The Association of Bone and Joint Surgeons

Abstracts of the 61st Annual Meeting

Maui, Hawaii
May 13-17, 2009
Total Knee replacement after Osteoarticular Allograft Failure

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Osteoarticular allografts can be used to reconstruct an extremity after the bone and articular cartilage are resected. Some patients who have an osteoarticular allograft reconstruction of their distal femur or proximal tibia subsequently have a total knee replacement. The general impression and limited literature suggest that these reconstructions function well and have an excellent long-term outcome. This review was done to determine the long-term outcome of a group of patients who had a total knee replacement after an osteoarticular allograft of the distal femur or proximal tibia.

From a database prospectively collected all patients who had an osteoarticular allograft of the distal femur or proximal tibia after the resection of a bone tumor were identified. The medical records of these patients were reviewed. The records of all patients who had a total knee replacement after an osteoarticular allograft were then carefully reviewed. Their age, sex, diagnosis, the length of the resection, the dates of resection and all knee replacements, and their final outcomes were recorded.

There were 75 patients who had a total knee replacement after having an osteoarticular allograft used to reconstruct their extremity after a bone tumor resection. Fifty-one of these patients had a distal femoral allograft. Thirty-five (35/51) of these failed at an average of 54 mos. (range 5-179 mos.). Twenty-four of the patients had a proximal tibial allograft. Seven (7/24) of these failed at an average of 37 mos. (range 1-71).

The theoretical advantage of replacing resected bone and articular cartilage with an osteoarticular allograft is that the bone would reconstitute bone stock for use in subsequent prosthetic replacements once the allograft articular cartilage failed and the joint degenerated. This has not proven to be an advantage. The high failure rate and short life spans of the total knee replacements used to salvage an extremity with an allograft distal femur makes the use of a distal femoral osteoarticular allograft probably unwarranted. A total prosthetic replacement is probably better. The same may not be true for the proximal tibia because the longevity of the secondary total knees is better than those in the distal femur and the allograft provides a site of attachment for the extensor mechanism not available on a total prosthetic proximal tibia. Whether it is better to use a composite reconstruction (allograft and total knee) after a resection of the proximal tibia is not answered by this review.
QUADRICEPS AND HAMSTRING FUNCTION BEFORE AND AFTER TKA

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Introduction: Muscle weakness is present before and after total knee arthroplasty (TKA). While quadriceps dysfunction is recognized and addressed in varied surgical approaches and post-operative rehabilitation, the purpose of this study is to document the less-frequently recognized or addressed hamstrings dysfunction.

Methods: Bilateral isometric quadriceps and hamstring strength was measured before and after (3wk, 6wk, 3mo, 6mo) unilateral, cruciate-retaining, quadriceps splitting TKAs for end-stage osteoarthritis (n=22). Patients participated in a standardized rehabilitation program for 8 weeks. Muscle strength was tested using an isokinetic dynamometer at 85 degrees of hip flexion and 60 degrees of knee flexion.

Results: Quadriceps and hamstrings strength both decreased significantly 3 weeks after surgery (-49.8±17.2% and -47.4±23.0% respectively, p<0.05). Quadriceps and hamstrings strength returned at similar rates, and approached pre-operative values by 3 months after surgery, with no further improvement at 6 months. Clinical symptoms associated with hamstring dysfunction, e.g. hamstring tendonitis, extended beyond the 6-month recovery period and evidence for dysfunctional hamstring co-activation was observed, i.e. patients often fired quadriceps and hamstrings simultaneously.

Discussion and Conclusion: This study documents the previously recognized changes in quadriceps strength attributed to activation deficit and atrophy, and revealed the previously undocumented changes in hamstrings strength over 6 months after TKA. Varied surgical approaches and therapy protocols have been published to address quadriceps weakness after TKA, but hamstring dysfunction has not been documented or addressed, i.e. there are no published reports. Unrecognized and untreated hamstring weakness documented in this study contributes to dysfunction and incomplete recovery in total knee arthroplasty.

Funding: NIH 1 UL1 RR025780, Physical Therapy Foundation Pittsburgh-Marquette Challenge Grant, American College of Rheumatology New Investigator Award.
PAPER #3

COMPLICATIONS FOLLOWING TOTAL KNEE ARTHROPLASTY IN THE SUPEROBSE, BMI >50

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To our knowledge there have been no published results on the outcomes of total knee arthroplasty (TKA) in the superobese patient. We retrospectively reviewed 133 knees in 105 patients undergoing primary TKA from 1996-2006 with a mean BMI of 53.6 (50-65.9). The mean age at time of index arthroplasty was 60.73 (42-84) with a mean follow-up of 35.6 months. Overall, there were 54 (40.6%) surgical complications and 15 (14.3%) medical complications including 2 perioperative deaths. Surgical complications included 20 knees with prolonged wound drainage, 4 knees with cellulitis or stitch abscesses, and 6 legs with residual neuropathy for a minor complication rate of 22.6%. There were 19 (14.3%) reoperations/major complications including 9 irrigation and debridements with component retention, 6 resection arthroplasties for deep infection, 2 revisions for aseptic loosening or malalignment, 1 revision for periprosthetic fracture, and 1 quadriceps tendon rupture. There were 5 intra-operative complications in 4 patients.

We conclude that while technically feasible, TKA in superobese patients (BMI >50) is associated with an alarmingly high complication rate. Patients should be counseled preoperatively regarding these risks and encouraged to lose weight or referred to a bariatric specialist optimally.
JOINT PRESERVATION INSTEAD OF JOINT REPLACEMENT - 12 YEAR FOLLOW UP

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Dedicated to J.R. Neff

Purpose: Cartilage-bone grafts might replace destroyed joint surfaces if they heal in contact. A profound understanding of the anatomy is requested. Based on that, a precise grinding technique with diamond coated instruments was introduced to Transplantation Centers in Germany. The diamond technique provides a contact healing of the load transmitting cartilage base plate, cancellous bone trabeculae and even hyaline cartilage.

Material and Methods: Thirty-eight patients between 18 to 74 years suffering osteonecrosis dissecans or severe unicondylar osteoarthritis in the knee or ankle were operated by a precise reconstruction of the joint surface using diamond instruments. The donor side was in all cases the ipsilateral patellar groove. The defect was refilled by a β- tricalciumphosphate cylinder combined with a custom-fit graft from the iliac crest preserving two layers of the inserting musculature. The outcome was evaluated by NMR, CT and graded according to Lysholm. In 7 cases a rearthroscopy, in one case histology from a preceded microfracturing, in another histology from a preceded OATS plasty and one biopsy from an autologous transplant was investigated.

Clinical Results: The results surprised. The morbidity was extremely low; the mean stay in the hospital comprised a period of 5 days; walking pattern and loading returned to normal within 4 weeks. There was no revision. The Lysholm score ranged between 76 and 100%.

NMR and CT revealed a well integrated hyaline cartilage and healed base-plate.

Rearthroscopy between 7 months and 11 years showed in young individuals a restitutio ad integrum, in elderly patients well preserved transplant cylinders and a donor bed refilled by fibro-cartilage.

Histology revealed hyaline cartilage with a well preserved base plate and vital cancellous bone. The microfractured surface showed a thick layer of loose fibrous tissue, whereas the intact OATS cylinders were surrounded by dense fibrous tissue.

Discussion and Conclusion: Joint surfaces have to be considered as an organ comprising the bony base plate, together with the underlying cancellous bone. The graft cylinders have to be implanted in a way that a through-going surface is reconstructed thus forming a new weight-bearing condyle. The transossseous approach is considered the smallest and most elegant way to reconstruct joint surfaces. A retrograde graft has to be locked by a K-wire for 6 weeks.

Figs. 1 and 2: 18 year old girl suffering osteochondritis dissecans. 7 years after grafting a suture-less healing is revealed.

Fig. 3: The donor bed post operationem and

Fig. 4: 3 years after
Clinical factors of implant alignment, BMI, tibial component size, tibial component slope, absence of metal backing and polyethylene thickness have been associated with failure in both TKA and UKA; however, the respective contribution of each factor is unknown. We examined the individual contributions of resection depth, metal backing, component size matching, coronal geometry, and polyethylene thickness to tibial loading following TKA as well as the effect of mobile bearing positioning following UKA. A full-field photoelastic shear strain analysis system was used to dynamically quantify strains on the cortex of the proximal metaphysis of tibiae axially loaded varus and neutral conditions. Metal backing proved the most significant factor in tibial loading post-TKA with metal backed tibial components exhibiting significantly decreased loading around nearly the entire surface of the proximal tibia when compared to all-polyethylene components of the same TKA design. Distal resection levels resulted in relative posterior and peripheral displacement of the tibial component within the tibial metaphysis, which significantly increased posterior and peripheral tibial loading. Oversized femoral components were found to increase peripheral loading while coronally dished articulations acted to centralize loading away from the periphery of the tibia. In mobile bearing UKA, bearing position significantly affects loading location and may relate to remodeling and pain following UKA. We conclude that edge loading and failure in knee arthroplasty are multifactorial processes and further understanding of tibial loading patterns will help prevent failure in the future.
WOUND BALLISTICS: INDIRECT FRACTURES TO BONE

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Introduction: There are approximately 100,000 nonfatal gunshot wounds in the United States per year. Having an understanding of the pathophysiology of ballistic injury has important treatment and prevention implications. The behavior of bullets in soft tissue only is well described (Fackler 1984, 1988). Bone injury is not as well studied and questions about the formation of fractures remain. It is controversial how indirect fractures (those produced by projectiles traveling through the adjacent soft tissue without striking the bone) are produced. One theory suggests that the temporary cavity is responsible for production of these fractures (Harvey 1946). A second theory proposes that a sonic wave preceding the bullet in tissue causes the fracture (Zunshen 1990). The purpose of this study is to evaluate the temporal relationship of pressure waves using strain gauge technology and high speed video to elucidate whether the sonic wave, the temporary cavity, or both, is responsible for the formation of indirect fractures.

Methods: Twenty-eight fresh frozen cadaveric diaphyseal tibia (2) and femurs (26) were implanted into ordnance gelatin blocks (Kind and Knox, Sioux City, IA). The gelatin was made of a 10% by weight mixture and stored at 4 degrees centigrade. Shots were made traversing through gelatin only, passing close to the edge of the bone, but not touching, to produce an indirect fracture.

Two different bullets were tested: a 9x19mm NATO handgun cartridge and a 5.56x45mm M995 rifle cartridge (Both Lake City, IL). The bullet weight for the M995 was 52 grains.

High speed video of the impact event was collected at 20,000 frames per second. Acquisition of the strain data was synchronized with the video and collected using TDAS Pro (Diversified Technologies, Seal Beach, CA) at 20,000 Hz. Strain gauges (031RB Vishay micro measurements, Shelton, CT) were attached to the opposite side of the bone from the projectile’s path. The exact time to fracture was made by analyzing the strain gauge output and video, and comparing the two to see when the fracture occurred. Confirmation of fracture was determined using both radiographs prior to excision from the gelatin and visual inspection of the bones upon removal.

Bone density measurements were taken of the bone specimens prior to testing. After shooting, the gelatin was dissected to measure the fracture, the shot line, and the behavior of the bullet. Measurements taken included the splits or cracks in the gelatin, representing the temporary cavity seen in tissue, as well as just what the bullet itself touched.

Results: Twenty-eight shots were made, two with the 9mm and twenty-six hit with the 5.56mm. Both 9mm shots and fourteen 5.56mm shots did not produce fractures. Four of the projectiles struck bone, causing comminuted fractures. These four samples were excluded from our calculations. Of the remaining eight fractures produced, the fractures that did occur were of a simple (oblique or wedge) pattern.

Comparison of the average distance from the bone was 9.68 millimeters (range 3-20) for bone fractures and 15.15 millimeters (range 7-28) for nonfractured specimens (students t-test, p=0.036).

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No fracture occurred using the 9mm bullets (velocity 862 fps) or when the M995 bullet velocity was less than 3,200 feet per second.

Strain gauge data also showed there was a consistent pattern associated with both fracture and non-fracture of bone. In the non-fracture cases, the strain data demonstrated a damped sinusoidal pattern that returned to baseline indicating that a fracture did not occur. However, in the fracture cases a sharp peak was noted indicating the exact time point of fracture.

Analysis of strain gauge data synchronized with the video demonstrated fracture of the bone after the passage of the projectile in all cases. Because of this, the fracture could not occur with the antecedent sonic wave.

**Conclusion:** In this study, indirect fractures were produced after passage of the projectile, as shown from analysis of the strain gauge data linked to the video. Thus, the temporary cavity, not the sonic wave, was responsible for creating indirect fractures.

Indirect fractures have been produced in the laboratory using animal models (Clasper 2002, Harvey 1962). Indirect fractures have a simple fracture pattern. The distance of the bone from the shot line was an independent variable for producing indirect fractures.

When reduced charges were used for the M995 cartridge, no fracture was produced. Given a particular bullet type, sufficient velocity is needed to produce the temporary cavity of sufficient pressure to cause bone fracture.
PAPER #7

INFLUENCE OF ORTHOPAEDIC TRAUMA AND ALCOHOL BINGE ON MARKERS OF THE IMMUNO-INFLAMMATORY RESPONSE

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Summary/Conclusion: Orthopaedic trauma and alcohol binge both significantly modulate clinically measurable serum and lung markers of the immuno-inflammatory response.

Introduction: Clinical evaluation of the inflammatory response is an important constituent in the management of multiply injured patients. Alcohol intoxication, present in 25-40% of trauma patients with orthopaedic injuries, is a known modulator of the immuno-inflammatory pathway. However, the significance of ethanol intoxication on the inflammatory response following orthopaedic trauma is currently not well understood. In the present study, we examine the influence of orthopaedic trauma and alcohol binge on measurable serum and lung markers of inflammation.

Methods: Eighty-five Sprague Dawley rats were administered either saline or alcohol in binge fashion for 3 days, followed by a sham operation or bilateral femoral intramedullary pinning and mid-diaphyseal closed fracture via blunt guillotine. Animals were sacrificed at injury, 6 hours, 24 hours, 48 hours and 72 hours after injury. Serum and lung tissue was collected and analyzed by immunoassay.

