary total knee arthroplasty, especially in Korean patients some of whom have large angular deformities preoperatively. We reviewed the clinical and radiological results of primary total knee replacements of 33 osteoarthritic knees in 28 patients with the use of metal block augmentation for uncontained peripheral tibial bone defects more than 5 millimeters in depth and more than a quarter of medial tibial plateau in width.. Those defects were encountered in 75 knees (9.6%) during 779 primary total knee arthroplasties performed by single surgeon between January 2002 and December 2004 at our center. Modular metal block augmentation was reserved for 42 knees (56%), while the other knees were managed with bone-grafting or cement-filling techniques. Clinical and radiological follow-up more than 12 months were available from 33(78.6%) of 42 knees.

At a mean of 32.2 months (range:12~75 months), 31 knees (93.9%) except two cases of failure were evaluated as good or excellent. The average pre-operative American Knee Society Knee and Function scores were 32.5 and 38.6 respectively, which increased to 82.9 and 79.8 respectively at the latest follow-up. There were no radiolucent lines (RLLs) beneath the metallic block or tibial tray, which were progressive or more than 2 millimeters on radiographs, in those knees. Revisions were required for one case of delayed infection and another case of aseptic loosening of tibial component. Non-progressive RLLs less than 2 millimeters at the cement-bone interface beneath the metallic block were noted in 10 (32.3%) of 31 knees. The RLLs appeared in 5 (41.7%) of 12 knees with metallic block augmentation alone and 5 (26.3%) of 19 knees which had been treated with the use of additional intramedullary stem augmentation, although this difference was not statistically significant. Since these radiolucent lines were not progressive or symptomatic at all, their clinical meanings or long-term consequences are not determined yet. All knees managed with the additional intramedullary stem augmentation revealed to have radiopaque lines adjacent to the stem on follow-up radiographs. The sclerotic halo around the tip of stem could be interpreted as evidence of the stem’s function in load sharing and might reflect secure fixation of tibial tray to bony interface.

We concluded that the use of modular metal block augmentation devices for peripheral tibial defects measuring more than 5 millimeters could provide a simple, rapid and dependable technique that provides predictable results. The observation that all knees managed with additional intramedullary stem augmentation would have sclerotic halo adjacent to the stem on follow-up radiographs may reflect an intramedullary stem is an important adjunct to bone defect management.
Effect of Stem Design and Methods of Fixation on Stem Tip Pain in Revision Total Knee Arthroplasty - A biomechanical study -

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Introduction: The use of stem provides consistent component alignment with immediate stable fixation and protect grafted bone by reducing stress on metaphyseal area in revision total knee arthroplasty. One of major concern with use of stems involves stem tip pain in cementless diaphyseal engaging stem. The purpose of this study is to evaluate the effect of stem design and method of fixation on stem tip pain in revision total knee arthroplasty by finite element analysis.

Materials and Methods: 3D finite element model of normal tibia was reconstructed from CT scan images of 26 year old male and the CAD model of revision total knee arthroplasty was developed using commercial software(CATIA, Dassault system, USA, version 8.20). The tibia component models were assembled based on conventional surgical procedure. The design changes of stem such as the length, diameter and slot was performed and methods of fixation including press fit and coefficient of friction was considered. The contact pressure and von-Mises stress around the stem and the micromotion at the interface were evaluated for a 2000N of external load by finite element analysis to investigate the effect of stem design and methods of fixation on stem tip pain.

Results: The longer length and larger diameter press fit stem significantly increase the contact pressure & stress at the end of stem. The distal slot reduces the contact pressure & stress at the end of stem. Less displacement between tibial component and bone was noted in the increased coefficient of friction.

Conclusion: It would be better to avoid using press fit stem with extended length and larger diameter in revision total knee arthroplasty. More flexibility of stem tip would be favorable because of less concentration of stress. Stem fixation with higher coefficient of friction would be recommended for less displacement of tibial component. Stem with shorter length enough to engage proximal diaphysis, closer diameter of proximal canal and minimal press fit could be accepted to reduce stem tip pain if patient’s surgical anatomy such as bone loss and quality is tolerable in revision total knee arthroplasty.

Key words: Revision total knee arthroplasty, Stem tip pain, Biomechanics

Changes of Thickness of Tibial Polyethylene Insert in Revisional TKA

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Purpose of Study: To investigate the amount and the factors of changes of the thickness of tibial polyethylene insert in revisional TKA compare to original thickness of primary TKA

Materials and Methods: One hundred and twenty cases of wear, loosening and instability were included in this study. Infection cases were excluded. The period between the primary TKA and revision TKA was 88.5 months(7.4 years) in average(range: 1year to 17 year 3 months). The amount of increase of the tibial polyethylene thickness according to the main cause of failure and the wear site was analysed.

Results:
1. The increased thickness was 6.7 mm in average.
2. The amount of increase in case of wear of anterior portion only was 2.3 mm, which was below the average.
3. The loosening cases showed 8.2 mm increase in average which was significantly greater than the average.
4. The cases of greater wear of medial side than lateral side showed 8.5 mm increase of the thickness which was significantly greater than the average.
5. The cases of only medial side wear showed 5.5 mm increase of the thickness, which was below the average.
6. The cases of the other causes such as patellar component wear, generalised wear, wear of posterior portion only, early wear less than 5 years after primary TKA because of flat polyethylene surface showed comparable amount of wear to the average.

Conclusion: The polyethylene thickness of revision knee always increased compare to that of primary TKA, which was variable according to the cause of failure.

The thickness of tibial polyethylene insert in revisional TKA compare to original thickness of primary TKA showed that it increased 6.7mm in average and was variable according to the cause of failure.
Abstract book for ISTA 2008

**OSB21-05**

**The Causes of Revision TKRA**

Je-Ho Woo

**Purpose:** To assess the causes of revision total knee arthroplasty (TKA).

**Materials and Methods:** We analyzed the causes of 113 revision total knee arthroplasties in 84 patients between December 1996 and June 2008. Patient history, medical record, and radiographs were reviewed to detect the main cause of failure of primary TKA.

**Results:** The causes of revision TKA were as follows: 44 infections (38.9%), 34 loosening (30.1%), 22 polyethylene wears or breakages (19.5%), 5 stiffness (4.4%), 4 polyethylene dislocations (3.5%), 2 patellar dislocations (1.8%), 1 patellar component failure and 1 instability (0.9%, each). The mean interval from the index operation to the revision surgery was 59 months (1 month-20 years).

**Conclusions:** Infection was the most common causes of revision TKA and followed by loosening, wear or breakage of polyethylene, stiff knee, dislocation of polyethylene and so on.

**Key words:** Knee, Revision arthroplasty, Causes.

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**CAUSES OF EARLY ASEPTIC FAILURES IN TKA**

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**Introduction:** To analyze the mechanism of failure and basic cause in cases of early failure which required revision within 5 years of their index total knee arthroplasty.

**Materials & Methods:** Between 1991 and 2006, 167 revision TKA of aseptic failure were performed. Revision diagnosis or reason for failure were categorized as wear of tibial polyethylene insert, failure of tibial base plate, early imbalance between medial and lateral soft tissue, tight or loose PCL and posterior capsule. The percentages of each failure category were calculated as a percentage of the overall number of revision TKA and a percentage of the early failures. A descriptive statistics were calculated for the time in situ for each failure category.

**Results:** Early failure within 5 years following index TKA occurred in 33 out of 167 TKA (20.0%). Average time in situ was 38.53 months (3.21 years).

Wear of the tibial polyethylene insert occurred in 12 out of 33 cases (36.4%). All cases showed tight PCL. Loosening was the second leading cause occurring in 9 cases (27.2%). Pure instability with tight MCL occurred in 3 knees. Catastrophic early wear within one year after index surgery occurred in 18 knees.

The cause of failure were flat surfaced poly in 11, fracture of metal tray 2, dislocation of the thick poly insert 1 and early poly wear due to unknown cause 4.

**Conclusion:** There were multiple factors of the early failure, which could be divided into design failure and surgical skill failure. However, they worked together in most of the cases.
OSB21-06

Treatment of Infected TKA using a Novel Technique for Intraoperative Construction of Antibiotic Spacers

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The author developed a novel technique was for intraoperatively creating an antibiotic spacer for two-stage treatment of infected total knee replacements. An intraoperative mold is made from the removed components and that mold used to create antibiotic spacers with surface contours similar to those of the original total knee replacement. The spacers restore leg length and knee stability. This allows limited function during the interval before reimplantation of the new total knee replacement.

The clinical results of 22 consecutive patients using this technique with minimum of 2 years follow-up appears to be at least equal or better than the previous reports. It is a cost effective and convenient technique for creating a suitably shaped and sized cement spacer for two-stage revision total knee replacement after infection.

OSB21-07

Arthrodesis of the knee with a Huckstep nail after a failed infected total knee arthroplasty

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Purpose: To introduce our surgical technique and report the clinical results of the knee arthrodesis with a Huckstep nail after a failed infected TKA

Materials and Methods: We retrospectively reviewed four patients who underwent knee arthrodesis with a Huckstep nail after failed infected total knee arthroplasty. The average age of the patients at the time of the arthrodesis was 73 years (range: 70-79 years) and the mean number of previous surgical procedures was 3.2 (range: 3-4 procedures). All patients had medical problems including diabetes mellitus and hypertension. We performed local bone graft in all cases. The duration of average follow-up was 20.2 months (range: 12-36 months).

Results: Bone union was achieved within 1 year after arthrodesis radiologically. There was neither displacement of nail nor loosening. The average limb-length discrepancy was 3cm, measured clinically. All patients had a discrepancy that was corrected with a shoe-lift.

Conclusion: Arthrodesis with a Huckstep nail after failed infected total knee arthroplasty provides immediate axial and rotational stability and allows weight-bearing without use of external support.
**Poster [HIP]_01. THA Research**

**PH01-01**

**Quality of life in patients undergoing total hip replacement after fracture neck of femur - Indian scenario**

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**Introduction:** The treatment algorithms for femoral neck fractures in elderly keep changing constantly and are still controversial because of increasing stress on improving the quality of life in elderly population and associated osteoporosis. Orthopedic surgeons have almost agreed to the advantages of arthroplasty over fixation in improving the outcome in elderly population, but differences still persist as to type of arthroplasty. Options include unipolar, bipolar or total hip arthroplasty. The objective of present study is to compare the outcome of bipolar and total hip arthroplasty in fracture neck femur in Indian elderly population.

**Materials and Methods:** A retrospective analysis was performed for comparing the quality of life index in 60 patients over the age of 55 years who underwent bipolar hemiarthroplasty (30 patients) or total hip arthroplasty (30 patients).

The follow up period ranged from 3 months to 3 years. Patients were interviewed by an independent observer by questionnaires based on Harris Hip score and Hospital for special surgery score performas and were examined clinically. The results were analyzed using unpaired T-test.

**Results:** Though the average period of stay for total hip arthroplasty group was significantly longer but it did not affect the quality of life after 3 months. Patients undergoing total hip replacement were found to be doing significantly better with regards to muscle power, range of motion and function as assessed by unpaired t test (p < 0.05), but no statistical significant differences were found as far as pain and walking scores were concerned.

**Conclusion:** Total hip replacement provides a better quality of life to elderly patient with femoral neck fractures compared with bipolar hemiarthroplasty. Though prospective studies with larger sample size and longer follow up are needed to make a definitive statement but the trends should be noted

**Level of Evidence:** Therapeutic Level IV  
**Key Words:** Fracture neck femur, elderly, total hip replacement, bipolar hemiarthroplasty

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**Poster [HIP]_01. THA Research**

**PH01-02**

**Novel Tissue Engineering Technology for the Treatment of Large Osteonecrotic Lesion of Femoral Head**

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**Background:** Preservation of the femoral head with large, lateral-located osteonecrotic lesions is challenging. We introduce novel tissue engineering technique to regenerate the bone for these challenging cases.

**Materials:** Ten milliliters of bone marrow was aspirated from iliac crest and mononuclear cells were collected. These cells were expanded and differentiated to osteoblasts using the osteogenic media and autologous serum for 2-4 weeks ex vivo. Porous bead-form scaffolds were made of calcium metaphosphate (CMP) and cells were seeded in a density of million/ml into 20 to 30 beads for 1 hour. The necrotic area was curetted and the beads were implanted through core tract in 9 hips of 7 patients (Steinberg IIc in 5 hips and IVc in 4 hips; Japanese Investigation Committee C1 in 4 hips, and C2 in 5 hips). The tract was blocked with a CMP rod. The age of the patients ranged from 16 to 37. Associated factors were; steroid in 4 hips, idiopathic in 3 hips, alcoholic in 1 hip, and traumatic in 1 hip. Kerboul combined necrotic angle was more than 200° in all hips (range: 200° to 380°). Minimum follow-up period was three years (range: 3 to 4 years)

**Results:** Two IIc lesions progressed to IVc; one with dome depression > 2mm and the other with < 2mm. One hip converted to THR. The other 7 hips did not progress radiographically. Follow-up radiographs showed evidence of partial regeneration of necrotic bone.

**Discussion:** Tissue engineering technique using the bone marrow stromal cell-expanded osteoblasts and CMP scaffold was very promising strategy for the treatment of large osteonecrotic lesions of femoral head.
A NATIONWIDE EPIDEMIOLOGIC AND CLINICAL ANALYSIS OF OSTEONECROSIS OF THE FEMORAL HEAD IN REPUBLIC OF KOREA

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This study was performed to elucidate the nationwide prevalence and clinico-epidemiological characteristics of osteonecrosis of femoral head in Republic of Korea. Among 133,189 patients who diagnosed as osteonecrosis of femoral head (ONFH) by any reason in database of national health insurance system in Korea from 2002 to 2006, three hundred and eighty-two samples were randomly extracted with 5% error range in 95% confidence interval. With a structured worksheet, medical records and radiographs of each sample were reviewed at corresponding clinic or hospital by one of the authors and trained orthopedic surgeons. With these data, we calculated the estimated annual prevalence and evaluated associated risk factors. The mean number of annual requests was 23,466. Among 382 samples, 274 were confirmed to have ONFH. Predicted diagnostic accuracy was 60.3% during 5 year interval. With this rate, we calculated mean annual predicted cases of ONFH during this period as 14,103. The prevalence was 28.91 patients per 100,000 populations. Alcohol abuse was noted in 45% and 22% was related to use of steroid. 37% showed bilateral involvement. Bone grafting procedures in any kind was the most frequently performed joint conservative procedure. With this, the first epidemiologic study for ONFH in Korea, we estimated nationwide annual prevalence of ONFH as 28.91 per 100,000 populations during 2002 and 2006. There is an absolute male predominance. Alcohol abuse is the most frequent risk factors. We believe that this result can serve as a baseline data for understanding the epidemiology, clinical characteristics and treatment of ONFH in our country.
SERUM SILVER LEVEL MONITORING IN RATS IMPLANTED THERMAL SPRAYED SILVER-CONTAINING HYDROXYAPATITE


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Surgical site infection related to orthopaedic implants is one of the serious complications. In the previous works, we developed a novel thermal spraying technology combined silver with hydroxyapatite (HA) in order to resolve such problems, and reported the property and antibacterial effect of them in vitro. However, no previous reports have investigated in vivo. Therefore, we monitored serum silver level in rats to clarify in vivo kinetics of silver released from the coating.

HA loaded with 3 wt % of silver oxide (HA-Ag) and plain HA powder were sprayed on surface of titanium disks (20 mm diameter \times 1 mm thick) by the flame spraying, which is a kind of thermal spraying method with acetylene torch. All these test pieces were obtained from Japan Medical Materials Corporation (JMM, Osaka, Japan). Both samples were implanted singly into the back subcutaneous pockets of male Sprague-Dawley rats (150-200g). Rats were housed individually and given ad libitum access to food and water. After 24 h, 48 h, 7 d, 14 d and 28 d, the rats were sacrificed, and then the blood was drawn from common iliac vein. All procedures were operated under anesthesia. These blood samples were spun down and serum silver levels were measured by an inductively coupled plasma mass spectrometry.

The average serum silver level in HA-Ag group had increased to more than 40 ppb until 48 h after implantation, and then decreased rapidly to normal level. There were significant differences (p < 0.05) between HA-Ag and HA group, at each measurement period.

This study provides novel and important information on in vivo release-property for HA-Ag coating, and suggests this coating is effective against not late but rather early infection related to orthopaedic implants.
**Poster (HIP)_01. THA Research**

### TOTAL JOINT REPLACEMENT CLINICAL OUTCOMES: GENDER DIFFERENCES

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**Purpose:** Medical research has classically been based on the male model, this is no different in the design of arthroplasty implants. Focus has recently shifted to gender-specific implant design but evidence is just developing in the literature as to gender specific outcomes. We hypothesised that outcomes in arthroplasty patients are affected by gender.

**Methods:** Patients were retrospectively identified from a prospectively collected database of total joint arthroplasties performed at one center. Six surgeons performed 1123 primary unilateral cemented TKA’s, and 989 primary unilateral cementless THA’s over a period of seven years. General demographic data was collected along with preoperative and 1-year clinical outcomes including the Harris Hip/Knee Society Score and Oxford Hip/Knee scores. These were compared to determine differences, if any, between males and females using independent samples t-test.

**Results:** The TKA sample was comprised of 540 (55%) females and 449 (45%) males. The THA sample included 744 (66%) females and 379 (34%) males. In the TKA group, females were significantly younger, had higher BMI and had differing rates of comorbidities and complications. Female KSS, Oxford and ROM outcomes were significantly inferior to male scores preoperatively and at 1 year follow up. Significantly more females reported higher pain scores than males from pre-op to 1 year. Interestingly, females showed significantly more improvement from pre-op to 1 year in both scores. In the THR group there were varying rates of complications and comorbidities by gender. Females did significantly worse in the HHS and Oxford hip score from pre-op until one year when results equalized. Similarly pain scores were higher for females preop and at 6 weeks but became equivalent thereafter. Females showed significantly greater improvements from pre-op to 1 year in both outcome scores.

**Conclusion:** As reported in the literature, results of this study indicate that women choose TJR at a later stage of disease than men do, presenting with inferior functional status. The effect of waiting seems most marked in the knee arthroplasty population with inferior outcomes and pain relief persisting out to 1 year. Surgeons must counsel females differently about expectations and recovery in joint arthroplasty.

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**Poster (HIP)_01. THA Research**

### 3D reconstruction process of femur using 2D X-ray images

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Personalized three-dimensional (3D) femoral geometry is a great aid in the surgical planning. X-ray image is still essential to diagnose and plan surgery in total hip replacement due to its lower cost and lower dose of radiation than computer tomography (CT). The purpose of the current study is to improve 3D reconstruction process using conventional X-ray images incorporating the anatomical parameters for building up the femoral model. For 3D reconstruction, the personalized femoral appearance and parameters were firstly prepared from X-ray images and the referential CT model with anatomical parameters was modified as follows: the axial scaling, shearing transformation and radial scaling. In this study, the reconstruction algorithm was applied to X-ray images obtained from the 28 years old male. The current study showed that this 3D reconstruction technique is clinically useful and feasible because this method was based on anatomical parameters and used for whole femur. This result can provide the basic model of individual femur for using finite element method of hip or knee joint, and designing the customized hip and knee implant. In addition, this result can be applied to the visualized 3D model with more effective parameters of individual femur in the surgery navigation system.

**Key words:** 3D reconstruction, Femur, Anatomical parameters, Numerical method, X-ray images
INCORPORATION OF FIBRONECTIN WITH CALCIUM PHOSPHATE FILM FOR IMPROVING IMPLANT FIXATION

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The fixation of titanium or titanium alloy implants is related to their surface composition and topography. Osteoconductive calcium phosphate coatings promote bone healing and apposition, leading to the rapid biological fixation of implants. It’s no doubt that the addition of certain biologically active protein with biomaterial will improve the bioactivity of the material. Previously, we examined the biocompatibility basic fibroblast growth factor (bFGF) incorporation with titanium implants. Now we investigate the effect of fibronectin (FN) incorporation with thin calcium phosphate film deposited on titanium by electron-beam evaporation since fibronectin (FN) is actively involved in cell adhesion, spreading, wound healing, cytoskeletal reorganization, and bone tissue formation. A FN-apatite composite layer was formed on the surface of titanium by biomimetic process. The coating process was carried out by immersing thin calcium phosphate film coated Ti in Dulbecco’s Phosphate buffered saline containing FN (20 ng/ml). The surfaces of samples were examined with FESEM, Fourier transform infrared spectroscopy and X-ray diffraction. The quantity of FN taken up and the kinetics of protein release were monitored by BCA method and Elisa. The fibronectin was immobilized in the newly formed apatite layer. The adhesion of osteoblast cells to the FN-apatite composite layer was to show the biocompatibility of implants, and FN-apatite composite layer could enhance osseointegration of implants in vivo.

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Effects of surface nature and heat treatment on low temperature degradation of 3Y-TZP

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Alumina and zirconia have been extensively used for orthopedic implants, such as hip and knee joint replacements. In 1982, Dr Hironobu Oonishi and Kyocera Corp. put the world’s first ceramic knee component, KOM, to practical use. This ceramic knee component shows excellent clinical results for long-time use. Now, the ceramic material of the knee component is changed from the alumina to the zirconia, and over 5000 ceramic components have been used in Japan so far. The 3 mol% yttria stabilized polycrystalline zirconia (3Y-TZP) has been used as surgical grade zirconia. The 3Y-TZP possesses higher fracture strength and toughness as compared to monolithic alumina. However, it is generally known that spontaneous transformation may also occur at relatively low temperatures in hydrothermal environment as in the case of human body for the 3Y-TZP. Therefore, there is a concern of the degradation of mechanical and wear properties as a consequence of the transformation (low temperature degradation).

Our previous studies confirmed that low temperature degradation can be prevented by optimizing sintering temperature and adopting a Hot Isostatic Press process. In this study, we evaluated the effects of surface nature of ceramic material and heat treatment. Since grinding and polishing of the ceramic implants (e.g. femoral heads) might induce phase transformation, residual stress and microcracks, it is needed to examine the validity of the manufacturing process.

At first, the 3Y-TZP samples with grinded (#400) and mirror polished surfaces were prepared and exposed in saturated vapor in an autoclave at 121°C for 150 hours (aging test). Some of the samples were subjected to a heat treatment and then to aging test. After the aging test, change in crystal structure was evaluated by X-ray diffraction. Then, for evaluation of the aging effects for microscopic area of the ceramic, a Vickers indentation was introduced on the surface before the aging test. Changes in crystal structure and residual stress were evaluated by a Raman spectroscopic technique.

In the results of the aging test, it was found that the degree of the increase in monoclinic fraction of both grinded and polished surfaces was lower in the samples with heat treatment than in those without heat treatment. These results indicate that the phase stability of the 3Y-TZP was improved by the heat treatment after machining. Around the indentation, circular-like deformation zone and cracks extending from the four corners of the indentation were observed. After the aging test, the transformed area gradually spread towards neighborhood regions depending on the aging time. Besides, a distinct progress of phase transformation at around the crack was also observed. On the other hand, in the samples subjected to the heat treatment, no transformed area was observed around the indentation. These results suggest that low temperature degradation could be prevented by the heat treatment after the machining. The residual stress fields induced in phase-transformed areas increased during aging test, and heat treatment after the machining was also able to prevent phase transformation even if surface damages, such as indentation or machining, were introduced on the samples.
Relationship between Microstructure and Mechanical Behavior of Porous HA/PLLA Biocomposite Material

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Much attention has recently been paid to bioabsorbable polymeric materials, such as poly(L-lactic acid) (PLLA), in the field of orthopedics and oral surgery. For example, PLLA has extensively been used as resorbable bone fixation devices. Recently, hydroxyapatite (HA) micro-particles filled PLLA has also been developed to improve the bioactivity, elastic modulus and absorption rate of biomedical PLLA devices. Porous structures of PLLA and HA/PLLA composites have also been developed to improve osseous conduction so that these biomaterials can be used as scaffolds in tissue engineering for regenerative medicine. Such porous materials may also be utilized as artificial bones in orthopedics. Thus, demand for porous PLLA and HA/PLLA is rapidly increasing, however, the relationships between their mechanical behavior and properties and their microstructure have not been well understood yet.

In the present study, porous structures of PLLA and HA/PLLA with continuous pores are developed by using a solid-liquid phase separation technique and a subsequent solvent sublimation process. Size of pores and porosity are varied by changing the concentration of the solutions. Compression and shear tests are performed to evaluate the elastic moduli and strengths. Field emission scanning electron microscopy (FE-SEM) of the deformation behavior at the critical transformation points from linear elastic to nonlinear deformation is conducted to characterize the mechanism of such microscopic deformation at the critical point. Microscopic deformation and failure behavior of such porous structures are then characterized on the basis of FE-SEM results, and then correlated with the macroscopic mechanical properties. Structural modification is also tried to improve the mechanical properties to extend the applicability of the porous biomaterials.

The 5 Year Follow-up Use of a Tantalum Trabecular Metal System for Early Stage of Osteonecrosis of the Femoral Head

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To evaluate the effectiveness of core decompression using the tantalum trabecular metal system for treatment of an early stage osteonecrosis of femoral head in minimum 1 year to maximum 5 years follow-up.

From January 2003 to August 2007, 36 patients in 46 cases underwent core decompression using the tantalum trabecular metal system. The ARCO classification system was used. Retrospective analysis was done. The conversion to total hip arthroplasty due to aggravating hip pain was defined as a clinical failure.

With the higher stage of ARCO classification and more lateral location of lesion, the conversions to total hip arthroplasty would be increased. The better outcome was noted with lower stage of ARCO classification and more medial location of the lesion.

The higher stage of ARCO classification and more lateral position of lesion, the failure rate of the tantalum trabecular metal system increases. The most important thing is to detect early stage of osteonecrosis of femoral head. The tantalum trabecular metal system is considered as a useful treatment of osteonecrosis of femoral head with lower stage of ARCO classification and medial location of lesion.
Review of performance and problems of Metasul Hip System

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We report the review of performance and problems of Metasul Hip System with metallic sliding face during mean time of 11 years or longer.

Subjects and methods: Twenty-three joints in 22 patients (17 females and 5 males) treated using cementless Metasul THA in our hospital from November of 1995 to April of 1998 were selected as subjects. The mean age at the time of surgery was 59 years, and disease included degenerative hip disease in 16 joints, femoral head necrosis in 5 joints, and rheumatoid arthritis in 2 joints. Mean follow-up period was 11 years and 3 months. We have investigated clinical results (JOA score), stem fixation by radiography (Engh), setting angle of socket, and presence or absence of osteolysis by CT, and the poor cases after surgery and problems were clarified.

Results: Clinical results (JOA score) were improved from preoperative mean of 41.3 points to mean of 89.3 points at the time of investigation. Stem fixation examination by radiography (Engh) for bone ingrown resulted in 95% in ingrown and 5% in ingrown suspension, showing excellent fixation. The abduction angle of the socket was 38.8 ± 4.5 degrees, and the anteverision angle was 14.6 ± 7.7 degrees, revealing that precise surgery was conducted. There were no joints which showed loosening in stem or socket, but CT imaging showed osteolysis in 5 joints (22%) in the stem side and 12 joints (52%) in the acetabular side. Dislocation in Poly Liner occurred in 4 cases which needed revision surgery with accumulated survival rate of 82.6%.

(Summary) When cementless Metasul Hip System was used, fixation of stem/metal shell was excellent, but there were problems in thickness and fixation of Poly Liner. Due to augmentation of activity, backside wear occurred, and osteolysis or dislocation of the liner was induced. THA System such as M2a which improves these defects using metallic liner may be promising hereafter.

Micro Arc Oxidized (MAO) Titanium Alloy to Enhance Biocompatibility

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The aim of this research was to characterize micro arc oxidized titanium (MAO-Ti), accompanied by biocompatibility test in vivo as well as in vitro in comparison to the different types of surface modification, machined, blasted and plasma spray. XRD and SEM investigations were performed in order to assess the structure and morphology. Biologic and morphologic responses to the osteoblast cell lines (Saos-2) were then examined, using Promega proliferation assay, alkaline phosphatase activity, αvβ3 integrin expression and cytoskeleton staining (Rhodamine-Phalloidin). The analysis of gene expression for osteocalcin and collagen I was done through RT-PCR. In addition, differential histologic evaluation and interfacial strength at the bone-implant interfaces were then evaluated in the distal femur of 4 beagle dogs. In summary, MAO-Ti appears to exhibit more favorable biocompatibility than the compared groups in vitro and in vivo as well.

Keywords: Micro Arc Oxidized (MAO), Biocompatibility, Titanium Alloy
IN VIVO STUDY OF SQUEAKING FREQUENCIES IN CERAMIC-ON-CERAMIC THR. COMPARISON WITH IN VITRO VALUES

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Introduction: The goal of the study was to compare the squeaking frequencies of Ceramic-on-Ceramic THR in-vitro and in-vivo among patients who underwent THR.

Method: Four patients, who underwent THR with a Ceramic-on-Ceramic THR (Trident™, Stryker®) presented a squeaking noise. The noise was recorded and analysed with acoustic software (FMaster®). In-vitro 2 alumina ceramic (Biolox Forte Ceramtec®) 32 mm diameter (Ceramconcept®) components were tested using a PROSIM™ hip friction simulator. The cup was positioned with a 70° abduction angle in order to achieve edge loading conditions and the head was articulated ±10° at 1 Hz with a load of 2.5kN for a duration of 300 cycles. Tests were conducted under lubricated conditions with 25% bovine serum and with the addition of a 3rd body alumina ceramic particle (200 µm thickness and 2 mm length).

Results: In-vivo, recordings had a dominant frequency ranging between 2.2 and 2.4 kHz. In-vitro no squeaking occurred under edge loading conditions. However, with the addition of an alumina ceramic 3rd body particle in the contact region squeaking was obtained at the beginning of the tests and stopped after ~20 seconds (dominant frequency 2.6 kHz).

Discussion and Conclusion: Squeaking noises of a similar frequency were recorded in-vitro and in-vivo. In-vitro noises followed edge loading and 3rd body particles and despite, the severe conditions, squeaking was intermittent and difficult to reproduce. The lower frequency of squeaking recorded in-vivo, demonstrates a potential damping effect of the soft tissues. No damage was observed on the components, however, the test duration was very short. Squeaking may be related to third body particles that could be generated by wear or impingement between the femoral neck and the metal back. Cup design seems to be of particular importance in noisy hip, leading to a high variability of squeaking rate according to the implants.

THE EFFECT OF VITAMIN E ON THE WEAR RESISTANCE OF HIGHLY CROSSLINKED POLYETHYLENE

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Ultra-high molecular weight polyethylene (UHMWPE) has been successfully used as a bearing material in total joint arthroplasty. However, longevity of these implants has been compromised by wear and fatigue damage of the polyethylene. The addition of vitamin E to the polyethylene is a process recently introduced in the market to stabilize free radicals produced during radiation crosslinking. The objective of the present study is to investigate the effect of the addition of vitamin E on the wear characteristics of UHMWPE. Sequentially crosslinked and annealed UHMWPE material (X3™, Stryker Orthopaedics, Mahwah, NJ) was used as a control. Trident™ acetabular cups (Stryker Orthopaedics, Mahwah, NJ) with inner diameters of 36mm and 44mm and a wall thickness of 3.8mm were tested on a 12 station MTS hip joint simulator. The simulator used a physiologic loading pattern with a maximum load of 2450N. The test was conducted under standard clean conditions with alpha calf fraction serum diluted to a protein concentration of 20 g/l for a total of 3 million cycles. All cups ran against CoCr femoral heads, and gravimetric measurements were taken every 500,000 cycles. Results show that sequentially crosslinked components, size 36mm, had an average volume loss of 9.4 ± 2.5 mm³, while vitamin E components of the same size had an average of 16.5 ± 3.1 mm³. This represents a 75% increase for vitamin E components that is statistically significant (p = 0.039). Size 44mm sequentially crosslinked components had an average volume loss of 6.8 ± 3.7 mm³, while vitamin E components had an average of 19.7 ± 3.2 mm³. This denotes a statistically significant increase of 192% for material with vitamin E (p = 0.011). Linear regression analysis yielded wear rates of 4.1 ± 0.9 mm/mc and 6.1 ± 1.3 mm/mc for size 36mm sequentially crosslinked and vitamin E components, respectively, which represents a non-significant increase of 49% for vitamin E components. Size 44mm sequentially crosslinked components had a wear rate of 3.8 ± 1.3mm/mc, while vitamin E components had a wear rate of 8.1 ± 0.7 mm/mc. This represents a statistically significant increase of 117% in wear rate for vitamin E components (p = 0.013). The results of this testing indicate that the addition of vitamin E degrades wear performance relative to sequentially crosslinked material. Research shows that the introduction of Vitamin E affects the ability to create crosslinks during irradiation by reacting with some of the free radicals. Oral et al have shown that the crosslink density decreases when Vitamin E is blended into UHMWPE. Their research has also shown that a decrease in crosslink density causes an increase in wear rate. The results of the current testing show that the addition of vitamin E to polyethylene reduces the wear resistance of highly crosslinked polyethylene.
EFFECTS OF ROUNDNESS AND ROUGHNESS OF ALUMINA CERAMIC HEAD ON WEAR PROPERTIES FOR LONG-TERM CLINICAL USE

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Aseptic loosening induced by wear debris of PE is the most common cause of long-term total hip arthroplasty failure. In the previous studies, we reported that the protruding contour and surface morphology of metallic femoral head brought an increase of PE wear. Alumina ceramics is advantageous (neutral shape and smooth surface) for precision machining compared with metal materials, because hardness of ceramics is higher than that of metal materials. In this study, we measured the roundness and the roughness of retrieved alumina ceramic and metallic heads, aiming to evaluate the change of surface morphology of those heads in vivo.

Fourteen retrieved alumina ceramic femoral heads (Kyocera Corp., currently Japan Medical Materials Corp.) were examined: ten femoral heads were made of small grain-size alumina ceramic (SG-alumina; mean grain size is 3.4 μm) with a diameter of 28 mm, with clinical use for 16-28 years (mean 22 years) and four femoral head was made of extra-small-grain size alumina ceramic (XSG-alumina; mean grain size is 1.3 μm) with a diameter of 26 mm, with clinical use for 14-19 years (mean 16 years). Six retrieved metallic femoral heads with average clinical use for 12-28 years (mean 18 years) were examined: a diameter of from 22 to 32 mm (e.g., Zimmer Inc., Stryker Corp.) The roundness of the retrieved femoral heads was measured by a contour tracer. The surface roughness in the contact area and the non-contact area of the retrieved femoral heads was measured by a surface roughness tester.

