PAPERS

PAPER NO. 91

MRI of the Semitendinosus and Gracilis Tendons Minimum Six Years After Autograft Harvest for ACL Reconstruction

Martina Ahlen, MD, Uddevalla, Sweden
Mattias Liden, MD, Uddevalla, Sweden
Åke Bovaller, MD, Trollhattan, Sweden
Ninni Sernert, RPT, Trollhattan, Sweden
Juri Kartus, MD, Trollhattan, Sweden

INTRODUCTION: The aim of the study was to investigate to what extent the semitendinosus and gracilis tendons had regenerated a minimum of six years after harvest for anterior cruciate ligament (ACL) reconstruction. The place of insertion and the area of the regenerated tendons were compared with the normal contra lateral side. To evaluate the function of the regenerated tendons, the strength in knee flexion and internal rotation of the tibia were measured on both sides.

METHODS: Twenty patients (nine female and 11 male) who had undergone ipsilateral ACL reconstruction a minimum six years earlier, median 8.5 (6-11), using semitendinosus and gracilis autografts underwent bilateral magnetic resonance imaging (MRI) of their knees. An experienced independent musculoskeletal radiologist evaluated all MRI examinations. Strength measurements in deep knee flexion and internal rotation were performed.

RESULTS: The semitendinosus tendon had regenerated in 18/20 (90%) and the gracilis tendon in 19/20 (95%) of the patients as seen on MRI. There were no significant differences between the insertion place of the tendons on the operated and non-operated side. The cross sectional areas of the regenerated tendons revealed no significant differences compared to the normal tendons on the contralateral side, as measured 4 cm above the joint line. The patients were significantly weaker in deep knee flexion at 60 and 180 deg/s but stronger in internal rotation of the tibia at 60 deg/s in the operated leg compared to the non-operated knee.

DISCUSSION AND CONCLUSION: The semitendinosus and gracilis tendons regenerated in the majority of patients and regained a nearly normal insertion place on the pes anserinus minimum six years after harvest. The regenerated tendons had a cross-sectional area similar to the non-operated contralateral side. The patients revealed a strength deficit in deep knee flexion but not in internal rotation.

PAPER NO. 92

Double-bundle ACL Reconstruction Cannot Prevent Osteoarthritis Compared with Single-bundle Technique

Jong-Keun Seon, MD, Hwasun, Republic of Korea
Eun-Kyoo K. Song, MD, Hwasungun, Republic of Korea
Chan-Hee Park, Jeonnam, Republic of Korea
Kyung-Do Kang, Hwasun, Republic of Korea

INTRODUCTION: The intent of double-bundle (DB) anterior cruciate ligament (ACL) reconstruction is to reproduce the normal ACL anatomy and improve knee joint rotational stability, and eventually prevent osteoarthritis after surgery. However, no consensus has been reached on the advantages of this technique over the single-bundle (SB) technique, especially for prevention of osteoarthritis after ACL reconstruction. The purpose of this study was to evaluate whether DB ACL reconstruction can prevent osteoarthritis or failure after ACL reconstruction compared with SB technique.

METHODS: One-hundred-thirty patients with ACL injury in one knee were recruited for this prospective study. Among them, 112 patients who were followed up with a minimum of four years (DB group; n=52 vs. SB group; n=60). Both groups were comparable with regard to preoperative data. We evaluated the stability result regarding Lachman test, Pivot shift test, and instrumented laxity based on Telos device. And we also compared Functional outcomes based on Lysholm knee scores, Tegner activity scores, and International Knee Documentation Committee (IKDC) subjective form scale. For the radiologic evaluation, we determined the degree of osteoarthritis based on Kellgren and Lawrence grade system at the time of final follow up and compared the number of patients with progression of osteoarthritis more than grade I. All of the operations were performed by one experienced orthopedic surgeon, and all clinical assessments were made by two independent examiners.