Results: Bilateral femur fracture significantly increased serum markers of inflammation including IL-2, IL-6, IL-10, GM-CSF, GRO/KC, MCP-1, CRP and WBC. Alcohol binge resulted in significant suppression of post-injury serum levels of IL-6, of IL-2, IL-10, CRP, and WBC. Bilateral femur fracture significantly altered levels of lung inflammatory markers including leptin, IL-1a, IL-1b, IL-1b, and GRO/KC. However, alcohol binge significantly increased lung levels of the proinflammatory markers IL-6 at 6 hours, and IL-1b, IL-2 and MIP-1a at 48 hours following injury compared to controls.

Discussion and Conclusion: These results indicate that orthopaedic trauma causes the elevation of clinically measurable serum and lung markers of inflammation. Alcohol modulates this measurable response in both serum and lung, and should be taken into account when evaluating the inflammatory response in intoxicated patients.
PDGFB

PDGFB

Biglycan

Has2

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PAPER #8

CD44 DEFICIENCY INCREASES MATRIX AND CYTOKINE EXPRESSION IN A MOUSE PATELLAR TENDON INJURY MODEL

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Introduction: CD44 is a polymorphic type I transmembrane glycoprotein that is expressed on most cell types including fibroblasts and leukocytes. Its main role is in mediating the uptake and clearance of hyaluronic acid (HA), but it is also associated with early inflammatory events and matrix remodeling. Interestingly, CD44 is highly expressed in wounded adult tendons but is almost absent in wounded fetal tendons that heal without scarring [1]. Using CD44 knockout mice, previous studies have demonstrated decreased macrophage recruitment and decreased expression of proinflammatory cytokines at the site of lung injury in CD44 knockout wounds [2]. In addition, we previously demonstrated improved mechanical properties at 3 and 6 weeks post injury in the patellar tendon of a CD44 knockout mouse [3]. Collectively, these studies demonstrate that CD44 plays a crucial role in inflammation and wound healing. Therefore, the purpose of the current study was to investigate the effect of CD44 on growth factors and matrix components early in the healing of the patellar tendon. We hypothesized that proinflammatory cytokines would be down regulated and extracellular matrix proteins would be up regulated in the CD44 knockout mice [4].

Methods: C57BL/6 wild type (WT, n=16) and CD44 knockout (KO, n=16) mice (C57BL/6 background) at twelve weeks of age were used (IACUC approved). Four mice from each genotype were sacrificed without injury to serve as uninjured controls (day 0). Patellar tendons from the remaining twenty-four animals were injured bilaterally [5]. Briefly, incisions were made adjacent to the tendon. A rubber-coated backing was placed underneath the tendon to provide support against a 0.75 mm diameter biopsy punch used to create a full thickness, partial width (~60%) transection. Skin incisions were sutured and mice were allowed normal cage activity until sacrifice at 1, 3 and 7 days post-operatively. Injured and uninjured tendons were subjected to quantitative real-time polymerase chain reaction (QPCR) (n=4 per group).

Individual patellar tendons were mechanically homogenized and RNA was extracted using the TRIZOL isolation system (Invitrogen) and RNeasy Mini Kit (Qiagene Inc.). CDNA was produced by reverse transcription-polymerase chain reaction from 100 ng of total RNA from each tendon using the Superscript first-strand synthesis system for RT-PCR (Invitrogen). CDNA was amplified by QPCR (ABI Prism 7300 Sequence Detection System; Applied Biosystems) with SYBR Green. Mouse specific primers were

![Figure 1: Gene expression in a patellar tendon injury in wild type (WT) and CD44 KO represented as relative quantity fold changes (2-ΔΔCT). All post injury time points are normalized to uninjured tendons (day 0) which is represented by a value of one.](image-url)
obtained for glyceraldehyde-3-phosphate dehydrogenase (GAPDH), type I collagen (Col1a2), type III collagen (Col3a1), decorin (DCN), biglycan (BN), hyaluronan synthase 2 (Has2), interleukin-1β (IL-1β), transforming growth factor beta 1 (TGFβ1), transforming growth factor beta 3 (TGFβ3), platelet derived growth factor B (PDGFB) and basic fibroblast growth factor (bFGF). Each replicate was performed in triplicate. The relative quantity of mRNA for each gene of interest was computed using the comparative $2^{-\Delta\Delta CT}$ method relative first to GAPDH within each specimen and then to the uninjured tendons within each genotype.

**Results:** The relative quantity of TGFβ3, bFGF and DCN was increased at least two fold at each time point post injury in the CD44 KO when compared to WT (Figure 1). Similarly, the relative expression of Col1a3, Has2 and PDGFB was increased at least two fold at 1 and 3 days post injury. Relative expression was also increased at least two fold for BGN at 1 day post injury and for TGFβ1 at 3 days post injury in the CD44 KO. There were no appreciable differences in Col1a2 and IL1β (data not shown).

**Discussion:** In support of our hypothesis, we demonstrated that the extracellular matrix components DCN, Col3a1 and Has2 had increased expression. Contrary to our hypothesis, we did not show decreased expression in proinflammatory cytokines IL-1β and TGFβ1 but we did demonstrate increased expression of TGFβ3, bFGF and PDGFB. The effects of cytokines and matrix components on cells are interdependent. For example, administration of bFGF to injured tendon increased expression of type III collagen [6]. Similarly, application of TGFβ3 to skin wounds reduced scar formation [7]. Conversely, DCN is closely related to both collagen metabolism and TGF-β activity [8]. As noted above, we have previously demonstrated that CD44 KO mice with the same patellar tendon injury had improved healing at 3 and 6 weeks post injury [3]. The possible synergistic effects in the current study may have created an improved tendon healing environment, leading to enhanced mechanical properties in the CD44 KO mouse. An absence of CD44 during injury may cause a prolonged presence of HA [9] which is a prominent feature in scarless fetal healing [10]. Similarly, HA-treated cells stimulated type III collagen and TGFβ3 expression [11], both of which are also indicative of scarless fetal healing. TGFβ1, which is up regulated in fibrotic scar, was also increased by HA; however, this effect was no longer present when cells were pretreated with CD44 silencing RNA. Therefore, an absence of CD44 may promote an environment that favors scarless wound healing. In summary, we demonstrated early changes in gene expression during tendon healing of a CD44 KO mouse. This study, coupled with our previous study [3], demonstrates the importance of understanding the role of CD44 in wound healing. The absence of CD44 may create a permissive environment for scarless healing which leads to improved mechanics. Future studies will examine compositional and structural changes post injury to further elucidate the role of CD44. Understanding how the absence of CD44 affects wound healing provides insight into the process of improved tendon healing and may serve as a target for development of novel treatment modalities.

**Acknowledgements:** This study was supported by the NIH/NIAMS. We thank Drs. R. Assoian and E. Pure for the mice [4].

MORBIDITY AND MORTALITY ASSOCIATED WITH PERIPROSTHETIC FRACTURES OF THE FEMUR

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Introduction: Periprosthetic femur fractures represent a common acute and delayed complication of hip and knee arthroplasty. This injury has become more prevalent as the elderly population increases and more joint arthroplasties are being performed.

Materials and Methods: This is a single surgeon prospective cohort control study of periprosthetic femur fractures involving THAs and TKAs from 1995 through 2004. We reviewed 93 periprosthetic fractures in 90 patients, with 69% THA and 31% TKA. We evaluated fracture healing, length of hospital stay, intra-operative time-motion analysis; fracture healing, morbidity, mortality, and complications.

Results: The average patient age was 80 years, with 19% males and 81% females. The average duration from arthroplasty to periprosthetic fracture was 6.7 years. Mean follow-up was 3.5 years. The mechanism of injury was fall (86%), MVA (9%), insufficiency (2.6%), and iatrogenic intra-operative (2.6%). 100% of THA periprosthetic fractures were treated with plate fixation. 75% of fractures proximal to a TKA were treated with plate fixation, and 25% with a retrograde IM nail. The average surgical time was 90 minutes and average EBL 500cc. Complications resulting from periprosthetic fractures were fatal PE (1%) 8 days post op, DVT (3%), and nonunion (4%). There were no post-operative infections. The average length of hospital stay was 9 days. Average time to weight bearing was 83 days. The rate of union was 96%. Twenty-seven patients (35%) died within an average of 1.4 years from the index procedure.

Conclusion: Our data revealed an improved fracture union rate, and decreased complication rate compared to historical controls. However, surgical management of periprosthetic femur fractures remains a morbid injury, showing a significant mortality rate within the first 24 months post injury, and presents significant technical challenges to the orthopaedic surgeon.

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A COMPARISON OF FOUR TYPES OF STERILE IRRIGATION TO POTABLE WATER IN A PORCINE OPEN FRACTURE MODEL

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Background: The treatment of open fractures in austere environments may be affected by limited resources. The U.S Army Field Medic Guide recommends dilute bleach as an alternative when sterile irrigation is not available.

Hypothesis: There is no difference in bacterial growth by colony forming units (CFU) on a contaminated, open fracture model after irrigation with sterile fluid (water and saline), potable water, or dilute bleach solution (0.25% and 0.50%). A similar decrease in CFU of two bacteria (S. aureus, E. coli) will occur compared to controls.

Methods: Sterile 1 cm tibial sections from porcine hind limbs were inoculated with S. aureus or E. coli and incubated at 37º C for 6 hours (Bhandari 2001). Each specimen was irrigated with 500 ml of fluid. The specimen and irrigant were incubated for 2 more hours. Then, 100 microliter of supernatant was plated on blood agar and incubated for 24 hours. CFU were obtained. For a significance of p< .05, 15 specimens were required (ANOVA). Five controls (no irrigation) were used for each condition.

Results: There was no significant difference between potable water, sterile water, sterile saline, and 0.25% bleach irrigation. There was a trend in less E. coli CFU for 0.50% bleach solution. E. coli had significantly more CFU regardless of irrigation (p < .001). The type of cleaning was not significant (p = .129) nor was the interaction effect (p = .119) for all irrigants. For the Irrigant CFU, there was no significant difference between the types of bacterial CFU (p = .8) and cleaning (p = .2), nor was the interaction effect significant (p = .2). Within each condition, CFU for S. aureus showed the least difference.

Discussion: E. coli produced more CFU compared to S. aureus due to its generation time (22 minutes E. coli vs 1 hour S. aureus) (Mahon 2000). There was no statistical difference in CFU between any of the fluids. There was a trend in decreased CFU for E. coli with 0.50% bleach. There was no difference in controls. This study evaluated bacterial growth on bone alone; its major limitation is as an in vitro animal model. However, tap water and sterile saline were equally effective in Emergency Room irrigation of nearly 1000 minor lacerations (Bansal 2002, Godinez 2002, Valente 2003, Moscati 2007). Castile soap is an effective irrigation additive (Anglen 1994,1996, 2003) but bleach was not here. The comparison of sterile irrigants to potable water and bleach solution has not been previously reported to our knowledge. Potable water and dilute bleach may be considered as alternative irrigants when sterile solutions are not available or in short supply, such as in disasters and combat.


Clinical Investigation Program #NMCP2006.0043
PAPER #11

COMPUTER-ASSISTED 3D PREOPERATIVE PLANNING FOR ALLOGRAFT SELECTION

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Purpose: Advances in computer software algorithms have permitted 3D reconstructions from CT images. Determining the size of the distal femur is critical for obtaining an appropriate allograft. The goal of this study is to compare radiographic, 3D reconstructions based in CT scans, and intraoperative bone measurements of distal femur allografts.

Materials and Methods: Twenty-three fresh-frozen femoral were selected from the bone bank and X-rays and computed tomography scans were performed. CT images were processed and measured with a 3D system. Details of selection of the allografts included: 1) CT scan; 2) DICOMs images are imported into Mimics; 3) segmentation of the images; 4) virtual 3D surface models; 5) measurements in dynamic virtual environment. The maximum total width of the distal femur defined as the transepicondylar axis, the maximum antero-posterior dimension of the medial and lateral condyles, and the width of the intercondylar notch were measured on plain radiographs and on axial CT views. Allografts were then measured in order to compare these dimensions with the ones obtained with radiographs and CT scans 3D model reconstruction. Accuracy was defined as measurements within 2 mm of corresponding intraoperative allograft dimension.

Results: Intraoperative allograft measurements were not significantly correlated with any radiograph variable, while CT dimensions correlated with allograft dimensions. Radiographs tended to underestimate the size of corresponding allograft dimensions, with a mean difference of 7.85 mm in the transepicondylar axis (range 1.2-14.7 mm). This method allows the authors to select the osteoarticular allograft accurately.