Out-of-roundness of SG-alumina and XSG-alumina heads was 0.15 μm and 0.19 μm, respectively. In contrast, that of metal heads was 2.43 μm, and the profiles were in wide distortion compared with both alumina heads. The surface roughness was 0.012 μm in the contact area, and 0.009 μm in the non-contact area of retrieved SG-alumina heads. The surface roughness in the contact area, 0.007 μm, of XSG-alumina was slightly higher than that in the non-contact area, 0.003 μm, and the both area of XSG-alumina represent lower value than SG-alumina, with all alumina heads having a reentrant surface profile. In contrast, the surface roughness of metallic heads was in a range of 0.003-0.053 μm and several heads showed the protrusion surface profile. In this retrieval study, the roundness and the roughness of both alumina ceramic femoral heads after long-term clinical use were low and stable compared with metallic heads. And also, the surface roughness increased in the order of XSG-alumina < SG-alumina < metallic head. The alumina ceramic femoral head showed the reentrant surface whereas the metallic head showed the protruding surface. When third-body wear occurs during the clinical use, generally reentrant form may occur on the ceramic surface whereas protrusion form may occur on the metallic surface. We have good clinical results more than 20 years using the SG-alumina, and clinical results for a long term will be expected with XSG-alumina of improved microstructure.
**Poster (HIP)_03. Bearing Surface**

**PH03-05**

**Mid-term performance of 3rd generation ceramic on ceramic total hip arthroplasty**

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**Purpose:** To analyse clinical and radiological results of total hip arthroplasty using 3rd generation ceramic on ceramic articular surface.

**Materials and Methods:** Between July 1999 and May 2005, 339 hips of 250 patients had primary cementless total hip arthroplasty with 3rd generation ceramic on ceramic bearing implants. And 325 hips of 236 patients were able to be followed up over 3 years. Male were 168 patients(237 hips) and female were 68 patients(88 hips). The mean age at the time of operation was 47.3(range, 25~76) years old and the mean follow up period was 62.4(range, 36~107.6) months. The preoperative diagnoses were ONFH in 250 hips, secondary osteoarthritis in 55 hips(dysplasia in 35, infection sequelae in 12, LCP in 2, CDH in 2), hemophilic arthropathy in 9 hips, ankylosing spondylitis in 7 hips etc.

We used Bicontact system(Aesculap, Germany) in 65 hips, Secure-Fit™(Stryker Howmedica Osteonics, U.S.A) in 206 hips, Trilogy AB™(Zimmer, U.S.A) in 54 hips. Clinically, Harris Hip Score, thigh pain, squeaking and other complications were evaluated. Radiologically, the serial radiographs were analysed.

**Results:** Clinically, the Harris hip score was improved from preoperative 66.0(19~91) to 96.2(58~100) at the last follow-up. Radiologically, there was no loosening of implants and visible wear and osteolysis. Heterotopic ossifications were noted in 5 cases. In complications, there was dislocation in one case, periprosthetic fracture in 2 cases and thigh pain in 9 cases. Intermittent squeaking sound has occurred in 8 cases(2.5%). Among these, one case of loud squeaking which happened after fall down had revision surgery. There was no infection and fracture of ceramic implant.

**Conclusions:** Our midterm results of THA with 3rd generation ceramic bearing system were very satisfactory and demonstrated that 3rd generation ceramic bearings remain as an excellent bearing choice because of their superior wear characteristics. However, the results of this study suggests that the squeaking would be one of strong potential risk factors for failure of ceramic on ceramic total hip arthroplasty and we must be very cautious to prevent squeaking.

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**Poster (HIP)_04. Design & Biomechanics**

**PH04-01**

**Design Considerations and Results for a Modular Neck in Cemented THA**

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**Introduction:** Cemented stems are still widely used in THA; however, there remain concerns with hip dislocation and wear debris. Restoring joint mechanics is essential for soft tissue balance and reduction of mechanical impingement. These concerns have lead to the development of a modular neck for cemented THA.

**Material and methods:** 200 R-120™ cemented stems were implanted in 190 patients since 2001. The shape of the stem is trapezoidal with a large collar that provides for impaction and compression of the cement. The stem collar is made with a cavity where a self-locking taper and a positive indexing mechanism provide 12 different positions to ensure proper restoration of joint mechanics.

One to five years follow up with a mean of 2.8 years. Two-thirds were female and one- third male. Age ranged from 39 to 87 with a mean of 73. Majority was treated for OA. A c.c. head (28mm or 32mm) and poly bearing in a cementless cup were used for all patients. Selection of neck position was recorded for all patients.

**Results:** 635 of all head-neck positions were other than neutral. There were 0 dislocations, no significant leg length discrepancies (+/- 5mm), and 0 infections. There was one stem removed due to a post-op peri-prosthetic fracture at 3 years that was treated with a long cementless stem. 1 death due to a PE ten days post-op. 1 intra-operative calcar fracture wired and healed uneventfully. 1 intra-op greater trochanter fracture that was treated with screws. 2 neck fractures revised to cementless stems.

**Conclusions:** Modular neck design aids in fine tuning joint mechanics after stem insertion, and allows for ease and access in case of revisions. This modular neck design has eliminated (to date) hip dislocations and we remain optimistic about its long-term potential to improve outcomes. Fatigue properties have been significantly improved and no additional neck fractures have occurred.
SELF CENTERING MECHANISM IN BIPOLAR ENDOPROSTHESIS - IS IT EFFECTIVE

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Introduction: Bipolar hip arthroplasty was separately introduced by Bateman and Giliberty in 1974 as an alternative to Moore and Thomson’s unipolar devices, in order to alleviate the associated problems of hip pain, acetabular protrusion and femoral stem loosening. Geometric configuration of first generation bipolar endoprosthesis used to cause varus fixation of outer head which led to the unacceptably high incidence of dislocation, component disassembly and fractures of the polyethylene bearing insert. Second generation endoprosthesis with a self centering mechanism were introduced to overcome these problems. This new design incorporates a polar offset by setting the center of rotation of the inner head proximal to the center of rotation of the outer head, which generates a valgus producing moment at the outer cup. There is a controversy whether this mechanism works in vivo, more so in indigenous prosthesis.

Objectives: 1. To study whether the self centering mechanism of bipolar endoprosthesis is effective in vivo 2. to study the differential motion of bipolar endoprosthesis in weight bearing position and in supine position.

Materials and Methods: A retrospective observational study was done on 37 subjects which included 21 males and 16 females. The first radiograph was taken with the patient standing and bearing full weight over the endoprosthetic leg and abducting the contralateral limb as much as possible. The second radiograph was taken with the patient standing neutral and bearing weight on both the legs. Abduction and adduction views were then taken in supine position. The radiographs were analyzed using the method similar to that of Drinker and Murray. The adductive motion from abduction to neutral position is within the range of inner bearing oscillation. Modified Harris Hip Score performs was used to evaluate the patients clinically. Results were analyzed using Wilcoxon Matched-Pairs Signed-Ranks Test, Students t-test and Karl Pearson correlation statistics.

Results: The mean outer head alignment changed from 42.46 degrees ± 13.62 (range 10 to 72 degrees) to 31.93 degrees ± 10.59 (range 8 to 50 degrees) in moving from abduction to neutral position in weight bearing position. The analysis showed that 68.66% of the total motion occurred at the outer bearing in weight bearing position whereas 73.86% of the total motion occurred at the outer bearing in supine position. The difference between distribution of motion between supine and weight bearing position was not found to be statistically different using Wilcoxon Matched-Pairs Signed-Ranks Test (p = 0.3164) and unpaired students t test (p = 0.35). No correlation was found between weight of the patient and time of follow up with outer head alignment and differential distribution of motion.

Conclusion: Self centering mechanism of bipolar endoprosthesis works in vivo under physiological loads and aligns the cup in neutral or valgus position till an average follow up of 10 months. Though the motion occurs at both the bearing surfaces outer bearing motion clearly predominated in both weight bearing as well as supine position.

Level of Evidence: Therapeutic Level IV

Key words: Bipolar, Self Centering mechanism, component motion
**RESTORATION OF FEMORAL OFFSET IN TOTAL HIP ARTHROPLASTY: IS IT POSSIBLE?**

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Femoral off-set is the perpendicular distance between femur longitudinal axle and the femoral head's rotation's centre. Femoral off-set influences following yardsticks: stability of the joint, ROM, muscular forcefulness, solicitations on the femoral component and acetabular component's usury. From numerous radiographies studies, is shown as off-set is not an indefeasible measure, but an average with a range of variability. Offset is one of the most important yardsticks to consider during the pre-operating planning since, as is broadly documented, it has a positive effect on the functionality of the prosthesis; difficulty remains to individualize the optimal offset value in patient with bilateral coxofemoral pathology or carriers of opposite side total hip prosthesis. Modular necks act independently in three spatial variables allowing to reach 27 points in the space, disposing of heads with 3 lenghts the real disponibility become of 81 points.

Usually we estimate the sizes and the orientation of the components manually and through a radiographic intra-operative control in order to choose the best match head-neck.

If we make a minimum mistake in cup position, the use of modular necks allow to correct this failure to obtain the most correct anatomic position producing negligible debris and the reduction of the mechanic stress.

Basing on our experience we think that the possibility to change length and version independently and sequentially is the unique technique avaible to correct the implant's orientation, even if in our series we have choose neutral neck in most cases. To obtain better functional outcome we are studying a device based on gait analysis and superficial electromyography to calculate pre and post operative off-set. The data that we have achieved are still too few to be able to produce results; if there is possible, presenting them in future editions.

**SHORT TERM OUTCOME OF CEMENTLESS STEM WITH LATERAL FLARE FOR ELDERLY FEMORAL NECK FRACTURES**

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**Background:** Elderly femoral neck fractures are often treated with cemented stems according to the reason that bone quality of the patients is not good enough to obtain the initial stability for supporting press fit cementless stem. Some elderly patients also have medullary expanding so called stovepipe canals which make initial stability of press fit stems difficult. Stems with lateral flare have some mechanical advantages to obtain proximal fixation compare to the straight stems without lateral flare. Concerning to initial stability, their vertical loads can be supported not only by proximal medial cortex but also by proximal lateral cortex. The stems also have rotational stability because of the proximal high fit and fill. As lateral flare is a transverse extension in axial section, the stem occupies the proximal canal widely. So it provides strong rototational stability.

The purpose of this study was to evaluate the outcome of press fit cementless stem with lateral flare for elderly femoral neck fractures with poor bone quality and with medullary expanding, and discuss validity of lateral flare stem for elderly osteoporotic bone patients.

**Materials and Methods:** We performed a retrospective review of the clinical records and radiographies of consecutive 42 patients (42 hips) of femoral neck fracture operated with cementless stems with lateral flare in 2005 and 2006. In this period, all displaced femoral neck fractures were operated using cementless stems with lateral flare ( Revelation, Encore ) in our hospital. We could follow 24 patients for over one year. 12 of 24 patients had so called stovepipe canals according to Canal Flare Index<3.0 (Noble et al). Minimum follow up duration was one year. The mean age of the patients at the time of operation was 78.2 years. The mean duration of follow-up was 1 year and three month. At the time of final follow-up, stem subsidence, stem fixation, spot welds and demarcation line at distal part of stem are assessed on radiograph. And operation time, blood loss at operation and complaint of thigh pain through all the follow up period are also investigated on clinical record.

**Results:** There was no stem subsidence over 2mm and demarcation line in two cases. All stems were assessed bone-grown fixation. We could find at least one spot welds in all patients around porous coated part of the stem. The mean operation time was 60.1 min and mean blood loss was 240.5 ml. There was no patient who complaints of thigh pain after operation.

**Conclusions:** Cementless stems with lateral flare were proved to obtain good initial stem fixation for elderly femoral neck fracture patients even they have poor bone quality and medullary expanding.
APPROPRIATE COMBINED ANTEVERSION FOR PATIENTS WITH EXCESSIVE ANTEVERTED OR RETROVERTED FEMURS IN TOTAL HIP ARTHROPLASTY AND THE UTILITY OF THE CHANGEABLE NECK

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Purpose: Combined anteversion (CA) is defined as the sum of the anteversions of acetabular and femoral components. In this study, we determined the appropriate CA in a variety of femoral versions using a total hip arthroplasty model. In addition, we also examined the usefulness of a changeable neck to improve range of hip motion in these cases.

Methods: Using a THA model, the range of motion (ROM) was tested in various CA values obtained by changing the anteversion of a cup in six increments after setting the femoral anteversion to 20° or 60° anteversion and 20° retroversion. The angle of the changeable neck was changed in 11 increments of 5°. To evaluate stability, the range of internal rotation at 90° flexion, the external rotation at 90° extension, and the range flexion was measured when any impingement occurred prior to dislocation. We defined the required ROM that met 40° internal rotation, 30° external rotation, and 110° flexion.

Results: In normal 20° anteversion group, the required ROM was achieved with CA between 30° and 50° without using any changeable necks. In excessive anteversion 60° group, the range of external rotation was less than 10° even when the acetabular component was set 10° retroverted, because of the bone impingement between the greater trochanter and the posterior acetabulum. When 25° retroverted changeable neck was used, ROM improved to 30° external rotation and satisfied the required ROM. In 20° retroversion group, the internal rotation angle was 31° even when the acetabular component was opened 35° anteverted, because of anterior neck-liner impingement. When 25° anteverted changeable neck was used, ROM improved to 39° internal rotation and 130° flexion.

Conclusion: In cases with normal anteversions, the required ROM can be achieved by adjusting CA. In cases with excessive anteversion or retroversion, there was a limitation of the CA adjustment. The use of changeable necks allows for further improvement of ROM by compensating femoral anteversions.
PH04-06

FINITE ELEMENT ANALYSIS OF BUFFERED IMPLANT FIXATION IN COMPARISON WITH CURRENT IMPLANT FIXATIONS

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The cemented and cementless implant fixations are popular in orthopaedic arthroplasty. However, these implant fixations have some problems such as cement failure, wear debris, stress shielding, revision and so on. To overcome these problems, we are developing a new concept of buffered implant fixation which uses a bone-friendly buffer between the implant and the bone. In this study, we performed a finite element analysis to evaluate the buffered implant fixation in comparison with cemented and cementless implant fixations in mechanical aspects. In addition, we investigated the effect of buffer taper angle to the stress distribution in the buffered implant fixation. Three-dimensional FEA of the cemented, cementless and buffered fixation were performed using the ABAQUS program. In these FEA, the ‘standardized femur’, which is the composite femur model supplied by Pacific Research Lab., was used as the bone model and the CPT stem and the Versys Fibermetal Midcoat stem were modeled for the cemented fixation and the cementless fixation, respectively. These three-dimensional models were meshed using the tetrahedral elements with 4 nodes (C3D4) and the additional contact definitions. The buffered implant fixation is similar with the polished cemented fixation except the material between the implant and the bone. The PEEK was selected as the buffer material. Also, several taper angles of buffer were simulated to change the stress distributions in the buffered fixation. The external load three times of mean body weight (74.3 kg) was cyclically loaded at the femoral head with the angle of 20° in adduction and 6° in flexion while the distal end of femur was fixed. In the buffered implant fixation, the taper-locked effects were observed. The buffered fixation had greater cyclic compression for the bone compared to the cemented fixation. Also, the failure probability of the buffer in the buffered fixation was less than that of the cement in the cemented fixation. The risk factors in the buffer were 0.148 for the tension and 0.176 for the compression while, the risk factors of cement in the polished cemented implant fixation were over than 1. Moreover, the buffered fixation had widely distributed compression compared to the cementless fixation and the stress distribution could be modified easily to change the taper angle of buffer. The FEA results showed that the buffered implant fixation would provide an appropriate mechanical environment.

PH05-01

Artificial femoral head replacement compared with DHS internal fixation of aged Patients with intertrochanteric fractures
-A Metaphase, Prospective, Randomized Study

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Objective: The purpose of this investigation was to Prospective compare the results of artificial femoral head replacement with those of treatment with a DHS internal fixation for unstable intertrochanteric fractures in elderly patients.

Methods: Sixty-one cases of aged patients with intertrochanteric fractures were randomized into two treatment groups. All patients were followed for a minimum of four years from 9.1999 to 4.2003, 29 patients were treated with artificial femoral head replacement, the other were treated with DHS internal fixation. The clinical results of two ways for the treatment of aged patients with intertrochanteric fractures were observed.

Results: There were no significant differences between the groups in terms of functional outcomes, blood loss, or units of blood transfused. Patients treated with artificial femoral head replacement had a shorter hospital stay and operative time, less time to weight-bearing, fewer general complications, and lower mortality rate compared with those treated with the DHS internal fixation.

Conclusion: In elderly patients with an unstable intertrochanteric femoral fracture, a artificial femoral head replacement provides superior clinical outcomes but no advantage with regard to functional outcome when compared with a DHS internal fixation.
Operative strategy and rehabilitation in the management of patient with ankylosed hip joints caused by late ankylosing spondylitis

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[Abstract]Objective: To investigate the effect of bilateral total hip replacement for patients with ankylosed hip joints caused by late ankylosing spondylitis (AS) and to discuss its related pre- and post-operation rehabilitation problems.

Methods: Data of 20 patients with ankylosed hip joints caused by late AS undergone total hip replacement (40 hips) were reviewed, among the total 14 patients (28 hips) undergone bilateral total hip replacement, other 6 patients (12 hips) underwent twice operation through assessment of the joint pain, range of motion and Harris score to make sure the curative effect of the Operative strategy

Results: The mean duration of follow-up was 3.8 years, all hip joints function was improved, and the flexion deformity of the involved hips were disappeared. The range of hip flexion were 75° to 105° (average 86.2°), and the range of hip extension were 5° to 15° (average 8.7°), the average Harris score was from 32.8 score pre-operation improved to 88.2 score post-operation, the patients experienced no pain on their hips, the pain of the knee and the lower back complained before the treatment were obviously relieved.

Conclusion: Bilateral total hip replacement is an effective treatment for ankylosed hip joint caused by late ankylosing spondylitis, early rehabilitation intervention is useful for the functional recovery of the joints.

Bipolar Hemiarthroplasty Using Non-cemented Femoral Stem in Non-traumatic Osteonecrosis of the Femoral Head - Nine to Nineteen years Follow-up -

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The purpose of this study is to evaluate the clinical and radiographic results of 20 patients (27 hips) who underwent primary bipolar hemiarthroplasty with non-cemented femoral stem and biarticular cup from January 1989 to April 1999 who were followed for more than nine years. Average follow up was 13.4 years (range : 9~19 years). The type of non-cemented femoral stem was Harris-Galante type in ten hips, Multilock porous coated stem in seven hips, and Multilock porous and tricalcium phosphate coated stem in ten hips.

The etiology of osteonecrosis of the femoral head was idiopathic in eleven hips, alcohol abuse in twelve hips and steroid administration in four hips. According to Ficat’s grading system, all twenty-seven hips were in stage I. Clinically, we evaluated the Harris Hip scores. We also evaluated the radiographic measurements around the femoral stems and the bipolar cups.

The average Harris Hip score improved from 57.2 points to 89 points; and 2(7.4%) hips were associated with thigh pain and 5(18.5%) hips with groin pain. Around the femoral stem there was progressive radiolucent line more than 1mm in width in 1(3.7%) hip, and osteolysis was present in 9(33.3%) hips. On evaluation of radiographs for stability of fixation, we found that 21hips(77.8%) showed osseous ingrowth, 11 hips(18.5%) showed stable fibrous ingrowth and another one hip showed unstable fixation. The osteolysis around the acetabulum was found in 9 hips (33.3%). Two hips showed evidence of migration of the bipolar cup. Five hips(18.5%) showed acetabular cartilage erosion more than 1mm. Seven hips(25.9%) required conversion to total hip arthroplasties, and in two hips, femoral stems were revised. The causes of failure of bipolar cup was central migration in 2 hips, and disassociation of femoral head, extensive osteolysis, and unknown groin pain after trauma in one each. Two bipolar cups were converted to acetabular cup at revision of the femoral stem. The overall failure rate of the primary operation was 26%. The survivorship of non-cemented femoral stem was 92.6% and 74% in bipolar cup at minimum 9 years follow up.

The current study demonstrated favorable results after bipolar hemiarthroplasties with non-cemented femoral stems. However, the osteolysis around the femoral stems and the acetabular cup emerged as main causes of need for surgical revision.

Key Words: Osteonecrosis, Non-cemented femoral stem, Bipolar hemiarthroplasty
LONG TERM RESULTS OF CEMENTLESS TOTAL HIP REPLACEMENT FOR REVERSAL OF HIP ANKYLOSIS

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Previously ankylosed or surgically arthrodesed hip joints can be converted successfully to a Total Hip Replacement (THR) in order to improve patient mobility and function. We present a long term prospective cohort study of cementless revisions of previously ankylosed hips.

Sixteen hips (15 patients) with a mean age of 52 years (range 16 to 75) had ankylosed hips for a mean of 36 years (range 3.5 to 65 years). They all received a cementless THR between August 1988 and January 2003 and were prospectively followed-up for a mean of 11 years (range 5.0 to 19 years). Two patients died during the study period of unrelated causes and none were lost to follow-up.

All patients showed improved mobility and function following the conversion of their ankylosed hips. The Harris Hip Score improved from a pre-operative mean value of 70 (Standard Error of Mean (SEM) 3.4) to a post-operative value of 83 (SEM 4.4) at the latest review, which was statistically significant (p < 0.05). There was one acetabular cup revision at 5 years post implantation for aseptic loosening. At a mean of 11 years post THR, all other femoral and acetabular components remained clinically and radiographically well fixed.

One patient with systemic ankylosing spondylitis and spontaneous bilateral bony hip ankylosis developed the unusual complication of Paget’s disease of the Left hemipelvis and proximal femur two years after successful bilateral THR surgery. His symptoms resolved following medical therapy for Paget’s disease.

We conclude that a previously ankylosed hip can be effectively converted to a cementless total hip replacement with good long term results.
UNCEMENTED TOTAL HIP ARTHROPLASTY WITH A METAPHYSEAL FEMORAL OSTEOTOMY FOR CROWE TYPE 3 OR 4 DEVELOPMENTAL DYSPLASIA OF THE HIPS WITH USE OF THE MODULAR S-ROM PROSTHESIS

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Objectives: Treating Crowe type 3 or 4 of hips tends to be technically difficult when performing total hip arthroplasty (THA) due to the severely dysplastic acetabulum and proximal femur in addition to a high dislocation of the hip. Since the socket is limited to being placed at the original hip center, a femoral shortening osteotomy is often required in order to prevent neurovascular problems. This osteotomy will need the stability of the femoral stem with both the proximal and the distal femoral bones. We used the modular S-ROM stem, which has a valuable proximal structure and a distal flute structure to stabilize the stem with the proximal and distal femoral fragments. The purpose of this study was to report the clinical and radiographic results of the primary THA with a shortening osteotomy while also using the S-ROM prosthesis.

Materials and Methods: Between 1994 and 2004, primary THA using the S-ROM prosthesis was performed on 7 hips in 6 cases (1 male, 5 females). Crowe type 3 or 4 was observed in one or 6 hips, respectively. The mean age at operation was 56 years old (range 51~60). The mean follow-up period was 41 months (range 24~56 months). Four hips had previously undergone a subtrochanteric valgus osteotomy. All of the hips underwent a step-cut femoral osteotomy at the proximal metaphysis for the shortening and/or correction of angulations with on-lay chip bone grafts. All of the used stems were straight type. The clinical outcome was evaluated using the clinical scoring system of hip joints established by the Japanese Orthopaedic Association (JOA). According to a 100 point scale, pain was determined to be 40, ROM was 20, gait was 20 and ADL was 20.

Results: No hips had undergone any revision surgery as of the most recent follow-up. Union was achieved at the osteotomy site in all hips. Neither osteolysis nor a loosening of the implant was radiographically observed. The mean JOA score before THA and at the last follow-up was 41 (31~48) and 81 (62~91) points, respectively. The mean postoperative days to start full weight bearing was 53 days (range 49~70). In two cases (28%), a procedure using circular wiring was performed to treat a crack in the proximal femur.

Conclusions: The S-ROM prosthesis was thus found to be useful for primary THA with a shortening metaphyseal femoral osteotomy for hips in patients with Crowe type 3 or 4 developmental dysplasia.
SECOND-GENERATION CEMENTLESS TOTAL HIP ARTHROPLASTY IN PATIENTS WITH OSTEONECROSIS OF THE FEMORAL HEAD

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Introduction: The rate of failure of primary THA in patients with osteonecrosis of the femoral head is higher than that in patients who undergo THA because of other diagnoses. We examined the results of cementless THA performed with second-generation in a consecutive series of young patients with osteonecrosis of the femoral head.

Materials & Methods: Sixty-five consecutive primary THAs with insertion of a femoral stem with a circumferential proximal porous coating (HG Multilock prosthesis) and a cementless acetabular component (Harris-Galante II) were performed in 52 patients with osteonecrosis of the femoral head. These patients were followed prospectively and evaluated at a minimum of 10 years after surgery. Four patients (4 hips) died and three patients (3 hips) were lost to follow-up monitoring. The remaining 45 patients (58 hips) had a mean of 11.1 years (range, 10 to 13.4 years) of clinical and radiographic follow-up.

Results: One stem (1.7%) was revised because of aseptic loosening. Eighteen cups (31%) were revised because of excessive polyethylene wear and osteolysis. One hip (1.7%) underwent revision of both acetabular and femoral component because of excessive polyethylene wear and osteolysis. The mean Harris Hip Score improved from 49 points before surgery to 92.8 points after surgery in patients who did not undergo reoperation. Osteolysis around the acetabular component was present in 22 hips (37.9%). Femoral osteolysis was seen in 9 hips (15.5%), and there was no osteolysis below the lesser trochanter in any hip.

Conclusion: Circumferentially porous-coated second-generation femoral prostheses provide excellent fixation in young patients with osteonecrosis of the femoral head. However, a high rate of polyethylene wear and osteolysis in these high-risk patients remains a challenging problem.
EFFICACY OF A NEW DEVICE FOR A SUBTROCHANTERIC OSTEOTOMY COMBINED WITH TOTAL HIP ARTHROPLASTY

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Introduction: In the case of a complete dislocated hip or a severe deformity of the proximal femur, total hip arthroplasty (THA) can still be combined with a proximal femoral osteotomy for shortening femur or correcting the deformity if needed. Subtrochanteric femoral shortening and a corrective osteotomy are considered to be an integral part of THA for such cases. A precise osteotomy is mandatory to achieve good results. Although, the freehand excision of V-shaped subtrochanteric osteotomy used to be performed frequently, this procedure was also subject to some pitfalls, such as poor coaptation of the osteotomy surface. A new device was thus developed to perform a V-shaped osteotomy in an identical central axis between the distal and proximal femur. The purpose of this study was to evaluate the efficacy of the device by comparing the perioperative results with those of a free-hand subtrochanteric osteotomy.

Materials and methods: From 1999 to 2002, THA combined with a double-chevron subtrochanteric osteotomy was performed by free hand (free hand group). From 2003 to 2007, THA combined with a double-chevron subtrochanteric osteotomy was performed using a new device (device group). The free hand group included 27 hips in 21 patients. The mean age of the patients (23 females and 3 males) at the time of the operation was 58 years. Fourteen were completely dislocated hips and 13 followed various proximal femoral osteotomies. The device group included 102 hips in 79 patients. The mean age of the patients (70 females and 9 males) at the time of the operation was 62 years. Seventy two were completely dislocated hips and 26 followed various proximal femoral osteotomies. Four parameters were used to evaluate the efficacy of the device: (1) operation time, (2) total blood loss, (3) C-reactive protein at postoperative 1 day and (4) early complications at the osteotomy site.

Results: The mean operation time, total blood loss, and C-reactive protein in the device group all significantly decreased in comparison to the free hand group. The decreases ranged from; 132 to 96 minutes (p<0.01), 1346 to 999 g (p<0.01), 4.9 to 3.0 mg/dl (p<0.05), respectively. Two types of complications were observed at the osteotomy site. Pseudoarthrosis at the osteotomy site was observed one case in each group and both of these cases underwent a stem revision (4% in the freehand group and 1% in the device group). A femoral shaft split was observed in 3 cases in the freehand group (11%) and 3 cases in the device group (3%) and all 6 cases were treated conservatively. There were no instances of nerve palsy, infections, or thromboembolic events resulting from these procedures.

Conclusions: The above described new device allowed for the easy and accurate performance of a subtrochanteric V-shaped osteotomy with THA for either a completely dislocated hip or a severely deformed proximal femur.
**UNCEMENTED ARTHROPLASTY FOR DYSPLASTIC OSTEOARTHRITIS WITH COXA PLANA AND RELATIVE OVERGROWTH OF THE GREATER TROCHANTER SECONDARY TO KALAMCHI & MACEWEN TYPE III OR IV DEFORMITY**

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**Introduction:** A special surgical technique and consideration is necessary in the total hip arthroplasty for dysplastic osteoarthritis after Kalamchi and MacEwen Type III or IV deformity (so called Perthes-like-deformity). There have been few reports concerning the total hip arthroplasty for Perthes-like-deformity. We evaluated the clinical and radiological outcome of 52 uncemented hip arthroplasties for the lesion.

**Material and Method:** We have performed 106 hips of uncemented total hip arthroplasty for dysplastic osteoarthritis after Kalamchi and MacEwen Type III or IV deformity. Among them, 52 hips of 47 patients (11 males and 41 females) were evaluated with minimum of three years follow-up. The average age at the surgery was 52 (28 to 65). The average follow-up period was 4.8 (3 to 8.1) years. Against the developmental dysplasia or dislocation, 29 hips of 26 patients had been treated by casting or surgery in infancy. Thirteen hips of 11 patients had no previous treatment before the arthroplasty. Spongiosa metal cup (GHE: ESKA implants, L beck, Germany) was used for 33 hips of 28 patients and Zweymüller type cup (Alloclassic cup: Zimmer Inc., Warsaw, IN, Bicon cup: Smith & Nephew Orthopedics AG, Rotkreuz, Switzerland) for 19 hips of 19 patients. Spongiosa Metal stem (GHE: ESKA implants) was used for 23 hips of 19 patients and Zweymuller type stem (Alloclassic stem: Zimmer Inc., SL stem: Smith & Nephew Orthopedics AG) for 29 hips of 28 patients. The average operative time was 108 (53 to 233) minutes. The average blood loss during the surgery was 731 (150 to 1749) milliliters. The adductor tendon release was added in 28 hips of 26 patients against the severe contracture. The patients were evaluated clinically (pre-surgical history, hip score, leg length discrepancy, Trendelenburg sign, and gait function) and radiologically (ATD before the surgery, alignment, and stability of implants). Average ATD before the surgery was -2.2 (-28 to 17) millimeters. The average leg length discrepancy was 1.9 (0 to 7) centimeters before the surgery and was improved to 0.1 (0 to 1) centimeters after the surgery. The average hip score was 54 (23 to 80) before the surgery and was improved to 90 (69 to 100) after the surgery. At the final follow-up, Trendelenburg sign was positive in 14 hips of 14 patients (26.9%) and the limping was not obvious in 38 hips of 33 patients (73.1%). All implants were stable at the final follow-up.

**Discussion:** Perthes-like-deformity often has the severe deformity. It has a shortening or an absence of the neck and an excessive antetorsion of the femur. When it has the coxa magna, the acetabulum is shallow, has the narrow anteroposterior diameter, and has the thin wall like the osteophyte. It is frequently accompanied by shortening of leg and contracture, as the lesion arises from the development disorders. Thus, the total hip arthroplasty, especially uncemented one, is complicated. However, the satisfactory result can be obtained by careful consideration and surgical procedure such as a provision against the bleeding and the soft tissue release.
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Treatment of Femoral neck fractures in Patients with Ischemic heart disease by Cemented hemiarthroplasty

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The use of polymethyl methacrylate in orthopaedic reconstructive surgery can increase the possibility of cardiovascular dysfunction remains a debate. This study was undertaken to determine if cemented hemiarthroplasty is safe in treatment of femoral neck fracture in patients with ischemic heart disease. Ischemic heart disease involves stable or unstable angina pectoris and myocardial infarction. Between 2000 and 2004, we performed cemented hemiarthroplasties for displaced femoral neck fractures on 158 consecutive patients. This retrospective study consisted of 44 patients with ischemic heart disease (group 1) or 58 patients of age matched control (group 2). Average age was 76.5 in group 1 and 76.4 in group 2. Average follow up period was 34.4 months. There were higher incidence of diabetes mellitus, hypertension or past episode of brain ischemia among patients in group 1 than in group 2. All patients in both groups were operated by the same surgeon (SKH). No difference was found in perioperative mortality rate, deep infection rate, the incidence of DVT or pulmonary embolism, the newly developed heart ischemic event or brain hemorrhagic lesion between the two groups. But there were more incidence of dislocation related to weakness by past brain ischemic lesion and the newly developed brain ischemia in patients of group 1 than group 2. More importantly, seven patients in group 1 had transient symptoms of dyspnea, signs of hypotension, and altered heart rates during two days postoperatively, which is suspicious of embolic phenomenon, even though it was not confirmed. More closer and careful observations are necessary in patients with ischemic heart disease after a cemented hemiarthroplasty for the treatment of femoral neck fracture.
A NEW SUBTROCHANTERIC OSTEOTOMY TECHNIQUE FOR TOTAL HIP ARTHROPLASTY IN HIGH DISLOCATED HIPS DUE TO THE SEQUELAE OF A SEPTIC HIP IN CHILDHOOD

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This study was undertaken to assess the feasibility of a new subtrochanteric osteotomy technique for total hip arthroplasty (THA) in cases with a high dislocated hip secondary to the sequelae of a septic hip in childhood. Eighteen patients (20 hips), aged 25 to 65 years (average 47.3 years), underwent THA using a cementless conical stem (Cone prosthesis®; Protek AG, Berne, Switzerland) with a new subtrochanteric osteotomy technique and were followed for an average of 23.6 months. All patients were graded as type III (high dislocation) according to the Hartofilakidis classification, and according to the Crowe classification 3 cases were of type III and 17 were of type IV.

The procedure was performed through a posterolateral approach and a provisional osteotomy was usually performed at the inferior half of the lesser trochanter. All acetabular component was inserted at the true acetabular and the acetabular cup was inserted in 5 cases and only a liner was inserted after cementing in 15 cases. The stem size and the amount of stem insertion was decided according to the preoperative planning and soft tissue tension. After final reduction, the greater trochanter was re-attached to the proximal femur with the hip in the abducted position. Cables or a grip system (Dall Miles®, Stryker Orthopaedics Inc., Mahwah, NJ, USA) were used for fixation, and if possible, additional screws were inserted.