RESULTS: All the patients recovered full range of motion within six months from surgery. Stability results of the Lachman test, pivot-shift test, and knee joint laxity test failed to reveal any significant intergroup differences (P > 0.05). In the pivot-shift result, double-bundle group showed four cases of grade II and single-bundle three cases of grade II (P=0.27). Clinical outcomes including Lysholm knee and Tegner activity scores were similar in the two groups (P > 0.05). However, statistical significance was only achieved for the IKDC subjective form scale (78.2 DB vs 73.1 SB; P=0.03). Concerning osteoarthritis at the final follow up, five patients (10%) in the DB group and six patients (12%) in the SB group progressed osteoarthritis more than one Kellgren-Lawrence grade at final follow up (P=0.75). Eight patients (four in the DB group and two in the SB group) had graft failure during the follow up and had anterior cruciate ligament revision surgery (P = 0.06).

DISCUSSION AND CONCLUSION: This trial showed that DB ACL reconstruction can’t prevent osteoarthritis progression compared with SB technique and the failure rate of the ACL reconstruction. Although DB ACL reconstruction produces better IKDC subjective form than SB ACL reconstruction, the two modalities were found to be similar in terms of clinical outcomes and stabilities after a minimum of four years of follow up.

PAPER NO. 93

“Practice Makes Perfect” in ACL Reconstruction

Annette Oesterhelt, New York, NY
Robert G. Marx, MD, New York, NY
Hassan Ghomrawi, PhD, New York, NY
Huong Do, MA, New York, NY
Joseph Nguyen, MPH, New York, NY
Stephen Lyman, PhD, New York, NY
Hassan Ghomrawi, PhD, New York, NY

INTRODUCTION: Anterior cruciate ligament (ACL) reconstruction is a common procedure requiring considerable technical skill. Between 100,000 - 200,000 ACL reconstructions are performed annually in the United States. Higher yearly surgeon and hospital volumes have been associated with improved outcomes following ACL reconstruction and other
orthopedic procedures. This and a variety of other factors have led to an increased focus on the importance of specialization in orthopedic care including subspecialty fellowship training before beginning practice. Our hypotheses were that 1) due to the technical challenges of ACL reconstruction, patients treated by surgeons who completed sports medicine fellowship training would be less likely to need a second ACL reconstruction within one year, and 2) there would be a “learning curve” with patients treated later in the early career of these young surgeons being less likely to need a second ACL reconstruction within one year. METHODS: A statewide database (SPARCS) from the New York State Department of Health, a census of all hospital admissions and ambulatory surgery procedures within the state, was used to identify ACL reconstructions performed in New York State between 1997 and 2006 by surgeons who performed their first ACL reconstruction in 1997 or later. Patient identifiers were tracked to identify subsequent ACL reconstructions within one year. The risk of a subsequent ACL reconstruction was modeled at the patient level using a generalized estimating equation. Career volume at the time of each ACL reconstruction and sports medicine subspecialty training were considered the main predictors of interest. Case-mix was adjusted for by age, sex, insurance type, comorbidities, and concomitant surgery. We also adjusted for annual hospital and surgeon volume and tested for interactions with these variables and career volume (there were none). RESULTS: A total of 12,778 ACL reconstructions were performed by 320 surgeons during the study period. The patients were 65% male with a mean age of 30.6±12.0 years. A total of 97% had no comorbidities and 57.5% had concomitant surgery at the time of index ACL reconstruction (51% meniscal procedure, 6.5% cartilage procedure). The frequency of a subsequent ACL reconstruction within one year was 1.7%. Adjusted for case-mix, a surgeon’s first 10 career cases were associated with a 5.1 (95% CI 2.0, 13.1) fold increased risk of subsequent ACL reconstruction compared to their career cases over 150 (reference group) This risk remains at 3.7 from cases 11 to 60 before declining to 3.0 for cases 61-120 and 1.4 for cases 121-150 (p-value for trend <0.001). There was no significant association with sports fellowship training with a slightly decreased risk of subsequent ACL reconstruction (odds ratio 0.9 [95% CI 0.7, 1.2] p=0.86).

DISCUSSION AND CONCLUSION: The early career volume, or “learning curve,” of a surgeon has a remarkable effect on the risk of a subsequent ACL reconstruction whereas the completion of a sports medicine fellowship appears to have little effect, if any. Since early career volume is a strong predictor of a subsequent ACL reconstruction, the results of this research raise important health policy issues regarding surgeon training and clinical competence. If our ultimate goal is to improve the quality of patient care and optimize healthcare resource utilization, the further specialization of ACL surgeons may qualify as a patient-centered cost-saving policy alternative.