Conclusions: Radiographic estimate of allograft dimensions can be inaccurate, while CT measurements correlate with intraoperative allograft real size. Use of osteoarticular allografts selected with 3D measurements based on CT scans might improve biomechanical loading in reconstructed joints. This procedure could be used to accurate selection of bone allografts in a national network database system.
TRANSCRIPTIONAL PROFILING IDENTIFIES THE INSULIN-LIKE GROWTH FACTOR AND THE TRANSFORMING GROWTH FACTOR-BETA SIGNALING AXES IN THE PATHOGENESIS OF OSTEOSARCOMA

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Background: Osteosarcoma (OGS) is the most common primary bone cancer. Although associated with skeletal development and various genetic abnormalities, the molecular pathogenesis of osteosarcoma is unknown. To understand the molecular basis of OGS, we used a comprehensive approach comparing the transcriptional profile of primary tumor cells and cell lines with their normal cell counterparts. In this study, serial analysis of gene expression (SAGE) was utilized to directly measure the transcriptome. This approach allows a straightforward comparison to the public databases to facilitate the exchange of information regarding the genetic basis of rare diseases such as OGS. (1)

Methods: Osteosarcoma Specimens: The OGS cell line SaOS-2 was purchased (ATCC, Rockville, MD). Human specimens were obtained in an IRB approved protocol from osteosarcoma patients at Memorial Sloan-Kettering Cancer Center. Cells were maintained as a monolayer in MEM-α media, supplemented with 10% fetal calf serum. Human mesenchymal stem cells (provided by Dr. Pamela Robey, NIH), were further induced towards osteoblastic differentiation with 50μM of ascorbic acid and 10mM of β-glycerophosphate x2 weeks before total RNA was extracted. The osteoblastic differentiation was confirmed by osteoblast-specific markers including alkaline phosphatase, osteocalcin, and collagen type Ia by RT-PCR. The mesenchymal stem cells, MSC89R, were selected for SAGE analysis based on their high colony-forming efficiency and multi-lineage differentiation potential (2). Cells were passed twice and collected for SAGE analysis or alternatively plated in 100-mm dishes at 10 cell/cm², cultured for 10 to 14 days, and a single cell-derived colony (CFUF35) was isolated using cloning cylinders for MicroSAGE (3). Osteosarcoma Xenografts: Tumor cells from patient-derived cell lines OS160CL and OS63CL were used to establish xenografts in mice under IACUC approved protocols. Specimens were histologically confirmed to be OGS using standard H and E staining. Construction of SAGE Libraries: Total RNA was extracted with a RNeasy mini Kit (Qiagen, Valencia, CA) According to the manufacturer’s instructions. SAGE libraries of normal human osteoblasts, two primary OGS specimens, 2 OGS xenografts (M160xeno, M63xeno), and two cultured OGS cell lines (SaOS-2, OS160CL) were constructed with an iSAGE Kit from Invitrogen (Carlsbad, CA). Sequencing reactions were carried out using a Bigdye Terminator V3.1 Cycle Sequencing Kit, and data was generated with an ABI 3100 sequencer (Applied Biosystems, Foster City, CA). To yield tags, the raw data was processed with the SAGE2000 v4.5 software (Invitrogen,Carlsbad, CA). The SAGE library of mesenchymal stem cells, MSC89R, was established by Donald Phinney et al using the same methodology. The SAGEmap database from National Center for Biotechnology Information, was used as reference for Taq-Unigenic identification. Two additional SAGE libraries were included for analysis, including a single cell-derived MSC SAGE library named CFUF35 (clone forming unit fibroblast 35) developed by Donald G. Phinney’s group using micro-SAGE methodology with 16,407 tags in total and an MSC SAGE library established by Marco Zago’s group (Ribeirão Preto, Brazil) using the standard SAGE methodology, with 202,962 tags in total (4). Quantitative Real-time RT-PCR: Real-time fluorescent quantitative RT-PCR was used to validate a fraction of genes identified by SAGE to be differentially expressed; using pre-designed primers and probes purchased from Applied Biosystems GAPDH was used as endogenous control for template loading. Thermal cycling was performed with a 7500-fast real-time PCR system (Applied Biosystems, Foster City, CA) using a 2 x TaqMan® Fast Universal If noted, the author indicates something of value received. The codes are identified as: a- research or institutional support; b- miscellaneous funding; c- royalties; d- stock options; e- consultant or employee; n- no conflicts disclosed; * disclosure not available at the time of printing.
PCR Master Mix provided by the manufacturer. In the first step, each SAGE library of OGS was pair-wise compared with that of MSC89R, and of osteoblasts, respectively. In the second step, only gene tags significantly differentially expressed in every osteosarcoma versus osteoblast and MSC89R simultaneously were pooled as true characteristic genes of osteosarcoma. Gene tags were grouped according to their functions as described in the literature. **Statistical Analyses:** A computer program was developed at the Dept. of Computer Science to facilitate the parallel comparison between the SAGE libraries. All statistical analyses were two-tailed and a P < 0.05 was regarded as statistically significant. The clustering analysis was performed using BRB-Array tools version 3.6, developed by Dr. Richard Simon and Amy Peng Lam in the Biometrics Research Branch of the National Cancer Institute, Bethesda, MD.

**Results:** Eight genes identified by SAGE were further validated by real-time PCR in these samples. The fold difference measured by SAGE (normalized to tags per 50,000 total tags per library) and detected by real-time RT-PCR. They were highly comparable ($r^2 = 0.8813$). The first group of seven genes identified by SAGE includes those involved in the IGF signaling. Three IGFBPs and three IGFBP-rPs, seen abundantly in MSCs and osteoblasts, were minimally present in any of the six osteosarcoma SAGE libraries—despite IGF-1 levels that were similar in MSC89R (129/50,000 tags), osteoblasts (66/50,000 tags), and osteosarcomas (mean: 67/50,000 tags). The differential expression was validated by Taqman real-time RT-PCR in a subset of the genes, including IGFBP3, IGFBP4, IGFBP6, IGFBP7, and IGFBP3. The second group of genes found to be down-regulated in regulated by the TGF-β signaling pathway, including the BMPs. The identified genes are involved in regulating TGF-β signaling at various levels, including ligand (Inhibin β), ligand release (TGF-β latent binding protein), ligand activation (Thrombospodin 1), receptor internalization, and signal transduction (Cavolin 1). Alterations are also present in extracellular antagonosteosarcoma includes eight genes involved in TGF-β signaling. This is particularly interesting because osteoblast differentiation is ists (Follistatin-like 1, Gremlin1, and CSRPI1), including members of the IGFBP (CTGF, IGFBP7, and CYR61) in the IGF-1 axis, which are important regulators of TGF-β signaling. It is possible that this group of molecules functions to coordinate the action of different types of growth factors, as well as cell-ECM interaction during cell proliferation and differentiation. Down-regulation of multiple elements in this superfamily suggests that impaired TGF-β signaling is an important contributor to the pathogenesis of OGS. Impaired TGF-β signaling in osteosarcoma is also suggested by down-regulation of a group of 39 genes largely regulated by TGF-β signaling. These include genes involved in the extracellular matrix (ECM) formation (type IV collagens, type VI collagen, Vemitin), ECM remodeling (SERPINs, TIMPs, LOX), and many constituents of the cytoskeleton. Six genes involved in cell cycle regulation and apoptosis were down-regulated in osteosarcoma, including p63 and p21, both of which are also potentially involved in TGF-β signaling.

**Conclusions:** For the first time, a highly-clustered transcriptional profile in osteosarcomas is revealed by SAGE despite being derived from different materials grown in various different conditions. Based on these transcriptional profiles, a coordinated theme of clustered gene deregulation in osteosarcoma has emerged. Cell proliferation driven by the IGF axes during bone growth is unrestrained due to down-regulation of IGFBPs and cell cycle regulators, which modulate IGF’s effects in normal bone cells. Tumor cells may also be maintained in an undifferentiated state secondary to impaired TGF-β/BMP signaling. This pattern is well preserved across tissue samples in various growth environments and may reflect a potential pathogenic basis for OGS. This well-coordinated expression pattern suggests that profound alterations in the signaling axes of IGF-1 and TGF-β, in concert with cell cycle regulators, may be involved in the pathogenesis of osteosarcoma.

**References:**

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●If noted, the FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use). For full information, refer to page 6.
Giant cell tumor of bone is a rare benign bone tumor most commonly occurring in the epiphyseal or metaphyseal-epiphyseal region of long tubular bones. It is one of only a few benign bone tumors which have been shown to metastasize to the lung. Because of the infrequency with which this occurs, few studies have attempted to identify disease related factors associated with an increased risk of pulmonary metastases. From 1984 to 2004, 174 patients with benign giant cell tumor of bone were treated at our institution. 122 of these 174 patients had a follow up of at least two years. Ten of these 122 patients (8.2%) developed biopsy-confirmed pulmonary metastases. All patients were evaluated relative to patient and therapy specific variables. The incidence of pulmonary metastases associated with each variable was assessed and a statistical analysis was performed to identify any factor associated with an increased risk of pulmonary metastases. We identified three properties of benign giant cell tumor of bone associated with an increased risk of metastasis: axial location, Enneking stage 3 disease, and more than one local recurrence. More aggressive local disease is historically associated with a higher local recurrence rate and also appears to increase the risk of pulmonary metastases. The increased incidence of pulmonary metastases associated with an anatomic location within the spine and pelvis may be attributable to the difficulty in performing an adequate surgical resection. There was no increased incidence of pulmonary metastases associated with surgical treatment type or particular appendicular location.
Gas gangrene is a necrotizing infection that spreads rapidly and leads to death if untreated. Prompt management that includes amputation of the extremity is necessary but the patient’s unstable condition may lead to delays because of reluctance to proceed with surgery or efforts to stabilize the patient’s condition with other measures. The purpose of this study was to determine the survival rate in patients undergoing amputation for gas gangrene and to evaluate whether surgery on critically unstable patients is associated with increased intraoperative mortality.

This is a retrospective study of 31 patients with gas gangrene treated at our institution. There were 25 male and 6 female patients of a mean age of 54 years (range, 37–75 years) with 33 involved extremities. All patients were compromised hosts and the most common comorbidity was diabetes mellitus present in 27 of 31 patients (87%). Preoperatively, systolic blood pressure was 109 mmHg on average, diastolic blood pressure was 62 mmHg, pulse was 111/min, and white blood cell count was 20,700/mm³. Sixteen of 31 patients were considered to be critically unstable (diastolic blood pressure < 60 mm Hg).

Management included emergent amputation combined with patient resuscitation and intravenous antibiotics. Gas gangrene involved the foot in 15 cases, the leg in 11, the thigh in 6, and the hand in 1 case. Below-knee amputation was performed in 21 cases, above-knee in 4, hip disarticulation in 3, through-knee in 2, Symes in 1, transmetatarsal in 1, and below-elbow amputation in 1 case.

All 31 patients survived the amputation procedure and their hemodynamic status improved. Systolic blood pressure significantly increased from 109 mm Hg preoperatively to 137 mm Hg at the first postoperative day, diastolic blood pressure significantly increased from 62 mm Hg to 81 mm Hg, and pulse significantly decreased from 111/min to 87/min. Twenty-eight of 31 patients were discharged in stable condition after a mean hospital stay of 24 days. Three patients died postoperatively (at 27, 29, and 36 days after surgery) resulting in an overall 10% mortality rate.

Gas gangrene has been associated with high mortality rates and radical surgery is considered the cornerstone of management. An aggressive protocol that included emergent amputation combined with patient resuscitation and antibiotics resulted in no intraoperative or immediate postoperative deaths, even in critically unstable patients. Emergent amputation for gas gangrene is associated with high survival rates and the patient’s critical condition should not delay surgical management.
PAPER #15

• TEN YEAR MINIMUM FOLLOW-UP OF THE FIRST 100 HIPS IMPLANTED WITH CONSERVE® PLUS RESURFACING

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Introduction: The main criticism made by surgeons opposed to Metal-on-Metal Resurfacing Arthroplasty (MMRA) has been the lack of long-term data regarding the performance of these devices. The purpose of our study was to review the clinical outcomes of the first series of 100 hips implanted in the US with MMRA, with a minimum follow-up of ten years.

Materials and Methods: From a complete series of 1203 hips resurfaced with the Conserve® Plus device, we selected the first 100 (89 patients) which were implanted between 1996 and 1998. Demographics: mean age 49; 68% males; 47 Charnley Class A; 39 Class B and 3 Class C. Diagnosis at surgery: OA 63%, DDH 8%, ON 19%, Post-traumatic 2%, Inflammatory arthritis and Rheumatoid Disease 5%, SCFE, LCP, and Melorheostosis 1% each. Femoral defects larger than 1cm were present in 54% of the hips.

Results: The mean follow-up was 10.9 years (10.0 to 12.1). Two patients (2 hips) were lost to follow-up and one patient died (death unrelated to surgery). The mean pre-operative UCLA hip scores were & post-op: 3.7 for pain, 6.1 for walking, 5.5 for function and 4.6 for activity. The post-operative UCLA scores were 9.5, 9.3, 9.0, and 6.9, respectively. The physical component of the SF-12 increased from a mean of 31.3 pre-operatively to 46.7 at the last follow-up and the mental component from 46.8 to 51.1. Range of motion normalized. There were 11 conversions to THR: 8 secondary to a loosening of the femoral component, 1 following a femoral neck fracture, 1 direct exchange due to sepsis, and 1 for recurrent subluxations due to impingement. There were 4 complications (1 wire removal from the greater trochanter; 1 dislocation; 1 excision of heterotopic ossification; 1 thrombophlebitis). Osteolysis was suspected from the radiographic analysis in 3 hips, 1 on the acetabular side and 2 on the femoral side. 6 hips had radiolucencies visible around the metaphyseal stem. These radiolucencies have now been identified for an average of 8.0 years (range 6.2 to 9.4) and the patients are asymptomatic. Using the time to revision for any reason as end point, the Kaplan-Meier survivorship was 93.8% (95% CI 86.8% to 97.2%) at five-year, and 86.8% (95% CI 76.9% to 92.6%) at ten years.

Discussion: Our ten-year survivorship results compare favorably to those of cementless total hip prostheses implanted in young patients during the same period and reported in the Swedish Hip Arthroplasty Register (2007) despite the fact that these patients were operated on with a surgical technique still in development. In addition, the radiographic studies show an extremely low prevalence of osteolysis and suggest a potential for much greater durability.


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Hard-on-hard bearing surfaces have been accepted as a valuable alternative for young and active patients needing a hip replacement because these combinations are resistant to wear. Initial development of alumina-on-alumina bearings faced complications such as fractures and socket loosening. But, with the increasing number of prostheses implanted, noise occurrence appeared as a new complication. The primary aim of the present survey was to quantify the prevalence of having noise in a population receiving alumina-on-alumina hip arthroplasty.

Two hundred and eighty-four ceramic-on-ceramic hips were performed in 238 patients (126 males and 112 females) from January 2003 to December 2004. The average age at the index operation was 52.4 ± 13.4 years (range, 13 to 74 years). We used the same type of prosthesis for all patients manufactured in all cases by Ceraver-Osteal®. Clearance between femoral and insert was between 20 and 50 microns in order to achieve minimal wear. The survey was conducted by an independent surgeon who did not participate in patients’ care during the last 6 months of 2007. He interviewed the patients by phone with a standardized questionnaire (appendix) that aimed to assess if noise was present and the characteristics of this noise if present. No suggestion was done on how they could describe the noise and they felt free to use the word that they considered to be the most adapted. Satisfaction was evaluated asking if the patient was very satisfied, satisfied or dissatisfied with its prosthesis. When the noise was present, the X-ray was independently evaluated to assess if sign of component fracture was present.