Postoperatively, range of motion exercises were encouraged after two to three weeks of bed rest and non-weight bearing crutch ambulation followed. Weight bearing was permitted only after obtaining radiological confirmation of bone union, but then active exercises were strongly encouraged to stretch abductors. Mean duration of surgery was 180.6 minutes, and mean perioperative blood loss was 1424.1ml. There were no intra-operative complications. Post-operative dislocation occurred in 2 cases and partial femoral nerve palsy developed in 1 case. Mean Harris Hip Score improved from 42.4 to 84.2. Mean lateral opening angle of acetabular cup and liner was 34.7° and mean anteversion was 20.8°. All femoral components were implanted in neutral to 5 degrees of valgus, and mean leg lengthening was 36.5mm. The mean time to greater trochanter union was 3.72 months.

Primary THA in highly dislocated hips due to the sequelae of septic hip in childhood using the described subtrochanteric osteotomy and a cone prosthesis was found to be safe and effective at restoring leg length and trochanteric rotation. But more follow-up is required to more comprehensively establish the long-term results of the described procedure.

Key words: High dislocated hip, septic hip sequelae, total hip arthroplasty, subtrochanteric osteotomy, conical stem.
TOTAL HIP ARTHROPLASTY IN SCFE A NOVEL TECHNIQUE TO REMOVE EMBEDDED KNOWLES PIN

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Introduction: In situ fixation of mild slips of the slipped capital femoral epiphysis (SCFE) is a safe and reliable method of treatment. Hardware failure and fractures are reported at the time of and after pin retrieval. There is high rate of difficulty in removing the pins in these patients even immediately after the epiphysis is fused. Major problems can be expected when arthroplasty is necessary years later, if the pins are still inside the proximal femur. We have come up with a novel technique to remove these pins during Hip Arthroplasty.

Method: The hip is exposed through posterior approach and the hip is dislocated. The neck is then cut for at the usual site for femoral component of THA usually finger breath above the lesser trochanter with a narrow saw blade. It is then segmented in both sagittal and coronal planes into approximately eight to ten pieces and removed piecemeal. The pins were thus exposed and cleared of any bony debris. After the head has been removed the pins are loose and hammered retrograde.

Discussion: Many patients who have been treated for SCFE have retained metal implants for long period of time. When these patients undergo Total Hip Arthroplasty, the surgeon encounters lot of technical difficulty in removing this retained metal work. We have come up with a novel technique to remove these pins. We feel this avoids unnecessary trauma to the outer cortex of femur and also reduces the operating time significantly.

LONG-TERM OUTCOME OF FIRST-GENERATION OMNIFIT/OMNIFLEX STEM WITH USE OF TRANSTROCHANTERIC APPROACH

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Objective: Long term outcome of cementless femoral stem with use of transtrochanteric approach was evaluated by clinical outcome and radiological change.

Subjects: 37 joints in 33 patients who underwent surgery in our department more than 15 years before (from 1986 to 1993) were studied. Used implants were Omnifit (Fit group, 19 joints: all joints were microstructured) and Omniflex (Flex group, 18 joints: all joints were microstructured). The preoperative diagnosis was secondary osteoarthritis caused by dysplasia of hip (29 joints), osteonecrosis of femoral head (2 joints), rheumatoid arthritis (4 joints), and others (2 joints). Mean age at surgery was 51 years (Fit group, 54.2 years; Flex group, 50.2 years) and average postoperative follow-up period was 17.8 years (Fit group, 19 years; Flex group, 16.5 years).

Method: Clinical outcome was evaluated by Japanese Orthopedic Association hip score (JOA score) and absence or presence of thigh pain. In radiological evaluation, the fixation of implant was evaluated by Engh's classification and the presence or absence of stress shielding, spot welds, radiolucent line, osteolysis, and sinking were studied.

Results: JOA score for Fit and Flex group was significantly improved from 35 to 79.3 points and 37 to 76.9 points, respectively. Improvement of pain and gait ability was marked. Thigh pain was observed in 1 joint only, in the Flex group. Radiological examination for Fit and Flex group showed bone ingrowth 100% and 61% of patients, respectively, showing good fixation for both groups. Radiological sign of Fit and Flex group showed stress shielding in 91% and 84%, spot welds in 73% and 44%, radiolucent line in 12% and 19%, osteolysis in 5.2% and 5%, and sinking in 0% and 11% of patients, respectively. Revision caused by loosening of stem was in only 1 joint in Flex group.

Discussion: For first generation of Omnifit/Omniflex stem, many cases of early loosening caused by surface structure characteristics had been reported. Long-term outcome in our department was relatively good compared to these earlier reports. Good initial placement of femoral component and sufficient canal fill ratio with use of transtrochanteric approach is one factor of this better result.
Long term survival analysis of Spongiosa Metal I cement less total hip prosthesis between Japan and Germany

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Introduction: Unique spongiosa like surface structure was introduced in 1982 by ESKA implants Germany. It is called Spongiosa-Metal I surface. The purpose of this retrospective study is to report and compare long term results of Spongiosa Metal I total hip prosthesis in Japan and Germany.

Method: In Japan, between June 1986 and August 1990 total 113 prostheses were implanted and consecutive 106 implants could be evaluated. In Germany, between May 1983 and December 1985 total 209 prostheses were implanted and consecutive 165 implants could be evaluated. The all evaluated prosthesis combined ceramic head and polyethylene inlay.

Results: In Japan, average follow up period was 17 years.85% of the patients had retained the original prostheses (cup, stem, ceramic head, and inlay). Survival rate was investigated by Kaplan-Meier method. Survival rate for the cup component was 95%, and for the stem component was 93%. In Germany, average follow up period was 21.8 years.88.5% of the patients had retained the original prosthesis. Survival rate for the cup component was 95%, and for the stem component was 85%.

Discussion: Main reason of the revision surgery was the ceramic head fracture (7 implants 6%) in Japan and the stem component loosening (14 implants 8%) in Germany. There was no ceramic head fracture in Germany. We thought that beating with the hammer when we install the ceramic head to the taper was one problem. Stem loosening was seen in undersized stem component. On the other hand, survival rate for the cup component was 95% in Japan and Germany. This was good result in comparison with other reports about long term survival.

Conclusion: 85% of the patients had retained the original prostheses average 17 years in Japan and 88.5% average 21.8 years in Germany. Main reason for the revision surgery is stem loosening and ceramic head fracture. Survival rate for the cup component was 95% in Japan and Germany. We are convinced with this spongiosa metal surface can bear long term use.

Transverse Subtrochanteric Shortening Osteotomy in Primary Total Hip Arthroplasty for Patients with Severe Hip Developmental Dysplasia

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Abstract: Twenty-Six total hip arthroplasties were performed in Crowe grade 3 or 4 hip dysplasia using subtrochanteric shortening osteotomy with 2-kinds of femoral stem (Primary monoblock and modular femoral stem). The average age was 46.2 years, and the average follow-up was 4.1 years. Acetabular reconstruction with structural autograft was used in 13 hips. Radiologically, hip centers were nearly normalized by vertical height of 10.6mm elevation and horizontal lengths of 1.7mm compared with uninvolved sites. Three of four osteotomy nonunions were managed with bone graft and other one waiting for surgery. One acetabular revision was performed for migration. One postoperative dislocation was managed successfully with closed reduction and abduction brace. One patient (>7cm) showed postoperative neurologic complications was noted. Harris hip score was improved from 35.6 to 81.7. A cementless modular distal fluted femoral stem is a useful device in these patients.

Key words: hip, dysplasia, arthroplasty, shortening osteotomy.
INVESTIGATION OF MACRO- AND MICROSTRUCTURAL DIFFERENCES IN COMMERCIALLY AVAILABLE RESURFACING HIP IMPLANTS.

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Introduction: Resurfacing hip implants differ in macro- and microstructure. Manufacturing related parameters like clearance or carbon content influence the wear behaviour of these metal-on-metal bearings. The aim of this study was to analyse the main macro- and micro-structural differences of commercially available resurfacing hip implants.

Methods: Ten different commercially available resurfacing hip implant designs were included in this investigation: - BHR™ (Smith&Nephew/MMT) - Durom™ (Zimmer) - Conserve Plus™ (Wright Medical) - Cormet™ (Corin) - Icon™ (IO) - ReCap™ (Biomet) - Adept™ (Finsbury) - ASR® (DePuy) - BS® (Eska) - Accis® (Implantcast).
The heads and cups were measured in a coordinate measuring machine and radial clearance as well as sphericity deviation were calculated. Surface roughness measurements were carried out. The microstructures of the heads and cups were inspected using SEM and element analysis was performed using EDX to identify carbides and the alloy composition.

Results: The mean radial clearance was found to be 85.53 µm. The range was from 49.47 µm (DePuy, ASR®) to 120.93 µm (Biomet, ReCap®). All implants showed a sphericity deviation of less than 10 µm. The highest sphericity deviation was found to be 7.3 µm (Corin Cormet™ head), while the lowest was 0.8 µm (Smith&Nephew BHR™ head). On average, the heads tended to have a higher sphericity deviation (4.1 µm, SD: 2.3 µm) compared to the cups (2.7 µm, SD: 1.4 µm). SEM revealed that most manufacturers use a high carbon alloy casting manufacturing process combined with heat treatment after casting (Corin Cormet™ and Wright Conserve™: head and cup; DePuy ASR®: cup; Eska BS®: head).

Conclusion: Commercially available resurfacing hip implants differ in design and manufacturing parameters, including macro- and microstructure, which are critical in achieving low wear and ion release. This study was designed to aid in the understanding of clinical observations. Also, specific information is now available for surgeons choosing an implant designs.
FEMORO-ACETABULAR CUP IMPINGEMENT AFTER TOTAL HIP RESURFACING ARTHROPLASTY

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Risk of impingement after total hip resurfacing arthroplasty may be great because femoral head-neck unit is preserved and there is little flexibility to adjust limb length and femoral offset, but this potentially worrisome phenomenon has been rarely reported. Impingement between femoral neck and acetabular cup was observed in a cohort of patients who underwent contemporary total hip resurfacing arthroplasty.

We then questioned whether patient demographics, component features or suboptimal position of components would be risk factors for impingement. We reviewed a consecutive series of 51 patients (61 hips) who underwent contemporary total hip resurfacing arthroplasty. The mean age at the time of the index arthroplasty was 38 years (range, 18 to 64 years). The most common diagnosis leading to the total hip resurfacing arthroplasty was osteonecrosis of the femoral head in forty-one hips (67%). All the procedures were performed by single surgeon through an anterolateral approach. All the patients were assessed clinically and radiographically at a mean of 32 months (range, 24 to 53 months) postoperatively.

Femoro-acetabular cup impingement, defined as the presence of bony spur at the femoral neck corresponding to abutment site of the metallic cup, was observed in seven of the 61 hips (11.5%). Of these, 5 patients reported limitation of activities due to groin pain. The average postoperative Harris hip score of impingement hips was inferior to those of non-impingement hips \( p = 0.004 \). No significant difference was detected between the impingement hips and non-impingement hips with regard to of patient demographics, component features and radiographic measurements including cup inclination, cup version, femoral component version, anteversion, femoral offset, stem-shaft angle, femoral offset and limb length discrepancy. Our multivariate analysis revealed that only acetabular cup uncoverage ratio had a significant association with femoro-acetabular cup impingement \( \left( p = 0.04, \text{odds ratio} 1.385 \ [95\% \text{ CI, } 1.014-1.891]\right) \). There was no aseptic loosening of components or femoral neck fracture.

We found a high incidence of impingement between retained femoral neck and metallic acetabular cup after contemporary total hip resurfacing arthroplasty in association with an increased acetabular cup uncoverage ratio. As patients with femoro-acetabular cup impingement showed inferior clinical results, it is crucial to avoid excessive protrusion of acetabular cup beyond bony margin by proper selection of acetabular component size and appropriate positioning.
Resurfacing arthroplasty in osteonecrosis of the femoral head  
- minimum 3 years follow-up -

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Purpose: To evaluate short to mid-term clinical and radiological results of metal on metal resurfacing arthroplasty in osteonecrosis of the femoral head.

Materials and Methods: 185 hips of 169 patients who underwent metal on metal resurfacing arthroplasty using Birmingham Hip Resurfacing system (Midland Medical Technololgies, Birmingham, UK) between December 1998 and May 2005 and was followed up more than 3 years were available for this study. All preoperative diagnoses were ONFH. The extents of necrotic area were analysed by preoperative MRI scanning. Their mean age at the time of operation was 37.7(range, 16-67) years old and mean period of follow-up was 88(range, 36-113) months. For the clinical assessments, Harris hip scores, UCLA activity scores, pain and ROM were evaluated. Radiological changes such as radiolucencies around the stem, impingement sign, neck narrowing, osteolysis around head and neck junction, loosening of implants, heterotopic ossifications were evaluated in the serial anteroposterior, translateral radiographs of the hip joint.

Results: Preoperative necrotic area was average 42.7(range, 11.5-60) %. Clinically, the average Harris hip score was improved from 85.2 points to 97.1 points at final follow-up. Average UCLA activity scores at the last follow-up was 8.8 and almost of the patients showed high activity and returned to their original job. ROM were very satisfactory. Radiologically, the mean inclination of acetabular component was 48.0°. There were no radiolucent lines around the acetabular components, but 3 cases showed radiolucent lines around the stem of femoral components. Osteolytic lesions were noticed in 10 cases around head-neck junction. 9 hips had impingement signs around the head-neck junction. There was no case which showed evidence of stress shielding. Moderate neck narrowing were shown in 3 cases. There were 6 cases of heterotopic ossification. One hip had a revision surgery to a total hip arthroplasty using big metal ball because of loosening of acetabular component. There was no patient complained limb length discrepancy and no infection, dislocation, thigh pain.

Conclusions: The midterm performance of metal on metal resurfacing arthroplasty in ONFH was very excellent in the aspects of pain relief, ROM of hip joints, rehabilitation and return to preoperative activity and minimization of common complications of conventional total hip arthroplasty. There was no mechanical failure related to the osteonecrosis and we can conclude that performing resurfacing arthorplasty in osteonecrosis less than 50% of extent can be justified. However, performing resurfacing arthroplasties in osteonecrosis of femoral heads needs meticulous surgical techniques and longer learning curve to prevent early failure. Even though our midterm follow-up study revealed excellent results, more long-term follow-up studies are mandatory to determine the survivorship and to verify the problems related to the increased serum metal ion and metal ion toxicity after resurfacing arthroplasty.
TOTAL RESURFACING ARTHROPLASTY AFTER FAILED HIP PRESERVING PROCEDURES FOR OSTEONECROSIS OF THE FEMORAL HEAD

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Introduction: The ultimate goal for treatment of osteonecrosis of femoral head (ONFH) is preserving the femoral head. To fulfill this, several joint preserving procedures were introduced. From simple drilling to complex vascularized bone grafting procedures, various results have been reported. According to those reports, each joint preserving procedure seems to have its particular role in certain stages of the disease. But when they fail, certain types of salvage operations are mandatory. Until now, total hip arthroplasty (THR) is generally accepted as a salvage operation regardless of the type of index operation or reason of failure. We believe that because the usual patients with ONFH are young and active, the viable portion of the remaining head and neck should be preserved even when the joint preserving procedures failed. From this viewpoint, we have tried to manage them with resurfacing arthroplasty if they fit the indication. In this brief review, we wanted to clarify the role and technical concern of resurfacing arthroplasty as a salvage procedure after failed joint preserving operations for osteonecrosis of the femoral head (ONFH).

Material and Method: Among 556 hips underwent resurfacing arthroplasty from September 1998 to October 2007, sixteen resurfacing arthroplasties (13 patients) were performed after failed joint preserving procedures for ONFH. Mean age at the operation was 39 years old. Ten were male. Seven vascularized fibular grafts, 3 multiple drillings, 3 core decompressions and 3 combined procedures were performed as initial operations. Mean duration from the index operation and resurfacing was 95 months. Mean follow up was 14 months. The patients were clinically evaluated with the Harris hip score, hip or thigh pain, and range of motion. As a radiological evaluation, we measured positions of the acetabular cup and femoral stem, radiographic changes at the neck and complications such as osteolysis, loosening or femoral neck fracture.

Results: The Harris hip score increased from 69.2 preoperatively to 89.5 at the final visit. Hip range of motions other than sagittal directions significantly improved after the operation. No patient complained of limp length discrepancy. One patient complained of unexplained hip pain, and another patient had trochanteric pain due to two debridement procedures for superficial infection. Other than those two cases, all patients regained their pre-morbid activity level uneventfully. Radiologically, eleven femoral stems in AP and eleven in lateral radiographs were exactly aligned along the previous operative tracts. However, there were no clinical complications related to the position of femoral component. The only case that the acetabular cup was implanted in high inclination (60 degrees) experienced sustained unexplained hip pain. There was no loosening or implant migration. Also, there was no detectable wear, osteolysis or complications such as femoral neck fracture.

Conclusions: We believe that the remaining hard bones at the femoral head as a result of previous operation can provide excellent mechanical support for the femoral component. For this reason, resurfacing in this situation can theoretically be safe. This can be more obvious if the patient selection, pin placement and preparation of bone bed were meticulously and precisely performed. Our experience suggests that even for the case of failed hip preserving procedures in ONFH, resurfacing arthroplasty can play a successful role as a salvage operation. Furthermore, this can be an excellent alternative between joint preserving procedures and conventional THA.
A Novel Approach to Reduction of Wear In THA

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Introduction: Polyethylene and metal has been the material of choice since the 1960’s.
We are now seeing the third generation of cross-linked polyethylene along with work on alternative hard on hard
bearings trying to reduce the generation of wear debris.
Issues have been raised from squeaking to high trace elements and strength characteristics of current materials.
Ideally, the surfaces for articulating bearing surfaces will be made from materials having high strength, high wear, and
corrosion resistance, a high resistance to creep, and low frictional moments.
This paper will review characteristics of a novel new approach for a bearing material.

Methods: A review of past and current materials along with mechanical testing in creating a new approach to the
development of a hydrophilic material replacing the polyethylene side of the bearing surface.
Studies have demonstrated the advantages of the full-fluid film layer of lubrication in-terms of enhanced wear
performance.
An acetabular buffer bearing was developed that features a pliable bearing surface formulated, biocompatible
polycarbonate urethane (PCU). A review of design objectives and testing will be highlighted in this paper.

Results: Wear studies have demonstrated performance up to twelve times better compared to polyethylene.
34 components have been implanted reaching two years post-op. Two devices have been removed both for non-related
implant issues. Retrieval analysis did not show any appreciable wear or damage to the bearing material.

Conclusions: To date we are encouraged by the early basic and clinical science, however, only additional research and
time will demonstrate the long-term viability of this material.
MINIMUM FIVE-YEAR FOLLOW-UP WEAR MEASUREMENT OF LONGEVITY HIGHLY CROSS-LINKED POLYETHYLENE CUP AGAINST A COBALT-CHROMIUM OR ZIRCONIA BALL

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Backgrounds: Ceramic heads and highly cross-linked polyethylene (HXLPE) as bearing surface materials have been introduced to reduce the production of polyethylene wear particles. The present study hypothesized that the wear rate of HXLPE could be further reduced when combined with a ceramic head. The purpose of this study was to compare the in-vivo wear of Longevity HXLPE against cobalt-chromium and zirconia heads after a minimum 5-year follow-up.

Materials and Methods: A prospective cohort study was performed in 102 cementless total hip arthroplasties (THAs) with the Longevity HXLPE socket (Zimmer) between June 2000 and October 2001. The same prostheses were used in all cases for both acetabular cups (Trilogy; Zimmer) and femoral stems (Versys Fiber Metal Taper; Zimmer). 26-mm zirconia heads (NGK) or 26-mm cobalt-chromium heads (Zimmer) were randomly used in 51 hips each. A minimum 5-year follow-up was completed for 93 hips of the original 102 hips. The zirconia head group comprised 47 hips (38 women; 9 men) with a mean age at operation of 57.5 years (range, 27-76 years). The cobalt-chromium head group comprised 46 hips (40 women; 6 men) with a mean age at operation of 57.1 years (range, 27-75 years). No significant differences between the groups were seen in age, gender, diagnosis, height, weight, BMI or liner thickness. The two-dimensional linear wear of Longevity HXLPE was measured using computer-assisted methods (PolyWare) on annual x-rays, and total head penetration rates and steady state wear rates were calculated. In addition, periprosthetic osteolysis was evaluated.

Results: At a mean 6.1-year follow-up (range, 5.0-7.2 years), the total head penetration rates were 0.034 ± 0.016 mm/year in the zirconia group. At a mean 6.0-year follow-up (range, 5.0-7.1 years), the total head penetration rates were 0.031 ± 0.015 mm/year in the cobalt-chromium group. The steady state wear rates were -0.010 mm/year in the zirconia group and -0.010 mm/year in the cobalt-chromium group. No significant difference was seen between the two groups (p=0.40 and p=0.91, respectively). Osteolysis was not observed around prostheses in any hips. Gender (male vs. female), age (<55 years vs. ≥55 years), BMI (<25 vs. ≥25) or liner thickness (<7 mm vs. ≥7 mm) revealed no influence on wear rate.

Conclusions: This study showed wear rates in bearing couples of Longevity HXLPE against either zirconia heads or cobalt-chromium heads at a mean of 6.0 years follow-up using PolyWare computer-assisted methods. At the mid-term follow-up, the wear rate of Longevity HXLPE sockets was very low and the magnitude of steady state wear rate could not be detected by this method. But neither total penetration rate nor steady state wear rates differed significantly between the groups. In conclusion, no advantage was seen with the zirconia head compared with the cobalt-chromium head in this period.
Wear Map Analysis with 28mm CoCr-CoCr Hip Retrievals - 11-years follow-up

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While there are many laboratory and clinical studies using metal-on-metal (MOM) bearings following the introduction of the 28mm MOM THR in 1985, the mapping of wear phenomena in such retrieval cases has been minimal. In laboratory studies, wear of 28mm MOM bearings was satisfactorily low for both run-in and steady-state phases. However some clinical results have not been as supportive as predicted by laboratory studies. We present a detailed analysis of 33 retrieved MOM hip bearings with 1 to 11 years follow-up.

We compiled 33 retrieval cases (Metasul™: Zimmer/CenterPulse Inc., Austin, TX) including clinical information, ion concentrations, ball diameters, cup designs and stripe wear damage. The bearing surfaces were mapped using reflected light microscope (RLM), white light interferometer (Zygo) and FEG-SEM (Philips). Wear maps were constructed according to types of surface wear identified.

Patients ranged from 36 to 76 years of age (Means: 56.9 years); 54% were males. Main causes for revision were progressive radiographic lines around the cups, osteolysis and pain. The 28mm ball diameter was used in 86% of cases (largest = 52mm ball). The CoCr liner incorporated a polyethylene adaptor in 75% of cases. Outside diameters of cups >50 mm was present in 75% of cases. Eight femoral stems were recovered; seven showed showed major impingement marks around the neck and five also had metallosis products evident (Mode-4A). Stripe wear was evident on 71% of CoCr balls with medial stripes twice as common as lateral. Stripe wear was identified in 25% of CoCr liners and extended 25-160° circumferences around the liners. Clear liner rim damage was present in 10 (30%) and 3 demonstrated severe damage of polyethelene adaptors.

There are many limitations to our retrieval study. These results were biased to cases that failed due to hip pain, radiographic signs of progressive osteolysis and some with high levels of metal ions. There was also the bias of having predominantly a CoCr sandwich design (polyethylene adaptor present in 75% cases). In 1970’s and 1980’s, larger diameter resurfacing designs were introduced with thin-walled UHMWPE cups. These offered the advantage of greater joint stability and range of motion. Unfortunately these large diameter bearings produced significant polyethylene wear debris and so were abandoned in favor of the smaller diameter balls. The 2nd generation MOM designs also incorporated small diameters (28, 32mm) for low frictional torques along with low wear characteristics alternate THR bearings. Thus use of the small ball added to the well-known risks of impingement, subluxation and dislocation with rigid metal cups cups. In this study, using the ‘damage modes’ from McKellop, normal mode-1 wear occurred in only 14% of cases whereas modes #2 to 4 had an incidence approaching 30% each and signs of cup impingement were evident in 64% of cases. Thus summarizing MOM wear phenomena in small 28mm sandwich cup designs, there was retrieval evidence showing that impingement damage modes #2 to 4 likely placed these patients at risk for the observed adverse wear effects.

Keywords: metal-on-metal bearings, retrievals, Impingement, Stripe wear
Comparison of minimal incision total hip replacement versus standard incision total hip replacement using the lateral flare hip system

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Purpose: To compare the early result of minimum incision surgery (MIS) to standard incision procedures with use of lateral flare hip system. Lateral flare hip has symmetric contact to medial and lateral cortical bone at high proximal part and it provides definite endpoint of stem insertion. From this point of view, we can say that this system is suitable for MIS. Among the 38 hips, 21 hips were performed by MIS (less than 10cm) and 17 hips were performed by Standard incision. MIS were performed from November 2004 to December 2005. And Standard incisions were performed from June 2004 to December 2005. Two surgeons performed all operations (NW and YT). The main surgeon decided whether MIS was applicable or not for each patient. Antero-lateral intra gluteal approach (modified Dall) was applied for all surgeries. The same rehabilitation program was applied on both groups postoperatively. The average follow-up period of MIS patients was 28.6 months and 34.7 months in standard incision. We investigated the early result of these patients.

Result: There was a relationship between patients’ height and the length of skin incision (p<0.05). No significant difference between two groups was proved in CRP, CPK and D-Dimmer (CRP: 13.9/11.9mg/dl, CPK: 405.5/380.5mg/dl, D-Dimmer: 6.1/5.3mg/dl). Both intraoperative blood loss and operation time were less in MIS group (blood loss 530.9ml vs. 772.8ml, operation time 99min vs. 115.4min) (p<0.05). The days until the patient was able to do active straight leg raising were 17.3 in MIS group and 22.4 in standard incision group and hospital stay days were 26.7 vs. 29.2. But no significant differences were proved in hospitalization. On roentgenografic findings, the inclination of acetabular cup was 42.0 degree in the MIS group versus 41.2 in the standard incision group and no significant difference was found. In Radiographic findings, one stable fibrous fixation was observed in each group. The other cases were bone ingrowth fixation. Japanese orthopedics association (JOA) hip score was not significant different in each group at the final follow up (88.1 in MIS group and 85.9 in Standard group). Also as the result at the term of 6, 12, 18 and 24 months after operation, JOA hip scores was not significant difference in each group. There were no revision cases in this study until the final follow up.

Conclusion: In the present study, intra-operative hemorrhage and operation time were significantly less in MIS group. It was supposed that at the patient selection, each surgeon decided the candidate of MIS due to patient’s hip condition. But in another situation, no significant difference was found for example in serum CRP, CPK and D-Dimmer levels. Clinical and radiological outcomes were not significantly different between MIS and Standard group in this study.
**Treatment of Femoral Neck Fractures by Bipolar Hemiarthroplasty through Short External Rotator Preserving MIS Approach in Patients with Neurologic disorders**

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We developed a modified posterior approach that preserved the short external rotator muscles to prevent dislocation after THA or BHA. The present study aimed to evaluate the effectiveness of short external rotator preserving posterior (ERP) approach for bipolar hemiarthroplasty in treatment of femoral neck fractures in patients with neurologic disorders. Between March 2004 and February 2006, we performed 187 cementless bipolar hemiarthroplasties for displaced femoral neck fractures on 36 patients with neurologic disorders, who were operated on by ERP approach (Group 1) and 151 patients without neurologic deficits, who were operated on by conventional posterolateral approach (Group 2). We compared operation time, the amount of postoperative blood loss, the early postoperative complication rates, the dislocation rate within 1 year, and duration of hospital stay between two groups. The amount of postoperative blood loss was significantly decreased in group 1. There were no significant differences in mean operation time and early postoperative complication rate including wound problem, deep vein thrombosis or infection and duration of hospital stay. There was no dislocation after operation in group 1, but seven patient (4.6%) had dislocation in group 2. Nine patients (25.0%) died within postoperative 1 year in group 1 and twenty six patients (17.2%) died in group 2. Cementless bipolar hemiarthroplasty through ERP approach provides a favorable outcome for treatment of displaced femoral neck fracture in patients with neurologic disorders who is considered as high risk of dislocation. Also it decreases the postoperative blood loss and the needs of postoperative abduction brace.

**DIRECT ANTERIOR APPROACH IN LATERAL POSITION: EASY AND TOLERABLE MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY**

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**Background:** Direct anterior approach (DAA) in supine position is one of the successful minimally invasive surgery (MIS) approaches, but it needs special traction table and stem selection is limited. DAA in lateral position is easier, and full porous cylindrical stem which needs femoral reaming is easily inserted in this approach. This paper will describe the technique and result.

**Methods:** 55 patients were followed for a minimum of 7 months after unilateral THA with DAA in lateral position. Approach and cup settlement is the same as usual DAA in supine position. After liner placement, proximal femur is pushed up antero-laterally with the hip hyperextension, external rotation and adduction, which make excellent view of femoral neck cut surface. Because the leg is shortened, soft tissue tension is not high and neurovascular relaxation is achieved. PCL retractor of TKA instrument is used to keep tensor fascia femoris muscle laterally over greater trochanter. No other special instrument is needed in stem insertion.

**Results:** Hip scores improved from 37.8 preoperatively to 87.8 postoperatively. Mean incision length was 9 cm and mean operation time was 85 minutes including routine intra-operative X-ray check. Neither auto blood donation nor cell saver was used. Blood transfusion was not needed. Stem position was over 2 degree varus in 5 (9%) and over 2 degree valgus in 3 (5%). There were no dislocations, loosening, infections, or femoral nerve injuries.

**Discussion:** In supine position, hip motion in sagittal plane is limited on the table. DAA in lateral position afford more extension with easily controlled external rotation and adduction, which is the key to insert stem easily. DAA in lateral position is easy and tolerable MIS.
BILATERAL SIMULTANEOUS TWO-INCISION MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY

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The two-incision technique uses strategically located incisions to insert the prosthesis components in to specific intermuscular or internervous planes in an effort to minimize damage to these tissues. Even though there are many reports about safety and benefits of bilateral simultaneous total hip arthroplasty (THA), none of them has reported about either one-incision or two-incision bilateral simultaneous minimally invasive (MI) THA. This study aimed to assess the feasibility of bilateral simultaneous MI two-incision THA in terms of clinical, radiological and functional outcomes.

Sixty two patients, in the age of 24 to 69 years were operated for bilateral simultaneous THA using modified two-incision technique and followed for average 41 months. In the technique of two-incision THA described by Mears, they used modification of Smith Peterson approach for insertion of acetabular component and femoral component is inserted through a small incision situated between greater trochanter and iliac crest, centered directly in line with the femoral shaft. We modified this technique and used part of Watson Jones approach for insertion of acetabular component with patient in lateral position. The posterior incision for insertion of femoral component is through intermuscular interval between gluteus medius and piriformis.

The average Harris Hip score improved from 41.8 (range, 10-59) preoperatively to 95.3 (range, 73-100) postoperatively (P < 0.05). WOMAC score improved from median of 66.2 (range, 31-96) preoperatively to 5.0 (range, 0-19) postoperatively (P < 0.05). Forty-nine (79.03%) patients were pain-free at the time of first follow up (6 weeks after surgery) and remained pain-free till the last follow up, while remaining thirteen (20.97%) had only slight pain. Out of those thirteen, three patients complained of occasional mild pain at last follow up. Fifty (80.64%) patients were walking without limp, while remaining twelve (19.35%) had only slight limp at 6 months. Out of those twelve, two patients had persistent limp at final follow up. Fifty-eight (93.53%) patients were walking without support, fifty-five (90.32%) were able to walk unlimited distance and fifty-five (88.70%) were able to climb stairs without using a railing. Walking with walker was started on average 3.7 days (range, 1-14 days) and walking with crutches was started on average 10.3 days (range, 1-49 days) postoperatively. Patients were able to walk without support on an average 48 days (range, 14-120 days) and use stairs without support and without any discomfort on an average of 50 days (range, 5-150 days). The average lateral opening angle of acetabulum was 40° and anteversion was 12°. All femoral components were implanted in neutral to 5° valgus position. None of the femoral component showed subsidence of more than 3 mm. The filling of the femoral canal by the prosthesis was excellent in all cases. Post-operative periprosthetic fracture occurred in 2 patients and delayed infection occurred in 1 patient.

In conclusion, bilateral simultaneous two-incision minimally invasive THA gives satisfactory clinical and radiological results in comparison with conventional THA. It is safe in experienced hands, without any additional risk of complications. It provides excellent functional outcome and patient satisfaction.
POOR ACCURACY OF MEASUREMENTS ON RADIOGRAPHS FOR CUP VERSION ANGLE AFTER TOTAL HIP ARTHROPLASTY

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The precise orientation of the acetabular component is one of the important factors in total hip arthroplasty (THA). Computed tomography (CT) provides image data for accurate measurements of the orientation of the acetabular component. However, in many studies in the literature, the orientation of the acetabular component after THA has been expressed as a combination of inclination angle (IA) and version angle (VA) measured on radiographs. For measuring VA, an anteroposterior (AP) radiograph of the hip joint, or a cross-table lateral radiograph has been used. The accuracy of these radiological measurements was not thoroughly studied. The purpose of this study was to evaluate the accuracy of measurements on radiographs comparing to those on CT.

Materials and methods: Twenty-four hips (21 patients) after THA were recruited for this study. The same acetabular components (Trilogy, Zimmer, USA) had been used without cement in all hips. An AP radiograph of the pelvis, an AP radiograph of the operated hip and a cross-table lateral radiograph of the hip were taken. From the AP radiograph of the pelvis, the angle between an inter-teardrop line and a tangential line to the opening face of the acetabular component was measured and defined as inclination angle on radiographs. From the AP radiograph of the operated hip, the length of two axes of the ellipse of the acetabular component was measured and a version angle was calculated using the Lewinnek’s method. This version was defined as the version from the AP radiograph (VAP). From the cross-table lateral radiograph, another version angle was measured using a modified version of Woo’s method, which is the angle between a gravity line shown by a metal chain and a tangential line to the opening face of the acetabular component. This angle was defined as the version from a cross-table lateral radiograph (VCL). The CT scanning of the pelvis was performed with 64-MDCT scanner (Aquilion TSX-101A/HA, Toshiba Medical Systems.co). The plane passing through the bilateral anterior superior iliac spines and pubic tubercles was used as references for measurements of inclination angle and version angle from CT image data. Accuracy of CT measurements had been validated using a phantom model. The absolute value of the difference between the measured angle on the radiograph and that on CT was defined as an error. Mann-Whitney U-test was used for statistics, and the level of significance was set at $p<0.05$.