PAPER NO. 94
Complications Following Anterior Cruciate Ligament Reconstruction in the English NHS
Simon Jameson, Middlesbrough, United Kingdom
Daniel J. Downen, MBBS, Newcastle Upon Tyne, United Kingdom
Paul Baker, MB, ChB, Newcastle Upon Tyne, United Kingdom
Philip James, PhD, Alcester, Warwickshire, United Kingdom
Ignacio Serrano-Pedraza, PhD, Madrid, Spain
Mike R. Reed, MBBS MD, Northumberland, United Kingdom
David Deehan, MD FRCS, England, United Kingdom

INTRODUCTION: Unlike the English National Joint Registry (NJR) for arthroplasty, no surgeon driven national database currently exists for ligament surgery in England. Therefore information on outcome and adverse events following anterior cruciate ligament (ACL) surgery is limited to case series. This restricts the ability to make formal recommendations upon surgical care. METHODS: Prospectively collected data, which is routinely collected on every NHS patient admitted to hospital in England, was analyzed to determine national rates of 90-day symptomatic deep venous thrombosis (DVT), pulmonary thromboembolism (PTE) rate, 30-day wound infection and readmission rates following primary ACL reconstruction between March 2008 and February 2010 (13,941 operations, annual incidence 13.5 per 100,000 English population). RESULTS: Ninety-day DVT and PTE rates were 0.30% (42) and 0.18% (23) respectively. There were no in-hospital deaths. Some 0.75% (104) of the consecutive patient cohort had a wound complication recorded. Another 0.25% (35) underwent a further procedure to washout the infected knee joint and 1.36% (190) were readmitted to an orthopaedic ward within 30 days. DISCUSSION AND CONCLUSION: This is the first national comprehensive study of incidence of significant complications following ACL surgery in England. This should allow meaningful interpretation of future baseline data supporting the development of a national ligament registry.

PAPER NO. 95
A Randomized Trial of Anterior Cruciate Ligament Injury Prevention in Adolescent Female Soccer
Markus Walden, MD, PhD, Kristianstad, Sweden
Isam Atroshi, MD, Kristianstad, Sweden
Henrik Magnusson, MSc, Linköping, Sweden
Philippe Wagner, MSc, Lund, Sweden
Martin Hagglund, PhD, Linköping, Sweden

INTRODUCTION: In the United States there are more than three million youth soccer players with nearly half of them females. Unfortunately, knee injuries are common, but there is limited evidence on the preventive effect of neuromuscular training. METHODS: The study is a two-armed parallel-group cluster randomized trial where female soccer players aged 12-17 years in 309 clubs in Sweden were cluster randomized into an intervention group (n=154) or a control group (n=155). The intervention group was instructed to complete a 15-minute neuromuscular warm-up program, consisting of six exercises focusing on knee control and core stability, twice a week throughout the 2009 season. Each exercise is subdivided into four steps of progressing difficulty and a pair-exercise. Coaches documented individual player exposure during the season, and acute knee injuries were examined by physical therapists and physicians assigned to the clubs. The primary outcome was anterior cruciate ligament reconstruction.
(ACL) injury rate and secondary outcomes were rates of severe knee injury (lay-off > four weeks) and any acute knee injury. RESULTS: In total, 121 intervention clubs (2,479 players) and 109 control clubs (2,085 players) were included for analysis. Unadjusted Cox regression according to intention-to-treat showed a 64% reduction of ACL injury rate in the intervention group (hazard ratio 0.14, 95% confidence interval 0.04 to 0.50, P=0.003), severe knee injury (HR 0.20, 95% CI 0.08 to 0.55, P=0.001), and acute knee injury (HR 0.53, 95% CI 0.31 to 0.95, P=0.03).

DISCUSSION AND CONCLUSION: A 15-minute neuromuscular warm-up program significantly reduced the ACL injury rate in adolescent female soccer. Compliant players also had significant decrease in rates of severe knee injury and any acute knee injury.