Four patients (six hips) died of unrelated cause during the follow-up. Three patients (three hips) live outside France and could not be followed (1.3%). Nine patients (ten hips) could not be traced and are considered lost to follow-up (3.8%). Two hundred and twenty-two patients with 265 hips were therefore surveyed. Among these 265 hips, 28 experienced noise generation (10.6%). It was defined as a snap for 6 patients, as a cracking sound by 6, as rustling by 6 patients, as a squeaking by 7 patients (2.6%), a tinkling by 2 patients, one patient was unable to define the sound she felt. No factor related to the patient influenced the occurrence of noise. Twelve patients were dissatisfied with the result of the hip prosthesis, 5 of them experienced noise (41.7%); 210 were satisfied or very satisfied, 23 of them experienced noise (11%); this difference was significant (p=0.002).

The origins of noise occurrence are unknown but several hypotheses can be suggested. Squeaking may be due to generation of stripe wear and absence of sufficient lubrication. Other types of noise can be due to microseparation, occult dislocation, impingement between the femoral neck and the acetabular rim but demonstration remains an issue.
While total hip arthroplasty (THA) is an effective surgical procedure for the management of hip fractures and degenerative joint disease, dislocation remains a difficult complication and a leading cause of revision surgery.

The datasets of the Australian and New Zealand National Joint Replacement Registries were analyzed to determine the contemporary surgical management of recurrent THA dislocation. 120,870 primary THAs performed since 1999 were included in this study. Functional outcome was assessed using the Oxford Hip Score (OHS). In addition, 15,471 questionnaires returned at six months following primary THA in New Zealand patients were analyzed. 258 patients (1.6%) reported one or more dislocations and 58 (0.37%) underwent revision, giving a 1 to 4.5 dislocation to revision ratio in the first six months following primary THA.

Dislocation was the most frequent reason for revision (28.6%) after mechanical loosening (29.5%). 570 patients in Australia and 307 patients in New Zealand underwent revision for dislocation. Exchange of cup or head/liner was the most frequent revision procedures. 37% of patients had their head size increased. During the follow up period, 12% of patients underwent re-revision. The lowest rate of re-revision was seen in patients with both components revised (4.9%), and the highest rate in those whom the stem only was revised (14.6%). The mean OHS post revision for dislocation was 22.9, versus 23.4 for revision for other reasons and 19.0 following all primaries.

Dislocation remains a significant cause of morbidity following THA, resulting in poorer functional outcome and high re-operation rates.
OUR TEN-YEAR EXPERIENCE WITH CERAMIC-ON-CERAMIC TOTAL HIP ARTHROPLASTY

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Part I: Clinical and Radiographic Outcome: In 2005, we initiated a 2-8 year follow up evaluation of patients who underwent 194 alumina ceramic-on-ceramic [COC] noncemented total hip arthroplasties [THA] at our institution from 1997-2003. We compared our experience with that of the other participants in a multi-center study of 1508 single manufacturer COC THA (15 institutions, 22 surgeons). The COC THA cohort included an initial prospective, randomized study (349 COC THA and 165 metal-on-plastic [MOP] THA) and 1159 subsequent (total 1508) COC THA. In the randomized study (mean age 50 COC and 53 years MOP), there were no differences between COC and MOP THA regarding demographics, clinical / radiographic outcomes, or revision rate. For the multi-center 1508 COC THA cohort, deep infection rate was 0.2% and revision rate was 0.8%, none for ceramic fracture. For our institution’s 194 COC THA cohort, clinical / radiographic outcomes mirrored the larger study and there were no deep infections or revisions.

Part II: Dislocation: In 2007, we initiated a 2-10 year follow up evaluation of the 290 patients who underwent 320 COC THA at our institution from 1997-2005, comparing dislocation prevalence in that cohort to a concurrent matched cohort of 237 patients who underwent 268 MOP THA at our institution. The COC THA cohort had a lower dislocation rate (0.6% COC, 4.9% MOP, p<0.003) and recurrent dislocation rate (0.3% COC, 2.6% MOP, p=0.04). Revision for instability was 0.3% for COC versus 1.5% for MOP THA (p=0.27). Of demographic and implant characteristics, a larger femoral head diameter (≥32 mm) correlated with a lower dislocation rate (0.9% for ≥32 mm, 4.9% for 28 mm, p=0.0001), as did a more varus femoral neck angle (0.7% for 127°, 4.5% for 132°, p=0.008). Both larger femoral head (p=0.0001) and more varus neck (p=0.0001) were more prevalent in the COC THA group.

Part III: Squeak: Also in 2007, we initiated a 2-10 year follow up evaluation of the same 320 COC THA (implanted 1997-2005) regarding the perception of hip noise, specifically noise described as a “squeak”. Mean age was 56 years and mean BMI was 27. Prevalence of reported noise was 63 (19.7%), of squeak 32 (10.0%), and of squeak associated with hip pain three (0.9%) of 320 COC THA. First presentation of squeak was predominantly <30 months postoperatively (75%). Squeak-inducing activities were predominantly casual walking or bending (78%). Overall rate of revision was three (0.9%) of 320 COC THA (one for instability, one for pain associated with clicking, and one for painless squeaking), making rate of revision related to squeaking 0.3%. Of demographic and implant characteristics, males of taller stature (p<0.05) and use of a smaller femoral neck diameter (p<0.03) correlated with squeaking.

Summary: Part I: Outcomes. Based on 2-8 year follow up of 194 COC THA, we found COC THA to be a safe hard-on-hard bearing alternative for a younger THA patient population, with clinical outcomes equivalent and no increased risk or complication compared with MOP THA. Part II: Dislocation. Based on 2-10 year follow up of 320 COC THA, we found: 1] COC THA to have a lower dislocation rate (0.6%) than a contemporary MOP THA series (4.9%), refuting a hypothesis that dislocation risk would be greater due to more limited COC modularity options; and 2] larger femoral head size and more varus femoral neck angle to be protective regarding dislocation for both COC and MOP THA. Part III: Squeak. Based on 2-10 year follow up of 320 COC THA, we found: 1] a rate of “squeak” after COC
THA of 10.0% (painless squeak 9.1%, squeak associated with pain 0.9%); 2] an overall COC THA revision rate of 0.9%, with rate of revision related to squeak 0.3%; and 3] etiology of squeak to be poorly defined, but with correlation with smaller femoral neck diameter supporting a hypothesis of edge loading (allowed by greater range of motion) as a contributing factor.
PAPER #19

LOSS OF OSSEOUS HOMEOSTASIS IS PRESENT IN RADIOGRAPHICALLY NORMAL KNEES WITH DOCUMENTED MEDIAL MENISCUS TEARS

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Background: Medial compartment arthrosis associated with loss of osseous homeostasis (positive technetium bone scan) is a well recognized long term sequelae in patients with documented medial meniscus tears. The temporal occurrence of this loss of osseous homeostasis has not to the present been shown.

Purpose: To report the preoperative scintigraphic imaging findings in 48 patients with MRI documented medial meniscus tears and normal radiographs.

Materials and Methods: Forty-eight adults (40 males and 8 females) without a history of prior injury or surgery between the ages of 27 and 55 (mean age 39) were included in the study. All patients had a normal preoperative Rosenberg x-ray (weight bearing PA radiograph), an MRI diagnostic of a structurally damaged medial meniscus, and a standard three-hour delayed technetium 99m-MDP bone scan of the knees.

Results: 46/48 (96%) of the technetium bone scans were positive (increased scintigraphic activity) manifesting loss of osseous homeostasis to the medial compartment of the knees with documented torn medial meniscus. All patients had surgical documentation of the medial meniscus tears.

Discussion: Loss of osseous homeostasis of the medial compartment of knees with documented medial meniscus tears was present at a time when the radiographic findings were normal. The conceptualization of the extent of the pathology in such patients needs to be changed to include loss of osseous homeostasis. Future studies documenting the post-operative history of surgically treated patients with medial meniscus tears may yield information of interest regarding the development of osteoarthritis (OA) of the knee. It is postulated that the restoration of osseous homeostasis may be an important marker that such knees are not at risk for the development of OA, whereas the persistent loss of osseous homeostasis may indicate an underlying increased risk of the early development of OA.
Background: Soft tissue fluid retention is a common problem following arthroscopy, with 2% of patients developing severe problems, such as neuropraxia and loss of airway. Increased arthroscopy time and irrigation fluid volume have been shown to result in greater soft tissue fluid retention. The purpose of this study was to evaluate whether newly introduced fenestrated outflow cannulae can minimize the fluid weight gain seen after shoulder arthroscopy.

Methods: After obtaining institutional review board approval, 28 consecutive patients undergoing shoulder arthroscopy were prospectively randomized into 2 groups: a Fenestrated outflow cannulae group and a Conventional cannulae group. Weight gain attributable to arthroscopy was obtained by calculating input/output differences. Patient and surgical data collected included age, sex, body-mass-index, shoulder pathology, and type of procedure, and patient positioning. Patient and surgical factors for the two groups were compared using Student’s t and chi-squared analysis. Linear regression was performed for both the Fenestrated and Conventional groups to assess the fluid weight gained as a function of procedure duration and irrigation volume used, with slope comparisons based on t-distributions.

Results: Both groups of patients were comparable by patient and surgical factors (p > 0.05, all variables). For weight gain as a function of arthroscopic fluid volume, the Conventional group showed a significantly greater slope than the Fenestrated group (slope = 0.0216 ± 0.0378 kg/l vs. 0.0021 ± 0.3405 kg/l, p = 0.041). For weight gain as a function of procedure duration, the Conventional group showed a significantly greater slope than the Fenestrated group (slope = 0.5416 ±1.1599 kg/hrs vs. 0. 0144 ± 0.9324 kg/hrs, p = 0.049).

Conclusion: Compared to conventional non-outflow cannulae, fenestrated outflow cannulae allow for procedures of longer duration and more arthroscopic irrigation fluid to be used without the associated weight gain seen with traditional cannulae. We recommend routine use of fenestrated outflow cannulae.
A NOVEL TITANIUM FOAM FOR ORTHOPEDIC LOAD-BEARING APPLICATIONS

George Markovich, MD (a,e-Wright Medical, e-Stryker)

Introduction: A novel 60-70% open porous titanium material was developed to serve as a scaffold for bone ingrowth in load-bearing orthopedic applications.

Materials and Methods: In order to evaluate this material, tests were conducted to determine the mechanical properties, chemical composition, adherence to a titanium alloy substrate and in vivo performance in metaphyseal and transcortical canine models.

Results: Ultimate compressive and flexural strength was shown to be dependent on porosity, with compressive strength reaching 79-93 MPa at ~70% porosity and 141 MPa at 64% porosity. The compressive modulus ranged from 2.5 GPa to 3.8 GPa. Flexural strength of samples near 70% porosity was in excess of 100 MPa. Abrasion resistance of the porous titanium coating per FDA guidance was found to be equivalent to that of porous bead coatings while exceeding the abrasion resistance of titanium plasma spray coatings. The coefficient of friction of the titanium foam was higher than that of porous bead coatings and equivalent to that of plasma spray coatings. Both lap-shear and tensile pull-off tests of porous titanium coated Ti6Al4V substrates resulted in adhesive tape failures greater than 40 MPa, exceeding the minimum strength requirement of 20 MPa set by the FDA. Elemental composition of the porous titanium was shown to be equivalent to that of porous titanium bead coatings. The canine studies showed rapid bone ingrowth and integration of the porous titanium specimens in both trabecular and cortical bone.

Conclusions: The extensive testing performed on this new porous titanium implant material has shown that it is an excellent choice for both orthopedic implant coatings and stand-alone implants.
Hemivertebra Excision to Manage Cervicothoracic and High Thoracic Scoliosis

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Study Design: Case series.

Objective: To assess the effectiveness and safety of hemivertebra excision in the management of congenital cervicothoracic and high thoracic scoliosis.

Summary of Background Data: Congenital cervicothoracic and high thoracic scoliosis is an unusual but potentially severe disfiguring cause of spinal deformity. Surgical options have typically been limited to posterior in-situ fusion, anterior and posterior arthrodesis, convex growth arrest, and long fusions.

Excision of hemivertebrae located cranial to the lumbar-sacral junction is controversial as compensatory curves reduce the impact on global spinal balance, and the risk of neurological damage increases. The ability of the spine to compensate, however, becomes increasingly limited the closer the hemivertebra is to the cervicothoracic junction.

Methods: Three patients with congenital cervicothoracic or high thoracic scoliosis underwent combined anterior and posterior hemivertebra excision and arthrodesis. The patients were followed clinically and radiographically.

Results: There were two males and one female. Average age at the time of surgery was 34 months (25 to 44 months). Follow up averaged 7.75 years (66 to 120 months). Preoperative Cobb angle measurements averaged 32 degrees (25 to 40 degrees). The primary hemivertebrae were located at C7, T1 and T4, and T4. There were multiple local associated vertebral anomalies, including bony bars, without spinal dysraphism or distal anomalies.

All patients were evaluated preoperatively with magnetic resonance imaging and two and three-dimensional computerized tomographic scanning of the spine.

The average Cobb angle corrected to 11° (0° to 25°) at two-years postoperatively, and 28° (15° to 32°) at the most recent follow-up. There were no postoperative neurological complications.

Conclusion: Although this is a small series of patients, circumferential hemivertebra resection at the cervicothoracic junction and high thoracic spine appears to be safe and effective. Based on McMaster’s study of the natural history of congenital scoliosis affecting the upper thoracic spine it is estimated that without operative management the scoliosis could have progressed to 45° to 65° or more over the follow-up period. The small amount of progression is related in part to the local associated congenital anomalies.