Results: Mean of the error for inclination angle was 2.2 degrees (range 0-6, SD 1.3). Comparing to this, both of the two methods for measurements of version angle on radiographs showed large errors. Mean of the error was 6.9 degrees (range 0-18, SD 8.0) for VAP, and was 6.0 degrees (range 0-14, SD 6.1) for VCL. There were no significant differences between errors for VAP and that for VCL. These results suggest that the measurements of version angle on AP radiographs or cross-table lateral radiographs should not be used for the studies of orientation of the acetabular component.
Is it Valid? - Anterior pelvic plane in Image-Free Navigation-Assisted Total Hip Arthroplasty -

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Introduction: The anterior pelvic plane (APP) has been introduced as a concept of the reference plane to image free navigation-assisted cup placement. With the neutral pelvis, the anteversion relative to the conventional coordinate system is equal to the that of relation to the anatomical coordinate system. This is the rationale of image free navigation system. But, currently, two major concerns about image-free navigation is tilting of anatomic coordinate system and the cutaneous palpation procedure. Therefore, it was the goal of this study to provide both the bone anterior pelvic plane (Bone_APP) and the overlying soft tissue plane (Soft_APP) simultaneously, and to find possible correlations of biometrical parameters and effect of anteversion were an additional motivation of this study.

Materials and Methods: 23 Korean adult patients underwent image-free navigation-assisted total hip arthroplasty. The tilting of Bone_APP, soft tissue thickness on ASIS, pubis, and then tilting of Soft_APP, and anteversion of cup were measured with reconstructed CT and 3D workstation system. Navigated anteversion were obtained by computer screen intraoperatively.

Results: The average age was 66.1 years, the average height was 162.5cm at a weight of 59.2 kg. The average body mass index was 22.3. And the average lumbar lordosis was measured as 30.4 degrees. The soft tissue on the level of the pubis was 17.6 mm thicker than that on the level of ASIS in average. In all cases, Soft_APP was positive, that is from 3.5 to 16.5 degrees of backward rotation. We also found a high-intersubject variability in the Bone_APP from 13.4 of forward rotation to 23 degrees of backward rotation. Overall, there are no correlation between biometrical parameters and difference of navigated data to others measured on CT. Averaged navigated data was 22.4 degrees. The average anatomic, operative, and planar anteversion were 29.2, 27.2 and 21.3 degrees respectively. The value of anteversion measured on the transverse plane and sagittal plane shows higher than navigated anteversion in paired comparison. This could be comprehended that the navigation system had under-estimated the anteversion than that of transverse and sagittal plane, This means navigation assessed pelvic plane as back ward tilting rather than forward tilting intraoperatively.

Conclusion: The anterior pelvic plane does not have satisfactory reliability which should be easily identified during the operation and would take into account variations of individuals including both bone and soft tissue plane. This is the rationale for necessity of tilt adjusted image-free navigation-assisted cup positioning.
Validation of a Simple Radiographic Method to Determine Variations in Pelvic and Acetabular Cup Sagittal Plane Alignment after Total Hip Arthroplasty

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Background and Purpose: Orientation of acetabular component, influenced by pelvic tilt, body position and individual variations affects the outcome following total hip arthroplasty (THA). Currently available methods of evaluation are either imprecise or require advanced image processing. We analyzed inter-subject and intra-subject variability of pelvic tilt, measured by sagittal sacral tilt (ST) and its relationship with acetabular component tilt (AT) by using a simple method based on standard radiographs.

Method: ST was measured on lateral radiographs of pelvis including lumbosacral spine obtained in supine, sitting, standing and lateral decubitus position for 40 asymptomatic THA patients and compared to CT data obtained in supine position. AT was measured on lateral radiographs (measured acetabular tilt: MAT) in each position and compared to measurement of AT on CT and an indirectly calculated AT (CAT).

Results: Mean ST changed from supine to sitting, standing and lateral decubitus positions as follows: 26.5° ± 15.5° (range 4.6° - 73.4°), 8.4° ± 6.2° (range 0.6° - 24.5°) and 13.4° ± 8.4° (range 0.1° - 24.2°) (p<0.0001, p=0.002, p=0.0055). The MAT on radiographs was not significantly different from the MAT measured on CT (p= 0.002) and the CAT (p=0.058). There is a good correlation between change in ST and MAT in sagittal plane (r =0.93).

Conclusion: Measurement of ST on radiographs is a simple and reliable method to track changes in pelvic tilt in different body positions. There is significant inter-subject and intra-subject variation of ST and MAT with postural changes and it may explain causes of impingement or instability following THA, which could not be previously explained.

Pelvic Tilt Before and After Total Hip Arthroplasty

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Introduction: While surgical navigation offers the opportunity to accurately place an acetabular component, questions remain regarding ideal component positioning in individual patients. Overall orientation of the spino-pelvic structures may be the most important determining factor affecting target acetabular component orientation. This study assesses supine and standing pelvic tilt, before and after hip replacement.

Methods: 39 consecutive patients undergoing primary total hip arthroplasty were studied prospectively. There were 22 men and 17 women, with an average age of 59.8 years (range 17 to80). Supine and standing radiographs of the pelvis and a CT study for CT-based surgical navigation were obtained prior to surgery. Post-operatively, supine radiographs were obtained at 6 weeks, and standing radiographs 12 weeks following surgery. X-Align, a previously validated 2D-3D radiograph-CT matching algorithm, was used to identify pelvic rotation within one degree with respect to the anterior pelvic plane.

Results: Preoperatively, mean supine pelvic tilt was 3.12° (+/-6.97, range -12.9° to 17.3°), decreasing to -1.62° (+/-6.99, range -14.7° to 18.1°) while standing. After total hip arthroplasty, the mean supine pelvic tilt was 2.92° (+/-6.76, range -12.2° to 17.0°) and the standing pelvic tilt was -3.15° (+/-7.06, range -18.9° to 14°). The difference in standing pelvic tilt before and after surgery was 1.53° (P=0.01), but the change in supine pelvic tilt was not statistically significant. The mean absolute flexibility of the pelvis going from supine to standing was greater postoperatively (6.09°) than preoperatively (4.99°).

Discussion and Conclusion: Measurements from the current study document that pelvic tilt is highly variable between individual patients. Patients generally have more pelvic tilt in a supine than standing position. After THA, supine pelvic tilt does not change significantly compared to preoperatively, but the change in pelvic tilt between the supine and standing positions is increased. Decreased anteversion and flexion in acetabular component orientation may be indicated in patients with significant negative pelvic tilt. Further studies of pelvic tilt in various positions before and after surgery may help to define more objective goals for acetabular component positioning in individual patients.
**PH10-01**

**A Modular distal fix cementless femoral prosthesis in revision hip arthroplasty**

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Modular femoral stem provides significant flexibility in total hip revision arthroplasty. There have been few clinical studies that have dealt with modular stem. We have evaluated the clinical and radiographic performance of 59 patients with distal fix modular Link MP stem. The average follow-up period was 6.4 years. The average Harris hip score was improved from 47 to 87.6. Of 19 patients with trochanteric osteotomy, greater trochanter was displaced in four patients. Re-revision was done to five patients. Three were for subsidence, one of them showed dissociation of the coupling part and the other two were for a nonunion of osteotomy site. There was no statistical relation (p=0.40) between stem subsidence and bone deficiency; the subsidence may have been too small for the canal. As a result of last follow-up, survival rate was 91.5 %( CI 95%, 89-101), but there was no case of recurrent dislocation or femoral stem fracture.  
**Key words:** Total hip revision arthroplasty, Modular cementless femoral stem

**PH10-02**

**OPEN REDUCTION OF A CHRONIC PROXIMAL DISLOCATION AFTER TOTAL HIP ARTHROPLASTY. A CASE REPORT**

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Total hip arthroplasty (THA) is a commonly performed surgical procedure for various arthritic conditions that affect the hip joint, and it has proven to be highly effective for the relief of pain and improvement in the quality of life. Despite many recent advances in THA, dislocation continues to be a frequent complication, and the incidence of dislocation ranges from 1% to 5% in primary THAs. The literature abounds with options for the treatment of recurrent dislocation after THA. However, to the best of our knowledge, successful treatment with open reduction of a chronic proximal dislocation after THA has not been reported previously in the literature. We report an unusual case of a chronic prosthetic dislocation that was caused by the buttonholing of a prosthetic femoral head by anterior soft tissue, which impeded reduction. A surprisingly good functional result was achieved by an open reduction and revision operation on a 56-year-old man, who had a chronic dislocation of a total hip prosthesis.  
5 years after the surgery, the patient has no clinical or radiographic evidence of recurrence of dislocation of THA. We believe that a chronic irreducible dislocation may hamper operations by adhesion and scar tissues. Especially soft tissue buttonholing makes it impossible to perform a closed reduction. We restored a much higher level of function by a single operation in a short time, and made the patient to be able to ambulate with fast recovery from the surgery. Equal limb lengths were restored and no neurologic compromise occurred.
Introduction: Despite the advances in total hip arthroplasty (THA), a dislocation after THA remains a disturbing complication. Dislocation after revision hip arthroplasty has been an underemphasized cause of failure in revision hip arthroplasty despite its higher dislocation rate than after primary THA. The effectiveness of posterior soft tissue repair in the posterior approach has been determined in primary THA. However, to the best of our knowledge, there are no reports dealing specifically with the effectiveness of posterior soft tissue repair in the posterior approach in revision hip arthroplasty. We investigated the influence of the posterior approach with soft tissue repair in revision hip arthroplasty by evaluating the rate of early posterior dislocation.

Material and Method: Ninety-one patients (96 hips) who had undergone revision hip arthroplasty through the posterior approach were observed for 1 year or until dislocation occurred. Fifty-six revision hip arthroplasties were performed using the posterior approach with soft tissue repair technique. The results of these procedures were compared with those of 40 revision hip arthroplasties that had been performed using the posterior approach without soft tissue repair.

Results: The dislocation rate of 10.0% in 40 hips using the posterior approach without soft tissue repair was reduced to 1.9% in 56 hips using the posterior approach with soft tissue repair.

Discussion: Considering the results, it is clear that the posterior soft tissue repair in revision hip arthroplasty is clinically important for achieving a lower dislocation rate after revision hip arthroplasty. We suggest that to prevent dislocation after revision hip arthroplasty when a posterior approach is used, the posterior soft tissue, including the capsule and short external rotators, should be preserved and repaired as much as possible.
FLEXIBLE MEDULLO-ENDOSCOPE FOR CEMENT REMOVAL AND BONE BED PREPARATION IN FEMORAL REVISION SURGERY

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Aim: Visualization of the femoral medullary canal is troublesome in revision surgery. To obtain better visual field of the canal and assist cement extraction and following reconstructive procedures, flexible endoscope was applied in femoral revision.

Materials and methods: Mean age and time to revision of fifteen cemented totally replaced hips were 69.3 (42-83) and 14.9 (3-25) years, respectively. Preoperative status of the revision regarding type of stem loosening was classified as possible in four cases, probable in two, and definite in five classified by Harris et al. No marked finding of loosening was in four. That of bone defect was type I in four cases, Type II in three, and Type III in three by Gustilo. Five cases showed no marked loss of the defect. Extraction of cement mantle was performed under flexible endoscopic inspection. Impaction bone grafting was performed in eight cases. Time for cement removal in association with type of loosening and bone defect and perioperative complications were evaluated.

Results: Retained cement mantle was extractable in all cases under good exposure and with maintenance of efficient working space. Interfacial granulation and fibrous tissues between bone and cement were easily removed. Endoscopic time for cement removal was 41.7 ± 10.3 minutes in average. It was 51.8 ± 6.2 minutes in no loosening, 41.3 ± 11.1 minutes in possible loosening, 38.5 ± 9.2 minutes in probable loosening, and 35.4 ± 8.3 minutes in definite loosening, which depended on the status of fixation between bone and cement. Type of bone defect also influenced the time. It was 52.4 ± 5.6 minutes in the cases of no marked bone loss, 43.8 ± 3.5 minutes in Gustilo type I, 28.3 ± 3.5 minutes in Type II, and 34.7 ± 2.5 minutes in Type III. The procedure was effective to prepare suitable bone bed for reconstruction, which allowed proper stem settlement and facilitated recovery of bone stock in the cases of impaction bone grafting. Intraoperative blood loss was 377 ml (212 - 1430) and total amount of blood loss including post surgical drainage was 593 ml (316 - 1680). Type of loosening and bone defect did not affect both whole and intra-operative bleeding volume. However, three occult fractures happened, in which two revealed minor cement leakage and one required additional osteosynthesis with extensive approach.

Conclusion: The data indicated that flexible medullo-endoscope could provide good visual field with maintenance of working space, potentially contributing to less invasive femoral revision surgery, if it would be combined with refined device for cement extraction to improve accuracy of the procedure.
TWO-STAGE REIMPLANTATION FOR PERIPROSTHETIC HIP INFECTION CAUSED BY RESISTANT MICROORGANISMS

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Two-stage reimplantation is currently the most widely accepted method of treatment for a periprosthetic hip infection, but it remains controversial whether the treatment protocol may be equally effective in the eradication of resistant microorganisms. We compared the results of two-stage reimplantation performed for periprosthetic hip infection caused by resistant microorganisms with those performed for periprosthetic hip infection caused by non-resistant microorganisms.

We reviewed a consecutive series of 32 patients (32 hips) who had a culture-proven deep infection at the site of hip arthroplasty and were treated by a two-stage reimplantation protocol. Based on the antibiotic sensitivities of the infecting microorganisms, the patients were divided into two groups. Resistant microorganism group consisted of 20 patients who had an infection with antibiotic-resistant bacterial strains (methicillin-resistant Staphylococcus aureus in 11 and methicillin-resistant Staphylococcus epidermidis in 9). Non-resistant microorganism group consisted of 12 patients who had an infection with antibiotic-sensitive bacterial strains. The treatment was considered a failure if the patient had a persistent infection after the first-stage procedure or a recurrence of infection after reimplantation. The mean duration of follow-up after the index procedure was 45 months (range, 24 to 123 months).

Among the entire series of the 32 patients, the second-stage reimplantation was able to be performed in 29 patients (91%) and the remaining three went on to a permanent resection of the hip because of persistent infections. After the two-stage reimplantation, four patients had a recurrence of infection (relapse of infection with the same microorganism in 3 and reinfection with different resistant microorganism in 1). Thus, overall treatment failure rate was 22% and all these failures occurred among patients with resistant microorganisms. Treatment failure rate of 35% in resistant microorganism group was significantly higher than that of 0% in the non-resistant microorganism group (p = 0.029).

None of the variables evaluated in this study was found to be significantly associated with the treatment failure in the resistant microorganism group.

Current two-stage reimplantation protocol showed a high rate of treatment failure in our patients who had periprosthetic hip infection caused by methicillin-resistant bacterial strains. Further study is needed to develop optimal treatment strategy for this difficult-to-treat condition.
**Revisional Hip Arthroplasty**

**PH10-07**

**Revision Total Hip Arthroplasty Using Allogenic Impaction Bone Graft and Cemented Cup in Acetabular Bone Deficiency - Ten Year Analysis**

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This study was to analyze the minimum ten years clinical and radiological results of revision total hip arthroplasties using allogenic impaction bone graft and cemented cup in acetabular bone deficiency. Fifty two revision total hip arthroplasties that had been performed in forty nine patients between March 1992 and June 1997 and had followed more than minimum ten years were included in this study. The clinical and radiological results were evaluated by Harris hip score and roentgenography including anterior-posterior view of pelvis and lateral view of operated hip. The mean Harris hip score was 47 points preoperatively, 81 points at three years, 84 points at seven years, and 82 points at ten years after revision. In radiological evaluation, osseous union between grafted bone and host bone was seen within four months in 47 hips, a complete grafted bone-cement radiolucent line of two millimeter or more in at least one zone was seen in 5 hips at two years, 7 hips at seven years, and 2 hips at 10 years follow-up. We recommend the technique using allogenic impaction bone graft and cemented cup to reconstruct the acetabular cavitory defect in revision total hip arthroplasties.

**PH10-08**

**Cementation of a Polyethylene Liner into a well-fixed Metal Shell**

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**Background**: A common clinical scenario encountered by an orthopaedic surgeon is a patient with a secure cementless acetabular shell and a failed polyethylene liner. One treatment option is to cement a new liner into the fixed shell. The purpose of this study was to evaluate the radiographic outcome of this technique.

**Materials and Methods**: From November 2001 to April 2006, 11 liners were cemented into well-fixed cementless acetabular shell of 10 patients. There were 6 males and 5 women of average age 54.3 (range 41~73) years at the time of the revision surgery. The indication for the revision procedure were aseptic loosening and wear in 9 cases, and periprosthetic fracture in 2 cases. The pre-existing screws in the shell were removed, and screw holes were filled with allogenic bone graft or cementation. The patients were evaluated the radiographic evidence of progressive loosening and osteolysis. The average follow up period was 35.2 (range 24~76) months.

**Results**: There were no changes in cup and liner position or progression of osteolytic lesion around the femoral or acetabular components in the last follow-up radiographs. No complications such as a deep or superficial infection or deep vein thrombosis occurred. There were no hip dislocations.

**Conclusion**: A liner cemented into a secure, well-positioned cementless acetabular shell provide stability and durability at short and long term follow up. This technique also has advantages of preventing bone loss associated with removal of a well fixed component, and lower surgical morbidity and more liner options. Careful attention to the preparation of the liner, the sizing of the component, and the cementing technique are likely to reduce the failure of this construct.

**Key Words**: revision total hip arthroplasty, cemented liner, acetabular shell, wear
**Early Postoperative Periprosthetic Femur Fracture in the Presence of a Non-Cemented Tapered Wedge Femoral Stem**

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Non-cemented tapered wedge femoral stems have gained popularity given their excellent long-term clinical success rates. However, there is sparse literature reporting the incidence of early postoperative periprosthetic femur fractures in patients with this stem design. The aim of this study is to report this incidence and to identify factors which may increase the risk of such fractures.

The charts of all patients who were implanted with a single design of a tapered wedge femoral stem at a single institution were retrospectively reviewed to identify any early periprosthetic femur fractures, defined as occurring within the first year of surgery. Demographic, operative, and radiographic details were analyzed for potential risk factors that may predispose to periprosthetic fractures, and compared to a cohort of patients with the same implant that was matched for age, sex, and pre-operative diagnosis and did not have a periprosthetic fracture.

Six fractures were identified in 2220 stems implanted over a five year period, for an incidence of 0.3%. The average time to fracture was nine weeks post-operatively. Five fractures were Vancouver Type B2, and the other was Vancouver Type A. Three stems were radiographically undersized, and two failed to achieve a proximal wedge fit because of distal fixation. When compared to the matched cohort, there was no statistical significance with regard to body-mass index, morphological cortical index, or canal-bone ratio. However the fracture cohort did have a statistically lower canal-calcar ratio (p < 0.05) and statistically higher canal-flare index (p < 0.05).

Early postoperative periprosthetic femur fracture around a tapered wedge stem is a rare but potentially devastating complication. Risk factors which may predispose to fracture are a proximal-distal mismatch in femoral geometry and an undersized implant.
FAILURE OF OSTEOINTEGRATION OF A PROXIMALLY-COATED NON-CEMENTED TAPERED STEM: IS THERE AN ANATOMIC PREDISPOSITION?

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Proximally-coated non-cemented tapered femoral stems have demonstrated excellent long-term clinical results. However, there is sparse literature reporting the incidence of failure of osteointegration in patients with this stem design. The aim of this study is to report this incidence and identify factors which may increase its risk.

206 elective primary total hip arthroplasties were performed consecutively with a single stem design over a three-year period. All patients were evaluated clinically and radiographically. Radiographic parameters were analyzed for any potential risk factors that may predispose to failure of osteointegration.

Three of 206 hips failed to osteointegrate and subsequently underwent revision surgery, for an incidence of 1.5%. The average time to revision was 1.2 years. The presenting complaint was persistent pain and radiographs revealed a progressive linear lucency at the proximal implant-bone interface in all three patients. Each patient had been implanted with a large-sized stem that had achieved a diaphyseal fit radiographically. This cohort had a statistically lower canal-flare index (p < 0.05) when compared to the rest of the study group. At the time of surgery, all stems were found to be loose and were easily removed.

Failure of osteointegration in this type of stem is an uncommon but serious complication that may necessitate revision surgery. Risk factors predisposing to a failure to osteointegrate are a mismatch between the patient’s proximal femoral geometry and the stem, specifically a large stem in a Dorr type C femur, leading to a diaphyseal rather than a metaphyseal wedge.

"Karayahesive" as Hydrocolloid Wound Dressing for Hip Arthroplasty

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"Karayahasive" is a kind of wound dressing film made of the Hevea sap and has the very strong adhesiveness. For the hip arthroplasties, we use it since October 2004. It applies the moist wound healing mechanism without preventing the self-wound-healing. The surgical exudate is kept under Karayahasive to apply the moist wound healing mechanism. As it has a very strong adhesiveness, we use it also as an alternative to the epidermal suture. In our method, we do not use any epidermal suture or staples. We use an anterolateral approach making an arcuate incision. After the subcutaneous tissue was sutured just like as in the case of using the epidermal sutures or staples, Karayahasive was attached to the skin. After application, the gauze dressing and the elastic bandage were placed on Karayahasive. Both Karayahesive and the gauze were not changed until the removals on the tenth day after surgery. No specific complication was observed. No patients suffered complications such as ruptured suture, infection, allergic reaction or cheloid / hyperplastic scar. Though Orientals have less ability of wound healing than Caucasian, a satisfactory wound healing was achieved without any epidermal suture. Comparing the conventional skin closure methods, Karayahasive brought about less pain; as no removal of staples was necessary, less time and labor, less medical waste, and better wound healing. As the disadvantage, some sensitive patients might mind the smell of the exudate under Karayahasive. The wound closure method using Karayahesive was very useful for the hip arthroplasty.
http://www.ista.to/congress/submitAbstract.php
Perioperative complications in total hip arthroplasty when using a pneumatic broaching system for for Zweymuller-type, square-tapered hip stems. A prospective review of 300 cases using implants from eight different manufacturers.

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The use of tapered titanium femoral stems has gained in popularity for primary total hip arthroplasty. One of the basic stem designs is a fully grit blast square tapered stem with distal fixation (Zweymuller-type). Another stem design (Muller-type), a proximally porous coated flat wedge stem with proximal fixation is associated with a low but significant perioperative femoral fracture risk. Both of these implant types are inserted with a broach-only technique. We theorize that the Zweymuller-type implant can be inserted safely with pneumatic broaching with a very low fracture risk even when broached by rotating residents with no prior experience.

We prospectively reviewed 300 consecutive hip arthroplasty cases using Zweymuller-type stems from eight different manufacturers implanted using the Woodpecker TM pneumatic broaching system. The series included both THA and hemiarthroplasty cases with a wide range of cortical/canal indexes. Patient age ranged from 14 to 98 (avg. 68). Half of the hip stems were inserted through a posterolateral modified Kocher-Gibson approach, and half through an anterolateral Hardinge approach. Approximately 25 rotating residents who were initially unfamiliar with this broaching technique and stem implant type performed the majority of the procedures. We routinely obtained an intra-operative AP pelvis x-ray to confirm trial implant size, alignment, and adjust the leg lengths.

The overall technique/implant-related perioperative complication rate was 2% (6/300). These included intra-operative femoral fractures(2), post-operative femoral fractures (1), dislocations(1), and deep infections(2). There were no cases of nerve palsy or leg length inequality >1cm. Rates of post-op blood transfusions and venous thromboembolism were not reviewed for the purposes of this study. Only one of the complications (one deep infection) required exchange of the original femoral component. There was no significant difference in complication rates between type of surgical approach, brand of square tapered stem manufacturer, or experience of the operating surgeon.

We conclude that hip arthroplasty using pneumatically broached, square tapered, cementless distal fixation (Zweymuller-type) hip stems has a low learning curve and can be implanted safely even in very osteoporotic bone. This technique/implant gives the surgeon control of stem anteversion for stability and leg length inequality correction. The incidence of certain perioperative complications can be reduced by using Zweymuller-type stems using pneumatic broaching regardless of approach, implant manufacturer, or surgeon experience. These patients will continue to be followed clinically for implant survivorship.
The Influence of Autologous Whole Blood Transfusion on Venous Thromboembolism and D-Dimer Levels in Lower Extremity Arthroplasty

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Venous thromboembolism (VTE) is a frequent, life-threatening postoperative complication of orthopaedic surgery. Preoperative autologous blood donation has been advocated to reduce the risk of transfusion reactions and to limit potential infectious risk associated with donor blood. Experimental data suggest that autologous leukocytes might lead to immunomodulation similar to the effect attributed to allogenic leukocytes, but autologous whole blood (WB) is often still being used in Japan. We investigated the incidence rate of VTE and plasma D-dimer levels of the autologous WB transfusion and compared the findings with autologous red cell concentrates (RCC) and fresh frozen plasma (FFP) with regard to the cases of lower extremity arthroplasty.

The subjects of this study were 138 patients with lower extremity arthroplasty who were scheduled to receive surgery. The operations included: 72 total hip arthroplasties (THA) and 66 total knee arthroplasties (TKA). Postoperatively, plasma D-dimer levels were measured latex agglutination turbidimetric immunoassay. Ultrasonography and contrast-enhanced helical computed tomography was used for diagnosing VTE.

There was no statistically significant difference in the post-surgery incidence rate of VTE between the autologous WB group (THA: 20.0%, TKA: 27.9%) and autologous RCC/FFP group (THA: 11.9%, TKA: 30.4%). On the first post-surgery day, the plasma D-dimer levels were significantly higher in autologous WB group (THA: 8.1 ± 9.5 mg/ml, TKA: 12.1 ± 15.9 mg/ml) compared to the autologous RCC/FFP group (THA: 4.2 ± 2.9 mg/ml, TKA: 8.0 ± 6.6 mg/ml). However, the plasma D-dimer levels were almost the same in both groups on the 14th day from the surgery. The results of this study suggest that donation and transfusion of autologous WB do not negatively influence the post operative VTE compared with autologous RCC/FFP. However, we must cautiously assess the plasma D-dimer levels of the autologous WB group on the first post surgery day because of the high propensity of showing false positive rate compared to the RCC/FFP group.
PERIOPERATIVE COMPLICATIONS OF THE PATIENTS WITH MENTAL DISORDERS UNDERGOING TOTAL HIP ARTHROPLASTY

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Aim: Mental disorder has been recognized as one of the troublesome factors in the perioperative management of the patients with total hip arthroplasty. However, precise clinical analysis regarding outcome of efficacy and complication in the surgery has not been reported in detail. Our institute has owed the treatment of the patients with various severe complications in the district of 1.2 million. The patients of hip disability with mental disorders have been introduced for the treatment and managed under co-operation with division of Psychiatry. This study focused on perioperative status and complications of the patients with mental disorders underwent total hip arthroplasty.

Materials and methods: Retrospective survey included consecutive 354 THAs of the 309 patients performed from January 1986 to December 2006. Reason for the surgery was due to dysplastic osteoarthritis; 251 cases (85.1%), rheumatoid arthritis; 45 (14.6%), idiopathic osteonecrosis of femoral head; 12 (3.9%) and post-traumatic arthritis 1 (0.3%). The mean age was 61.0 (29-83) years. The rate and status of the patients with mental disorders, their perioperative complications and hospitalization period were analyzed, and compared with those of the patients without disorders.

Results: Fifteen patients with mental disorders (4.9%) received THA and the mean age was 54.8 (34-76) years. Eleven patients (73.3%) was due to dysplastic osteoarthritis, 3 (20.0%) to osteonecrosis of the femoral head, and 1 (6.7%) to rheumatoid arthritis. The disorder was categorized into mood disorder (7 cases), schizophrenia (6), somatoform disorder (1) and alcohol dependence (1). Pain relief was achieved and gait ability was improved in all the patients. Dislocation was found in 3 cases (20.0%), who were all dysplastic osteoarthritis, and which occurred after 8, 30, and 49 days, respectively. One patient had a possibility of implant malposition. Two-thirds was due to inactivity and/or impairments of attention influenced by the psychotic drugs, but not failed into recurrent type of dislocation. The rate was significantly higher than that of the patients without the disorders (2.3%), (p<0.05). Infection, major bleeding, serious thrombo-embolic events, and anesthetic complications were not found. Type of psychotropic drug was antidepressant (13 cases), antipsychotic (9), anticholinergic (5), antialcohol (3), antimanic (2) and antiepileptic (1). Their mean number of the drug type was 4.1 in the patients of mental disorders, 4.7 in the patients with dislocation and 3.9 without dislocation, which was significantly high in the patients with dislocation. (P<0.05). Hospitalization period of the patients was 37.2 (8-47) days, which was not significantly different from those of the patients without the disorders; 36.9 (10-94) days (P=0.86)

Discussion: Postsurgical dislocation was evident finding in the series of the patients with mental disorders. Two thirds seemed to be affected by the medicated drugs, but not failed into recurrent type. Other major complication was not experienced and the treatment was successfully achieved under management under co-operation with division of Psychiatry and rehabilitation unit. THA for the patients with mental disorders contributed to recovery of hip disability.
CATASTROPHIC FAILURE OF METAL HEADS IN REVISION TOTAL HIP ARTHROPLASTY DONE FOR CERAMIC FRACTURES

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Introduction: The tribological properties of bearing surfaces are one of the main topics in discussion in the orthopaedic research. Hard-on-hard bearings are one of the ways to reduce wear rates. Modern hard-on-hard bearing low wear rates depend on the correct pairing of bearing surfaces and strict manufacturing tolerances in surface roughness, clearance, and roundness.

There have been some concerns in using ceramic bearings, particularly regarding the fracture rate and their subsequent management. Hence, we present here 2 similar cases that highlight the catastrophic failure of metal head when used subsequently to treat the complication of ceramic fractures in Total Hip Arthroplasty (THA).

Case Details: Two patients underwent primary THA at different centres with ceramic-on-ceramic bearing. After an initial asymptomatic period of 2 years, ceramic fracture occurred in both the cases, which were subsequently replaced by metal-on-polyethylene bearings by the primary surgeons. One year after the revision of bearings, both the patients developed severe pain and discomfort, which on further investigation revealed massive metallosis, wear of the metal head and aseptic loosening of the acetabular components with cavitation in acetabulum. Both the patients underwent revision THA under the senior author at our tertiary centre-Wrightington Hospital. Intraoperatively near total erosion of the metal head was noted with more than one litre of black, dense material collection in and around the hip joint revealing extensive metallosis. The acetabular cup was grossly loose and significant loss of bone stock was noted due to metallosis. Single stage revision surgery was performed with impaction bone grafting for deficient acetabulum and cemented components were used. At one-year follow-up none of the cases have shown any further wear or complications.

Conclusion: One of the main objectives of successful THA is to improve implant longevity. To achieve this understanding the mechanisms of wear between the interacting surfaces is extremely important. The use of ceramic head is good, but there is always a risk of fracture. We do not recommend using metal heads in cases with prior ceramic fractures, as the wear of metal is most likely to occur as it is an ongoing process due to the residual ceramic debris. Hence in these difficult scenarios we recommend usage of ceramic-on-polyethylene as a safe option to prevent catastrophic erosion of metal head and improve implant longevity.
GIRDLESTONE RESECTION ARTHROPLASTY OF THE HIP: WHAT KIND OF LIFESTYLE AFTER IT?

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In the last months of 2007 we started to retrospectively review 60 patients who had undergone Girdlestone resection arthroplasty of the hip between 1994 to 2006. The most frequent indications for this procedure were sepsis around prosthesis, aseptic loosening, pseudoarthrosis after femoral neck fractures or medical compromised patients who had an high risk of hip reimplantation procedure. The evaluation of patient’s satisfaction ranges a lot in literature and no valid guidelines have been published.

All our patients were submitted to limb shortening measurement and functional evaluation according to SF-36 score and Harris Hip Score. There were 20 men and 40 women with an average age of 70 years old (range 96-43 on operation time), the mean follow up was 133 months (range 14-167 months). Some patients were lost at the follow-up, the main reason was death for related and unrelated causes (overall mortality of 30%). The aim of this study was to analyze patient’s satisfaction and functional outcomes after Girdlestone arthroplasty which appears in our experience, despite the limits, a valid surgical option in order to improve hip function, decrease or cancel pain and control infections when implantation or reimplantation is not possible.

Modular endoprosthetic reconstruction for segmental bone defects in non-neoplastic limb salvage

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Introduction: Segmental bone defects with complex fractures or chronic infections comprise a very special subset of patients. Modular endoprosthetic reconstruction is an operative solution. Without reconstruction amputation/disarticulation is the likely outcome.

Aim: To analyse preliminary results of modular endoprosthetic reconstruction in nonneoplastic limb salvage.

Methods: 11 patients(9 - distal femoral replacement, 2- total femoral replacement) underwent salvage reconstruction between January 2005 and March 2008 for chronic periprosthetic infections(6 - single stage revision; 2 - two stage revision) and complex periprosthetic fractures(3) with segmental bone defects. Microbiological and haematological evidence of infection was confirmed in the infection group and treated with concomitant community based antibiotic therapy as per guidance from specialist team.

Results: The mean age and follow up were 74.2 years and 27.5 months respectively. No intraoperative complications identified. Average post operative mobilisation was with frame at 5 days, 2 sticks at 2 weeks. 1 patient required plastic surgical intervention at index operation. 1 patient had recurrence of infection. Radiographs at 6, 12 & 24 months showed no changes from immediate post-op. Microbiological and haematological evidence of infection eradication was considered as successful treatment. Knee range of movements averaged full extension to 95 degrees. Oxford knee scores showed maximal improvement in the single stage revision group.

Conclusion: Salvage endoprosthetic reconstruction has provided an opportunity to avoid amputation. A significant improvement in overall range of motion, knee scores, pain relief and stability was achieved in this highly complex subset of patients. Multidisciplinary support from plastic surgeons and specialist microbiologists is essential.
FORMAL PATIENT EDUCATION PRIOR TO HIP OR KNEE ARTHROPLASTY LOWERS COSTS AND LENGTH OF STAY

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Introduction: Ranked as the second most common cause of long-term disability amongst American adults, osteoarthritis (OA) affects well over 60 million Americans per year. OA is one of the major contributors to health care-related economic cost in the US, which is generally considered unacceptably high when compared other Western industrialized nations.

Methods: Three hundred and thirty-five patients undergoing primary unilateral or bilateral total hip arthroplasty (THA), metal-on-metal hip resurfacing (MOMHR), total knee arthroplasty (TKA), or unicondylar knee arthroplasty (UKA) were offered voluntary participation in an one-on-one preoperative education session with a preoperative educator. Length of stay (LOS) and in-patient costs was collected for patients who received individual pre-operative education. This was then compared to patients who chose not to participate in the education sessions using linear regression models.