PAPER NO. 96
The Relationship between Chronicity of ACL Deficiency and Intra-Articular Injury in 5,086 Patients
Kesavan Sri-Ram, London, United Kingdom
Leo A. Pinczewski, FRACS, Wollstonecraft, Australia
Justin P. Roe, MD, Sydney, Australia
Lucy J. Salmon, PhD, Sydney, Australia

INTRODUCTION: To determine the relationship between advancing months from ACL rupture and the incidence of intra-articular meniscal and chondral damage. METHODS: From a prospectively collected database of 5,086 consecutive patients undergoing primary ACL reconstruction, using hamstring graft, carried out between January 2000 and August 2010 were identified. Data collected included the interval between injury and surgery, type and location of meniscal tears (requiring meniscectomy) and location and severity of chondral damage (ICRS grading system). Patients were grouped according to time interval and age. RESULTS: The median time from ACL injury to ACL reconstruction was three months (range 0.25 to 480). Overall, an increasing incidence of medial meniscal injury and chondral damage occurred with advancing chronicity of ACL deficiency. The incidence of medial meniscal injury requiring meniscectomy increased from 18% of patients undergoing ACL reconstruction within four months of injury to 59% of patients if ACL reconstruction was delayed more than 12 months (P=0.001). The incidence of lateral meniscal tears did not increase significantly over time. The increasing incidence of secondary pathology with advancing chronicity was more pronounced in the younger age groups. The risk of a medial meniscal tear requiring resection was significantly less if surgery was performed before five months in the <17 years group (Odds Ratio 2) and 17-30 years group (OR 1.9), but less so in the 31-50 years group (OR 1.5) and >50 years group (OR 1.5). Advancing age was associated with a greater incidence of chondral damage and medial meniscal injury, but not lateral meniscal injury. Males had a greater incidence of lateral meniscal tears (34% vs. 20%), but not medial (28% vs. 25%) or chondral damage (35% vs. 36%), compared to females. DISCUSSION AND CONCLUSION: The incidence of chondral damage and medial meniscal tears increases with advancing time after ACL injury. Particularly in younger patients, ACL reconstruction should be performed within four months of ACL injury in order to minimize the risk of irreversible damage to meniscal and chondral structures.
What is the Rate of Subsequent Surgery Following ACL Reconstruction in the MOON Cohort?

Carolyn Hettrich, MD, MPH, Iowa City, IA
Warren Dunn, MD, MPH, Nashville, TN
Emily K. K. Reinke, PhD, Nashville, TN
Annunziato Amendola, MD, Iowa City, IA
Christopher C. Kaeding, MD, Columbus, OH
Richard D. Parker, MD, Cleveland, OH
Rick W. Wright, MD, Saint Louis, MO
Kurt P. Spindler, MD, Nashville, TN

INTRODUCTION: Subsequent surgeries have profound effects on patients' satisfaction and outcomes following anterior cruciate ligament reconstruction (ACLR). There have been no prospective studies to date describing the rate of all subsequent surgeries at short and midterm follow-up, along with analysis by type of ACLR and graft choice. METHODS: A total of 988 patients (545 male) were prospectively enrolled in a multicenter study from January 2002 to December 2003. Two- and six-year follow-up for subsequent procedures were obtained in 91.8% and 91.3% of patients respectively. Operative reports were obtained, and all procedures were recorded. RESULTS: A total of 186 patients (18.8%) underwent at least one subsequent surgery on the ipsilateral knee, with 96 patients (9.7%) undergoing at least one surgery on the contralateral knee by six-year follow-up. On the ipsilateral knee, 18.4% of the subsequent surgeries were for arthrofibrosis, 20.7% were revision ACLR (6.4% of entire cohort), 7.1% had procedures related to hardware, and 31.7% had procedures done to the cartilage or the meniscus. The rate of deep infections was 0.3%, with two patients having early infections, one patient with late infection. Ipsilateral subsequent surgeries are listed in the table below. A total of 672 of the reconstructions were single incision, of which 5.4% had procedures for arthrofibrosis, 2.4% for hardware removal, and 8.3% for cartilage/meniscus, and 7.5% revision ACL reconstructions. A total of 312 were done by two-incision technique, and rates for these surgeries were 3.2%, 1.9%, 6.8%, and 4.2% respectively. Of the 988 patients, there were 469 BTB, 346 hamstrings, four Achilles, and 164 tibialis anterior grafts. BTB had a 3% rate of subsequent surgery for arthrofibrosis, vs. 8.8% in the hamstring group. Some 3.7% of the BTB grafts were revised, compared to 7.5% in the hamstring group. For hardware removal, rates for BTB and hamstring were 1.3% and 4.2% respectively. For the contralateral knee, there were 56 primary ACLRs (5.6%) and eight revision ACLRs. Statistical analysis was performed with free open-source R statistical software. Sample size considerations guided variable selection to generate a model as complex as the data would allow without overfitting the data. To examine the association between subsequent surgeries and risk factors, a logistic regression model was used in which the dependent variable was the presence or absence of a subsequent surgery. As complex as the data would allow without overfitting the data, a logistic regression model was used in which the dependent variable was the presence or absence of a subsequent surgery. For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