Limiting the length of spinal fusion minimizes interference with longitudinal spinal growth and chest development. Hemivertebra excision addresses the deformity directly, provides immediate correction, and halts or reduces progression of scoliosis in these challenging situations.


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INTRODUCTION: Spinal growth modulation with an anterolateral polyethylene spinal tether has been proposed as an alternate non-fusion treatment strategy for idiopathic scoliosis. While clinically the tether would be implanted on the convexity of the curve to mechanically achieve deformity correction, experimentally the tether has been shown to consistently create spinal deformity in an immature porcine model. The effect of this spinal growth modulation on the health of the intervertebral disc however has not been previously evaluated in detail.

PURPOSE: The purpose of this study was two fold: 1) to assess three-dimensional spinal deformity creation over six months of growth modulation compared to sham surgery controls and; 2) to compare disc health between tethered and control animals based on magnetic resonance (MR), gross morphological, histological, and biochemical analyses.

METHODS: Six immature Yucatan mini-pigs were instrumented with anterior vertebral body screws connected by a polyethylene tether over four consecutive thoracic vertebrae (T8 to T11). An additional six animals underwent sham surgery with screw placement without a tether and were also allowed to grow for six months. Pre-op, post-op and monthly radiographs were obtained and the spines were harvested en-bloc (T6 to T13) after the six month survival period. Computed tomography (CT) and MR studies were performed post-harvest and the spines were then sectioned for histological and biochemical analyses. Deformity creation was evaluated based on radiographic and CT measurements of coronal and sagittal Cobb, coronal vertebral and disc wedging, coronal and sagittal vertebral body height differences, coronal and sagittal disc height differences, and vertebral rotation. Intervertebral disc health was evaluated based on gross morphology, MR grading, histologic grading and biochemical analyses [water content (1 – g dry weight/ g wet weight), proteoglycan content (g GAG / g wet weight), and cell density (10^6 cells / g dry weight)]. ANOVA (p<0.05) was used to compare 6-month post-op data between the control and tethered animals.

RESULTS: Radiographs and CT images demonstrated significant coronal deformity creation (17.5º±4.0º vs. 1.8º±0.5º; p=0.001), increased thoracic kyphosis (change from pre-op: 5.3º±0.9º vs. 2.4º±1.6º; p=0.002), and significant axial plane deformity (T9 vertebral rotation: 4.5º±1.3º vs. 1.0º±0.8º; p=0.004) in the tethered animals compared to sham controls. Although tethered discs were significantly more narrowed compared to the sham controls at 6-months post-op, macroscopic, MR and histologic evaluation revealed no signs of degeneration with bulging gelatinous nuclei, discrete fibrous lamellae within the annuli, and uniformly hyperintense T2 signal intensity from the nuclei. In addition, biochemical analysis demonstrated no significant difference in average water content (85%±4% vs. 86%±3%; p=0.2), proteoglycan content (7.7%±1.8% vs. 7.3%±2.3%; p=0.4), or cell density (380±110 vs. 350±100; p=0.4) in the nuclei of tethered and control discs. Only average water content (60%±7% vs. 68%±5%; p=0.001)
of the annulus fibrosus was found to be statistically different between the two animal groups (tethered versus control, respectively).

**Conclusions:** Six months of spinal growth modulation with an anterolateral polyethylene tether created significant spinal deformity in all three planes compared to sham controls. Although disc health was qualitatively maintained, quantitative changes in annulus water content and disc height were observed. These changes likely represent the discs’ metabolic response to the compressive loads generated by the flexible tether.

**Clinical Significance:** Dynamic compression created by a flexible spinal tether is able to consistently modulate endochondral vertebral ossification without detrimentally affecting the health of the intervertebral disc, at least in the short term. Clinical trials are needed to evaluate the ability of an anterolateral spinal tether to correct deformity while preserving spinal flexibility and intervertebral disc health.
DYSPHAGIA FOLLOWING ANTERIOR CERVICAL ARTHRODESIS IS ASSOCIATED WITH CONTINUOUS, STRONG RETRACTION OF THE ESOPHAGUS

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Background: The prevalence of dysphagia after anterior cervical decompression and arthrodesis is estimated at 50% within 1 month, and 21% at 12 months. Its exact etiology is, however, not well understood. The objective of this study was to explore the relationship between intra-operative intra-esophageal pressure due to surgical retraction, esophageal mucosal blood flow at the level of surgery, and post-operative dysphagia. Our hypothesis was that sustained elevated pressure on the esophagus during anterior cervical arthrodesis is associated with postoperative dysphagia.

Methods: Seventeen patients scheduled for anterior cervical arthrodesis were studied. Patients with previous neck surgery, trauma, tumors, infections, gastroesophageal reflux or neurologic disorders associated with dysphagia were excluded. Esophageal intra-luminal pressure in the upper esophageal sphincter was measured (mmHg) throughout the procedure with a custom-made manometry probe and mucosal perfusion was measured (Tissue Perfusion Units) at the level of the surgery with a Laser Doppler Flow-meter, throughout the procedure. The type of retraction chosen by the surgeon was noted. Postoperatively, patients were specifically evaluated for dysphagia on the first post-operative day, at 6 weeks, 3 months and 6 months post-operatively using the M.D. Anderson Dysphagia Inventory.

Results: Four of 11 patients who had dynamic retraction and 5 of 6 patients who had static retraction during surgery developed postoperative dysphagia. The average pre-operative M.D. Anderson Dysphagia Inventory score for all the patients decreased from 98.3 ± 1.9 to 81.5 ± 15.9 on the first post-operative day. There was an inverse relationship between intra-luminal pressure and mucosal blood flow. Patients with dysphagia had significantly higher average intra-luminal pressures (60.8 ± 54.3 vs. 54.4 ± 51.8 mmHg, P<0.0001 compared to asymptomatic patients.

Conclusions: Patients with dysphagia following anterior cervical arthrodesis were exposed to higher intra-operative esophageal pressure and decreased esophagus mucosal blood flow during surgical retraction than patients without dysphagia. Dynamic retraction seemed to be associated with a lower incidence of post-operative dysphagia.
On February 14, 1779, the British explorer Captain James Cook was killed by Hawaiian natives on the beach of Kealakekua Bay, Hawaii (The Big Island). To this day, descendants of both sides of the incident have put their own spin on the story.

This presentation will link Cook to his friend and occasional dinner companion, Dr. Benjamin Franklin, who encouraged private support of one of Cook’s expeditions to the South Pacific, attempting to assure scientific, commercial and humanitarian purposes for the voyage.

During the Revolutionary War, Franklin, now an opponent of British foreign policy and an early target of British naval patrols in the North Atlantic, nevertheless, created a memorable document to ensure Cook’s safe passage through waters controlled by the American Navy. Unfortunately, Cook’s untimely death made Franklin’s document unnecessary.
USE AND ABUSE OF THE IMPACT FACTOR AND OTHER CITATION INDICES

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While the Impact Factor is widely known and accepted, many authors and institutions do not understand the origins, purposes, capabilities, and limitations of this factor. The concept of the Impact Factor was described by Garfield in 1955 and was established with the first results of a Science Citation Index by Garfield and Sher in 1961 as a tool to help librarians select those journals to which they would subscribe. Garfield has recently commented he had no idea the Impact Factor would become so controversial, nor that over the years it would apply not only to journals, but also to authors. The developers of the Science Citation Index evolved that initial effort into the Institute for Scientific Information (ISI) which became a source of a far broader range of information about scientific publications.

When interpreting the Impact Factor of a journal, several other computed indices and other factors must be kept in mind: the immediacy index and the cited half-life. The impact factor reflects the frequency of recent citations; the immediacy index reflects the promptness with which citations occur; the cited half-life reflects the time over which citations occur. ISI groups journals by fields because these indices vary so much between given fields. Journals in rapidly moving fields, such as genetics or molecular biology have high impact factors, high immediacy indices, and short cited half lives. Journals in slowly moving fields, such as most surgical fields have relatively low impact factors, low immediacy indices, and long cited half lives. The types of articles also influence citation rates. Impact factors will also be affected by the “philosophy” of a journal: those which consider themselves an “authors” journal will typically have lower impact factors because they may be less selective or publish more educational articles. Similarly, those journals which have a high number of submissions compared to numbers of articles published can likely be more selective.

Within the literature on the impact factor, authors almost universally acknowledged this factor alone is not a good measure of quality, either of the journal or of the authors publishing within the journals. Nonetheless, it is often misused in this way. While alternative indices have been proposed which might better reflect the differences between fields, these have not been introduced by ISI, nor used outside of research in the field. The index remains most useful for librarians determining those journals to which they might subscribe. It is much less useful for authors deciding to which journals they should submit manuscripts and should not be used for purposes of promotion and tenure.
SUCCESSFUL TREATMENT OF ORTOLANI-POSITIVE HIPS WITH PAVLIK HARNESS, ABDUCTION ORTHOSIS, AND ORTHOPEDIC OFFICE-BASED ULTRASOUND

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Purpose: To review the outcomes of treatment of developmental dysplasia of the hip (DDH), specifically of dislocated, but reducible (Ortolani-positive) hips.

Methods: A retrospective review was conducted of all patients <6 months of age presenting for treatment of DDH over 2 ten-year periods. Inclusion criteria consisted of: clinical evaluation performed by senior orthopedic staff documenting Ortolani-positive examination; monitoring with clinical, ultrasound, and radiography evaluations. Patients with insufficient follow-up, neuromuscular disease, or provocative dislocatable hips were excluded. In Group I (1984-94), treatment involved initiation of Pavlik harness and parental education at time of initial diagnosis. Group II (1997-2007) was treated the same as Group I with the addition of serial orthopedic office-based ultrasound examinations and use of a hip abduction orthosis in hips remaining unstable after 3 weeks in the Pavlik. Records were assessed for failure to achieve or maintain hip reduction, type of further treatment, and development of AVN.

Results: In Group I, average time of follow-up was 28 months. Forty-four out of 52 hips (85%) were treated successfully. Eight patients required further operative treatment. In Group II, 42 Ortolani-positive hips were identified in 40 patients. Of those, 36 met the inclusion criteria and were included in the study. Average follow-up to final evaluation was 35 months. Thirty-four out of 36 hips (94%) were treated successfully. Two hips required further treatment. There were no documented cases of AVN in either group.

Conclusion: In 1994 (POSNA), we presented a series of 52 Ortolani-positive hips (Group I) with a success rate of reduction of 85%. Now, our protocol for treating Ortolani-positive hips has evolved to include serial orthopedic office-based ultrasound in all patients and use of a hip abduction orthosis in hips remaining unstable after 3 weeks in a Pavlik harness. Three previous studies at major centers reported successful reduction in only 63-71% (POSNA 2006, JPO 2001, JBJS 1990). In Group II, our current success rate of 94% exceeds that previously reported by us and is significantly greater than these 3 previous studies (all p<0.005).

Significance: For the difficult group of dislocated but reducible hips, our current treatment module has decreased our failure rate from 15% to 6%. Successful reduction of these hips in infants avoids operations, spica casts, and AVN.
A NEW APPROACH IN THE MANAGEMENT OF METASTATIC DISEASE TO THE HIP

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With the advancements in chemotherapy for adenocarcinoma, patients are living longer with systemic disease. The most common spread of disease to bone is the spine and hip. Impending fractures and pathologic fractures are commonly treated with radiation, bisphosphonates and internal fixation. A significant number of patients who have sustained pathologic fractures and treated with internal fixation may develop non-union. Such patients have persistent pain from the time of their initial surgery until a definitive procedure is performed (average length of time was greater than 4 months). Many patients will have multiple procedures and are unable to ambulate during the post operative period. We have used a more definitive approach to patients with metastatic disease to the hip. In the pelvis, early curettage, autograft and total hip replacement with multiple screws throughout the socket is performed. For the proximal femoral fractures, removal of the proximal screws and total hip replacement with a constrained liner provides immediate weight bearing and pain control. Similarly, patients who develop non-unions of the proximal femur will have removal of hardware and the diseased femur followed by segmental total hip replacement. This unique approach has reduced the number of surgeries and hospital admissions while improving the quality of life dramatically for these patients.
Investigation of bone marrow morphology was performed both in vivo and in vitro in bones of 48 young (3 month) and 49 old (12 month) rats. The relative marrow content of precursor and fat cells were quantitated in different bones, different locations within the bone and in different aged animals. The marrow cells were quantitated using both routine histological sections of the bones and marrow cell harvest, culture, differentiation potential and phenotypic stains. These methods were then applied to histological sections of young and old rats undergoing tibial lengthening by distraction osteogenesis to correlate the area of endosteal new bone formed adjacent to local marrow constituents.

We found that bone marrow morphology can be reproducibly quantitated using hematoxylin and eosin stained longitudinal sections of decalcified rat tibiae by converting the images to gray density and then using NIH Image Analysis software to threshold density of either fat cells or nucleated cells. Bone marrow morphology varies according to location from proximal to distal and according to age in the marrow compartment. Nucleated cells were most numerous in the middle compartment, followed by the proximal compartment and finally the most distal marrow compartment. Nuclear cells were more numerous in young rats compared with old rats at all three levels. The number of fat cells were inversely proportional to nucleated cells at each level and age. Marrow cell harvest, culture and selective differentiation for colony forming units correlated with the in situ marrow analysis. CFU-OB, CFU-F and CFU-AP were all significantly greater in young rat marrow, while CFU-AD were greater in marrow from old rats. The marrow cell culture data was directly correlated to the number of cells harvested at each site (cell density). Using the DO model in young and old rats, we found that the area of endosteal new bone correlated directly to the area of nucleated cells ($R= 0.639, p<0.01$) and inversely to the area of fat cells ($R= -0.33, p<0.01$).

We conclude that the local marrow compartment, directly adjacent to the distraction gap during bone lengthening, is primarily responsible for osteoblastic progenitor cell populations that form endosteal new bone. The data also suggest that with advancing age, stem cell differentiation is directed away from osteoblast cell lines toward adipocytes.
PAPER #30

BIOMECHANICAL STUDY OF ROTATOR CUFF REPAIR WITH MARGIN CONVERGENCE TECHNIQUES

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Objective: The technique of margin convergence has been applied to rotator cuff repair to enhance the security of fixation by decreasing the mechanical strain at the margins of the tear. The purposes of this study were to evaluate the effect of margin convergence on rotator cuff repair strength and to determine which method was mechanically superior.