Results: Patients who chose to participate enjoyed a significantly shorter LOS than those who did not receive education, controlling for age, sex, type of procedure, and number of co-morbid conditions (3.1 ± 1.1 vs. 4.5 ± 4.7; p<0.01). THA patients participating in the preoperative education program exhibited a calculated cost savings of $861 per case over non-educated patients (p=0.06), while TKA patients participating in the program exhibited a statistically significant savings of $1,144 per case (p=0.02). This translated into a cost savings of $84,351 for 93 THA patients and $93,493 for 74 TKA patients at our institution, accounting for the cost of the patient educator. Of higher significant impact on cost savings was the number of co-morbid conditions for both THA (p=0.01) and TKA (p=0.01) patients. If applied in the national setting, national cost savings projections for a mean 0.84 day reduction in LOS for educated THA patients estimated a savings of nearly $800 million; a mean 0.56 day reduction for preoperatively educated TKA translated into a projected savings of $1.1 billion on the national scale.

Conclusion: Preoperative education in the setting of hip and knee arthroplasty is an important cost-savings tool for hospitals, Medicare and third party payers in this era of rising health care costs.
COMPARISON OF PERI-PROSTHETIC BONE MINERAL DENSITY BETWEEN TRABECULAR METAL AND CEMENTED TIBIAL COMPONENT

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Introduction: The introduction of porous tantalum metal (Trabecular Metal; Zimmer, Warsaw, IN) for acetabular component fixation in total hip arthroplasty has shown optimum fixation qualities and “gap filling” effect. It is reported that high volumetric porosity (70% to 80%), low modulus of elasticity (3 MPa), and high friction characteristics of trabecular metal make it conductive to biologic fixation. Recently, trabecular metal was introduced in tibial component for total knee prosthesis. However, the effect of trabecular metal tibial component on the bone mineral density (BMD) was not reported. The purpose of this study was to compare the BMD of proximal part of the tibia between trabecular metal and another cemented tibial component.

Materials and Methods: 31 knees receiving trabecular metal tibial component and 33 knees receiving cemented tibial component (PFC Sigma RP, Depuy, Warsaw, IN) had dual energy x-ray absorptiometry (DEXA) scans at preoperatively and 3 weeks, 3, 6, 12, 18, 24 months post-operatively. To assess peri-prosthetic BMD, three regions of interest (ROI) were measured for each case. They were medial aspect (ROI 1), center aspect (ROI 2) and lateral aspect (ROI 3) of tibia. At the same time, BMD of femoral neck, wrist, lumbar spine and contra lateral knee were measured as reference. All of the operation was performed by one surgeon (AK) through medial parapatellar approach. The day after operation, drain was removed and patients were allowed to walk. Average follow up period was 1.8 (range: 1.5 to 2) years.

Results: Preoperative knee score, BMD in femoral neck, wrist, lumbar spine, and knee between two groups were not significantly different between two groups. In both groups, BMD in tibia decrease postoperatively. Comparing postoperative decrease of BMD in lateral aspect of tibia (ROI 3) between both groups, it was significantly less in trabecular metal component (-0.09 g/cm² +/-0.27) than cemented tibial component (-0.31 g/cm² +/- 0.21) (p=0.0007).

Discussion: To our knowledge, this is the first report on BMD change after total knee arthroplasty using trabecular metal monoblock tibial component. Previous literature on BMD relating to TKA described that bone loss behind the anterior flange of the femoral component has been shown to range 22% and 36%. And it was also reported that there was no significant difference in relative change of periprosthetic BMD of proximal tibia between cemented and conventional cementless component. Our results suggest that trabecular metal tibial component decrease the relative change of BMD, comparing to cemented tibial component. This difference might be caused by the difference of fixation and bone loading characteristics between trabecular metal and conventional cementless component. Our DEXA study revealed that trabecular metal tibial component showed a favorable effect on BMD of proximal part of the tibia after total knee arthroplasty.

CONCLUSION: DEXA study revealed that trabecular metal tibial component reduced postoperative decrease of BMD around the component in TKA.
Plastic Deformation Analysis of UHMWPE Tibial Insert of PS Type Knee Prostheses under Repeated Deep Flexional Motion

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Knee prostheses have widely been used for severely damaged knee with osteoarthritis or articular rheumatism. PS type knee prosthesis is one of typical artificial knee joint systems and characterized by possessing the post-cam structure to stabilize the motion of the knee at large flexion angles. Post is a projection placed on the surface of UHMWPE tibial insert, and severe fracture and wear of the post are sometimes reported. It is therefore very important to understand the stress state of the post under real flexion motions in order to prevent such damages. It is also well known that the contact and bearing surfaces of a human knee is subjected to very high force especially during deep knee flexional motion such as squatting, and it is naturally expected that the tibial insert of a knee prosthesis deforms plastically under such high force condition.

In this study, three dimensional dynamic finite element analysis of two types of PS knee prosthesis clinically used worldwide, Stryker’s Scorpio Superflex and NRG, are performed to characterize the plastic deformation behavior due to stress concentration generated in their tibial inserts under deep knee flexion motions. The new system NRG is recognized as a modified version of Superflex. Especially, the shape of the post is tried to be improved in order to reduce stress concentration and mobility. Continuous repeated flexional motion such as flexion-extension-flexion motion is considered in the analysis. Internal rotation of the tibial component and insert with flexional motion is also considered. It is found that severe stress concentration is generated in the post for both models and also in the condylar surfaces, and the stress concentration in Superflex is much higher and wider in NRG. Plastic deformation is therefore observed at these stress concentration points. The relationship between residual stress and plastic deformation in the tibial inserts is then discussed based on the analytical results.
Prevention of Cold-Preservation Injury of Articular Cartilage by Epigallocatechin-3-O-Gallate Regulating Cell Cycle and NF-κB Expression

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Although epigallocatechin-3-O-gallate (EGCG), the predominant catechin from tea, has various pharmacological and biological activities including anti-carcinogenic, anti-thrombotic and anti-inflammatory effects, relatively a little is known about its beneficial effects on the non-frozen preservation of mammalian cells and tissues. In the present study, a storage solution containing EGCG was employed to testify the hypothesis that cold preservation of osteochondral allografts was attributed to EGCG-mediated reversible regulation of cell cycle. Human articular cartilages were obtained from knee joints of 10 patients (58 - 86 years old) undergoing total knee arthroplasty at Marunouchi Hospital, Matsumoto, Japan. Cartilage specimens were procured by osteotome under sterile conditions from the donor and placed in saline for 1 hr until the end of surgery. Immediately after surgery, the specimens were transferred in a storage solution (serum-free RPMI 1640 media with 1% antibiotic-antimycotic solution without or with 1 mM EGCG) and kept at 4°C. The specimens were then delivered to the senior author (Prof. Hyon) within 1 day from procurement. Additionally, fresh cartilages were delivered in a complete media with 10% fetal bovine serum at room temperature after procurement from the donor. Because of this necessary processing delay between tissue procurement from the donor and its delivery, 1 day was set as the data point for the fresh specimen. All procedures involving human subjects received prior approval from Marunouchi Hospital, Osaka City University Graduate School of Medicine and the Institutional Review Board of Institute for Frontier Medical Sciences, Kyoto University, and all subjects providing written informed consent.

On receipt of the cartilage tissues, the specimens were replaced with either 20 ml of a storage solution without or with EGCG and then stored at 4°C for 1, 2 and 4 wk. At the end of each storage period, chondrocyte viability (CCK-8 assay), biochemical and immunohistochemical composition [glycosaminoglycans (GAG) and (type II) collagen], and biomechanical property (compressive elastic modulus) were assessed. The regulatory effects of EGCG on cell cycle distribution as well as expression levels of cyclins (CCNs) and nuclear factor-κB (NF-κB) were also investigated in articular chondrocytes. Chondrocyte viability of cartilages preserved with EGCG was significantly well-maintained for at least 2 weeks with high contents of GAG and total collagen. These beneficial effects of EGCG were confirmed by histological and immunohistochemical observations showing well-preserved cartilaginous structures and delayed denaturation of extracellular matrices. The compressive elastic modulus of cartilages preserved with EGCG was almost in the same range as that of fresh ones. Moreover, the penetration of FITC-conjugated EGCG into the matrices of cartilages and its incorporation into the cytosol of cells in lacunae was observed. Increased cell population at the G0/G1 phase by EGCG returned to the normal level after EGCG removal, whereas decrease at the G2/M phase did not. Negatively regulated expression of CCND1, CCNE2 or NF-κB in EGCG-treated cells was restored by removing EGCG, but not CCNA2 and CCNB1. It is suggested that EGCG play effective roles in preserving articular cartilages by reversibly regulating cell cycle at G0/G1 phase and NF-κB expression.
ARE MORE NATURAL TKA KINEMATICS OBTAINED WITH AN ACL-SUBSTITUTING DESIGN?

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Posterior-cruciate ligament retaining (CR) total knee arthroplasty (TKA) designs have long been used with excellent clinical success, but have shown kinematics that are significantly different from the natural knee. Recently, variations on traditional CR designs have been introduced. The purpose of this study was to compare deep-flexion knee kinematics in patients with two types of CR-TKA: one group received a traditional non-conforming symmetric articular configuration, and one group received a design incorporating a lateral compartment which is fully congruent in extension, but lax in flexion - approximating the function of the anterior cruciate ligament.

In vivo kinematics were analyzed using 3D model registration and plain radiographs of kneeling and squatting activities in 20 TKAs in 18 patients with a minimum follow-up of 12 months. Two surgeons worked together placing all components. Ten knees received a traditional CR-TKA (CR Group), and 10 knees received an ACL-substituting TKA (AS Group). CR Group subjects averaged 66.1 ± 7.4 years and were 12.3 ± 0.5 months post-op. AS Group subjects averaged 68.0 ± 5.4 years and were 12.4 ± 0.7 months post-op. True lateral radiographs were taken in 4 positions: 1) with the patient in a weight-bearing, single-leg stance, 2) kneeling at 90°, 3) kneeling at maximal flexion, and 4) squatting. Two-way repeated measure ANOVA was conducted to determine if there were effects of design or flexion angle on the AP tibiofemoral contact position. Medial and lateral sides were analyzed separately. The level of significance was set at p<0.05.

There was no significant difference in the average post-operative Knee Society Clinical/Functional Scores between CR Group (96 ± 2 / 88 ± 11) and AS Group (94 ± 2 / 92 ± 9). Clinical ROM was recorded using a handheld goniometer. The clinical pre-operative passive ROM was 113° ± 15° (80° -135°) for CR Group and 116° ± 20° (65° -140°) for AS Group (p=0.75). The clinical post-operative passive ROM was 117° ± 11° (100° -130°) for CR Group and 127° ± 13° (115° -60°) for AS Group (p=0.07). During squatting, the implant flexion angle was greater for AS Group (119° ± 15°: 101° -157°) compared to CR Group (104° ± 10°: 94° -123°, p=0.02). Tibial external rotation at maximum kneeling and squatting activities were significantly larger in AS Group knees (10.2° ± 4.8° / 9.0° ± 3.9° versus 16.6° ± 4.1° / 15.8° ± 4.1°, p=0.00/ p=0.00). Average tibiofemoral contact position of the lateral condyle during squatting activity was significantly posterior in AS Group compared to CR Group (-11.2 ± 5.6mm vs. -6.2 ± 3.0mm, p=0.02).

Substitution of the ACL by a lateral compartment which is conforming in extension may provide more natural stability and function with knee arthroplasty. In this comparison of two small groups, knees with the ACL-substituting design exhibited femoral AP translation and rotation closer to the natural knee than did knees receiving a traditional symmetric CR prosthesis. The long-term success of TKA depends not only on kinematics factors, such as those reported here, but also on polyethylene wear and patellar complication. A longer-term clinical study will be required to determine if high flexion activity will lead to increase polyethylene wear or patellar complications.
Introduction: Posterior stabilized (PS) type knee prosthesis characterized by Post-Cam structure as stabilizer has successfully been used in TKA worldwide, while failure and fracture problems of tibial insert made from polymeric material (UHMNWPE) are still important issues from clinical and mechanical points of view. It is therefore needed to understand the mechanical conditions of the tibial insert under different kinds of TKA motions. The aim of this study is to characterize the mechanical condition of tibial insert under contact between femoral component and tibia insert during flexional motion using dynamic 3-D finite element (FE) method. 3-D FE models of two different kinds of PS type prostheses clinically used were developed and stress analyses were performed from full extension to 135 degree knee flexion. Effects of the different Post-Cam structures on the stress states were investigated, and a guideline towards risk assessment of PS type prosthesis was discussed.

Materials and Methods: 3-D FE models of Stryker’s PS type knee prostheses, Scorpio Superflex and NRG, were developed base on their CAD data. The tibial post of Scorpio Superflex type knee prosthesis shapes angular, while NRG shapes round. Four nodes tetrahedral elements were used to construct the FE models. Nonlinear spring models were attached to the front and back of the tibial component to express the effect of soft tissues on the movement of real TKA knees. Vertical load and horizontal load were applied to the femoral and tibial components, respectively, to express a deep knee bending (squatting) motion. Flexion motion was introduced by rotation the femoral component from full extension to 135 degree. Internal rotation of 5, 10, 15 degrees were also introduced by rotating the tibial component simultaneously with the flexional motion.

Results: Maximum Mises equivalent stress during knee flexion with 5, 10 and 15 degrees internal rotation of the tibial component of Superflex were much higher than that of NRG, especially at the flexion angle of 120 degree. NRG exhibited stress concentrations on both the Post and condylar surfaces and stress levels were much lower that that of Superflex. The maximum stress in NRG was found to be reduced to about half of Superflex. Mises equivalent stress distribution also showed that flexion with internal rotation generated higher stress concentrations on the condylar surfaces of both prostheses.

Discussion: The analytical results well demonstrated that the design modification of the tibial insert of NRG effectively reduced the stress concentration with rotated tibial component. The lower stress level in NRG corresponds to the lower reaction force and hence lower resistance to flexional motion than Superflex. This implies that the round post is more suitable for deep flexion than the angular post.
Biomechanical Analysis of the Surgical Position of Tibial Insert in Total Knee Replacement: a Finite Element Analysis

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The goal of total knee arthroplasty (TKA) is to relieve pain and restore the function of the knee joint. Recently, the number of TKA cases in Korea has increased considerably with increase in elderly population and change in lifestyle. Accordingly, demand for TKA design that is capable of better accommodating anatomical dimensions and lifestyles of Koreans is also on the rise. During the prototype design process for the Korean-TKA, different stem and keel designs of the tibial base plate have been attempted to improve fixation and longevity of the implant. In this study, we conducted a biomechanical analysis of the tibial base plate using finite element analysis (FEA). Specifically, biomechanical effects of insert positioning in the tibia were assessed to investigate the likelihood of tibial fracture and implant loosening due to mal-positioning of the implant.

A 3-D finite element (FE) models of the left femur, patella, and tibia were developed from computed tomography (CT) scan data (a normal Korean male, 27 years of age, 70 kg). 2-D truss elements were chosen to represent ligamentous structures such as lateral & medial collateral ligament, posterior cruciate ligament, patella tendon and patella ligament. Nonlinear elastic material properties for the soft-tissue structures were also adopted from literature. The surgical model was then constructed after inserting Korean-TKA prototype in the intact model. Here, the implant was the posterior cruciate ligament retaining type (CR) with the fixed bearing system. To simulate loading on the knee joint in heel strike and toe-off positions, 15° and 45° flexions of the femur orientation were simulated under the compressive load of 3.8 and 5.7 times of body weight (BW= 700N), respectively, in a uniform pressure at the horizontal section of the femur. The tibia was assumed to be completely constrained. The surgical position of the tibial insert was varied from the center either to the medial or to the lateral direction by 3-mm. The peak von Mises stresses (PVMS) at the stem and the keel regions of the tibial insert were assessed.

With respect to the central positioning the lateral shift of the tibial plate resulted in higher PVMS than the medial. Particularly, increases of 24.5%, 29.8%, and 28.4% were observed at the stem, the lateral keel, and the medial keel, respectively, due to lateral mal-positioning of the implant. With the medial shift, on the other hand, PVMS increase remained at around 6% level at the stem and the lateral keel. A decrease of 4.5% was noted at the medial keel region. In this study, a computational approach was used to evaluate biomechanical effect of tibial plate positioning on the stress distribution within the implant. The lateral mal-positioning showed more stress concentration than the medial. This may be due to the fact that body weight is transmitted more to the lateral portion of the tibia (5.5:4.5) that is smaller and thinner than its counterpart. These results suggest that the lateral deviation of the implant can be more likely cause TKR loosening and tibial fracture.

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AUTOMATED ESTIMATION OF 3D IN VIVO KNEE KINETATICS WITH DUAL X-RAY IMAGES BY PIXEL-BY-PIXEL COMPARISON FOR TOTAL KNEE ARTHROPLASTY

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In the knee joint surgery such as total knee arthroplasty (TKA), the implant should be inserted in proper position with correct bone alignment because the abnormal kinematics of implanted knees by implant mal-positioning or mal-alignment could cause failure of surgery. Therefore, quantitative information of a 3D kinematics of the knee joint is very helpful to evaluate the surgical treatment such as planning of size and alignment of the implant. In this study, a 2D/3D image matching method was developed to estimate the kinematics of the knee joint based on an automated pixel by pixel comparison of images.

Two projection images were obtained from the 3D object in two perpendicular directions where the given dual X-ray images were taken. The 3D object was translated and rotated automatically and continuously until its projection images were matched with the X-ray images in a given tolerance range. The optimization algorithm was used to minimize the root mean square error between the gray scale values of each pixel in the projection image and the given X-ray image. For estimating the position and orientation of the knee joint, the 3D knee joint models were reconstructed from CT data. The 3D model was matched with the given dual X-ray images by using the developed 2D/3D image matching method. The tibial and femoral components were then combined into the whole knee joint model. By adding fiducial markers based on clinically conventional method, the posterior and mediolateral translation of femur with respect to tibia as well as the flexion angle were measured.

In the experiment with the cubic phantom, the position errors were below 0.10 mm and the orientation errors were below 0.05° when using dual X-ray images. For the given dual X-ray images, the relative in vivo kinematics of the femur was measured as the posterior translation was 3.0 mm and the mediolateral translation was 0.9 mm. In addition, the flexion angle of the knee joint from the sagittal view was 51° while the angle measured from the given X-ray image was 50°.

The previous 2D/3D image matching methods operated manually took long time and was dependent on the operator. Recently, automated image matching method has developed by applying optimization algorithms. In this study, the optimal position and orientation were obtained by the direct pixel by pixel comparison, which are easy to implement and modify the algorithm. The present automated method could accelerate the matching process and stabilise the repeatability. In addition, the image matching method with dual images was used to improve the out-of-plane accuracy since the image matching method with a single X-ray image has a limitation of methodology in detecting out-of-plane translation and rotation though the in-plane accuracy was acceptable. The present 2D/3D image matching method is a powerful tool for the accurate determinations of 3D position and orientation of the knee joint and could provide informative characterization of implant designs and surgical options of the knee surgery.
MACROSCOPIC AND MICROSCOPIC CONTACT ANALYSIS OF RETRIEVED KNEE PROSTHESIS USING FINITE ELEMENT METHOD

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INTRODUCTION: The wear phenomenon of ultra-high molecular weight polyethylene (UHMWPE) in knee and hip prostheses is one of the major restrict factors on the longevity of these implants. Despite quite a number of studies on the wear of UHMWPE, the wear mechanism is not clear yet. In order to minimize the wear of UHMWPE and to improve the longevity of artificial joints, it is necessary to clarify the factors influencing the wear mechanism of UHMWPE. Especially for the artificial knee joint with anatomical design, the contact stresses in the UHMWPE tibial insert are generally higher than the yield stress of the material during normal gait. In addition, the predominant types of wear on reported simulator-tested and retrieved UHMWPE tibial inserts are delamination and pitting. These facts suggest that the fatigue fracture that causes micro-cracks both on and below the surface of the UHMWPE tibial insert and the generation of wear particles as fatigue type are closely related to the repeated plastic deformation. On the metallic femoral components of the retrieved knee prostheses with anatomical design, a number of microscopic scratches caused by various factors were observed. It is thought that microscopic surface asperities caused by this surface damage contribute to increasing and/or accelerating wear of the UHMWPE tibial insert. The primary objective of this study was to investigate the factors influencing the wear mechanism of UHMWPE tibial insert in knee prosthesis.

MATERIALS AND METHODS: In this study, macroscopic and microscopic elasto-plastic contact analyses of the UHMWPE tibial insert based on macroscopic and microscopic geometrical measurements from retrieved knee prosthesis were performed using finite element method (FEM) in order to investigate the mechanical state, plastic deformation behavior in the UHMWPE tibial insert and microscopic wear of the polyethylene caused by microscopic surface asperity. For this purpose, the determinative method of the contact position between the femoral component and the UHMWPE tibial insert for the retrieved knee prosthesis was developed. The three-dimensional FEM model of the retrieved knee prosthesis with worn contact surfaces was produced. Three-dimensional microscopic surface profile measurements of damaged surface of a retrieved metallic femoral component by using a laser microscope and reproduction of the femoral component surface by using 3D CAD software were performed in order to produce the 3D FEM models of the microscopic asperity based on actual measurement data.

RESULTS AND DISCUSSION: The analysis results of this study suggest that maximum plastic strain below the surface is closely related to subsurface crack initiation and delamination of the retrieved UHMWPE tibial insert. The worn surface whose macroscopic geometrical congruity had been improved due to wear after joint replacement showed lower contact stress at the macroscopic level. The aspect ratio, shape ratio and indentation depth of the microscopic asperity have a significant effect on increasing and/or accelerating wear on the UHMWPE. Higher aspect ratios, shape ratios and indentation depths cause higher contact stresses and plastic strains in the UHMWPE. These are therefore significant factors influencing the wear mechanism of UHMWPE.
Retrieval Wear Phenomena after 10-years Experience of Metal-on-Metal Bearings


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From 1985 metal-on-metal (MOM) designs of resurfacing (RSA) and total hip arthroplasties (THR) have been available over a large diameter range (28-60mm). In-vitro studies indicated satisfactory low wear performance for all designs and diameters tested (wear = 0.1 to 7 mm³). While reports from many centers have been encouraging, some have reported adverse effects. We reviewed clinical and metal ion studies in large diameter retrievals and compared these to 28mm MOM cases. Patients with the latter THR ranged 36-76 years of age and were followed 9-11 years. Main finding in our revisions was osteolysis and pain. The 28mm ball was represented 86% of cases; 71% balls had stripe wear. For liners, 25% had circumferential stripe wear and impingement was evident in 64% cases. Seven cemented stems were recovered with impingement marks; 26 stems were undamaged and therefore not revised. Using the concept of ‘damage modes’ from McKellop, normal wear mode #1 was evident in only 14% of 28mm retrievals whereas incidence of ‘abnormal’ modes #2-4 approached 30% each. Thus the 28mm MOM appeared susceptible to impingement risks with CoCr liners. Summarizing MOM retrievals, damage modes 2-4 were most likely implicated in revisions. The performance of such ‘small diameter’ THRs will be contrasted to our large diameter THR and RSA experience. The questions to be reviewed include, how much of the reported MOM adversity was predictable and how much risk was due to a) wear of small diameter MOM, b) adverse cup positioning and hip instability, c) cup-stem impingement issues or d) design conformity issues?

Clinical Implications of Anthropometric Patellar Dimensions for Total Knee Arthroplasties in Asians

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Comprehensive anthropometric information is essential to avoid patella-related complications after TKA. We compared the anthropometric patellar dimensions of Korean and Western patients. In particular, we determined whether the reestablishment of original patellar thickness, residual bony thickness, and pre- to postoperative deviations between the median ridge position and the component center position influence the clinical and radiographic outcomes of TKAs. We measured anthropometric patellar dimensions in 752 osteoarthritic knees treated with TKA in 466 Korean patients and compared them with those of Western patients reported in the literature. We investigated the effects of postoperative overall thickness deviations, residual bony thickness after bone resection, and postoperative deviations of component center positions from median ridge positions versus clinical and radiographic outcomes evaluated 1 year after surgery. Korean patients undergoing TKA had thinner and smaller patellae than Western patients. We found no associations between pre- to postoperative overall thickness differences and clinical and radiographic outcomes and no differences between knees with a residual bony thickness of 12 mm or more and knees with a residual thickness of less than 12 mm, with the exception of WOMAC pain scores. We found no associations between postoperative deviations of component center position and clinical or radiographic outcomes. Our findings indicate bone resection for patellar resurfacing can be flexible without jeopardizing clinical outcome.
**LIMB ALIGNMENT AND POSITION OF THE COMPONENTS IN BILATERAL TOTAL KNEE ARTHROPLASTY WITH ROBOTIC AND MANUAL TECHNIQUE (A PROSPECTIVE, RANDOMIZED STUDY)**

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Bilateral sequential total knee replacement with a Zimmer NexGen prosthesis (Zimmer, Warsaw, Indiana) was carried out in 30 patients. One knee was replaced using a robotic-assisted implantation (ROBOT side) and the other conventionally manual implantation (CON side). There were 30 women with a mean age of 67.8 years (50 to 80).

Pre-operative and post-operative scores were obtained for all patients using the Knee Society (KSS) and The Hospital for Special Surgery (HSS) systems. Full-length standing anteroposterior radiographs, including the femoral head and ankle, and lateral and skyline patellar views were taken pre- and post-operatively and were assessed for the mechanical axis and the position of the components. The mean follow-up was 2.3 years (2 to 3). The operating and tourniquet times were longer in the ROBOT side ($p < 0.001$). There were no significant pre- or post-operative differences between the knee scores of the two groups ($p = 0.288$ and $p = 0.429$, respectively). Mean mechanical axes were not significantly different in the two groups ($p = 0.815$). However, there were more outliers in the CON side (8) than in the ROBOT side (1) ($p = 0.013$). In the coronal alignment of the femoral component, the CON side (8) had more outliers than the ROBOT side (1) ($p = 0.013$) and the CON side (3) also had more outliers than the ROBOT side (0) in the sagittal alignment of the femoral component ($p = 0.043$). In terms of outliers for coronal and sagittal tibial alignment, the CON side (1 and 4) had more outliers than the ROBOT side (0 and 2).

In this series robotic-assisted total knee replacement resulted in more accurate orientation and alignment of the components than that achieved by conventional total knee replacement.

**Using Preoperative MRI for Determining Rotational Alignment of the Femoral Component in Total Knee Arthroplasty and Evaluation of the Accuracy. -an in-vivo study -**

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Correct rotational alignment of the femoral prosthesis in total knee arthroplasty is important for correct patella tracking, patellofemoral joint contact forces, varus-valgus positioning in flexion, and the avoidance of anterior femoral notching. But achieving correct femoral rotation can be difficult, and there are reports of highly variable rotational alignment with the use of fixed surgical landmarks to determine femoral rotation. Minimal invasive technics makes it more difficult to identify these surgical landmarks. Computer assisted surgery may increase the accuracy of coronal and sagittal positioning but probably does not increase the accuracy of rotational positioning.

We used preoperative MRI to aid us in determining femoral rotation preoperatively and used that information to implant our femoral components and evaluated the results. We measured the angular difference between the surgical epicondylar axis and the posterior condylar axis of twenty patients preoperatively using MRI images and then used that angle to implant the femoral component. For a second group of twenty patients, computer assisted balanced flexion gap technic (Aesculap. Orthopilot system) was used to determine the rotational alignment of femoral components. CT scans were taken postoperatively and the accuracy of the rotational alignment was analyzed for both groups.

The ranges of error were as follows; (1) Preoperative MRI Group, 8degrees (3 degrees IR to 5 degrees ER). (2) Gap technic group, 21degrees (11 degrees IR to 10 degrees ER). If an error of more than 5 degrees from neutral alignment is defined as an outlier, 2 in the preoperative group and 6 in the GAP method group would fall in the outlier zone.

In conclusion, using preoperative MRI to determine the femoral rotational alignment and then using that information to implant the femoral component could aid in avoiding errors in rotation positioning of the femoral prosthesis. It is a simple and effective method to avoid rotational positioning errors with no learning curve.
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**Objects:** We have studied knee morphology using 3DCT considering the bone cutting surface in Total Knee Arthroplasty (TKA) in Japan. Subjects were 50 knees in 49 with knee disorders, consisting of 20 knees in 20 men and 30 knees in 29 women. The age range was 16-77 year old (the mean age 52.2).

**Method:** The image of a patient’s knee joint was taken by three-dimensional perspective imaging device (SIEMENS, ARCADIS) before surgery, and it was structured with the three-dimensional computer software (K.G.T, INTAGE Realia Professional) to measure the knee joint configuration. In the measured site with assumption of the bone cutting surface of the femur side in TKA, the valgus angle of femur was 60° to the bone axis and the maximum transverse diameter and the maximum anteroposterior diameter of the external condyle were measured at the femur side 8 mm proximal to the external condyle, and the tibial side was vertical to the bone axis and the maximum anteroposterior diameter of the internal and external condyles were measured at the tibial side 2 mm distal to the interior joint surface. The ratio of the anteroposterior diameter and the transverse diameter was computed by these measurements.

**Result:** The average measurements of the femur were 70.82mm of the transverse diameter, 51.2mm of the anteroposterior diameter, and 0.73 of the ratio of the anteroposterior diameter and the transverse diameter. The average measurements of the tibia were 72.5mm of the transverse diameter, 46.7mm of the anteroposterior diameter of the interior condyle, 46.7mm of the anteroposterior diameter of the exterior condyle, and 0.75 and 0.64 of the ratio of the anteroposterior diameter and the transverse diameter of the interior and exterior condyles, respectively.

The measurements of the femur were bigger in any sites of men than women, and the transverse diameter was bigger, the anteroposterior diameter tended to be smaller.

The transverse diameter did not clearly correlate with the ratio of the anteroposterior diameter and the transverse diameter at the tibial side, and different correlations were shown between men and women respectively.

**Discussion:** At the femur side, a Japanese knee was flatter than a Westerner’s knee just like the previous reports in Japan. The knee is bigger, the knee tends to become flatter, and men are more likely to have the tendency than women. At the tibia side, there were differences for correlation of the flat level between men and women, and it suggested the potential sex difference.

**Conclusion:** The measurement with 3DCT is easy-to-use, and the variation is small compared to an actual measurement value. We want to put it to use for implant design in references to these measurements for the future.
A simple radiographic view with a landmark of an anterior and posterior femoral condyle for determining rotational alignment of the femoral component in total knee arthroplasty

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Introduction: Recent studies suggested that trans-epicondylar axis (TEA) as the origin of collateral ligament was valuable axis for the parallel cut of the posterior condyle. An alternative landmark of the angle between the TEA and anterior trochlear line of the lateral and medial femoral condyles (trochleo-epicondylar angle) for determining the rotational positioning of the femoral component could be considered. We here report a simple radiographic view with a landmark of the anterior and posterior femoral condyle for determining the rotational alignment of the femoral component in TKA.

Subjects and methods: Our new radiograph presented an axial view of distal femur of a patient. The patient lay in the supine position and flexed the knee about 120 to 130 degrees. An x-ray beam was applied to the knee at the angle of 20 degrees to the ground surface. We measured the external rotational angle between posterior condylar (PC) line and clinical TEA that was condylar twist angle, and the internal rotational angle between the anterior trochlear line (AT line) and clinical TEA. This study involved 122 knees in 82 patients with osteoarthritis of the knee, an average age of 67.3 years. And we compared our measured angle with the angle from 3D reconstructed images with 3-dimensional helical CT system (n=35).

Results: The former angle was 5.6° ± 2.8° and the latter was -5.7° ± 3.2°. There was a variation by individual patients, the condylar twist angle was negative correlation with tibio-femoral angle. The internal rotation angle of the trochlear line and clinical TEA (trochleo-epicondylar angle) was 4.9° ± 2.1°. The tibio-femoral angle was positively correlated with the trochlear line angle. The trochlear line angle from 3D-CT was 5.6° ± 2.0°. The average of the difference between our view and the 3D-CT was 0.5° ± 1.0°, R=0.87 with a Spearman’s rank test.

Discussion and conclusion: We improved the simple radiographic view in order to evaluate the TEA and PC line, and also the anterior trochlear line, for assessing the rotational alignment of the distal femur in total knee arthroplasty (TKA). We are able to measure and evaluate both angles and do double-checking the condylar twist angle and trochlear line angle. Our new radiographic technique is easy to measure the condylar twist angle, and the angle between AT line and clinical TEA (trochleo-epicondylar angle), simple and reliable, and may be an alternative method for the assessment of TEA of the femur in TKA as preoperative planning.
THE TRIBOLOGICAL PERFORMANCE OF A CFR-PEEK-OPTIMA MOBILE BEARING UNICONDYLAR KNEE JOINT

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The introduction of unicondylar knee prostheses has allowed the preservation of the non-diseased compartment of the knee whilst replacing the diseased or damaged compartment. However, as is well known, there is concern that the body’s biological reaction to ultra-high molecular weight polyethylene (UHMWPE) wear particles leads to bone resorption and subsequent loosening and failure of the joint. Also, in some cases, delamination of the UHMWPE tibial bearing surface has been found to occur leading to failure of these conventional joints. Therefore new material combinations have been investigated within the laboratory.

MATERIALS AND METHODS: The unicondylar knee that was tested consisted of CoCrMo tibial and femoral components between which a mobile Pitch-based carbon fibre reinforced polyetheretherketone (CFR-PEEK OPTIMA®) meniscal bearing was mounted. The joints were supplied by INVIBIO Ltd. Tribological tests were performed on these knees using the Durham six station knee wear simulator and the Durham friction simulator II. In both cases the loading and motion were similar to the standard walking cycle. On the six station wear machine five stations applied both the loading and motion and were the active stations and one applied loading only as it was used as the loaded soak control station. Approximately every 500,000 cycles, the wear of the CFR-PEEK meniscal bearings was assessed gravimetrically (using a Mettler Toledo AX 205 balance, accurate to 0.01 mg) and the loaded soak control was used to take account of any change in weight due to lubricant absorption. The joints were tested to 5 million cycles (equivalent to approximately 5 years in vivo) with diluted new-born calf serum as the lubricant which gave a protein content of 17 gl⁻¹. At periods throughout the wear test the surface topography was measured on the Zygo NewView 100 non-contacting profilometer. Friction tests were performed at the beginning and the end of the wear test.