The Swedish National Anterior Cruciate Ligament Register, Outcome of Surgery for Nearly 18,000 Patients

Juri Kartus, MD, Trollhattan, Sweden
Magnus Forssblad, MD, MSc, Stockholm, Sweden
Jon Karlsson, MD, Gothenburg, Sweden
Richard Frobell, PhD, Lund, Sweden
Par Herbertsson, MD, Lund, Sweden
Johanna Adami
Joanna Kvist, RPT, PhD
Li Fellander-Tsai, MD, Stockholm, Sweden

INTRODUCTION: The Swedish National ACL (anterior cruciate ligament) register was initiated in January 2005. Until the end of year 2010, 17,794 patients have been registered; having undergone either primary ACL reconstruction or revision ACL reconstruction. The register covers over 90% of all ACL procedures in Sweden. The objectives with the register are to identify the impact of demographic variables, surgical techniques, implants and other factors on the outcome of ACL reconstruction. METHODS: The register is a general database and the registrations are made using a web-based protocol. It consists of two parts, one patient section with self-reported outcome scores and one surgeon-based part where factors such as age, gender, cause of injury, previous surgery, time between injury and reconstruction, graft selection, fixation technique and concomitant injuries are reported. The self-reported outcome scores are registered pre-operatively, and at one, two, and five years. RESULTS: The male:female ratio was 58:42 both for primary (n=16, 767) and revision (n=1, 027) reconstructions. The mean age at primary reconstruction was 26 and 28 years for females and males respectively; the corresponding at revision reconstruction was 26 and 29 years respectively. The cause of injury was soccer in half of the male patients and in one third of the female patients. In 2005, 81% of the primary reconstructions were performed using the hamstring tendon autograft; in 2010 the corresponding figure was 98%. In 2010, cortical button was used for fixation on the femoral side in 60% of the patients, and on the tibial side the fixation was made with a metal or absorbable interference screw in 50% of the patients. Pre-operatively there was impairment in the KOOS score especially in sports/recreation and knee related quality of life.
life. All dimensions of the KOOS score were significantly improved at one, two and five years post-operative. In terms of the KOOS, revisions did significantly worse than primary reconstructions at all follow-up occasions and smokers were significantly worse than non-smokers both pre- and post-operatively. Patients who had concomitant meniscal or chondral injuries at reconstruction did marginally worse at five years than patients without such injuries. Double bundle reconstructions did marginally worse than single bundle reconstructions at one year; at two years the opposite was found. During a five-year period the cumulative incidence to undergo a contra lateral ACL reconstruction or revision reconstruction of the index knee is >9%. The corresponding incidence for a 15-18 year old female soccer players is 22%. DISCUSSION AND CONCLUSION: The Swedish ACL Register provides unique opportunities for quality surveillance and research with the aim to improve treatment protocols and enhance the standard of care. Revision reconstructions do worse than primary ones, smokers do worse than non-smokers and young female soccer players have a major risk to injure and reinjure their knees is the important information extracted from the register.