Methods: Eighteen Kangaroo shoulders were divided into three groups (n=6). A full thickness tendon defect was created in the supraspinatus tendon at humeral insertion with a size of 1.0×1.5 cm, thereby simulating a massive rotator cuff tear in human shoulder. Three different techniques were employed for rotator cuff repair: Mitek suture anchor alone (Group 1), margin convergence alone (Group 2), and margin convergence plus Mitek suture anchor (Group 3). Combined loads were applied in each specimen first with cyclic loading at a rate of 33mm/sec between 10 and 180N with 2 seconds interval at loading extremes. After cyclic loading was complete the construct was loaded to failure at a rate of 5 mm/min. ANOVA and LSD multiple comparisons of the means were applied for testing (significant level, \(p<0.05\)).

Results: Cyclic load test showed progressive gap formation in each repaired specimen with increasing cycles. Group 1 reached 50% failure (5-mm gap formation) at an average of 34 cycles, Group 2 at 75 cycles and Group 3 at 65 cycles. There were significant differences between Groups 1 and 2 (\(P\leq0.001\)), and Groups 1 and 3 (\(P\leq0.001\)). After 100 loading cycles, the size of gap formation was on average 6.8 mm, 6.1 mm and 4.7 mm in Groups 1, 2 and 3 respectively. There was a significant difference between Groups 1 and 3 (\(P\leq0.015\)). All specimens eventually reached their ultimate failure (10 mm gap formation with or without any suture, tendon or anchor rupture). Ultimate failure occurred at 374±13N for Group 1, 415±37N for Group 2 and 464±63N for Group 3. Group 1 demonstrated failure due to 2 sutures breakage at the anchor, 2 tendon breakages, and 2 muscle-tendon junction failures. In Group 2, one failure with knot loose, others failure occurred at muscle-tendon junction with progressive gap formation to 10 mm at the ultimate loading. In Group 3, three of 6 specimens underwent tendon failure, 2 muscle tears and one suture failure at the anchor.

Conclusion: The rotator cuff repairs with the techniques of margin convergence or margin convergence plus suture anchor had much superior mechanical strength in gap formation and ultimate failure load. However, the progressive gap formation after cuff repair seemed always presence if only the existing of any cyclic loads, which may facilitate clinically understanding the phenomena of re-tear or residual defect after rotator cuff repair.

Key Words: biomechanics, rotator cuff repair, shoulder, margin convergence
OUTCOMES AFTER ARTHROSCOPIC REPAIR OF ARTICULAR SIDE PARTIAL ROTATOR CUFF TEARS

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Introduction: The treatment of partial-thickness articular side RCT remains controversial. Debridement alone, as well as acromioplasty combined with debridement, have both been associated with higher failure rates. Traditional open repairs risk damage to the deltoid origin, require takedown of intact cuff tissue, and may result in undiagnosed pathology. We report the results of a prospective nonrandomized consecutive series of 34 patients treated with arthroscopic acromioplasty and anatomic arthroscopic repair of articular side RCT (Ellman Grade III) without takedown of the intact bursal side RC tissue.

Methods: Between November, 2003 and December, 2005, all patients with a partial articular side RCT representing >50% thickness who failed conservative management underwent arthroscopic acromioplasty and arthroscopic repair of the rotator cuff utilizing a suture anchor technique. Patients were evaluated pre and post-operatively with American Shoulder and Elbow Surgeons (ASES) scores.

Results: Thirty-four patients with an average age of 46.5 were evaluated. At the time of submission, complete 2 year follow-up data had been collected on 31 patients. ASES scores improved an average of 40.7 points. There were 18 excellent, 4 good, 4 fair, and 5 poor outcomes. VAS pain scores improved an average of 4.84 points. Of those patients with clinical exams beyond 12 months post-op, ROM improved mildly compared with pre-op (5.7° FF, 6.3° ER). Thirty of 31 patients were subjectively satisfied and would have the surgery again.

Discussion and Conclusions: Partial thickness RCT are an accepted cause of shoulder pain and disability. Disagreement exists regarding the appropriate management of articular side lesions. Arthroscopic acromioplasty with arthroscopic RC repair offers reliable pain relief and functional improvement with low complication and failure rates, and should be considered in patients who fail conservative management.

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PG. ##32

**CLINICAL UTILITY OF THE WHIPPLE TEST FOR PARTIAL TEARS OF THE SUPRASPINATUS TENDON**

Edward G. McFarland MD (n), Xiaofeng Jia MD, PhD (n), Jong Hun Ji, MD (n), Vinodh K Pannirselyam, MD (n), Steve Petersen, MD (n)

**Background:** The Whipple test has been described as a test for making the diagnosis of partial tears of the supraspinatus tendon, especially in overhead athletes who have a painful shoulder. A positive Whipple test has been touted as an indication for operative intervention in this patient population. Our goals were to determine the prevalence of this test in patients with a variety of diagnosis and to determine the clinical usefulness of the Whipple test in patients with shoulder pain. Our hypothesis was that a positive Whipple test should not be used as an indication for surgery in overhead athletes.

**Methods:** We prospectively studied 249 patients who underwent arthroscopy of the shoulder for a variety of diagnosis. Of these patients, 80 were involved in overhead sports, 31 of them have partial rotator cuff tear. Preoperatively all patients underwent a Whipple test upon physical examination. Variables considered for the test to be positive were pain alone, weakness alone or the presence of pain and weakness. All patients underwent diagnostic arthroscopy to evaluate the status of the rotator cuff.

**Results:** The prevalence of Whipple test for all diagnoses was 189/249 (75.9%) for pain, 63/249 (25.3%) for weakness and 23% (58/249) for both pain and weakness. The Whipple test for pain had the highest sensitivities for massive rotator cuff tears (100%), acromioclavicular joint arthritis (88.2%) and glenohumeral arthritis (87.5%). The highest specificities, when a positive test is both pain and weakness, were for massive rotator cuff tears (79.3%), full thickness rotator cuff tears (79.1%) and glenohumeral arthritis (77.3%). The sensitivity for partial rotator cuff tears for overhead athletes was highest for pain 74% but the specificity was 33%. The highest specificity for partial tears in overhead athletes was for the combined findings of pain and weakness (77.6%) but the sensitivity was only 10%. Multivariate analysis demonstrated that weakness with the Whipple test was highly associated with less supraspinatus muscle strength (p<0.001).

**Conclusions:** This study demonstrates that the Whipple test is positive in a wide variety of shoulder conditions. The Whipple test is highly sensitive for massive rotator cuff tears but is generally not specific for rotator cuff pathologies. A positive Whipple test in an overhead athlete does not increase the likelihood significantly for the diagnosis of partial tear of the supraspinatus tendon and should not be used to substantiate operative intervention in this patient population.

**Level of Evidence:** Prognostic Studies Level II
VERTICAL HUMERAL OSTEOTOMY FOR STEM REMOVAL AND REVISION. TECHNIQUE AND RESULTS

Gregory P. Nicholson, MD (c-Zimmer), Dana Piasecki, MD (n), Geoffrey S. Van Thiel, MD, MBA (n), Anthony A. Romeo, MD (n), Stacy L. Twigg, PA-C (n)

Revision of a well-fixed humeral stem can be difficult with increased OR time and blood loss, potential tuberosity fracture and diaphyseal compromise secondary to bone quality, and need for distal bone windows or extended osteotomy. We report the results of a vertical humeral osteotomy (VHO) technique that allows efficient stem removal without the need to then utilize a long stem implant for revision.

Methods: Thirty-five cases (19 female, 16 male) of well-fixed humeral stem removal and revision by Vertical Humeral Osteotomy (VHO) were reviewed at avg. follow-up of 28 months (18 mn-7yr). The avg. age was 63 yrs. (47-79). There were 23 cemented and 12 uncemented stems. Six were infected (5 cemented, 1 uncemented) but not loose, thus requiring VHO removal.

Technique: After prosthetic head removal, a small osteotome is used around the top of the stem circumferentially for a depth of 1-1.5 cm. to “de-bond” the proximal stem from the cancellous proximal bone of the tuberosities. Then a small oscillating saw is used to perform the VHO beginning proximally just lateral to the biceps groove and carried down through bone and cement to the implant. This continues down the shaft (approx 10 cm. in length) between the insertion of the deltoid and pectoralis major tendons. It does not extend below the stem tip. Then two ½ inch osteotomes are placed vertically in the osteotomy to “flex” open the humeral tube to “de-bond” the implant. A “footed” impactor is then placed on the proximal medial collar and a mallet used to remove the implant. Two cerclage wires are placed around the humerus and lightly tightened. A new implant is cemented into the old cement mantle and the cerclage wires tightened. In an infection this technique allows access to remove residual cement and spacer placement and subsequent secondary re-implantation.

Results: All revision stems were cemented (18 back into existing cement mantles). No long stems were necessary. No L-shaped windows or distal windows were required. There were no intra-operative fractures of the tuberosities or diaphysis. After re-implantation, there was no cement extrusion. There has been no stem lucencies, loosening, or re-infections. There were no cerclage wire complications. Implant specific removal slap hammers were not required.

Discussion: With the increase in shoulder arthroplasty, there will be an increased need for revision. Humeral stem removal can be fraught with difficulty and complication. This technique was found to be versatile for all implant types and indications. It preserves the humeral bone tube and tuberosities.

Conclusion: Vertical Humeral Osteotomy allows efficient removal of cemented and uncemented stems without humeral bone compromise. There were no intra-operative complications and no long stem implants were required.
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PAPER #34

TOTAL ELBOW ARTHROPLASTY IN OBESE PATIENTS

Christian J.H. Veillette, MD, MSc, FRCSC (n), Alex A. Malone, MD (n), Bernard F. Morrey, MD (e-Zimmer)

Purpose: A high bodyweight increases the stress transferred through a total elbow arthroplasty (TEA) to the surrounding bone. We conducted a retrospective review to evaluate complications, outcome and implant survivorship of primary TEA in obese patients compared with non-obese patients.

Methods: Seven hundred twenty-three semi-constrained primary elbow implants were reviewed at an average follow-up of 73 months. There were 550 women and 173 men with a mean age at the time of surgery of 62 years. The diagnoses were rheumatoid arthritis (376), post-traumatic arthritis (111), nonunion (139), acute fracture (62), osteoarthritis (18), and other (17). There were 159 obese patients with a body mass index (BMI) > 30 kg/m$^2$ and 564 non-obese patients with a BMI < 30 kg/m$^2$.

Results: Sixteen percent of implants required revision or removal in the obese group compared with 10% in the non-obese group (p=0.04). Kaplan-Meier survivorship at 10 years was 84.5% (95% CI, 79.9%-89.1%) in the non-obese group compared with 70.9% (95% CI, 60.1%-81.4%) in the obese group with implant revision as the endpoint (p<0.01). Obese patients had a higher rate of loosening (11.3% vs 5.5%, p<0.01), heterotrophic ossification (6.3% vs 1.8%, p<0.01), hematoma (3.14% vs 1.06%, p<0.05), bushing wear (7.6% vs 3.6%, p<0.05), extensor mechanism problems (3.8% vs 1.2%, p<0.05) and osteolysis (5.0% vs 2.5%, p<0.05) than non-obese patients.

Conclusion: The results of the present study suggest that clinical obesity, defined as BMI ≥30, has a negative effect on the outcome and complication rate of primary elbow replacement.

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**ONCE-DAILY ORAL RIVAROXABAN COMPARED WITH SUBCUTANEOUS ENOXAPARIN EVERY 12 HOURS FOR THROMBOPROPHYLAXIS AFTER TOTAL KNEE ARTHROPLASTY: RECORD4**

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**Background:** Rivaroxaban is an oral, once-daily (qd), fixed-dose; direct Factor Xa inhibitor with low propensity for drug-drug interactions, no food interactions, and no requirement for routine monitoring or dose adjustment. RECORD3 showed that oral rivaroxaban 10 mg qd given 6-8 hours postoperatively significantly reduced VTE after total knee arthroplasty (TKA) compared with subcutaneous (sc) enoxaparin 40 mg qd initiated preoperatively (12 hours before surgery) and restarted 6-8 hours postoperatively, with similar rates of bleeding. RECORD4 was designed to determine the efficacy and safety of rivaroxaban versus the North American enoxaparin regimen – 30 mg every 12 hours [q12h] – after TKA.

**Methods:** Patients (N=3,148) were randomized to receive oral rivaroxaban 10 mg qd (initiated 6-8 hours after surgery) or sc enoxaparin 30 mg q12h (initiated 12–24 hours after surgery) for 10-14 days. Patients underwent mandatory, bilateral venography between days 11 and 15. The primary efficacy endpoint was the composite of any deep vein thrombosis (DVT), non-fatal pulmonary embolism (PE), and all-cause mortality up to day 17. The main secondary efficacy endpoint was major VTE: the composite of proximal DVT, non-fatal PE, and VTE-related death. Major bleeding was the main safety endpoint.

**Results:** Rivaroxaban significantly reduced the incidence of the primary efficacy outcome versus enoxaparin (6.9% vs 10.1%; \(p=0.012\); relative risk reduction 31%). Major VTE occurred in 1.2% of patients receiving rivaroxaban and 2.0% of patients receiving enoxaparin \(p=0.124\). Symptomatic VTE occurred in 0.7% and 1.2% of patients \(p=0.187\), respectively. The incidence of major bleeding was 0.7% and 0.3%, respectively \(p=0.110\). In RECORD3, major bleeding occurred in 0.6% and 0.5% of patients, respectively. The similar rates with rivaroxaban are consistent with the same timing of the first postoperative dose in each study. Conversely, the lower rate of major bleeding with enoxaparin in RECORD4 is attributable to the greater delay in

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dosing (6–8 hours vs 12-24 hours). Bleeding leading to re-operation occurred in 0.3% vs 0.1% of patients in the rivaroxaban and enoxaparin groups. Postoperative wound infections were similar (0.4% for both regimens), as were surgical site bleeding rates (0.6% in the rivaroxaban group vs 0.5% in the enoxaparin group). Cardiovascular events occurred in 0.5% vs 0.7% of patients, respectively. There was no evidence of compromised liver function in either group.