RESULTS AND DISCUSSION: The average volumetric wear rate of the medial and lateral components was found to be 1.70 and 1.02 mm³/million cycles respectively (range 0.66 - 2.73 and 0.59 - 2.45 mm³/million cycles respectively). This is lower than the reported wear rate of metal-on-UHMWPE unicondylar knee joints (6.69 and 2.98 mm³/million cycles for the medial and lateral components respectively) [1]. The surface topographical analysis of the CFR-PEEK bearings showed a reduction in surface roughness and also a change to more negative skewness (i.e. more valleys than peaks) which may aid in lubrication. Before and after wear testing the joints were found to be operating in the boundary/mixed lubrication regime.

CONCLUSIONS: The Pitch-based CFR-PEEK unicondylar knee joints performed well in these wear tests. They gave lower volumetric wear rates than metal-on-UHMWPE unicondylar knee prostheses. The friction tests showed that at physiological viscosities, these joints operate in the boundary/mixed lubrication regime. These results show that this novel joint couple may potentially be an alternative solution for the reduction of wear and osteolysis.

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One Year Outcomes of Robotic Guided UKA

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Introduction: Clinical outcomes of UKA procedures are sensitive to malalignment of the components, and thus show significant variability in the literature. This study evaluates the early clinical results of a new surgical procedure designed to significantly increase the accuracy and precision of the alignment of the components, and thus increase post-operative functional outcomes.

Materials and Methods: A new UKA technique has been developed, which combines tactile guided robotic technology with image guided surgery. Three-dimensional planning of the implant positioning is followed by precise resection of the bony surfaces. 223 patients have received a UKA from three clinical sites using this new technology. To date, 14 patients are 1 year and 84 patients are 6 months postoperative. Clinical data from all patients are included in an IRB approved registry.

Results: From 223 UKAs, there have been no revisions and 6 reoperations; 2 for infection, 1 for arthrofibrotic band release, 1 for quad tendon arthrotomy separation, 1 for a femoral fracture at the navigation pin site and 1 for unexplained medial pain. Data for patients one year post-operative showed significant improvements, compared to pre-operative values, in range of motion (p<0.02), Knee Society Scores (p<0.0001) and WOMAC scores (p<0.01), particularly pain (p<0.01) and stiffness (p<0.01).

Conclusions: This initial series of robotically guided UKA implantations provided significant improvement in the post-operative function of patients in every functional measurement with no revisions to date. The introduction of new procedures and technologies in medicine is routinely fraught with issues associated with learning curves and unanticipated pitfalls. Because the explicit objectives of this novel technology are to optimize surgical procedures to provide more safe and more reliable outcomes, these favorable results provide the potential for significant improvements in orthopedic surgery.
Robotic Assisted UKA is More Accurate than Manually Instrumented UKA

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Introduction: Successful clinical outcomes following unicompartmental knee arthroplasty (UKA) depend on accurate component alignment, which can be difficult to achieve using manual instrumentation. A new technology has been developed using haptic robotics that replaces traditional UKA instrumentation. This study compares the accuracy of UKA component placement with traditional jig-based instrumentation versus robotic guidance.

Materials and Methods: Forty-four UKAs performed using standard manual instrumentation were compared to 33 performed with a robotically guided implantation system without instrumentation. Each was performed using a minimally invasive surgical approach. The two groups were identical in terms of age (p=0.74), gender (p=0.65) and BMI (p=0.72). The coronal and sagittal alignment of the tibial components were measured on pre- and post-operative AP and lateral radiographs. Postoperative tibial component alignment was compared to the pre-operative plan.

Results: For both techniques, the surgical objective was to match the natural tibial posterior slope. The RMS error of the tibial slope was 3.5° manually compared to 1.4° robotically. In addition, the variance using manual instruments was 2.8 times greater than the robotically guided implantations (p<0.0001). In the coronal plane, the goal of the manual technique was to implant the tibial component perpendicular to the anatomic tibial axis, while the robotic implantations attempted to match the natural varus of the medial compartment. The average error was 3.3° ± 1.8° more varus using manual instruments compared to 0.1° ± 2.4° when implanted robotically (p<0.0001).

Conclusions: Tibial component alignment in UKA is significantly more accurate and less variable using robotic guidance compared to manual, jig-based instrumentation. By enhancing component alignment, this novel technique provides a potential method for improving outcomes in UKA patients.

Does Less Medial Tibial Plateau Resection Make a Difference in UKA?

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Introduction: Potential benefits of an inlay design of UKA compared to onlay components include less post-operative pain and quicker recovery due to a lower volume of bone removed, in particular preservation of the densely innervated periosteum and medial tibial plateau periphery. This study assesses the clinical consequences of removing less tibial bone in UKA.

Materials and Methods: 79 UKA patients from a single surgeon were included in this study, 45 patients receiving a standard onlay UKA and 34 receiving an inlay UKA implanted using a robotically guided system. A radiographic technique was developed to measure the depth of resection of tibial bone stock relative to the initial medial joint line. All patients received the same pain management and rehabilitation protocol and the length of hospital stay was measured.

Results: The average depth of medial tibial plateau resection was significantly less with inlay tibial components (3.7 ± 0.8mm) relative to onlay tibial components (6.5 ± 0.8mm, p<0.0001). While the average length of hospital stay was the same for both onlay (LOS = 1.0 ± 0.2days) and inlay (LOS = 0.9 ± 0.5days) UKA procedures, a significantly higher percentage of inlay patients went home the day of surgery (18% vs. 2%, p<0.0001).

Conclusions: The depth of medial tibial plateau resection with a typical fixed bearing onlay UKA design is twice as much as an inlay tibial UKA. This has significant consequences for potentially using only primary components at future conversion to total TKA. Likely due to the less invasive (from a host bone perspective) nature of inlay UKA, a significantly higher percentage of these patients are able to be treated as outpatients.
FIXED BEARING, MEDIAL UNICONDYLAR KNEE ARTHROPLASTY RAPIDLY IMPROVES FUNCTION AND DECREASES PAIN: A PROSPECTIVE, SINGLE SURGEON REPORT ON 3-YEAR MINIMUM FOLLOW-UP

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Introduction: Unicondylar knee arthroplasty (UKA) has seen a resurgence in the past decade. Perpetuation of this trend can only be supported through prospective demonstration of efficacy with validated outcomes measures.

Materials & Methods: Thirty-three consecutive cemented medial Miller-Galante UKA’s (Zimmer, Warsaw, IN) were performed in 32 patients (7 males/25 females; mean age of 67 ± 9 years). Average weight, height, and body mass index (BMI) of the patient population was 189 ± 31 lbs (Range, 145-293), 65 ± 4 in (range, 60-75), and 33 ± 5 BMI (range, 25-43), respectively. Average polyethylene thickness (as labelled) for this cohort was 8.3mm (range, 8-12mm). Outcomes were prospectively assessed via the SF-12, WOMAC, and Knee Society Score (KSS). No patients were lost to follow-up. Kaplan-Meier survivorship and Student’s t-test were performed using GraphPad Prism 4 software (GraphPad Software Inc., San Diego, CA).

Results: Minimum follow-up was 39 months with a mean follow up period of 49 (range, 39-59) months. One knee was converted at 6 months at another institution to a TKA. Kaplan-Meier survivorship analysis reported 97% survivorship at 59 months (95% CI). Of the 32 knees remaining, mean preoperative KSS and WOMAC pain scores improved significantly from 52 ± 7 (range, 37-67) to 89 ± 9 (range, 67-100) (p<0.0001) and from 40 ± 22 (range, 0-80) to 93 ± 14 (range, 35-100) (p<0.0001), respectively. Additionally, average SF-12 Physical Component scores significantly increased from 30 ± 7 (range, 18-51) at baseline to 49 ± 10 (range, 28-59) at time of follow-up (p<0.0001). Overall stiffness and physical function assessed via the WOMAC index also exhibited statistically significant improvement, bettering from mean baseline scores of 54 ± 24 (range, 0-100) and 52 ± 19 (range, 25-87) to 84 ± 19 (range, 50-100, p<0.0001) and 88 ± 15 (range, 44-100, p<0.0001), respectively. No significant cement/bone interface radiolucencies were found upon thorough radiographic review at 3 years post UKA.

Discussion & Conclusion: The significant improvements observed in knee function & stiffness, and decreases in pain at a mean of 4 years after medial UKA are encouraging. Coinciding results from the physical component of the SF-12 assessment indicate reassurance of physical improvements regarding patient lifestyle. 97% survivorship in the short term would be discouraging if not for the specific circumstances of the sole conversion to TKA. This specific patient went against the advice of the operative surgeon and solicited services at an outside institution in conversion to a TKA despite markedly improved function (Pre-op/3 month post-op WOMAC and KSS of 30/75 and 60/91). Clinical and radiographic follow-up will continue in order to assess the long-term efficacy of medial UKA with the Miller-Galante prosthesis using strict patient selection criteria.
Unicompartmental arthroplasty of the knee (UKA) is technically challenging because the prosthetic devices must function in concert with a mostly normal joint. Malalignment is common, leading to patient dissatisfaction and early failures. However, UKA remains attractive as a temporizing treatment in early disease. Until now, resurfacing UKAs were performed with free-hand techniques. This study is only the second report investigating the use of a tactile guidance system (TGS—essentially, a robotically assisted surgery) for the performance of UKA.

Methods: The first 20 patients who underwent resurfacing using a Mako Surgical Inc. TGS system by a single surgeon were studied. Surgical goals were to place the components to replicate closely the patient’s native bony architecture. The surgical plan was completed on a workstation, and then executed with the TGS system through a mini-arthrotomy. Stelkast, Inc resurfacing components were implanted with methymethacrylate. Intraoperative measurements of component position were obtained. Pre- and postoperative radiographs were also measured for alignment correction, change in angulation of the joint line relative to the femoral and tibial anatomic axes, femoral component alignment relative to the femoral anatomic axis, and change in tibial slope.

Results: All cases could be completed as planned. None were converted to a full arthrotomy. None required conversion to a different implant. There were no failures of the TGS, associated navigation, or the CAT-scan based preoperative plan. Intraoperative measurements showed an average femoral component position of $0.89\pm3.36$ degrees of varus relative to the mechanical axis, with 62.5% being varus and 37.5% being valgus. The average femoral component flexion was $11.1\pm2.11$ degrees, with no outliers (less than 5 degrees; greater than 15 degrees). The tibial component position was $4.60\pm1.76$ degrees of varus, with all components in varus as desired. There was an average of $5.00\pm2.37$ degrees of slope, with 25% outliers (less than 3 or greater than 7 degrees).

Postoperative measurements showed an overall limb alignment correction of $4.29\pm2.60$ degrees, femoral joint line change of only $0.43\pm0.49$ degrees, and an overall component alignment relative to the anatomic axis of $4.54\pm3.77$ degrees of valgus. On the tibial side, the joint line varus was corrected by $3.00\pm2.04$ degrees and the slope was changed by $4.29\pm3.24$ degrees, including 19% outliers (less than 3 degrees, more than 7 degrees). However, 33% of the outliers were outliers preoperatively as well. Interestingly, the bone level after resection on the tibial side averaged $5.36\pm3.00$ degrees of varus, suggesting that component placement must be carefully watched.

Discussion: TGS seems to be extremely accurate and precise in recreating individual patient anatomy. This also applies to cases in which the patient anatomy dictates placement of components in so-called outlier positions. It is unknown whether these outlier positions really translate into poorer outcomes. Impressively, there were no failures to execute the intended surgical plan and no failures of the TGS system. Future research will attempt to correlate component placement in native anatomical positions with functional outcomes and failures, as well as cost-effectiveness of the system.
Cost Effectiveness of Computer Navigation for Total Joint Arthroplasty in a Community Hospital

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Introduction: While computer navigation has been shown to improve radiographic alignment and eliminate outliers in limb and component position in total joint arthroplasty, adoption has been relatively slow. One argument against the use of navigation has been the concern about the cost of the capital equipment and surgical disposables. The purpose of this paper was to evaluate whether the direct cost of patient care was greater for the senior author, who navigates all joint replacements, than other surgeons, who perform total joint arthroplasty without navigation.

Methods: The author’s institution is a 200 bed community hospital that performs over 1000 joint replacements per year. This study consisted of reviewing the fiscal year 2007 data at the author’s institution and comparing the direct costs of medical care, length of stay and discharge disposition for the senior author to his peers at his institution.

Results: In fiscal year 2007, the hospital performed 624 primary total knee and 213 primary total hip replacements of which the senior author performed 284 (45%) knees and 156 (73%) hips respectively. The average charge for the entire hospital was $38,877 and LOS was 2.7 days for knees, and charges of $40,076 and LOS was 2.7 days for hips. The senior authors charges were $33,801 and LOS was 2.4 days for knees and $36,403 and LOS 2.4 for hips. 78% of the knees and 81% of the hips were discharged to home overall for the institution and 86% of both knees and hips by the senior author. The capital equipment purchase for navigation was $204,000 or $463 per primary arthroplasty (senior author).

Conclusions: Computer navigation did not increase the direct cost of primary total joint replacement for the senior author relative to his peers even if the entire capital equipment purchase was added to the case cost.

Correction of Cutting Errors with Navigation System in Total Knee Replacement

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Abstract topic: Computer-Assisted Surgery & Robotic Surgery
Achieving precise component alignment of total knee arthroplasty produces good clinical outcome. However, the cutting errors between planned and final bone resection planes during the procedure of total knee arthroplasty were less evaluated. The aim of this study was to evaluate the cutting errors during total knee arthroplasty using the navigation system. In a prospective series of 60 total knee replacements with image-free navigation system, the planed resection plane and final resection plane in frontal and sagittal planes were evaluated. The cutting errors SDs ranged from 1.01” to 1.21” in final frontal femoral and tibia plane and 1.23” in final sagittal femoral and tibia plane. The cutting errors showed only significant difference in the sagittal plane of femoral resection and only 9 cuts (4%) of all plane and the maximal error was 4in only 2 cases (0.8%). Our results support to use the navigation system to adjust the cutting block and correct the cutting errors. This would lead to a more precise cut and result in better leg alignment and component orientation than the conventional TKR technique.
Minimally Invasive Computer-assisted Arthroplasty (Initial results for comparing Orthopilot and Ci navigation system) Using Preoperative MRI for Determining Rotational Alignment of the Femoral Component in Total Knee Arthroplasty and Evaluation of the Accuracy - an in-vivo study -

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The minimal invasive total knee arthroplasty has demonstrated shorter hospital stays, less postoperative blood loss, and less pain associated with these techniques but concerns are raised about inaccurate implant alignment due to limited visibility. The combination of computer assisted arthroplasty and MIS could aid in the improvement of the accuracy of implantation.

This prospective randomized study presents the initial results of the first 25 cases of two different imageless computer-assisted arthroplasty, the Orthopilot (B. Braun-Aesculap, Tuttlingen, Germany) and the Ci navigation system (DePuy, Munich, Germany). The same surgeon performed all TKA procedures using the mini-midvastus approach. Coronal and sagittal alignments of the femoral and tibial components were determined using postoperative full length radiographs.

Comparison of the 2 groups demonstrated no difference in postoperative limb alignment, femoral and tibial coronal alignment, and sagittal tibial alignment. The sagittal alignment between the 2 groups showed different results. The Orthopilot group showed a tendency toward flexion of the femoral components, and the Ci navigation group showed a tendency toward extension of the femoral components. The tourniquet time was longer by an average of 16 minutes in the Ci navigation group. One complication of femoral fracture through the pin site occurred in the Orthopilot group. Combined CAS and MIS has he advantage in improving the accuracy of component alignment but caution is needed for improving sagittal femoral component alignment.

CLINICAL APPLICATION OF ELECTROMAGNETIC NAVIGATION IN TOTAL KNEE ARTHROPLASTY

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Computer based navigation system improved the accuracy of limb and component alignment and decreased the incidence of outliers. The majority of previous studies were based on the infrared navigation system. We evaluate the availability and accuracy of the electromagnetic(EM) navigation system in total knee arthroplasty. From July 2006 to January 2007, 40 patients (50 TKAs) with osteoarthritis were participated in this study. AxiEM (Medtronics) was used and Nexgen CR (26 cases), and Nexgen CR flex (24 cases) were used. We analyzed the failure mode of navigation (7 cases), operation time and radiologic results (limb and component alignment). Total registration time was 4 minutes 45 seconds in average (Range: 3 minutes 45 seconds ~ 6 minutes 55 seconds). Failures in clinical applications resulted from non-recognition of EM tracker or paddle by metallic interference in 4 cases and from informational changes during surgery by fixation loss or loosening of the tracker in 3 cases. Radiologically, the mechanical axis changed from -11.2±2.71 (Range: -25.8~3.1) to 1.0±1.25 (Range: -2.1~4.0) and 1 case of outlier occurred (valgus 4°). Component alignment is measured as followed: 89.3±1.6° of Theta angle, 89.9±1.5° of Beta angle, 1.8±2.5° of Gamma angle, 86.1±2.9° of Delta angle. There were no complications related to the EM navigation.

The EM navigation system helped to achieve accurate alignment of component and lower leg axis without any complications. The EM navigation system helped to achieve accurate alignment of component and lower leg axis without any complications. The EM navigation system helped to achieve accurate alignment of component and lower leg axis without any complications. However, metallic interference may be still problematic. The EM navigation system helped to achieve accurate alignment of component and lower leg axis without any complications. However, metallic interference may be still problematic.
Comparisons of Clinical Outcomes Between Floating-Platform and Rotating-Platform Posterior Stabilized Mobile Bearing Systems in Total Knee Arthroplasty

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Introduction: Mobile bearing TKA systems have drawn great attention as an alternative solution for the limitations of fixed bearing designs. Recently rotating platform posterior stabilized (RP-PS) was developed to take advantage of the benefits originating from the design features of the traditional rotating platform mobile bearing system and the traditional posterior stabilized fixed bearing system with post and cam mechanism. Despite its theoretical advantages, the clinical outcomes of TKAs with RP-PS mobile bearing system remain to be determined. In theory, compared to fixed bearing systems, clinical performances of mobile bearing knees may be more sensitive to the rehabilitation status due to its relatively small constraint by the prostheses. Therefore, the clinical outcomes can be vary with the follow-up periods. This study was conducted to compare the longitudinal clinical outcomes of TKAs with a RP-PS mobile system and with a floating platform mobile bearing system.

Methods: 163 TKAs with one of two mobile bearing systems (E.motion-FP and E.motion-PS: B.Braun-Aesculap, Tuttingen, Germany) were included in this study. All surgeries were performed by a single surgeon using a computer assisted navigation system (Orthopilot, B.Braun-Aesculap). Clinical outcomes evaluated at 6 months, 12 months, and 24 months were compared between the 70 knees with E.motion-FP and the 93 knees with E.motion-PS. Radiographic measurements of limb alignment and implant positioning showed no significant differences between the two groups.

Results: Compared to TKAs with the FP prostheses, TKAs with the RP-PS prostheses had greater maximum flexion (128.9 vs. 135.3, p = 0.001) and tended to be more satisfactory (satisfaction level: 3.4 vs. 3.1, p = 0.052). The other clinical outcome scales (AKS knee and function, PF, WOMAC, and SF-36) showed comparable results. No failures were found in both groups.

Conclusion: We found that TKAs with the RP-PS mobile bearing system have greater maximum flexion and patient satisfaction than TKAs with the FP mobile bearing system. The long term benefits 2009

SPONTANEOUS OSTEONECROSIS OF THE KNEE INVOLVING BOTH MEDIAL FEMORAL CONDYLE AND MEDIAL TIBIAL PLATEAU UNDERTAKEN TOTAL KNEE ARTHROPLASTY

- 3 CASES REPORT-

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Spontaneous osteonecrosis of the knee (SPONK) usually involves a single condyle or plateau. The medial femoral condyle is most often involved and spontaneous osteonecrosis of medial tibial plateau is a rare condition, representing only 2% of all necrosis reported in the knee. Therefore, SPONK with both involvement of medial femoral condyle(MFC) and medial tibial plateau(MTP) might be extremely rare. SPONK in each MFC or MTP respectively might be extended into corresponding side of the knee at their advanced final stage, however, in that situations, significant degenerative change would accompany and it might be difficult to differentiate final staged SPONK form severe osteoarthritis. To the best of our knowledge, SPONK affecting both medial femoral condyle and medial tibial plateau without significant secondary osteoarthritis changes is not reported, even though it was difficult to know which occurred first. We experienced 3 patients with histologically proven osteonecrosis of the medial tibial condyle and medial tibial plateau, and report their radiologic features. All 3 patients showed similar radiographic patterns. Medial portion of medial tibial plateau and lateral portion of medial femoral condyle showed subchondral collapse. Standing anteroposterior radiograph at 30 degree knee flexion showed well fitted features such as locked medial condyle. Varus angulation was present. Significant degenerative changes was not shown except for subchondral sclerosis. T1-weighted coronal and Fat suppressed T2-weighted MR images showed subchondral collapse with ill-defined diffuse bone marrow edema changes on both tibial and femoral condyles. At surgical findings, longitudinal track-like groove was shown in both medial femoral condyle and medial tibial plateau. Articular cartilage was denuded and showed glistening surface with bone defect of lateral side of medial femoral condyle and medial side of tibial articular surface. Histological analysis shows necrotic bone, surrounded by an area of fibrovascular granulation tissue on both femoral and tibial sides. Total knee arthroplasty was performed in all 3 patients. As a result of very low prevalence of both involvement of MFC and MTP and limited number of our cases, we could not conclude that radiologic features in our cases are typical radiologic pattern of both involvement. However, based on our cases, we believe that this characteristic radiologic features may considered as one of the possible various radiologic findings of simultaneous involvement in MFC and MTP and allow diagnosis for SPONK with both involvement in MFC and
Effects of the Alterations of Posterior Slope, Joint Line and Posterior condylar Offset on Clinical Outcomes after TKA with Four Different Implant Types

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Background: Previous studies reported that several kinematic parameters such as tibial posterior slope, joint line, and femoral posterior condylar offset influence clinical outcomes including maximum flexion after total knee arthroplasty (TKA). However, the effects of the kinematic factors may vary with the implant type. We aimed to determine whether implant type influence the associations between the three kinematic factors (posterior slope, joint line, posterior condylar offset) and clinical outcomes. We hypothesized that the associations between the kinematic factors and clinical outcomes would differ among four implant types [fixed bearing cruciate retaining (FB-CR), fixed bearing posterior stabilized (FB-PS), mobile bearing cruciate retaining (MB-CR), and mobile bearing posterior stabilized (MB-PS)]. Methods: A retrospective review of 1300 TKAs performed with one of the four implant types (FB-CR, FB-PS, MB-CR, MB-PS) was performed to select 50 TKAs for each implant type of which 1 year clinical outcomes (maximum flexion, AKS scores, patellofemoral scores, WOMAC, and SF-36) were available. Three radiographic parameters (posterior slope, joint line, and posterior condylar offset) were measured using pre- and post-operative lateral radiographs and postoperative alterations were calculated from the measurements. The correlations between the alterations in the radiographic parameters and the clinical outcomes were compared among the four groups by the implant type. Results: In 4 designs of implant (FB-CR, FB-PS, MB-CR and MB-PS), the mean increase in posterior condylar offset was +0.22, +0.67, +0.33 and +1.26, respectively. The mean joint elevation was -0.31, +1.34, -0.12 and +1.96, respectively. The mean posterior slope was 6.10, 5.64, 5.01 and 4.59, respectively. The mean maximum flexion was greater in the PS designs than in the CR designs (137.0° in FB-PS and 136.4° in MB-PS vs. 132.2° in MB-CR and 130.1° in FB-CR, p < 0.05). No significant correlations between the alterations in the radiographic parameters and the clinical outcomes in all implant types but the MB-CR type. In MB-CR type, the elevation of joint line was significantly associated with worse WOMAC stiffness and function scores (correlation coefficient = 0.36 and 0.30, respectively) and the increase of posterior condylar offset was associated with a worse WOMAC pain score (correlation coefficient = 0.39). Conclusion: Our findings indicate that the effects of the alterations in the kinematic parameters on the clinical outcomes vary with the implant type. This study also indicates that implant type is more important in determining postoperative maximum flexion than the alterations in the kinematic parameters.
KNEE RANGE OF MOTION DEPENDING ON DIFFERENT FEMORAL COMPONENT DESIGN: ELUATED IN VIVO BY A NAVIGATION SYSTEM

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Introduction: ROM after TKA can be influenced by multi-factors such as preoperative range of motion, body habitus, implant design, intraoperative surgical technique, and postoperative rehabilitation. Recently many implant manufacturers have made modifications to traditional total knee designs to improved maximal knee flexion and range of motion. Some posterior cruciate ligament (PCL) stabilized total knee prostheses that incorporate design features intended to improve knee kinematics in high flexion were introduced and the use of these prostheses has attracted attention. Recently in the cruciate retaining (CR) prosthesis, high-flexion knee (CR-Flex) and gender-specified prosthesis were designed to allow a greater and safer flexion after TKA. The aim of this study was to evaluate the effect of cruciate retaining typed different femoral component design on knee range of motion using a computerized navigation system.

Materials & method: 30 patients who underwent primary TKA because of primary osteoarthritis were included. EM navigation system was used in all cases. After tibia and femoral cutting using standard CR cutting block, standard fixed bearing CR knee (NexGen CR, Zimmer, Warsaw, IN) trial was inserted. If surgeon is satisfactory with alignment, stability and ligament balancing, the maximal knee extension and flexion was recorded using gravity by navigation system. Then, high-flexion fixed bearing CR knees (NexGen CR-Flex and Gender solution NexGen CR-Flex knee, Zimmer, Warsaw, IN) trial was inserted after additional posterior cutting. The maximal knee extension and flexion was evaluated exactly same way.

Results: Preoperative mean varus deformity was 10.52°. The mean flexion contracture was 7.52 ± 6.81° and further flexion 129.9 ± 7.94°. The average intraoperative maximal flexion of NexGen CR was 133.5 ± 5.35° (125-146°) and that of hyper-flexion design were 135.5 ± 5.77° (125-147°) in Nexgen CR-Flex and 136.1 ± 5.76° (126-146°) in Gender knee. All knees showed greater than 125° of flexion regardless of the implant design. All knees can achieve physiologic leg alignment and nearly full extension of the knee after operation.

Conclusion: Hyper flexion designs showed subtle increase in mean maximal flexion and overall range of motion of the knee compared with the standard design, when it measured using navigation system intraoperatively. But clinically, it is not certain that these differences can lead to significant improvement of range of motion.
Poster (KNEE)_06. Primary Knee Aarthroplasty

PK06-06  

Comparison of the results between MCL complete detachment and medial epicondylar osteotomy for severe varus deformity in TKA  

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The objective of this study was to compare the results between MCL complete detachment and medial epicondylar osteotomy for severe varus deformity in TKA. We reviewed 8 cases of MCL complete detachment (group I) and 11 cases of medial epicondylar osteotomy (group II) for severe varus deformity (from February 2001 to December 2006). In MCL complete detachment, we performed the reattachment of MCL and putting on the brace. Clinical outcome measures included Knee Society score (KSS), Function score (FS), and range of motion (ROM). Radiological outcomes were medial instability as determined by valgus stress radiograph, alignment by whole extremity radiograph. Group I had 4 neutral and 4 varus alignment and group II had 9 neutral, 1 varus and 1 valgus alignment. There were no significant differences in clinical results between both two groups, for KSS (95.1 vs 91.1), FS (82.5 vs 88.2), and ROM (0.6-115° vs 0-118.8°). However, there were significant differences in medial instability compared normal side. Group I had the differences of 4.1 degree at postoperative 3 months and 2.1 degree at final follow-up. Group II had 0.9 degree at postoperative 3 months and 0.4 degree at final follow-up. Medial epicondylar osteotomy for severe varus deformity in TKA could be useful technique for medial stability of the knee regardless of the alignment.

PK06-07  

MRI FOR COMPARISON OF PARTICLE DISEASE BETWEEN A FIXED-BEARING AND ROTATING-PLATFORM TOTAL KNEE ARTHROPLASTY  

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We previously reported no clinical differences in short-term results in 26 patients that underwent fixed-bearing (FB) total knee arthroplasty in one knee followed by a rotating-platform (RP) version of the same implant in the contralateral knee at a later date. This study presents intermediate-term results in this unique cohort and uses optimized MRI for detection of particle disease in both knees. Patients from the original series were asked to complete questionnaires regarding both knees. In addition, both knees were evaluated with optimized MRI, which has been shown to be useful in evaluating early particle disease and osteolysis before its appearance on radiographs. Nine patients have been enrolled to date. At an average follow-up of 8.3 years for the FB side and 6.5 years for the RP side, no significant differences were found with respect to knee preference, pain, or overall satisfaction. Seven patients underwent MRI studies of both knees. Two FB knees demonstrated a massive intracapsular burden of particle disease (average 3066 mm3) with reactive synovitis, compared to no obvious particle disease in any RP knees. Osteolysis was seen around the femur in one FB knee and around the patella in two FB knees, compared to only around a single patella in the RP side. RP knees continue to demonstrate excellent patient satisfaction that is comparable to clinical results of the FB design; however, FB knees demonstrate higher rates of particle disease and early osteolysis on MRI. This is the first study to demonstrate in vivo advantages of RP over FB designs. It is unclear whether this is due to the slightly longer follow-up period for the FB knees or a decreased wear rate in the RP design; these differences may become apparent with longitudinal follow-up.
**Poster (KNEE)_06. Primary Knee Arthroplasty**

PK06-08

**Changes in varus-valgus laxity after mobile-bearing total knee arthroplasty with a minimum five-year follow-up**

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*Introduction*: We performed a randomized, prospective, stress arthrometric study on 60 knees in 60 patients who had received mobile-bearing prostheses to determine the changes in varus-valgus laxity with time using a Telos arthrometer, and to evaluate the relationship between laxity and retention of the posterior cruciate ligament (PCL).

*Materials and Methods*: Thirty patients received PCL-retaining (PCLR) prostheses [K01] with an average of 75 months of follow-up (range: 60-106 months). Another 30 patients received PCL-sacrificing (PCLS) prostheses with an average of 78 months of follow-up (range: 60-109 months). In all patients, the preoperative diagnosis was osteoarthritis. The coronal conformity of the PCLR and PCLS designs was similar. All of the total knee arthroplasty (TKA) procedures were judged to be clinically successful (Hospital for Special Surgery scores: PCLR 92 points, PCLS 92 points). The patients had no clinical complications. Varus-valgus laxity was measured with the knee in extension six months, one year, two years, and five years after surgery. The intrasubject error was less than 1 degree.

*Results*: Varus laxity measurements with the PCLR prosthesis at six months, one year, two years, and five years were 3.7, 4.0, 4.1, and 4.2 degree, respectively. With valgus laxity, measurements at the same time periods were 3.5, 3.5, 3.5, and 3.6 degree, respectively. Varus laxity measurements with the PCLS prosthesis at six months, one year, two years, and five years were 4.3, 4.3, 4.3, and 4.4 degree, respectively. With valgus laxity, measurements at the same time periods were 3.7, 3.4, 3.5, and 3.6 degree, respectively. There were no significant differences in varus and valgus laxity between the PCLR and PCLS groups using repeated measure ANOVA methods (p > 0.05).

*Discussion*: Coronal laxity did not change with time in patients who had good clinical results. There were no significant differences between the PCLR and PCLS groups in changes in the varus-valgus laxity for a long time after the patients received prostheses. Therefore, we conclude that the PCL doesn’t affect coronal stability in extension, and that the characteristics of the component geometry may act as a resistance factor. Our results suggest that surgeons should appreciate the importance of obtaining balanced coronal laxity for long-term success following mobile-bearing TKA.

PK06-09

**Short -term results of Minimally Invasive TKA using Mini-midvastus approach.**

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*OBJECTIVE*: To present the short -term results of Minimally Invasive total knee arthroplasty using a Mini-midvastus approach.

*METHODOLOGY*: From 2006 thirty knees in twenty-five patients who had rheumatoid arthritis or osteoarthritis underwent primary total knee arthroplasty. The mean age of the patients was 73.8 years. The mean follow-up was 12.6 month. The prosthesis used was Vanguard CR or PS (Biomet, Warsaw, IN). All patients were assessed by the knee scoring system of the Japanese Orthopedic Association (JOA score).

*RESULTS*: The JOA score improved from 44.8(pre-operative) to 79.3 (post-operative) at the final examination . There was not significant improvement in flexion angle after the surgery. The most prominent observation was reduction of knee pain, and improvement of extension. The average incision length was11.6cm(10-13.5cm). Mean operating time was 133.6minutes.Minimally Invasive total knee arthroplasty using a Mini-midvastus approach in rheumatoid arthritis and osteoarthritis patients resulted in improvement in extension angle and pain.
INTRA-OPERATIVE FLEXION BALANCE DOES NOT NECESSARILY CORRELATE WITH POST-OPERATIVE INSTABILITY IN TOTAL KNEE ARTHROPLASTY.

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PURPOSE: To investigate the correlation between intra-operative Flexion Balance (IFB) and post-operative Flexion instability in Posterior-Stabilized Total Knee Arthroplasty (TKA).

MATERIALS AND METHODS: Eighty-three knees (4 males and 79 females, average 74 y/o) with primary TKA (Zimmer NexGen LPS flex fixed-bearing) for varus osteoarthritis in our hospital between January 2006 and December 2007, were included in this study. After bone-cutting independently and balancing manually, Extension Balance (EB) and IFB were measured with seesaw type tensor. Post-operative Flexion Balance (PFB) was evaluated as post-operative instability with Kanekasu’s Epicondylar view at the least more than 6 months postoperatively. Varus inclination (lateral joint opening) was indicated as plus. In addition, pre-operative standing FTA (femoro-tibial angle), the change of FB (CFB=PFB-IFB) and True Correction Angle (TCA=FTA-174-EB), we had defined, were calculated. The TCA was hypothesized to mean the extent of medial soft tissue release. With these data, the correlation between IFB and PFB, CFB and TCA were analyzed. Of these, furthermore, in the well-balanced knees (IFB ≤±2°), same analyses were done. Statistical analysis was performed with StatView software.

RESULTS: Each data (n=83) in all subjects was as follows (Mean ± SD, degrees.); EB: 2.74 ± 2.74, IFB: 1.61 ± 3.67, PFB: 1.73 ± 2.66, CFB: 0.01 ± 4.25, FTA: 185.3 ± 6.7, TCA: 8.65 ± 6.52, respectively. Though there was no correlation between IFB and PFB (r=-0.09, p=0.57), CFB was correlated with TCA (r=0.40, p<0.01). Each data in the well-balanced knees (n=43) was as follows, EB: 3.09 ± 2.71, IFB: 0.70 ± 1.30, PFB: 1.22 ± 2.52, CFB: 0.57 ± 2.3, FTA: 185.5 ± 6.5, TCA: 8.42 ± 6.09, respectively. There was a correlation between IFB and PFB (r=0.41, p<0.01), however, FBC was not correlated with TCA (r=-0.26, p=0.10).