PAPER NO. 100
Transphyseal Anterior Cruciate Ligament Reconstruction in Patients with Open Physes: A 10 Year Follow Up Study
Rafael Calvo, MD, Santiago, Chile
David Figueroa, MD, Santiago, Chile
Alex vaisman, MD, Santiago, Chile
Felipe Novoa, Santiago, Chile
Agustin Leon, MD, Santiago, Chile
Pablo Mococain-Mac Iver, MD
INTRODUCTION: Surgical treatment of anterior cruciate ligament (ACL) tears in patients with open physes is still controversial. The debate focuses on the possible risk of growth plate damage due to intraarticular operative reconstruction techniques. The purpose of this study was to review at a long term follow up the clinical results of a group of patients with open physes that underwent to ACL reconstruction using a transphyseal technique. METHODS: A retrospective analysis of our database was performed; from January 1998 through April 2010 we performed 2,157 ACL reconstructions. Of those, 27 patients met the inclusion criteria (10 or more years of follow up, open physes seen on plain radiograph at the moment of surgery and surgery performed by the same team). None of the patients was lost on follow up. Lysholm and subjective IKDC score where obtained, operative data, return to sports, rerupture and limb length discrepancy were also recorded. RESULTS: The average age at surgery 14.8, and the mean follow up was 10.6 years. All patients underwent transphyseal reconstruction using hamstring tendon autographs. The most common femoral fixation was a cortical button (22/27), and the most common tibial fixation used was a bioabsorbable interference screw (14/27). The average preoperative Lysholm and subjective IKDC scores were (55 and 40), at follow up; there was a significant difference (94 and 92 points respectively, p<0.001). A total of 95.8% of patients had excellent or good results according to Lysholm score. All patients were able to return to sports, 24/27 patients returned at the same or higher level, and only three patients returned at a lower level. Two patients complained about instability during sports, three reruptures (11.1%) were noticed, and no clinical limb length discrepancy were noted at follow up. DISCUSSION AND CONCLUSION: In our series we found that the transphyseal ACL reconstruction using hamstring tendons is a safe option without significant growing plate damage; therefore with no limb length differences in adulthood. Functionally it presents high scores and satisfaction, but a higher rate of reruptures is to be expected.

PAPER NO. 101
Influence of ACL Graft Choice on the Likelihood of Early Revision ACL Reconstruction
Gregory B. Maletis, MD, Baldwin Park, CA
Maria CS Inacio, MS, San Diego, CA
Jamie L. Desmond, San Diego, CA
T. T. Funahashi, MD, Irvine, CA
INTRODUCTION: Selection of the graft for primary anterior cruciate ligament reconstruction (ACLR) surgery may be influenced by multiple factors. Recent studies suggest that allograft tissue may be associated with a higher failure rate, especially in young active patients. Nevertheless, trends within the U.S. have been increasing allograft tissue usage. The purpose of this study is to examine the influence of graft type on the likelihood for revision ACLR surgery within a large community based ACLR Registry (ACLRR). METHODS: A prospective observational study of patients entered into the ACLRR between 02/2005 and 06/2010 was conducted. The exposure of interest was graft type, categorized into autologous bone-patellar tendon-bone (BPTB), autologous hamstring tendons (HS) or allograft. Forty-two medical centers and 214 surgeons enrolled patients in the registry. Failure was defined as revision ACLR requiring the replacement of the graft. Revision surgeries were captured prospectively using both passive surveillance (reporting by the surgeon) and active surveillance (independent review of patients’ electronic medical records). Patient characteristics were compared according to revision status. A Cox-regression model adjusting for gender, race, age, body mass index (BMI) and surgeon clustering effects was used to assess the risk of aseptic revision by graft type. RESULTS: Of the 9,817 primary ACLRs in the study, 150 (1.5%, 95% CI 1.3%-1.8%) underwent aseptic revisions. Average age was 30 yrs (SD=11.4), and 64% were men. The median follow up time was 1.1 years (range 0-5 years). The graft type distribution was 28.4% BPTB, 30.7% HS, and 40.9% allografts. Patients that underwent revision procedures were younger (23 vs. 30 years, P<0.001), and had a lower BMI (26 vs. 27 Kg/m2, P=0.005) compared to patients who were not revised. The graft survival rates at 2.7 yrs were BPTB: 98.0% (95% CI 97.1%-98.7%), HS: 96.9% (95% CI 95.8%-97.8%), and allografts: 96.0% (95% CI 94.8%-96.9%). After adjusting for age, gender, race, and BMI, allografts were found to have a 3.02 (95% CI 1.93-4.72) higher risk of aseptic revision than autograft BPTB, P<0.001. Similarly, autograft HS were found to be at a 1.82 (95% CI 1.10-3.00) higher risk of revision than autograft BPTB, P=0.019. Younger age was also independently associated with risk of revision, with a 7% decrease in risk per year increase in age. DISCUSSION AND CONCLUSION: Graft selection at initial ACLR influences the likelihood of the need for early ACL revision. Compared to autograft BPTB, allografts had a three times higher risk and autograft HS a 1.8 times higher risk of ACL revision. A protective effect of 7% per year was noted with increasing age.
Can Anatomical Femoral Tunnel Position Improve Clinical Outcomes in Anterior Cruciate Ligament Reconstruction?