**Conclusions:** Rivaroxaban has superior efficacy to enoxaparin 30 mg q12h for VTE prevention after TKA, with a similar safety profile. Rates of major bleeding were not significantly different between the two regimens.

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PAPER #36

ANATOMIC AXES DO NOT ACCURATELY PREDICT THE KINEMATIC FLEXION AXIS OF THE KNEE

J. David Blaha, MD (a,c,d-Wright Medical Technology), David DeBoer, MD (a,c,d,e-Wright Medical Technology), C. Lowry Barnes, MD (a,c,d,e-Wright Medical Technology), Richard Obert, MS (e-Wright Medical Technology), Satya Namabu, MS (e-Wright Medical Technology), Paul Stemniski, MS (e-Wright Medical Technology), Michael Carroll (e-Wright Medical Technology)

Introduction: Placing the femoral component of a total knee arthroplasty so that the flexion axis of the replaced joint matches that of the normal should lead to ligament isometry and a balanced joint. The relationship of the flexion axis to anatomic landmarks is not completely understood. The helical axis is a kinematic parameter that represents the flexion axis of the knee combined with internal and external rotation. We have used the results from this and previous studies to define a flexion axis of the knee with internal and external rotations largely eliminated. The purpose of this study was to compare the correlation between the kinematic flexion axis we have defined and commonly defined anatomic axes that have been used as guides for the implantation of total knee components.

Methods: Six cadaver lower extremities were skeletonized except for the knee joint. Passive navigation markers were implanted, and CT scans obtained. The limbs were then placed in an open-chain lower extremity test rig that allows full range of knee motion. Three-dimensional kinematic data were recorded using an IR camera tracking markers on the lower extremity. The helical axis of motion was calculated and superimposed on the 3-D models from the CT. Anatomic landmarks were found on the 3-D models representing the trans-epicondylar axis (TEA), spherical and cylindrical fits of the femoral condyles all of which have been suggested to be predictive of the kinematic flexion axis of the knee. Data were evaluated by comparison of the helical axis to the landmark axes over varying ranges of flexion and the variation in helical axis direction within that range was also calculated.

Results: The least variation in the helical axis occurred at 40-50° of flexion (2.89 ± 0.722°) confirming previous work that showed flexion motion with internal and external rotation minimized in this range. The helical axis in this range was defined as the flexion axis. The anatomic axes defined by the TEA, cylindrical and spherical axes all deviated significantly from this flexion axis (3.127 ± 2.029° p=0.013, 5.111 ± 1.710° p=0.002, 5.115 ± 2.129° p=0.001).

Conclusion/Discussion/Summary: None of the anatomic landmarks considered in this study represent a consistently valid approximation of the kinematic flexion axis of the knee when the flexion axis is defined by a kinematic parameter. The TEA represents the closest approximation of the three with a 95% CI between 0.998 and 5.256°. If a total knee joint prosthesis is to be placed so that the kinematic flexion axis of the replaced knee matches that of the normal, reliance cannot be placed on the commonly used anatomic landmarks evaluated in this study.
PAPER #37

THE IMPORTANCE OF BONY IMPINGEMENT IN RESTRICTING KNEE FLEXION AFTER TOTAL KNEE ARTHROPLASTY (TKA)

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Introduction: Restricted knee flexion after TKA is a multifactorial complication, although the only consistent predictor of postoperative flexion is preoperative flexion. One potential factor is impingement between the bone exposed by the posterior femoral cut and the tibial insert.

Methods: CT scans of 42 knees were obtained after TKA. At 2 years postoperatively, in 6 knees range of flexion was less than 110° (Low-Flex group), in 13 knees flexion was greater than 125° (High-Flex group). The CT scans were reconstructed to extract tibiofemoral bone geometry. CAD models of the implants were aligned to the CT images. Bone and implant geometry were imported into KneeSIM, a software program that simulates deep knee flexion (Fig.1). The maximum flexion possible before impingement between the posterior surface of the lower end of the femur and the tibial insert was recorded.

Results: In 4 of the 6 knees in the Low-Flex group, substantial exposed bone was visible on radiographs and CT images. No or minimum exposed bone was visible in the any of the 13 knees in the High-Flex group. The KneeSIM model accurately predicted the maximum clinical flexion in the High-Flex group (Table 1).

Fig. 1 Imported models on KneeSIM

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Table 1

<table>
<thead>
<tr>
<th></th>
<th>Clinical</th>
<th>KneeSim</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Flex group (13 knees)</td>
<td>130.8 ± 4.0° (125-140)</td>
<td>128.1 ± 4.8° (116.7-134.1)</td>
</tr>
<tr>
<td>Low-Flex group (6 knees)</td>
<td>87.5 ± 9.4° (75-100)</td>
<td>108 ± 9.9° (100.5-125.4)</td>
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</table>

**Discussion and Conclusion:** The computer model accurately predicted knee flexion range of motion based on implant-bone impingement. The small overestimation was likely because soft-tissue interposition was not simulated. These results emphasize the importance of bony impingement and the need to remove exposed bone at the posterior femoral cut.
PAPER #38

INTER- AND INTRA-OBSERVER VARIABILITY OF PRE-OP NAVIGATION – A CADAVERIC VALIDATION STUDY

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Little Rock, AR

Introduction: Computer navigation repeatability is often cited as a benefit over standard instrumented methods in Total Knee Arthroplasty (TKA). Initial capital cost and added OR time are two drawbacks for computer assisted tracking systems. An alternative approach is to preoperatively prepare a patient specific alignment guide based on CT or MRI data. The repeatability of such guides has not been studied to date. This experiment attempts to quantify the inter- and intra-observer repeatability of guide placement and deviation relative to the planned orientation.

Methods: A CT scan of a cadaver lower extremity was obtained and converted to a 3D solid computer model. A virtual total knee replacement was performed on the femur and a custom alignment guide was created that uniquely positioned the femoral component in the virtually determined orientation. The specimen was placed in a surgical rig and infra-red (IR) markers were attached to the femur and registered on a motion tracking system. Placement and registration of the guide was performed by four orthopaedic surgeons, in rotation, a total of sixteen times. Variation of the guide position was calculated between each trial.

Results: Angular variation between all trials was 1.18 ± 1.20 degrees in flexion and 0.5 ± 0.74 degrees in varus/valgus. Intra-observer variation was between 0.10 and 1.22 degrees. Rotational placement of the guide was 1.75 ± 1.37 degrees. Intra-observer variation was less than 2.53 degrees.

Discussion: The results obtained by this study indicate the positional and rotational position of a custom pin placement guide is repeatable. The precision exceeded 1° in all but one case for rotational alignment and the accuracy was better than 3°. With the ability to accurately determine landmarks on a computer model of the bone, the accuracy and repeatability of the guide position would be expected to exceed 3° more frequently than traditional instrumentation.
PAPER #39

MANAGING ACUTE INFECTIONS AFTER ORIF WITH HARDWARE IN PLACE

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Purpose: Managing infections in acute fractures treated with ORIF is an ongoing dilemma. Little published data exists to support the current practice of suppressing these infections while leaving stable hardware in place until the fracture heals. This study evaluates the effectiveness of this approach.

Methods: Potential subjects were identified from a central trauma database and were selected based on specific inclusion and exclusion criteria. Patients who developed infections after the definitive ORIF of acute fractures were candidates for inclusion. Infections had to have occurred after definitive fixation and before union. Six months follow up was required for all cases that went on to union (successes). Fractures that required hardware revision or removal were considered failures and were included regardless of follow up. Data including age, gender, tobacco use, diabetic status, site of fracture, OTA class, open grade, type of fixation, joint involvement, and organism were gathered and compared between the groups through analysis of variance.

Results: Sixty-nine cases were available for analysis. Suppressive treatment with stable hardware left in place was successful in 47 cases (69%) and failed in 22 cases (31%). The only independent predictor of outcome was smoking. A Kaplan-Meier survivorship analysis demonstrated smokers to be at significantly higher risk of failure than nonsmokers (log-rank test = 6.85, p = 0.009) with more failures and earlier failures in the smoking group. In the group of 47 patients who were managed successfully to union by suppressive therapy, 19 went on to have hardware removed for various reasons, and 28 were left with hardware in place. Of the group with retained hardware, 10 (36%) developed recurrent infections requiring hardware removal. In the group of 19 with hardware removed after union, three (16%) also developed recurrent infections.

Conclusion: Our study suggests that it is possible to achieve union and manage infection with hardware in place. However, the success rate (69%) is not as high as one would like. This is particularly true for smokers who had a 3.7 times greater likelihood of failure per month than non-smokers. Given the relatively high failure rate it may be time to consider different treatment strategies.

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INJECTABLE IN SITU SETTING HYDROGELS AS BMP DELIVERY VEHICLES

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University of Connecticut Health Center, Farmington, CT

Background: Injectable in situ forming hydrogels are receiving considerable attention as potential candidates for developing minimally invasive procedures for musculoskeletal repair. Some of the advantages of injectables over preformed scaffolds include ability to introduce to the defect site via a minimally invasive surgical procedure thereby reducing surgical cost and patient discomfort, ability to encapsulate and maintain homogeneous distribution of cells and bioactive molecules that can stimulate the regeneration of bone and cartilage in a biomimetic fashion and ability to provide a good fit in the case of irregular defects. We have previously developed a physiological temperature setting injectable chitosan-inorganic phosphate solution (CS-AHP) as a biocompatible carrier vehicle for biomedical applications. The objective of the study is to evaluate the efficacy of CS-AHP as a BMP carrier via ectopic bone formation in a rat model.

Methods: Briefly, sterile CS-AHP solution was prepared (CS, sterilized by autoclaving and AHP by filter sterilization) and reconstituted rhBMP-2 solution was added to it (2.2 µg/0.5 mL). Chitosans having two different degrees of de-acetylation (78.9 and 84.5%) were used. The mixture (0.5 mL) was injected using a 21 gauge needle into the subcutaneous pouch of Sprague Dawley rats. Following the subcutaneous implantation, the bone formation activity induced by the hydrogel was followed as a function of time. After 12 weeks postoperatively, rats were euthanized and the implants were excised and fixed in formalin solution. The extent of bone formation was evaluated using radiographs, μCT and histological analysis.

Results: Both CS-AHP implants with rhBMP-2 showed significant ectopic bone formation at the injection site. Control implants that lacked rhBMP-2 did not show any bone formation. After 12 weeks, the amount of newly formed bone in CS-AHP gels with 78.9% deacetylation was found to be higher compared to 84.5%.

Conclusion: Overall, the results of this study show that rhBMP-2 can be encapsulated in the novel injectable delivery vehicle for sustained release over a prolonged period of time with retention of bioactivity.
PAPER #41

• EXOGENOUS BMP-7 MITIGATES PMMA PARTICLE-INDUCED INHIBITION OF MC3T3-E1 OSTEOPROGENITOR CELL DIFFERENTIATION

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Stanford, CA

Background: Wear particles induce chronic inflammation, which stimulates osteoclastic bone resorption and inhibits the differentiation of mesenchymal stem cells in the peri-prosthetic tissues. Because mesenchymal stem cells and osteoprogenitors are the precursors for osteoblasts, their viability is crucial to bone regeneration in the implant bed. Bone morphogenetic protein-7 (BMP-7 or OP-1) is a growth factor that stimulates the differentiation and maturation of mesenchymal stem cells and osteoprogenitors to osteoblasts. We hypothesized that addition of BMP-7 could mitigate the inhibitory effects of PMMA particles on MC3T3-E1 osteoprogenitor cells in vitro.

Methods: MC3T3-E1 subclone 14 preosteoblasts (ATCC) were grown in osteogenic media containing 50 µg/mL ascorbic acid, and 10 mM β-glycerophosphate for 20 days with medium and BMP-7 replacement every four days. Cells in osteogenic medium were treated with BMP-7 (200 ng/ml) (Stryker Biotechnology) with/without endotoxin free PMMA particles (1-10 µm, Polysciences) at concentrations of 0, 0.300, 0.150, and 0.075% v/v. To determine the amount of mineralization, cells were incubated in 5% silver nitrate under UV light for 1 hr after 20 days of culture. Images of the stained area were measured using Adobe Photoshop 5.5. Alkaline phosphatase was extracted by lysing each well of adherent cells in 1.5 ml of 0.5% Triton-X (Sigma) for 1 hr at room temperature with shaking. Activity levels in lysate supernatants were then measured using the QuantiChrome™ Alkaline Phosphatase Assay Kit (BioAssay Systems).

Results: PMMA particles suppressed alkaline phosphatase activity and the mineralization of MC3T3-E1 cells in a dose-dependent manner. Addition of BMP-7 mitigated this suppressive effect at all PMMA doses tested. Interestingly, the presence of BMP-7 during the first 4 days of PMMA exposure yielded the same level of mineralization as addition of BMP-7 for other prolonged durations. The same effect was also observed when the cells were allowed to differentiate and mature for 4 days before being exposed to PMMA particles and BMP-7.

Conclusions: Addition of BMP-7 can mitigate the inhibitory effects of PMMA particles on MC3T3-E1 osteoprogenitor cells. Local treatment with BMP-7 may represent a new therapeutic candidate for the treatment of particle-associated bone loss.

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PAPER #42

THE EFFECTS OF BASIC FIBROBLAST GROWTH FACTOR ON ACUTE ROTATOR CUFF INJURY IN A RAT SHOULDER MODEL

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Background: There is a high incidence and prevalence of rotator cuff disease. Laboratory studies using growth factors that accelerate the formation of tendon tissue and accelerate the strength of a healing tendon could have the potential of accelerating the post-operative rehabilitation after rotator cuff repair. The utilization of growth factors with rotator cuff repairs may also decrease the incidence of post operative re-rupture of the repaired tendon. Basic fibroblast growth factor (bFGF) has been shown to increase cellular proliferation and collagen synthesis in vivo and in vitro.