DISCUSSIONS & CONCLUSIONS: Same rectangular balance has been thought to be one the most important factors to obtain the good post-operative stability in TKA. For correcting alignment of lower extremity, medial or posteromedial release are generally needed to perform mainly in extended knee. Even if well-balanced EB was achieved, IFB does not necessarily prove to be well, rather than sparse. This might be because intra-operative balance was not measured under physiological condition, especially after wide posteromedial release. Soft tissues released for balancing would be repaired and shortened over time, so it seems to be natural that intra-operative balance would change. We reported that EB was correlated with post-operative instability in the previous congress (ISTA2006). However, it remains unknown as for FB. Our study demonstrated that CFB increased in accordance with the extent of soft tissue release (TCA), and that IFB was correlated with PFB only in the well balanced knees. This means that the measurement of IFB was not useful for predicting PFB in the imbalanced knees. That’s why we should achieve adequate balance & gap during operation and should recognize that FB was influenced by various factors, not only soft tissues but also rotation and inclination of components. In the future, how to measure IFB, including tensor and measurement condition, should be considered and established to predict knee balancing for good clinical results.
THE EFFECT OF PATELLAR EVERSION TO THE EXTENSION AND FLEXION GAPS IN TOTAL KNEE ARTHROPLASTY

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Purpose: The effect of patellar position on soft tissue balancing in total knee arthroplasty (TKA) is under debate. We developed the digital tensor system to measure the load (N) and the distance (mm) of extension and flexion gaps in medial and lateral compartment separately with setting of femoral component trial. The gap load and distance of posterior stabilized (PS) and cruciate retaining (CR) TKA in both patella everted and reset position were measured.

Materials and Methods: Thirty-four patients who underwent primary TKA for medial type osteoarthritis using medial parapatellar approach were included. The load was measured at the gap distance, which is equal to the sum of implants including polyethylene insert.

Results: In extension, there was no significant difference between the load in patella everted and reset position in both PS-TKA and CR-TKA. In flexion, there was a significant decrease of the load, which is comparable to the increase of gap distance of approximately 2mm, by resetting the patella from eversion in PS-TKA. There was, however, no significant difference in CR-TKA by resetting the patella. There was no significant difference in the ratio of medial / lateral load in both PS-TKA and CR-TKA.

Conclusion & Significance: Soft tissue balancing of PS-TKA with medial parapatellar approach should be performed after resetting the patella.

Role of Infrapatellar Fat Pad in Primary Total Knee Arthroplasty

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Purpose: To investigate the role of infrapatellar fat pad on primary total knee arthroplasty.

Materials and Methods: We evaluated 100 patients who had undergone TKA from August 2002 to July 2003, with open box posterior substituting femoral component implant (Scorpio PS Knee™). The study was performed prospectively and randomly allocated. We divided two groups. Group 1 (50 knees) was preserved infrapatellar fat pad and repaired fad at wound closure. Group 2 (50 knees) was excised infrapatellar fat pad as possible and repaired only joint capsule. We analyzed and compared clinical results of Knee Society knee (KS) score, function score, patellar score and Insall-Salvati ratio in both groups. The complications of each group were evaluated. Patients were followed up for mean 40 months(17~52 months).

Results: Mean KS score was 91.9 (91.94 ± 5.58) in Group 1 and 90.9(90.92 ± 6.38) in Group 2. Mean function score was 81.6(81.64 ± 13.18) in Group 1 and 83.7(83.79 ± 17.71) in Group 2. Mean patellar score was 29.9(29.89 ± 9.10) in Group 1 and 27.9(27.90 ± 1.80) in Group 2. And mean patellar height as Insall-Salvati ratio was 1.19(1.19 ± 0.17) in Group 1 and 1.23(1.23 ± 0.11) in Group 2. The differences between the Group 1 and Group 2 in all of index were statistically insignificant. In complications, 2 cases of recurrent hemarthrosis were observed in Group 1 patients.

Conclusion: The difference of clinical outcomes whether infrapatellar fat pad was excised or not were statistically insignificant. However, preservation of infrapatellar fat pad on open boxed PS TKA showed unique complications such as recurrent hemarthrosis which might be caused by fat pad adhesion to intercondylar notch. We propose that infrapatellar fat pad on primary PS TKA with open box design would like to be excised for prevention of unique complications.

Key Word: Infrapatellar fat pad, Total knee arthroplasty, Hemarthrosis
Arthroscopic Fat Pad Resection for Anterior Knee Pain in deep flexion after Total Knee Arthroplasty

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Introduction: Achieving deep flexion of knee after total knee arthroplasty (TKA) is particularly desirable in some Asian and Middle Eastern who have daily or religious customs typically use full knee flexion. After TKA, some patients complained about anterior knee pain during deep knee flexion. We evaluated the efficacy of arthroscopic fat pad resection in a series of patients suffering from anterior knee pain associated with high flexion achievement after TKA.

Methods: The efficacy of fat pad resection via arthroscopy for treating anterior knee pain associated with high flexion angle was evaluated in eight knees of eight patients among 207 knees performed between 1996 and 1999. The mean age of patients was 71.1 years when the primary TKA was performed. All implants were posterior stabilized type (IB-II, Nexgen PS and LPS). The symptom of anterior knee pain during deep knee flexion developed within one year after TKA in all cases. In addition to pain in eight knees, two patients have crepitation as the knee was flexed and extended and three patients had hydrarthrosis. Impingement and fibrosis of fat pad were confirmed, and fibrous structures were removed by arthroscopy.

Results: Before arthroscopy, the symptom obviously subsided after injection of local anesthesia into infrapatellar fat pad. Patellar clunk syndrome is also soft tissue impingement and suprapatellar fibrous nodule becomes entrapped intercondylar notch on the femoral component during knee flexion. On this point, these cases does not cause by patellar clunk syndrome. After fat pad resection, the symptom disappeared, and keeps symptom-free after a mean follow-up of six years five months in all cases. Any complications following fat pad resection, such as patella baja and necrosis, were not experienced.

Discussion: Those cases achieving higher flexion angle tended to experience severe pain and shorter time interval between TKA and arthroscopic surgery, suggesting impingement of the infrapatellar fat pad is closely related to deep flexion after TKA. These results demonstrate that the anterior knee pain due to repetitive infrapatellar fat pad impingement is one of the complications during deep knee flexion after TKA, and the arthroscopic fat pad resection is useful to relief the anterior knee pain. Because of our experience with patients encountering anterior knee pain, we have begun to remove 70 to 80% of the fat pad during the primary TKA procedure since 1999, and until today, none developed anterior knee pain thought to be associated with fat pad impingement, patellar baja nor patellar necrosis. We suggest that fat pad resection is necessary to prevent the anterior knee pain due to fat pad impingement during deep flexion in TKA.

GENDER AND SIZE DIFFERENCES IN OSTEOARTHRITIC KNEE MORPHOLOGY

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562 osteoarthritic knees rated as stage 1 or more according to Kellgren’s osteoarthritic knee classification were selected randomly and analyzed radiologically. Eighty cases with the height of 155 cm-160 cm, for which a large number of male and female cases are available (34 male cases, 46 female cases) were extracted for analysis. The values measured were significantly larger in male than in female in any region. In order to clarify differences in morphology between the sexes, the ratio between the values measured of various regions was computed. As a result, the value(AP/ML ratio) obtained by dividing the length of medial femoral condyle in anterior-posterior direction and the depth of medial femoral condyle in proximal-distal direction by the width of femur at articular level was 0.87±0.03, 0.56±0.03 in female against 0.81±0.04, 0.52±0.03 in male, respectively. A statistically negative correlation was found between femoral width and AP/ML ratio. The value(AP/ML ratio) obtained by dividing the length of medial tibia condyle in anterior-posterior direction by the width of tibia at articular level was 0.61±0.05 in female against 0.59±0.04 in male. A statistically negative correlation was found between femoral width and AP/ML ratio. That is, the larger the medial-lateral width of the tibia becomes, the smaller becomes the AP/ML ratio. When the differences between the sexes were studied, the values measured of various regions were significantly larger in males than in females even in the group of the same height. Moreover, The AP/ML ratio of the current components does not follow the negative correlation between the width and AP/ML ratio. It was concluded that the size variation of the currently available components should be reconsidered.
REVISION WITHIN THE FIRST 5 YEARS AFTER PRIMARY TOTAL KNEE ARTHROPLASTY

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This study was conducted to investigate the cases which were obliged to receive revision surgery within the first 5 years after primary Total Knee Arthroplasty (TKA).

The subjects of this study were 15 patients (5 males & 10 females, mean age at revision 72 years) who had undertaken revision surgery within 5 years since 1996. Intervals between primary and revision TKA averaged 29.8 months.

Prosthesis used for primary TKA was as follows; 11 Zimmer NexGen LPS-flex fixed bearing, 2 mobile bearing, 2 CR type.

Revised components, cause of revision, JOA score as clinical results and FTA as radiographic evaluation were examined.

Revised parts were as follows; 1) All components: 2, 2) Both Femoral and Tibial components: 4, 3) only Femoral component: 2, 4) only Tibial component: 5, 5) only patella component: 1, 6) only articular surface: 1. Stemmed Femoral components were used in 6 out of 8 knees, stemmed Tibial components in 9 out of 11 knees.

The causes of revision were as follows; a) infection: 1, b) loosening: 7, c) inadequate component position: 4, d) instability: 2, e) pain: 1.

Primary TKA remains one of the most successful orthopedic procedures. Survivorship was generally reported over 15 years in the previous article. However, there are some cases in which revision TKA is necessary by some causes. There seems to be various types of causes for revisions, such as loosening, inadequate position, abrasion of components and others. Though loosening of components due to traumatic cause was inevitable, other causes, such as inadequate position of component, imbalanced soft tissues and infection, which depend on our technique, should be cared during and after surgery. From our study, except for 7 (2 trauma, 5 unknown) out of 15 knees, almost half of revision TKA (8 knees) might be due to technical demand. As for surgical techniques, in the case of poor bony quality, we routinely use stemmed components and should try not to impact strongly on setting component to prevent from sinking. In the case of non-traumatic cause, 3 out of 12, though the position of tibial component was acceptable, tibial component sank because of bony weakness and/or imbalanced soft tissues resulting pain.

Adequate position and balance of components should be achieved during primary TKA. In our department, we are trying to revise and routinely use stemmed components as soon as possible, when loosening of component is confirmed. Metal augmentation, if necessary, is mainly used for bone defect to do early rehabilitation.

We concluded that adequate position of components and soft tissue balance was very important at the time of primary TKA. Clinical results of revision TKA were almost equal to those of primary TKA, however, long term follow-up will be needed.
OUTCOME OF REVISION TOTAL KNEE ARTHROPLASTY USING CONSTRAINED CONDYLAR KNEE PROSTHESIS: MINIMUM 2 YEAR FOLLOW UP

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Introduction: Constrained condylar knee (CCK) prosthesis offers an implant option for complex revision total knee arthroplasties in which stable varus-valgus constraint as well as rotational control is needed for severe bone defect and ligament insufficiency. The aim of this study was to evaluate the clinical and radiological outcome of CCK prosthesis in revision TKA.

Materials and Methods: Fifty-one revision TKAs performed using CCK prosthesis between Jan. 1998 and Feb. 2006 were performed. The mean follow-up period was 5 years and 3 months (2 to 9 years) and the interval between initial and revision TKA was 8 years (4 months to 21 years). The mean age was 67 years. Range of motion (ROM), knee society (KS) score, hospital for special surgery (HSS) score, complication rate and failure rate was evaluated. The tibiofemoral angle and radiolucent line was also evaluated on plain radiograph.

Results: The mean ROM improved from 81.9° to 102°. The mean KS score improved from 49.3° to 79.7°, and KS function score from 50.3 to 71.0 (P<.001). The mean HSS score improved from 50.7 to 78.7 (P<.001). Tibiofemoral angle improved from valgus 3.1° to valgus 5.6° (P<.001). Radiolucent line more than 2mm was observed around 4 femoral and 4 tibial components. Complications including 1 skin necrosis, 1 tibial tubercle nonunion, 2 infections, 3 periprosthetic fractures and 5 arthrofibrosis were observed. Overall rating was excellent or good in 88% at the last follow up.

Conclusion: Revision TKA using CCK prosthesis showed comparable results with other reports in average 5 years follow-up.

ARTRODESI S OF THE KNEE USING COMPUTER NAVIGATION AND THE ILIZAROV METHOD IN FAILED TOTAL KNEE ARTHROPLASTY

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Arthrodesis is used most commonly as a salvage procedure for failed total knee arthroplasty (TKA). For successful arthrodesis, a stable fusion technique and acceptable limb mechanical alignment are needed. Although the use of intramedullary alignment rods might be helpful in terms of achieving an acceptable limb mechanical axis, fat embolism and intramedullary dissemination of an infection or reactivation of latent infection might occur in failed TKA cases. However, computer-assisted surgery allows precise cuts to be made without breaching medullary cavities. Here, the authors describe a case of knee arthrodesis performed by computer navigation and the Ilizarov method in a patient with a past history of infection. A 45-year-old man visited our hospital with failed total knee arthroplasty. Fortunately, even though infection was treated by debridement with component retention, mild heating was present over the knee, but ESR(erythrocyte sedimentation rate) and CRP(C-reactive protein) were within normal ranges. X-ray showed subsidence of the femoral component and a radiolucent line around the femoral component. Arthrodesis was planned for this patient due to disabling pain, a long-lasting severe functional deficit, failure of the primary TKA for ankylosed knee, and the patient’s poor economic status and his strong desire for arthrodesis. The computer navigation surgery system and the Ilizarov method were used for two reasons. The first reason was that the patient had a past history of infection. At preoperative evaluation, even though ESR and CRP levels were within normal range, we could not completely rule out the possibility of latent infection due to suspicious findings such as long lasting disabling knee pain, mild heating over the knee, severe osteolytic radiographic changes around the femoral component. In that situation, inserting an IM rod to achieve acceptable mechanical alignment might have reactivated and disseminated a possible latent infection to the femoral or tibial medullary canals. The second reason was that we wanted to reduce the possibility of fat embolism by using computer navigation without instrumentation within the medullary canal. A CT-free, wireless computer navigation system was applied, with trackers fixed to the femur and tibia and no requirement for the use of an IM rod with component retention. Navigated femoral and tibial bone resections were then performed using Stryker software. The femoral resection was conducted at 0° of flexion to the sagittal axis, and the tibial resection at 7° of flexion to the sagittal axis. Arthrodesis was held in proper axial and rotational alignment with bone surfaces compressed together. Finally, knee arthrodesis was completed using the Ilizarov method. Based on our experience of the described case, we believe that arthrodesis for failed TKR, especially failure secondary to intraarticular infection, can be considered as another indication for computer navigation.
SALMONELLA SEPTIC ARTHRITIS FOLLOWING TOTAL KNEE ARTHROPLASTY FOR RHEUMATOID ARTHRITIS IN A PATIENT RECEIVING ETANERCEPT. A CASE REPORT

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The treatment of rheumatoid arthritis (RA) has recently seen a paradigm shift with the introduction of biologic therapy, but there is concern that this will result in an increased incidence of infection. The occurrence of infection in RA patients who have undergone biologic therapy has recently been documented in a few reports, but this is the first report of Salmonella infection after total knee arthroplasty (TKA) in a RA patient receiving etanercept therapy. Here we report the successful treatment of a rare case of Salmonella septic arthritis.

A 61-year-old man with a 4-year history of RA was treated with methylprednisolone and methotrexate, and he consulted us because of right gonalgia. Treatment with infliximab was started, but as this was not effective, his medication was changed sequentially to etanercept 6 months later. Finally, TKA was performed on the right knee with antibiotic-loaded acryl cement (ALAC). The postoperative course was uneventful, etanercept was administered routinely from the 2nd postoperative week. The patient was discharged after 4 weeks. Five weeks after TKA, however, the patient visited us because of acute swelling and tenderness around the right knee. His laboratory values included a white blood cell count of 9300/mm$^3$, an erythrocyte sedimentation rate of 81.0 mm/h and a C-reactive protein level of 11.3 mg/dl. Fluid obtained by joint aspiration was cloudy and dark-yellow, and prosthetic joint infection was diagnosed. The patient underwent emergency debridement by arthroscopic surgery, followed immediately by injection of 0.5 g carbapenem every 12 hours and continuous closed irrigation-suction of the joint for 2 weeks. Culture of the joint fluid revealed Salmonella enteritidis infection, which was not sensitive to aminoglycoside which we used as ALAC[DD1]. We did not carry out stool culture because the patient had had no episode of diarrhea[DD2] or gastroenteritis prior to the onset of arthritis. The patient was treated with intravenous carbapenem for 3 weeks, oral levofloxacin at a daily dose of 300 mg for 2 weeks successively, and oral minocycline at 200 mg daily for 3 months. At follow-up 12 months after surgery, physical and blood examinations and plain radiographs demonstrated no recurrence of the infection, and the patient has resumed taking etanercept. The range of flexion in the treated knee is 0 to 145 degrees. Salmonella arthritis is classified as septic arthritis and reactive arthritis, and septic arthritis is more likely if Salmonella is identified by culture of joint fluid. Salmonella septic arthritis has not been considered an intraoperative contaminant during joint replacement, the Salmonella infection in this case may have occurred through the haematogenous route. Recently, it has become apparent that biologic therapies can play major roles in the pathogenesis of RA, and also that immunosuppressive drugs may become risk factors for Salmonella septic arthritis. In conclusion, our patient had a successful outcome after prompt debridement and treatment with appropriate antibiotics, without the need for implant removal. It is important to be mindful of the possibility of infection and to carry out surgery immediately if a patient presents with symptoms after biologic therapy.

Abstract Topic: Clinical Outcome of Arthroplasty

Preference of POSTER presentation
PK08-03

Treatment of Periprosthetic Supracondylar Femur Fractures following a Total Knee Arthroplasty - Minimal invasive technique using locking condylar plate -

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Introduction: The purpose of this was to evaluate the clinical and radiological results of the minimal invasive treatment of the supracondylar periprosthetic fracture after total knee arthroplasty using locking condylar plate.

Materials and Methods: From January 2001 to June 2007, the 9 cases of the periprosthetic supracondylar femoral fracture were included in this study. The average age of the cases was 67 years old (range: 62-73 years old). The average duration of follow-up was 2 years 1 months (range: 12~48 months). The implants of the index operation were posterior cruciate substitution implants without stem. According to the OTA classification, all cases were classified as 33A.

Results: All cases were treated using AO locking condylar plate. The fracture was extended into undersurface of the anterior flange of the femoral component. Locking condylar plate was fixed by the minimal invasive percutaneous technique. The average time of bone union was 5.4 months (range: 4-7 months) without additional bone graft. The average range of motion was 95 degrees and HSS (Hospital for Special surgery) score was 75 points in last follow-up. Femorotibial angle at the last follow-up was average valgus 5 degree.

Conclusion: Minimal invasive percutaneous fixation using locking condylar plate was useful to treat the periprosthetic femoral fracture which was alternative method to retrograde femoral nail.

Key Words: Knee, Periprosthetic fracture, Femur, Locking condylar plate

PK08-04

Treatment of Soft Tissue Defects after TKA Using Saphenous Neurocutaneous Island Flaps

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The purpose of the study was to evaluate clinical outcomes in patients receiving saphenous neurocutaneous island flaps for reconstruction of soft tissue defects after total knee arthroplasty (TKA). Four patients (2 men, 2 women; mean age 61 years) with post-TKA soft tissue defects were treated with saphenous neurocutaneous island flaps between November 2001 and August 2007. The mean follow-up period was 3.5 years. Initial diagnoses were traumatic arthritis, rheumatoid arthritis, arthritis due to previous osteomyelitis and tuberculous arthritis. One patient developed deep infection after TKA, so revision TKA with Nexgen® LPS (Legacy® posterior stabilized) was performed after soft tissue reconstruction. One soft tissue defects developed after TKA with Nexgen® LPS due to long-term steroid use for rheumatoid arthritis. Two cases occurred after placement of Nexgen® LCCK (Legacy® constrained condylar knee). Two cases developed secondary to diabetes mellitus and tuberculous arthritis. Soft tissue defects were located over the patella (1 case), patellar tendon (1 case), and medial side of the knee (2 cases). The flaps ranged in size from 3x4 cm to 8x5 cm. All flaps were proximally based. All flaps survived completely. The postoperative range of motion was between 3° and 100°. Because saphenous neurocutaneous island flaps are well matched with local tissue and are tough, thin, pliable and sensate, they are an ideal option for reconstruction of soft tissue defects after TKA.

Key Words: Knee, TKA, soft tissue defect, saphenous neurocutaneous island flap
### Poster (KNEE)_09. Miscellany

**PK09-01**

**IS AUTOLOGOUS DRAINAGE BLOOD REINFUSION ADVANTAGEOUS OVER NO DRAIN IN PRIMARY TKA?**

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**Purpose:** Primary total knee arthroplasty is associated with considerable blood loss, and allergenic blood transfusions are frequently necessary. Because of the cost and risks of allogenic blood transfusions, the autologous drainage blood reinfusion technique has been developed as an alternative. A number of studies have compared reinfusion techniques with standard suction drainage, but few reports compared with no drain use. We analyzed early results after primary total knee arthroplasty using autologous drainage blood reinfusion and no drain.

**Materials and Methods:** We selected 30 patients who underwent primary total knee arthroplasty using no drain between November 2005 and March 2006 and matched for age and gender with 30 patients who underwent primary total knee arthroplasty using autologous drainage blood reinfusion technique between January 2003 and October 2005. All operations were done under pneumatic tourniquet and meticulous hemostasis was performed after deflation of the tourniquet. We have retrospectively reviewed the preoperative data (age, gender, body mass index, diagnosis, history of the knee surgery, infection and anticoagulant therapy, and medical comorbidities) and the postoperative data (hemoglobin, hematocrit and platelet during hospitalization, the amount of allogenic blood transfusion and narcotics, complications, rehabilitation process, and clinical scores).

**Results:** All preoperative and postoperative variables except the postoperative second and seventh days hemoglobin and 2nd day hematocrit showed no significant differences between two groups. The hemoglobin and hematocrit also showed no significant differences at the postoperative fourteenth day.

**Conclusion:** The autologous drainage blood reinfusion method in primary total knee arthroplasty does not have significant clinical benefit over no-drain method with regards to allogenic blood transfusions, narcotics uses, the incidence of complications and rehabilitation processes.

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**PK09-02**

**A HYDROCOLLOID FILM KARAYAHESIVE AS AN ALTERNATIVE FOR EPIDERMAL SUTURE IN TOTAL KNEE ARTHROPLASTY**

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Karayahesive is a viscoelastic film made of Karaya gum. The Karaya gum includes some polysaccarides and is extrated from Karaya gum tree (Sterculia urens). It applies Moist Wound Healing Mechanism which has been proposed by plastic surgeons. According to this mechanism, the spontaneous wound cure can be promoted by preventing wound becoming dry, keeping a wet environment around wound, and reducing the inhibitors against wound healing. It was originally developed as a wound dressing material to use after the ordinal skin closure. We remarked its strong adhesiveness, as a modification, we use it as an alternate for epidermal suture. Since June 2006, we have been using it for 183 knees. Among them, in this study, we evaluated 158 knees in 183 (18 male, 165 female) patients with minimum of two months follow-up. The diagnosis at the surgery was osteoarthritis for 137 knees, rheumatoid arthritis for 20 knees, and aseptic necrosis of the femoral condyle for one knee. The average age at the surgery was 70.8 (40 to 84). The average of follow-up was 8.5 (two to 21) months. In all knees we used a parapatellar medial approach. Without any epidermal suture, the wound was closed by attaching Karayahesive. Before attaching Karayahesive, we made the ordinal subcutaneous suture just like as the conventional skin closure. We wipe off the blood to dry the skin. Without any epidermal suture, we attached Karayahesive to reduce the wound tension. After attaching it, we made the ordinal gauze dressing and compression bandage. No dressing change was necessary until the removal. Karayahesive was removed two weeks after the surgery, together with clot and overlaying dressings. After the removal, most patients require no additional dressing and could go into bathtub on the same day. The excellent primary wound healing was obtained in 152 knees. In six knees, the wound disrupted. However, re-attach of Karayahesive provided early healing of the disrupted wound successfully. Comparing the ordinal epidermal suture, the patients complained less pain at the removal and irritation after the surgery, and Karayahesive provided better wound healing. It saved time and labor as no epidermal suture and no dressing change were necessary. It saved cost of the medical waste. On the other hand, it was difficult to observe the wound; as it was concealed by clot. We had to be very careful not to miss early symptom of the infection. In conclusion, for the knee arthroplasty Karayahesive was not only very useful wound closure material but also the excellent alternate for the epidermal suture.
THE EFFECT OF CLOSED-SUCTION DRAINAGE AFTER TOTAL KNEE ARTHROPLASTY

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Introduction: To assess the clinical comparison of closed suction drainage group and non drainage group after simultaneous total knee arthroplasty.

Materials and Methods: We analyzed the thigh circumference, ecchymosis, wound infection, transfusion amount, knee score and range of motion in 140 cases (70 patients) done with PFC or PFC-sigma model between 1998 and 2005. 100 cases of them (group Ⅰ) were inserted hemovac and the others (group Ⅱ) were not inserted hemovac.

Results: The average thigh circumference in group Ⅰ was 43.8 cm (preoperative), and 47.3 cm (postoperative), in group Ⅱ was 43.2 cm (preoperative) and 47.9 cm (postoperative). The knees that had no drains had a higher incidence of ecchymosis. However, the final result of knee score and range of motion of knee joint were not affected significantly by nonuse of closed suction drainage. There were no infection sign in both groups.

Conclusion: The clinical comparison of closed suction drainage group and non drainage group after simultaneous bilateral total knee arthroplasty was not significantly different in wound healing, clinical and rehabilitation course. The use of suction drainage must be carefully selected after primary total knee arthroplasty.

Investigation of Pathological Features in Synovium of Rheumatoid Arthritis Treated with Biological Agents to Elucidate Using Rooney’s Synovitis Scoring System

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Object: To invest of pathological features in synovium of rheumatoid arthritis treated with biological agents.
Method: Synovial tissues obtained at surgeries of total knee arthroplasty. Patients treated with biological agents were 10 patients, not with the agents were 20. Using with infliximab patients were 7 patients, and with etanercept were 3. Synovial tissues were examined to evaluate in histologically (Rooney’s score)
Result: Scores of the synoviocyte hyperplasia and perivascular infiltrates of lymphocytes and were significant higher than the other scores. We suspected that these biological agents regulated clinical features of rheumatoid arthritis through the synoviocyte activity and lymphocyte functions.
Cementless Total Ankle Arthroplasty for Osteoarthritis with Avascular Necrosis of the Talar Body

Two Case Reports and a Review of the Literature

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To date nine cases treated by cementless total ankle arthroplasty for avascular necrosis of the talar body have been described in the English literature. However, these reports show high complication rates including collapse of the talar component, and as a result cementless total ankle replacement is not recommended for the treatment of avascular necrosis of the talar body. The authors report two cases of ankle osteoarthritis with avascular necrosis of the talar body that were treated by cementless mobile bearing total ankle arthroplasty, because preoperative magnetic resonance images and radionuclide bone scanning showed revascularization of the talus. Recent follow-up plain radiographs of ankles showed no loosening or subsidence. The authors conclude that cementless total ankle arthroplasty for the treatment of avascular necrosis of the talar body is likely to be successful if necrotic bone has healed by creeping substitution and has enough strength to support an implant.

REVISED TOTAL ANKLE ARTHROPLASTY WITH FEMORAL HEAD ALLOGRAFT -A CASE REPORT-

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There was used cement in first generation total ankle arthroplasty, but first generation of ankle arthroplasty was abandoned because of aseptic loosening of component. For the treatment of aseptic loosening of ankle arthroplasty, there had been many methods. One of methods of revisional ankle arthroplasty is the ankle arthodesis. The authors report a case of revisional ankle arthroplasty using allograft with hybrid external fixation.

45 year old male had surgery of cemented total ankle arthroplasty on his right ankle 20 years ago. He went to our clinics because of motionless and pain of his right ankle. He got the mild pain on his right ankle after 5 years surgery. His pain was managed by oral NSAIDS for 15 years. The pain was aggravated recently. There were osteophytes on posterior aspect of ankle joint and radiolucency around the implant, subtalar arthrosis at the radiograph. There was also sclerosis around the ankle joint.

The authors decided revisional surgery. At the operative findings, we can see the loosening of talar and tibial component and large posterior osteophyte bridging between remained talus and tibial bone. There were no infection signs. After remove the implant, there was big space remained. For the regaining the limb length, we used femoral head allograft. The graft was fixed with 6.5 mm cannulated screws and addition fixed with ilizarov external fixation. Also additional auto bone graft from the osteophytes was applied. Compression over the ilizarov external fixation was done at the end of the operation. Weight bearing was allowed immediate after surgery. Ilizarov ring was removed 6 weeks after surgery. At the 3 months after surgery, bony union was obtained on radiographs. AOFAS score was improved from 30 to 70 6 mo after surgery. There was no pain on his right ankle. Patient satisfied with arthrodesis with allograft at final follow-up.
Purpose: The purpose of this study is to compare the two prosthesis which was used for total ankle arthroplasty.

Materials and Methods: From Sept. 2003 to Jun 2007, 13 patients and 14 ankles that could be follow up more than 2 years. Semiconstrained type (Group I, 7 cases) and Unconstrained type (Group II, 7 cases) were used for total ankle arthroplasty. Mean age was 63.2 year-old, 12 ankles are men and 2 ankles were women. Mean follow up periods were 31.1 months. The criteria to compare the clinical result were postoperative range of motion (ROM), AOFAS foot score and residual bone stock of medial malleolus.

Results: Postoperative ROM of group I was 37.5 ± 7.1 degree and of group II was 51.4 ± 8.9. Postoperative AOFAS score of group I was 76.1 ± 13.8 and of group II was 86.0 ± 5.7. Residual bone stock in medial malleolus of group I was 6.1mm ± 0.7 and of group II was 11.5mm ± 0.9. Total number of complication in our study was 9 cases. 3 cases were a malleolar fracture, two occurred at intra-operation, the other at follow-up period. Re-operation was done in 6 cases, 3 cases were calcaneal corrective osteotomy, 2 cases were resection of a heterotopic bone and one case was pedicular flap operation for skin problem.

Conclusion: In our hospital, mobile bearing type prosthesis showed good result than a semiconstrained type in respect of ROM improvement and of residual bone stock in medial malleolus. AOFAS score between two groups showed no definite difference. But small number of patients and short term follow up period is a defect in our study, afterward more population and long term follow up period are needed.
DESIGN AND EVALUATION OF A MULTIPLE HEIGHT EXPANDING INTERVERTEBRAL CAGE

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Introduction: The success of spinal fusion is widely accepted. However, room for improvement is possible as complication rates remain between 5%-10% due to tears, device migration, improper sizing and lead to pseudoarthroses.[1] In an attempt to improve outcomes, an expanding intervertebral cage that can be adjusted inter-operatively for proper segmental distraction and support has been designed and undergone preliminary evaluations.

Materials and Methods: The main features of the device include a locking spacer that is rotated into position providing both proper distraction and stability based on clinical need. All of the rotating spacers associated with the device possess equivalent minor diameters with distraction height achieved by varying major diameters. Once the appropriate spacer has been identified, a locking mechanism is engaged, locking the spacer in place. In order to ensure parallel distraction while retaining segmental lordosis, the baseplates encompass a variety of angles and are guided bilaterally during distraction.
To evaluate this design, a finite element model (Solidworks, Cosmos, Concord, MA) was employed on a 12° lordosed, 18mm distraction height device under a compressive load of 2745N. This represents the least stable condition as the lordosis angle and height are at the maximum values clinically appropriate. Static and dynamic mechanical testing were performed. Static testing consisted of applying at compressive load at 25mm/min (858 Mini Bionix, MTS, Eden Prairie, MN) until failure of the device or a maximum load of 7000N was sustained. Maximum load, device stiffness and overall deformation were extracted from the load versus deflection data.
Dynamic testing (ELF 3300, Bose, Minnetonka, MN) involved sinusoidal loading from -50N to -300N at a rate of 60Hz. This load represents the approximate mass of the torso. The device was cycled for 5 million cycles with load and displacement data acquired at 250,000 cycle intervals at a rate of 500Hz. Net deflection was computed at 250,000 cycle intervals while compressive stiffness was computed at 500,000 cycle intervals. Non-linear regression analyses were performed for both deflection and stiffness versus cycle number in order to elucidate the behavior of the device.

Results and Discussion: Finite element analysis revealed a maximum stress level of 163MPa equating to a safety factor of 6.5 in the case of titanium alloy. Static testing revealed that when fully distracted, the device sustained a compressive load in excess of 7160N and displayed a compressive stiffness over 28500N/mm. It has been reported that the vertebral body will fail at levels below 5000N/mm. With respect to fatigue testing, the device achieved the required 5 million cycles. Non-linear analysis of the deformation data (R²>0.78) displayed a net deflection change of 0.041mm with a subsidence rate of 0.3mm/million cycles. Compressive stiffness (R²>0.99) was altered at a rate of 0.36N/mm/million cycles.
These results confirm that this novel design can enhance the likelihood for osseointegration by maintaining the micromotion levels below the reported critical value of 75μm.[3]

Conclusions: The design of novel expanding and interoperatively adjustable intervertebral spacer has been realized and appears viable based on preliminary mechanical and finite element analysis.

References:
EFFECTS OF MALALIGNMENT OF TOTAL DISC REPLACEMENT ON KINEMATICS AND LOAD-SHARING CHARACTERISTICS OF THE LUMBAR SPINE

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The total disc replacement (TDR) devices are gaining popularity because of their capability of allowing joint motion at the index level. Studies have shown that motion preservation can reduce the likelihood of further degeneration at the adjacent level with better surgical outcome. Current lumbar TDR devices require an anterior approach for implantation. However, it is known that its clinical outcome may depend on implant insertion and placement during surgery. Only limited number of biomechanical studies regarding the effect of placement orientation on the clinical outcome is currently available. The purpose of this study was to investigate effects of various surgical placement of a lumbar TDR on the kinematics and load-sharing characteristics using finite element method (FEM).

A previously-validated 3-D nonlinear FE model of the intact lumbar motion segment (L3-S1) based on computer tomography (CT) images of a cadaveric specimen (male, age 56, no pathologies) was used as the baseline FE model. Then, implantation of ProDisc-L (Spine Solutions, Inc., Synthes, Paoli, PA, USA) was simulated into the L4-L5 disc space through anterior approach with removal of the nucleus, anterior longitudinal ligament, and the anterior part of the annulus. The location of lumbar TDR was varied in the sagittal and the coronal planes. In the sagittal plane, the implants were placed anteriorly at 3-mm (S-3), 5-mm (S-5), and 7-mm (S-7) offset from the posterior margin of the endplate. In the coronal plane, the devices were shifted from the baseline position laterally to the right by 1-mm (C-1), 2-mm (C-2), and 3-mm (C-3) from the mid-sagittal line along the lower endplate. All of the models were subject to 150N compressive pre-load and flexion/extension moments of 10Nm at the superior endplate L4, while the inferior endplate of L5 was fully constrained. Changes in motion (ROM) and facet loads at the index and adjacent levels were assessed at different implant position.

Results showed that deviation from the central placement (from S-3 to S-7 and from C-1 to C-3) decreases ROM while increasing facet load at the index level. The effect was more pronounced in the sagittal plane than in the coronal plane: 10% decrease in ROM and 1% increase in facet load in the sagittal plane vs. no significant change in the coronal plane. As expected, changes were more evident during extension than in flexion. While the kinematics of the spine was restored to the pre-operative stage at the index level (L4-5), the ROM decreased at the adjacent level (L5-S1) in a compensating manner. The overloading of the facet seemed to indicate mal-alignment of the implant can further trigger facet degeneration, which may require unwanted revision or additional surgical treatment. Acknowledgements: This study was supported by the Korea Food and Drug Administration (08142 MEDICAL INSTRUMENTS 358).
COMPARISON OF BIOMECHANICAL PERFORMANCE FOR THREE ARTIFICIAL DISCS IN LUMBAR SPINE

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Even though spinal fusion has been used as one of the common surgical techniques for degenerative lumbar pathologies, high stiffness in the fusion segment could generate clinical complications in the adjacent spinal segment. To avoid these limitations of fusion, the artificial discs have recently used to preserve the motion of the treated segment in lumbar spine surgery. However, there have been lacks of biomechanical information of the artificial discs to explain current clinical controversies such as long-term results of implant wear and excessive facet contact forces. In this study, we investigated the biomechanical performance for three artificial discs in the lumbar spinal segments by finite element analysis.

A three-dimensional finite element model of five spinal motion segments, from L1 to S, in intact lumbar spine was reconstructed from CT images. Finite element models of three artificial discs, semi-constrained and metal on polyethylene core type (ProDisc® II, Spine Solutions Inc., USA; Type I), semi-constrained and metal on metal type (Maverick™, Medtronic Sofamor Dane Inc., USA; Type II), and un-constrained and metal on polyethylene core type (SB Charité™ III, Dupuy Spine Inc., Switzerland; Type III) were developed. Each artificial disc was inserted at L4-L5 segment, respectively. Upper and lower plates of artificial discs were attached on the L4 and L5 vertebrae. Some parts of ligaments and intervertebral disc in L4-L5 motion segment were removed to insert artificial discs. Nonlinear contact conditions were applied on facet joints in lumbar spine model and artificial discs. Bottom of sacrum was fixed on the ground and 5Nm of flexion and extension moments were applied on the superior plate of L1 with 400N of compressive load along follower load direction.

In extension, all three artificial disc models showed higher rotation ratio at the surgical levels, but lower rotations at the adjacent levels than those in the intact model. There was no big difference of the intersegmental rotations among the artificial disc models. For the comparison of the peak von-Mises stresses on the polyethylene core in flexion, 52.3 MPa in type I implant was higher than 20.1 MPa in Type III implant while the peak von-Mises stresses were similar, 25.3 MPa and 26.5 MPa in Type I and III, respectively in extension. The facet contact forces at the surgical level for the artificial disc models showed 140 to 160 N in extension whereas the facet contact force in the intact model was 60 N.

From the results of this study, we could investigate the biomechanical characteristics of three different artificial disc models. The relative rotation at the surgical level would be increases at the early outcome after total disk replacement. The semi-constrained type artificial disc could generate higher wear risk of the implant than un-constrained type. Also all types of artificial disc model have higher risk of facet joint arthrosis, and especially in the semi-constrained and metal on metal type. The results of the present study suggested that more careful care must be taken to choose surgical technique of total disc replacement surgery.

In-vitro Testing and 3 Years Clinical Experience with an Innovative Elastomeric Lumbar Disc Prosthesis

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Introduction: Current total disc prostheses are 2- or 3-pieces devices, including 1 or 2 bearing surfaces, and providing 3 or 5 degrees of freedom but with no, or very little, resistance. The ESP® is a one-piece deformable implant made of silicon and polycarbonate polyurethane elastomer securely fixed to titanium endplates. It allows limited rotation and translation with elastic return. This cushion without fixed rotation center achieves 6 degrees of freedom including shock absorption. An earlier attempt to use elastomers (Acroflex®) failed clinically due to the polymer. This highlights the need for accurate in-vitro fatigue testing and clinical evaluations.

Methods: In-vitro fatigue testing with more than 40 millions cycles were performed on different samples for compression, flexion-extension bending, lateral bending, torsion and shear. A prospective trial was initiated in 2004 for L3-L4, L4-L5 and L5-S1 levels. Total disc replacements have been performed in 153 lumbar levels through extra-peritoneal mini-invasive anterior approach.

Results: After in-vitro testing, microscopic examination showed that the polymer core remained unchanged without evidence of cracking or other degradation. Gravimetric analysis revealed insignificant changes in weight. The geometrical characteristics and the cohesion of the implants remained stable. After 3 years clinical experience, there was no device related complication, except one early revision for a post-traumatic implant migration. VAS and ODI scores improvements were equivalent to other published series.

Discussion and Conclusion: In-vitro fatigue testing and short term results of the innovative ESP® prosthesis demonstrate the reliability of the concept. The results are equivalent to other series with conventional implants.
**PM01-08**

**DYNAMIC COMPRESSIVE CREEP BEHAVIOUR OF UHMWPE UNDER THE HIGH PRESSURES IN THE TOTAL JOINT REPLACEMENTS**


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**Introduction:** Ultra-high molecular weight polyethylene (UHMWPE) has been used for the bearing liner or inlay components in total joint replacements such as total hip, knee, and artificial disk since 1960s. UHMWPE components generate wear debris during articulation, which play a key role in osteolysis, subsequent aseptic loosening, and eventually revision surgery. Efforts to solve the wear problem in UHMWPE and to quantify the amount of wear have driven many studies. But in vivo radiographic penetration depth measurement is the result of both wear and viscoelastic creep. Previous study reported that over 70% of the dimensional changes in UHMWPE acetabular cups were due to creep [1]. Creep deformation was quantified under the static and dynamic compressive pressures (2, 4, 8MPa) that are clinically relevant for the hip joint loads in normal motions [2,3]. However, according to the finite element stress analyses in UHMWPE components under the active motions in hip, knee, and artificial disk replacements, very high level of contact pressures locally ranged from under 10MPa up to over 60Mpa. In this study, we quantified the creep of UHMWPE under the several high levels of dynamic compressive pressures and compared the results from the previous results.

**Materials and Methods:** For creep tests, UHMWPE rectangular blocks (10mm long, 10mm wide, 8mm thick) were manufactured from molded unirradiated Chirulen®1020 sheet (MediTECH, Deutchland). MTS 858 hydraulic test machine was used for conducting the dynamic compressive creep tests under the four different sinusoidal (1Hz) maximum pressures of 10, 20, 40, and 60MPa and minimum pressures of 1, 2, 4, and 6MPa, respectively. All tests were conducted for a total duration of $4 \times 10^3$ minutes at ambient conditions. During the test the displacements of crosshead were stored and the changes in thickness of block specimen divided by the initial thickness were calculated to get the creep strain.

**Results and Discussion:** The mean dynamic compressive creep strain increased as the loading time increased and had a linear relationship ($R^2=0.96$) with the logarithmic scale of time for all maximum pressures. Over 90% of total creep strain occurred within the first $10^3$ minutes. The rates of creep strain (slopes of curve fitting in logarithmic scale of time) for each maximum pressure were listed in Table 1 with the rates of creep strain for low maximum pressures from the previous study [3]. The rates of creep strain increased linearly as the maximum pressure increased for both current study ($R^2=0.96$) and previous study ($R^2=0.99$). The slope of linearity for the current study with high levels of contact pressures was a little larger than that for the previous study with low levels of contact pressures. This difference in the slope of linearity between current and previous studies lies in the creep recovery during measurement of specimen thickness by micrometer in the previous study. Neglecting this difference, the results of current study can be extrapolated to anticipate the creep strain of UHMWPE under the dynamic compression for the low levels of contact pressures.

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**References**


SPINAL STABILIZATION IN SPINAL DISORDERS? PERSONAL EXPERIENCE

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A total number of 428 patients underwent surgical procedure due to different acquired spinal disorders. Conservative approaches were tried where it was indicated. When there was no improvement with conservative treatment then surgical procedures were adopted.

METHODS: It was a prospective study which was done in both Govt. (NITOR & SSMC) and private hospitals irrespective of age & sex. Total period was from August 2002 to February, 2008. Age of the patients ranged between from 8-65 years. In this series male was more dominant than female. In this series main causes were traumatic, infective, degenerative & neoplastic disorders.

RESULTS: Excellent and satisfactory results were achieved in incomplete unstable injuries. No neurological improvement detected in complete injuries. Maximum Pott’s paraplegia regained their neurological function and bowel bladder dysfunction except one who recovered her one limb function full but other limb become spastic. In PLID maximum patients improved immediately after surgery. Few patients required physiotherapy after surgery and improved later on. In Spondylolisthesis patients became symptoms free after decompression and in situ fixation by instrumentation.

CONCLUSION: Proper selection of cases is very important in spinal disorders. In incomplete spinal injuries satisfactory results can be achieved in maximum cases but in complete spinal injuries no neurological development are achieved but for early mobilization surgery is helpful. Maximum spinal disorders can be managed conservatively but surgical intervention should be done in earliest possible time when indicated.

Normal Glenoid Size of the Korean in 7th and 8th Decades

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Purpose: To evaluate the normal glenoid size of the Koreans in their 7th and 8th decades with the Computed tomographic (CT) studies.

Materials and Methods: The CT images were obtained from normal scapulae of the patients (mean age : 68.8, range 62-76) with the humeral fracture cases. A Display workstation version 2.0.73.315 was used to measure the scans to determine the maximal superoinferior(SI) and anteroposterior(AP) diameter of the osseous glenoid vault.

Results: The average diameter of curvature of the glenoid were 31.2 ± 2.3mm(range, 27 to 34mm) in the superior-inferior directions and 26.1 ± 2.4mm(range, 22 to 31 mm) in anterior-posterior.

Conclusion: This study showed the normal glenoid size of the Korean and it is smaller than the size which the international literature reported. It would be important factor for the treatment of fracture or arthroplasty implant designs.

Key Words: Shoulder, Glenoid size, Superoinferior diameter, Anteroposterior diameter

Reverse Total Shoulder Arthroplasty for Rotator Cuff Arthropathy
- 2 cases and Technical Reports -

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The treatment of rotator cuff arthropathy due to irreparable massive rotator cuff tear is still challenging. We performed reverse total shoulder arthroplasties for 2 cases of cuff tear arthropathy. The short term follow-up after the surgery reveal excellent results by ASES and UCLA score. However, these results still require long term follow-up and the study about implant design for the shoulder anatomy of the Koreans.

Key Words: Shoulder, Cuff tear arthropathy, Reverse total shoulder arthroplasty
 Reproducibility, repeatability and face validity of a model of a distal radius fracture

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Aims: The distal radius fracture model prototype has been produced as a means for teaching reduction of a distal radius fracture. In this study we aim to test the repeatability and reproducibility of the force required to correct the shortening of the radius. In addition a questionnaire was carried out to assess face validity

Methods and materials: The distal radius fracture model prototype has been designed and manufactured to simulate reduction of a dorsally displaced, radially angulated, shortened fracture of the distal radius. We designed a mounting rig for the model and used a Hounsfield tensometer to measure the degree of movement of the distal fracture fragment when various degrees of force were applied. Force was applied to reproduce correction of radial shortening. Reproducibility was tested by resetting of the tensioning device at the rear of the model. The questionnaire was constructed using a series of 5 point, verbally anchored Likert items.

Results: Mean force required for reduction was 191.4 N (Newton) (range 189.4 - 193.4N). Standard deviation for repeated measurement was 1.65 N. Graphs of force versus extension showed one consistent point of slippage which could be explained by movement in the spring tensioner for distal radial displacement. On repeated testing the model tensioning device also showed good reproducibility of results. The results for face validity showed that most people rated the model as having an appearance consistent with that of a fractured distal radius (median score for appearance 4.7, tactile properties 4.7) but that the biomechanical properties of the reduction were not scored as highly ( median score 3.9). The median score when asked about the usefulness of the model for teaching junior staff was high ( 4.52)

Conclusions: This prototype produces repeatable performance parameters on reduction of the fracture. Overall experience with the prototype is good but it requires further refinement

 EVALUATION OF THE RESULTS OF INTRA MEDULLARLY INTERLOCKING NAIL IN THE MANAGEMENT OF FRACTURE OF DIFFERENT LONG BONES

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Introduction: Intra-medullarly nail techniques for fracture fixation has gained Universal acceptance over the past 50 years. Closed interlocking nail fixation is the procedure of choice for femoral shaft fracture specially in poly trauma. Unlocked Nail can be considered when a non comminuted fracture occurs through the narrowest part of the medullarly canal. Unlocked Nail does not resist axial and rotational deformation of the fracture. Interlocking fixation controls bending and rotational deformation but allows nearly full axial load transfer by bone. Interlocking nails can be used in almost all long bones.

Methods: A total of 67 cases were stabilized by intra-medullarly interlocking nails. It was a prospective study done in SSMC & Private hospital from the period of January 2004 to February 2008. Total period of follow up was about 4 years. Both male & female were included in this series. Fresh, delayed fracture & Non Union all were included. Maximum cases were closed fracture but few were fresh but open fracture. Simple unstable fracture comminuted segmental fracture, implant failure was the selection criteria. Fracture, tibia femur and humerus were selected for this study. Both closed and open techniques were applied in this series without any support from C-arm.

Results: In maximum cases bony union was achieved in expected time. In few cases healing process was delayed due to extensive soft tissue damage during the occurrence of fracture and non-cooperation of patients during post operative period. Excellent results were achieved in fresh cases. Over all result of this series is very satisfactory.

Complications: Breaking of screws was in 2 cases, bending of nail was in one case due to early weight bearing. Revision of surgery done in 2 cases.

Conclusions: Intra Modularly interlocking nail fixation is very simple devise for unstable comminuted and segmental fracture shaft of long bones. If C-arm is available in that case procedure becomes more simple and easy. But without C-arm sometimes surgery becomes very lengthy and in that case expected results may not be achieved.
Sponsored Luncheon Lecture
Articulation Surfaces in THA from History until Today, What was the Progress and What is Proven?

Corrado Piconi

Among the many complications that lead to revision surgery of a Total Hip Replacement, aseptic loosening is still the most frequent one. Taking into account the role of wear debris in the event cascade leading to aseptic loosening, many different technical approaches have been developed thus far to minimize the volume of wear debris from THR bearings. Taking into account the role of material hardness in the wear of the system, a considerable effort has been devoted e.g. to improve by irradiation the polymeric chains crosslinking in UHMWPE, to optimise the distribution of carbides in Cobalt-Chromium alloys, to increase the hardness of different metallic alloys by the formation of hard ceramic layers by chemical or physic treatments.

Nevertheless, it is noted that the wear behaviour of ceramic bearings made out pure alpha-alumina remained unsurpassed thus far, and that it is a reference for THR bearing wear since 38 years of clinical use.

Today, hip replacement has become a rather frequent treatment that has been extended to many young and active patient. This has made more challenging the design of implants and of bearings because of the extension of the lifespan of the replacements and of the higher activity level they have to face. Moreover, the appropriate selection of the bearing couple is becoming more and more relevant, as it is noted that a relevant number of implant are operating in off-normal conditions. These are including verticalized sockets, presence of third bodies in the bearing gap, microseparation of the bearing components during the gait cycle, joint subluxations and impingements due to patient activity either to ligament laxity. In these of-normal conditions not all the bearings perform in the same way, giving rise to conditions that may give rise to acute or chronic complications, in some cases of still unknown consequences e.g. surface layer spallation or delamination - leading to UHMWPE catastrophic wear, or sustained increase of Cr, Co, Ni ions in the body.

In Ceramic-on-Ceramic bearings a typical complication is stripe wear, that has been documented in pure alpha-alumina in case of verticalized sockets either following the repeated shocks due to joint microseparation. Other complication specific to ceramic are the fractures of the components due to severe traumas (like e.g. in road accidents) either inlay chipping that may take place intraoperatively.

To overcame these limits, the favourable properties of zirconia have been exploited to improve strength and toughness of alumina in a composite material, reinforced further by platelets nucleated in-situ during sintering. The mechanical properties of the new Alumina Matrix Composite (AMC) are superior to the ones of both alumina and of yttria-stabilized zirconia, without the handicap of Low Temperature Degradation (LTD) due to hydrothermal reactions with the biologic environment. Nevertheless, this do not mean that the material has unlimited performances, and care is demanded in its use especially in devices more challenging in design.
Hard/Hard Bearings - Are There Special Requirements for the Asian Market?

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Modern Total Hip Replacement (THR) is in general one of the most successful surgical treatments although the functional requirements of modern patients are more and more demanding. Challenges arise from an extended life-span, a higher activity level requiring more sophisticated artificial materials, and a larger required range-of-motion (ROM) caused by the younger patients’ eagerness to continue a sporty lifestyle. The design criteria for modern THR resulting from these patient demands also depend on the anatomical conditions as well as the socio-cultural circumstances of the patients.

Asian people require in general a higher ROM due to their habit to squat during daily activities which is not common in western societies. The outcome of a THR regarding the ROM is influenced by the size of the bearing couple, the design of the acetabular component, the head-to-neck ratio, and the implantation angles. In the case of a wrongly designed or a misaligned component, e. g. a verticalized socket, subluxations and impingement might occur leading to edge-loading between the ball head and the insert. This leads in all material couplings to problems: in hard-soft couplings (ceramic or metal ball head and polyethylene insert) to strongly increased polyethylene wear, in hard-hard bearings (metal-on-metal or ceramic-on-ceramic) to point loading followed by stripe wear and, in the case of a metal-on-metal coupling, a much higher metal ion level in the blood. Therefore, an appropriate choice of the prosthesis design together with the necessary surgeon’s diligence is necessary to avoid this kind of complication.

Other important design challenges come from possible anatomical differences between different ethnical groups. It has been shown that the “asian knee” has a different mean thickness in anterior-posterior as well as medio-lateral direction compared to caucasian. As another example, an extensive study of mexican people has shown a significantly different femur geometry concerning the height of the Trochanter major compared to the cross section of the femoral axis and the neck axis. For asian people it is widely accepted that the mean femoral size is smaller. The nonobservance of these geometrical factors in implant design may again lead to higher wear rates or subluxation and impingement followed by dislocation.
VTE Prophylaxis Use in Patients after Orthopaedic Surgery
- An Evolving Practice -
; Importance of VTE Prevention after Orthopaedic Surgery

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Major orthopaedic surgeries such as total hip and total knee replacements are considered a major risk factor for venous thromboembolism (VTE). Without prophylaxis, DVT occurs in 10-40% of general surgical or medical patients and 40-60% of patients following major orthopaedic surgery. There has, however, been a perception that VTE is less common in Asia than in Western countries. New evidence has emerged recently that contradicts this perception. Results from multinational epidemiological studies (SMART, AIDA, ENDORSE) clearly showed that the rate of venographic and symptomatic thrombosis after major joint replacement in Asian patients is similar to that previously reported in patients in Western countries. However, thromboprophylaxis is not routinely used in Asia, even in situations considered high risk in Western countries. The ENDORSE study reported that less than 20% of at-risk surgical patients in Asia received prophylaxis compared with over 80% in Western countries. This leaves the majority of patients at risk of developing VTE and VTE-related conditions, which continues after hospital discharge. Current guidelines recommend the use of thromboprophylaxis for at least 10 days and up to 35 days in patients undergoing total joint replacement. Available anticoagulants are effective at preventing VTE but are associated with various limitations, such as parenteral administration as in the case of UFH and LMWH. A narrow therapeutic window, unpredictable pharmacology, frequent coagulation monitoring and dose-adjustment as in the case of vitamin K antagonists (VKAs). Several new, oral anticoagulants are in advanced clinical development, including the direct thrombin inhibitor, dabigatran, and the direct Factor Xa inhibitors, rivaroxaban and apixaban.
VTE Prophylaxis Use in Patients after Orthopaedic Surgery
- An Evolving Practice -

; Transforming the Future of Primary VTE Prevention Following Major Orthopaedic Surgery Rivaroxaban and the RECORD Trials

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Rivaroxaban, an oral, direct FXa inhibitor has shown in large phase III trials to be both superior to enoxaparin a low molecular weight heparin for VTE prophylaxis in patients undergoing MOS, and to also have a good safety profile. RECORD, a pivotal clinical trial program investigating rivaroxaban for the prevention of VTE after THR and TKR surgery, consists of four multinational, randomized, double-blind, double-dummy phase III studies (RECORD1,2,3 and 4) comparing rivaroxaban 10 mg once-daily with enoxaparin 40 mg once-daily or 30 mg twice-daily. The RECORD program has consistently shown superiority of rivaroxaban to enoxaparin at preventing VTE after major orthopaedic surgery. Results from the RECORD 2 study confirmed the benefit of extended thromboprophylaxis after THR. Rivaroxaban was more effective than enoxaparin at reducing the incidence of VTE and all course mortality in patients undergoing THR, with a relative risk reduction (RRR) of 70% in total VTE (RECORD 1). In the TKR populations, rivaroxaban was superior to both once-daily (RECORD 3) and twice-daily (RECORD 4) enoxaparin, with a RRR of 49% and 31.4%, respectively. It also significantly reduced the incidence of symptomatic VTE in TKR patients (RECORD 3). Rivaroxaban groups had low and similar bleeding rates to enoxaparin across the RECORD program. Thus, with its superior efficacy and a good safety profile, oral, once-daily fixed dosing with rivaroxaban could transform the future of VTE prevention after major orthopaedic surgery and improve the quality and reliability of patients care.
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S 1  CeramTec AG Medical Products Division

Fabrikstraße 23-29, 73207 Plochingen, Germany
Phone: 49-7153-611 0 FAX: 49-7153-611-950
E-mail: Medical_products@ceramtec.de
Homepage: www.ceramtec.com

Exhibit Items
BIOLOX® forte (alumina)
• Ballheads
• Inserts
BIOLOX® delta (alumina composite) Ballheads
• Inserts
• Knee Components

Description
CeramTec’s BIOLOX® materials are the most widely used ceramic components in arthroplasty. They are extremely wear-resistant and biocompatible, helping to avoid particle disease and allergic reactions. Since 1974 more than five million ceramic BIOLOX® components have been used in hip joints. CeramTec AG, the global market leader for bioceramics in joint replacement, is also an internationally leading supplier of innovative technical ceramics for the electronics, telecommunications, automotive, medical, machinery, metal, electrical and chemical industries, developed, produced and distributed by 2900 employees world-wide.

S 2  Kolon Pharmaceuticals, INC.

Kolon Sporex. 1324-14, Seoco-dong, Seoco-Ku, Seoul, 137-070, Korea
Phone: 82-2-580-6400 FAX: 82-2-3474-0740
E-mail: choihj@kolon.com
Homepage: http://kolonpharm.co.kr/

Exhibit Items
Morniflu® Tab (NSAIDs)

Description
- Well Balanced Inhibitor of COX / 5-LOX : The Most advanced NSAIDs
- Improvement in the Potency of Analgesic Effect
- Better Control of the Inflammatory Process in OA, RA
- Gastric-sparing Propertied

S 3  DePuy Inc.

2AF LS Yongsan Tower, 191 Hangangro 2ga, Yongsangu, Seoul, Korea
Phone : 82-2-2094-3500 FAX : 82-2-2094-4450

Exhibit Items
Orthopaedic joint replacement products

Description
Offering a leading range of orthopaedic and neurological solutions: The DePuy companies provide a full-line of orthopaedics products, spanning a wide range of orthopaedic and neurological solutions. We offer options to treat soft tissue injuries through the replacement of joints and spinal fusion. This range of solutions makes the DePuy Franchise the leader in Restoring the Joy of Motion™ for patients around the world.

S 4  Corentec Co., Ltd.

11F Chungho Tower, 748-1 Banpo 1-dong, Seocho-gu, Seoul, 137-040 Korea
Phone: 82-2-3445-5492-5 FAX: 82-2-3445-5497
E-mail: nanying8888@corentec.com
Homepage: www.corentec.com

Exhibit Items
COREN® FEMORAL STEM, COREN® ACETABULAR CUP, COREN® BIOLOX FORTE BALL HEAD, COREN® BIOLOX DELTA BALL HEAD, COREN® BONE SCREW, COREN® BIOLOX FORTE INSERT, COREN® BIOLOX DELTA INSERT, AEGIS ™  Pedicle Screw Set, IS CAGE, TKR SYSTEM

Description
A manufacturer of artificial joints, Corentec Co., Ltd. is committed to promoting the well-being of patients with arthritis or trauma. Therefore, we have created and provided artificial joints which are structurally and functionally similar to human joints so the patients can get back on their feet as soon as possible.

S 6  a Curexco Technology Company

1433 N. Market Blvd. Suite 1, Sacramento, CA 95834, USA
E-mail : issramesh@aol.com
Homepage : www.robodoc.com

Exhibit Items
ROBODOC System

Description
Curexco Technology Corp. which manufactures Robodoc is the global frontier in the Orthopedic surgery. Robodoc is the only automated surgical robot to achieve the surgical result as preplanned. Robodoc has been used in more than 24,000 cases in worldwide and approved by FDA. The value of Robodoc is safety and accuracy in orthopedic surgery. Surgeon and patient is satisfied with the value.

S 7  Stryker Korea

11F, Dongsung Bldg, 158-24, Samsung-dong, Kangnam-gu, Seoul, 135-090, Korea
Phone: 82-2-3451-7500 FAX: 82-2-522-4156
E-mail: Innis.lee@stryker.com
Homepage: http://www.stryker.co.kr

Exhibit Items
(Surgical implants and instruments)
Scorpio NRG, Exeter, Secur-fit, Triathlon, Accolade

Description
Scorpio NRG: PS & CR Primary Knee System using Single Radius design
Exeter: Total Hip System - Cemented Stem
Secur-fit: Total Hip System - Cementless stem and Cup
Triathlon: Total Knee System - Primary
Accolade: Cemented and Cementless Femoral Hip System
S8  FINSBURY ORTHOPAEDICS
13 Mole Business Park, Randalls Road, Leatherhead, Surrey, KT22 7BA, UK
Phone: 44 (0)-1372-360830  FAX: 44 (0)-1372-360779
E-mail: info@finsbury.org
Homepage: www.finsbury.org

Exhibit Items
Orthopaedic Implants

Description
Finsbury Orthopaedics is the world leader in hip resurfacing technology. Our latest generation of hip resurfacing implant, the ADEPT has been well received by the Orthopaedic community and addresses real clinical issues such as sizing and femoral neck alignment. Thirty decades of collaborative development with pioneering orthopaedic surgeons has resulted in a portfolio of products which Finsbury now market directly in the UK, Germany, Australia and Turkey. Sales turnover has increased dramatically and is set to grow further as the company establishes more overseas operations and launches its well established products worldwide.

S9  Daewon Pharm.
467-24 Kunja-dong, Kwoangjin-gu, Seoul, Korea
Phone: 82-2-2204-6992  FAX: 82-2-469-9784
E-mail: tagisong@hotmail.com
Homepage: http://www.daewonpharm.com

Exhibit Items
Pelubi Tablet

Description
For the first time in the world, Daewon pharmaceutical company has developed 12th Korean new drug, Pelubi tablet. Pelubi is a kind of NSAIDs which has excellent safety and efficacy for osteoarthritis patients. Daewon will launch October in 2008 firstly in Korea. We want to introduce Pelubi as a solution for OA patients by your prescription.

S10  Sanofi-aventis
735, Yeoksam 1-dong, Gangnam-gu, Seoul 135-755, Korea
Phone: 82-2-527-5550  FAX: 82-2-527-5559
E-mail: ByungChae.Kwak@sanofi-aventis.com
Homepage: http://www.sanofi-aventis.co.kr

Exhibit Items
Actonel

Description
Sanofi-aventis is one of the world’s leading pharmaceutical companies. Backed by a world-class R&D organization, sanofi-aventis is developing leading positions in seven major therapeutic areas: cardiovascular, thrombosis, oncology, metabolic diseases, central nervous system, internal medicine, and vaccines.

S11  Pfizer Pharmaceuticals Korea Ltd.
Pfizer Tower, 1-11, Hoehyun-dong,3-ga, Jung-gu, Seoul, 100-771, Korea

Exhibit Items

Phone: 82-2-317-2362  FAX: 82-2-317-2127
E-mail: Hee-yeon.kim@Pfizer.com
Hai-lee.choi@Pfizer.com
Geoun-won.bae@Pfizer.com

Exhibit Items

Celebrex

Description
Celebrex is a COX-2 selective inhibitor that relieves arthritis pain, stiffness, and inflammation.

S12  Synvasive Technology Inc.
4925 Robert J. Mathews Pkwy El Dorado Hills CA 95762, USA
Phone: 1-916-939-3913  FAX: 1-916-939-3919
E-mail: customerservice@synvasive.com
Homepage: www.synvasive.com

Exhibit Items
eLIBRA Dynamic Knee Balancing System™, and STABLECUT™ Surgical Saw Blades

Description
Synvasive Technology, Inc. is committed to providing surgeons innovative solutions to enhance reconstructive surgery. The eLIBRA Dynamic Knee Balancing System™, is changing the way surgeons balance the flexion gap in primary knee surgery. Synvasive is also the exclusive provider of STABLECUT™ Surgical Saw Blades, patented technology providing control, precision and safety during bone resections related to total joint surgery.

S13  Hanlim Pharm.Co.Ltd.
1656-10, Seocho-dong, Seocho-gu, Seoul, Korea
Phone: 82-2-3489-6212  FAX : 82-2-3489-6109
E-mail: kgfkjm@hanmail.net
Homepage: www.hanlim.com

Exhibit Items
PANORIN

Description
PANORIN - Offers you these advantages
Modulates Bone Remodelling
Achieves a Better Bone Quality
Reduces the Risk of Fractures
Has Excellent Digestive Tolerance

S14  DJO Surgical
9800 Metric Blvd.
Phone: 1-512-832-9500  FAX: 1-512-834-6320
E-mail: John.winslow@djosurgical.com
Homepage: www.djosurgical.com

Exhibit Items
3DKnee™ Total Knee System; Foundation™ Total Knee System; Revelation™ Lateral Flare™ Hip System; X-att™, Highly Crosslinked Polyethylene; Reverse Shoulder Prosthesis
**Description**

DJO Surgical, a division of DJO incorporated, designs manufacturers, markets and distributes orthopedic surgery products around the world. DJO Surgical’s knee, hip and shoulder product offerings include many different product variations to suite a wide range of applications, patient and surgeon requirements. In addition, to convention technologies, the Company has developed and markets many leading edge, proprietary patented devices including: the 3DKnee™, Keramos™, ceramic-on-ceramic acetabular hip implant and the Reverse Shoulder Prosthesis. Maximum 5 lines

**E3 MAKO Surgical Corp.**

2555 Davie Road, Fort Lauderdale, Florida 33317, USA  
Phone: 1-954-927-2044  FAX: 1-954-927-0446  
E-mail: contactus@makosurgical.com  
Homepage: www.makosurgical.com

**Exhibit Items**  
Tactile Guidance System™

**Description**

MAKO Surgical Corp. is an innovative orthopedic medical device company developing advanced solutions for keyhole orthopedic surgery. Founded in 2004, the company has developed and released the MAKO Tactile Guidance System™. This proprietary, FDA-cleared surgeon-interactive robotic arm system allows surgeons to achieve consistently reproducible precision with a procedure called MAKOplasty™.

**E4 SK Chemicals life science business group**

948-1 Daechi3-dong, Kangnam-gu, Seoul, Korea  
Phone: 82-2-2008-2907  FAX: 82-2-2008-2329  
E-mail: lkjung.kim@skchemicals.com  
Homepage: www.skchemicals.com

**Exhibit Items**  
JOINS Tab.

**Description**

SK chemicals Life Science Business Area : Medicine, health food, medical supplies, biologics and biotechnology lie at the heart of its life science business, This will enable SK chemicals to lead Korea’s pharmaceuticals industry as it breaks into the overseas markets. SK Chemicals continues to produce the best products through the synergy created between subsidiaries R&D Center and in2Gen. The compay is now focusing on the development of foreign markets.

**E5 Young Chang Publishing Co., Ltd**

404 Sejong Bldg , 41-7 Cheongnyangni 1(il)-dong, Dong Dae Mun-gu, Seoul, Korea  
Phone: 82-2-926-3223  FAX:82-2-924-3227  
E-mail: webmaster@orthobook.com  
Homepage: www.orthobook.com

**Exhibit Items**  
Orthopedic Surgery Books

**Description**

Young Chang publishing company has been publishing and importing the Orthopedic titles only from the year 1988. We are proud of our good reputation by all of Korean Orthopedic Surgeons.
New Trends in NSAIDs

Dual Inhibition of COX/5-LOX

Morniflu Tab.
(Morniflumate 350mg)

Phospholipids

Arachidonic acid

Cyclooxygenase

5-Lipoxygenase

Cyclic endoperoxide

Leukotrienes

Thromboxans TXA2
TXB2
Prostaglandins PGE2
PGF2α
Prostacyclins PG12

Leukotrienes LTB4
LTC4
LTD4
LTE4

Dual Inhibition of COX/5-LOX
Morniflu Tab.은 COX와 5-LOX 이중 억제 작용으로 더욱 뛰어난 진통작용 및 항염효과를 가집니다.

Less G.I. Trouble
Morniflu Tab.은 Mild Irritant로 작용하여 위장관 보호성 Prostaglandins을 증가시키며,
위장관 손상에 관여하는 Leukotriene의 합성을 차단하여 위장관 내막성이 우수합니다.

Drug Information

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Challenging for the better human life, we are always with you.
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Pfizer Pharmaceuticals Korea Ltd

SUPPORT ORGANIZATIONS

ISTA 2008

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