Hypothesis: Administration of bFGF in an alginate gel will increase early healing mechanical parameters in injured rat rotator cuff tendon.

Study Design: Controlled laboratory study.

Methods: The Infraspinatus tendons of 49 shoulders of 350 grams – 400 gram Male Sprague Dawley rats were exposed to recombinant basic fibroblast growth factor (rbFGF) or vehicle control. An additional 6 shoulders served as control tendons for comparison to intact tendon exposed to rbFGF. For the injury model, 2 groups had surgically created 1mm (half tendon width) full thickness defect 2mm from the insertion site on the humerus. A dose of 200ng of rbFGF or vehicle control (Alginate) was administered to randomly chosen rats. A third group received 200ng of rbFGF on an intact tendon. Tendons were harvested 1 week, 2 week and 4 weeks. In all groups, the Infraspinatus tendon was dissected, isolated and left attached to the humerus. In the injury model, the intact portion of the injured tendon was divided across tendon fibers at the level of the injury leaving only the healing granulation tissue in continuity with the remaining proximal and distal portions of the tendon and loaded to failure. In the second model, uninjured intact rbFGF treated tendons and the control tendons were loaded to failure.

Results: In the injury model, the week 1 injury group’s average load to failure was 0.60N versus 0.61N in the rbFGF injury group P = 1.000. At 2 weeks, the injury group’s average load to failure increased to 1.03N versus 2.08N in the rbFGF injury group P = 0.440. At 4 weeks, the injury group’s average load to failure increased to 3.93N versus 5.56N in rbFGF P = 0.013 representing a 41% increase in ultimate load. At 4 weeks, the granulation tissue size of the injury group was 0.4mm² versus 2.7mm² in the rbFGF injury group P < 0.001. Stiffness at 4 weeks for the injury tendons was 2.15 N/mm versus 3.54 N/mm in the rbFGF treated group P = 0.006. However, stress measured 8.19N in the injury group which was markedly high than the rbFGF treated group 2.07N P < 0.001.

In the intact tendon model, both uninjured untreated tendons did not differ from rbFGF treated uninjured tendons in ultimate load to failure, 36.38N versus 43.67N respectively P = 0.931. No

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difference was seen in the tendon area measurements of untreated intact tendon 1.8mm$^2$ versus 2.0mm$^2$ in intact tendon with treated with rbFGF $P = 0.320$. No difference was seen in stiffness in the intact uninjured tendons 20.34 N/mm versus 20.24 N/mm in intact tendon treated with rbFGF $P = 1.000$.

**Conclusions:** At 4 weeks healing tissue of acutely injured rotator cuff exposed to rbFGF has an increase in ultimate load to failure (41% compared to control), stiffness and area of callus size when exposed to rbFGF. Uninjured tendons exposed to rbFGF do not differ from control in ultimate load to failure, stiffness and size of tendon at 4 weeks. However, stress is markedly less at this time indicating that the ultimate load to failure increase is largely the function of increased area of the healing tendon.

**Clinical Relevance:** Our findings suggest a role of rbFGF or similar growth factors in accelerating the healing of injured rotator cuff tendon.
Background: With exercise, body temperature increases. The increase is more within joints and the more actively the joint is moved the more heat that is generated. Joint heat is dissipated through synovial fluid, the joint capsule and by tissue perfusion. Prosthetic joints generate more heat than normal joints and this may accelerate wear of the bearing surface and periprosthetic bone resorption. Different patients and different prostheses may generate or dissipate heat differently. Almost all testing to date has assumed joints operate at room or body temperature which is not correct.

Methods: Temperature measurements were made in eleven patients with one or both hip joints resurfaced. Temperature recordings were made at rest, after walking for 20 minutes, and after walking for 60 minutes. The heat generated in normal, arthritic and resurfaced hip joints was measured. Eight different hip resurfacing prosthetic combinations were studied.

Results: The synovial fluid in a normal hip increased by 1 degree C after 20 minutes of walking and by 2 degrees C in 60 minutes. For the arthritic hip, the increase was 2 degrees C after 20 minutes and 3 degrees C after 60 minutes. A resurfacing hemiarthroplasty with metal had an increase of 2 degrees C in 20 minutes and 3 degrees C in 60 minutes. Using a ceramic hemiarthroplasty the temperature increase was 3 degrees C in 20 minutes in 4 degrees C in 60 minutes. A ceramic-on-metal resurfacing prosthesis had an increase of 4 degrees after walking 20 minutes and 5 degrees after walking 60 minutes.

A metal-on-metal resurfacing prosthesis generated an increase in temperature of 7 degrees in 20 minutes and 6 degrees in 60 minutes. A Ceramic-on-polyethylene resurfacing prosthesis generated an increase in temperature of 5 degrees in 20 minutes and 7 degrees in 60 minutes. A metal-on-polyethylene coupling had an increase of 6 degrees in 20 minutes and 7 degrees in 60 minutes. A metal-on-polyurethane resurfacing prosthesis generated an increase in temperature of 5 degrees in 20 minutes and 5 degrees in 60 minutes. A ceramic-on-polyurethane resurfacing prosthesis had an increase in temperature of 5 degrees in 20 minutes and 5 degrees in 60 minutes.

Discussion: An elevated temperature in a resurfaced hip joint can discourage cell growth and result in more fibrous tissue with bone resorption and osteolysis. Heat also accelerates polyethylene wear, oxidation and degradation. Polyurethane, however, is heat stable and does not show accelerated wear in response to elevation in temperature. Polyurethane has been used as the bearing surface in artificial cervical disk prostheses but only on a limited basis in hip prostheses. Metal-on-metal joints do generate increasing heat with additional time walking unlike the other bearing surfaces. Ceramics used against polyethylene generate less heat than metal articulating with polyethylene.

Conclusion: The synovial fluid temperature inside the hip joint increases with exercise. The temperature increase with metal-on-metal and metal-on-polyurethane increases is less than with...
metal-on-polyethylene. This may be a consideration in the selection of bearing surface materials for resurfacing prostheses. Testing and performance data should consider actual joint temperatures with use rather than assume constant body or ambient temperatures. Also, the relative heat stability of a prosthetic choice should be considered. This study suggests polyurethane based polymers may be the superior bearing choice for a hip prosthesis.
COMPARISON OF MUSCLE STRAIN DURING ANTERIOR VS POSTERIOR MIS SURGICAL APPROACHES FOR TOTAL HIP ARTHROPLASTY

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Introduction: Minimally invasive total hip arthroplasty (THA) proposes being “muscle sparing” and therefore allowing more rapid recovery. Extreme positioning of the limb occurs during certain portions of the procedure including hip dislocation, acetabular preparation, femoral preparation, and component insertion. Despite the small incision, the muscles may undergo excessive strain and therefore, knowledge of the strain and elongation of the individual muscles around the hip during these maneuvers is important.

Methods: Five fresh cadaver dissections were performed to obtain resting muscle fiber lengths and overall dimensions of the periarticular hip muscles. The information was used with a 3D whole-body kinematic simulation program to interactively move the lower limb into the positions needed to perform a total hip arthroplasty using either a minimally invasive anterior or posterior approach. During the simulation, joint angles, muscle origin to insertion path lengths, and moment arms were monitored. Muscle strain was then calculated as change in fiber length relative to resting length. Comparisons were made between the two approaches.

Results: Great variation in muscle strain was observed during the simulations with maximum strains over 100% observed. The greatest strains were observed in the quadratus femoris during the femoral component insertion position of the posterior MIS approach.

Conclusion: During the posterior MIS approach, much of the posterior muscle architecture was placed at or beyond the ultimate tensile strength of fresh cadaver or living muscle as reported in the literature. Less strain was observed during the anterior MIS approach. This highlights the importance of considering the potential for indirect trauma to the peri-articular muscles during a minimally invasive approach.
PAPER #45

HIP ARTHROSCOPY FOR THE DIAGNOSIS AND TREATMENT OF SYNOVIAL CHONDROMATOSIS

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Newton, MA

Introduction: This study looks at the role of arthroscopy in the diagnosis, treatment and surgical outcomes of patients with synovial chondromatosis of the hip joint.

Materials and Methods: A retrospective review was done of 32 patients diagnosed with synovial chondromatosis of the hip at arthroscopy at minimum 2 year follow up (range 2 to 15 years). The average age was 40 years old (range 26–62). The number of loose bodies was from 5 to 300 mostly clustered in the fovea. The length of time for hip symptoms ranged from 6–180 months, average 4.6 years. Arthroscopy was performed in lateral position with distal distraction. Intra-articular position is confirmed by fluoroscopy and joint fluid aspiration. Extra-long cannulas are introduced through anterior and posterior peritrochanteric portals. Loose bodies are removed with lavage or alligator clamps. The larger loose bodies often require morcellization with motorized shavers. Partial synovectomy was performed on each patient. The procedure is performed as an outpatient and patients are allowed to weight bear on crutches the same day.

Results: Only 50% (15) of the patients demonstrated loose bodies on radiographs, 8 on plain films, 1 on CAT scan, and 7 out of 12 patients with gadolinium enhanced MRI. At arthroscopy 26 patients had torn or frayed acetabular labrums. Twenty four patients (75%) had femoral head changes, 5 with grade III or IV lesions. Twenty-eight patients had socket changes (88%), 11 with Grade III or IV lesions. Four patients were reoperated for recurrent symptoms: one at 5 years, 2 at 4 years, and 1 at 1 year.

Conclusion: Hip arthroscopy is often the only means for diagnosing synovial chondromatosis in patients with intractable hip pain. It is a valid treatment of synovial chondromatosis at early to intermediate follow-up.
ACETABULAR RECONSTRUCTION WITH POROUS TANTALUM IMPLANT CONSTRUCTS IN TOTAL HIP ARTHROPLASTY FOR PERIACETABULAR TUMORS

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Mayo Clinic, Rochester, MN

Acetabular reconstruction during total hip arthroplasty (THA) for periacetabular tumors may be challenging due to bone loss and prior irradiation. Given their reported success in other scenarios involving bone loss and irradiation, we hypothesized that porous tantalum acetabular implants might also be successful for periacetabular tumors.

A joint registry search identified 16 patients with periacetabular tumors who underwent THA with porous tantalum implants with minimum 2-year follow-up (for surviving patients). Acetabular reconstruction followed tumor curettage and consisted of an uncemented porous tantalum shell. When required for mechanical stability, additional screws, porous tantalum augments, pelvic plate, and/or a cup-cage construct was added. Clinical and radiographic results were reviewed.

14/16 patients underwent primary THA. 14/16 patients had prior periacetabular irradiation. Mean survival was 2.4 years. Mean follow-up length for all surviving patients was 27.4 months (20.8 overall). There were 4 Class I, 3 Class II, and 7 Class III Harrington defects. Revision cases included 1 Type 2 and 1 Type 4 AAOS defects. Acetabular reconstruction consisted of cup only (4 cases), cup+plate (1), cup+cage (5), cup+augment+plate (1), cup+augment (4), and cup+augment+cage (1). At latest follow-up, pain was improved in 10 patients, unchanged in 3; ambulation was improved in 10 patients, unchanged in 2, worsened in 1 (3 patients unknown); mean Harris Hip Score improved from 41 to 82. No cases of radiographic loosening or progressive radiolucent lines occurred.

At short-term follow-up, porous tantalum acetabular implants, appropriately augmented to achieve sound initial mechanical stability, appears effective in THA for periacetabular tumors. Longer term data is needed.
A COMPARISON BETWEEN DIRECT ANTERIOR SURGERY OF THE HIP (DASH) AND ANTEROLATERAL (AL) SURGICAL APPROACHES TO TOTAL HIP ARTHROPLASTY: POSTOPERATIVE OUTCOMES

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Introduction: This study compared clinical and function outcomes at 6 week, 6 month and one year intervals between DASH and AL approaches. Unlike the anterolateral procedure, the DASH does not require transverse dissection or subsequent repair of muscle or tendon. Accordingly, this study was undertaken in order to evaluate function and pain differences that may be attributed to a change in surgical approach.

Methods: Two surgeons performed 211 DASH procedures in 198 pts. preceded by 259 AL THA’s in 238 pts between October 2003 and July 2007. Prospective Harris Hip scores evaluated pain and function in subscales. Osteoarthritis was the primary diagnosis in each procedure. Participants included 269 women and 167 men. Mean age for the DASH cohort was 67yrs, 68yrs for the AL cohort. Gender, age, weight, height and BMI did not differ statistically between groups. Preoperatively, mean Harris Hip scores—including both pain and function subscales—did not differ statistically between groups.

Results: Six weeks postoperatively, the DASH cohort had superior mean Harris Hip scores, less pain, and better function (means = 89, 40, and 28 respectively) compared to the AL cohort (means = 74, 37, and 18 respectively; p<0.002 for each). Ambulation, need for support devices, stair climbing, and ability to don socks and shoes were also superior in the DASH cohort at six weeks (p<0.001 for each). Six-week postoperative activity levels were higher in DASH hips (p<0.001); fewer DASH pts were sedentary or semi-sedentary (29% versus 72%). Every measure evaluated demonstrated the DASH superior at six months after surgery. At 1 year postoperative, the DASH continued to deliver superior results with respect to the need for assistive devices (p = 0.011, see Figure 1) and stair climbing (p < 0.001, see Figure 2); moreover, at one year postoperative, only 9% of DASH pts were sedentary or semi-sedentary, compared to 33% of AL pts (p < 0.001).

Complications among the DASH cohort included: one dislocation reoperation; one deep infection treated with irrigation and debridement; one trochanteric fracture which did not require surgical intervention; four cortical perforations resolved without fixation (three involving a sharp-tipped rasp which is no longer used); two superficial wounds resolved with excision and closure; and one injury to the lateral femoral cutaneous nerve.

Conclusion: Patients undergoing the DASH approach to THA showed improved function and pain scores 6-weeks and 6-months postoperatively when compared to AL THA. There is also functional superiority which continues to 1-year postoperatively.