Jong-Keun Seon, MD, Hwasun, Republic of Korea  
Eun-kyoo K. Song, MD, Hwasungun, Republic of Korea  
Chan-Hee Park, Jeonnam, Republic of Korea  
Kyung-Do Kang, Hwasun, Republic of Korea

INTRODUCTION: The findings of several biomechanical studies support placing the femoral tunnel at an anatomically ideal position to achieve anterior and rotational knee stability after anterior cruciate ligament (ACL) reconstruction. However, no firm consensus has been reached regarding the merits and demerits of ACL reconstruction using an anatomical femoral tunnel versus a high femoral tunnel (11 o’clock). The purpose of this prospective study was to compare intra-operative stability and clinical outcomes of ACL reconstruction between anatomic femoral tunnel and high femoral tunnel techniques.

METHODS: Fifty patients who underwent ACL reconstruction (25 in the anatomical femoral tunnel group and 25 in the high femoral tunnel group) were followed up for a minimum of two years. The authors compared intra-operative anterior, internal rotational, and external rotational stabilities at 0°, 30°, 60°, and 90° using a navigation system after reconstruction, and compared clinical outcomes (Lysholm knee and Tegner activity scores, and Lachman and pivot shift test findings) and radiographic stabilities at final follow-up visits.

RESULTS: The anatomical femoral tunnel group showed significantly better intra-operative internal rotational stability at 0° and 30° of flexion than the high tunnel group, but not at other angles (60° and 90°). Intra-operatively, no significant inter-group differences were found for anterior and external rotational stabilities at any flexion angle. Furthermore, clinical outcomes, including Lysholm knee and Tegner activity scores and Lachman test, showed no significant differences between the two groups. However, stability result based on pivot shift test radiological stability data obtained at final follow-up were significantly better in anatomical tunnel group than non-anatomical tunnel group.

DISCUSSION AND CONCLUSION: The anatomical femoral tunnel group showed better internal rotational stability during ACL reconstruction than the high femoral tunnel group. Moreover, it provided better stability based on pivot shift test, but not Lachman test and clinical outcomes.

PAPERS, POSTERS & SCIENTIFIC EXHIBITS SPORTS MED/ARTHRO
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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

**PAPER NO. 104**

**A Simple Method of ACL Tunnel Evaluation on MRI and Plain Radiography: The Inclination and Femoral Tunnel Angle**

Kenneth Illingworth, MD, Pittsburgh, PA  
Daniel Hensler, MD, Pittsburgh, PA  
Zachary M. Working, Pittsburgh, PA  
Jeffrey A. Macalena, MD, Minneapolis, MN  
Scott Tashman, PhD, Pittsburgh, PA  
Freddie H. Fu, MD, Pittsburgh, PA

**INTRODUCTION:** Postoperative determination of femoral and tibial tunnel position after anterior cruciate ligament (ACL) reconstruction can be challenging without the use of three dimensional computed tomography (3D CT). The purpose of this study was to evaluate the femoral tunnel angle on plain radiographs and the inclination angle on magnetic resonance imaging (MRI) as tools for assessing tunnel positioning after single bundle ACL reconstructions. The hypothesis is that the femoral tunnel angle and inclination angle are reliable methods for evaluating tunnel position after ACL reconstruction while aiding in determining whether an ACL reconstruction falls outside an anatomic range as defined on 3D CT.

**METHODS:** Fifty consecutive patients evaluated by the senior surgeon were included with single bundle (SB) ACL reconstructions with postoperative posterior to anterior flexion weight bearing radiographs, MRI and CT scans. Femoral tunnel angles were determined from postoperative radiographs by obtaining the angle between the femoral tunnel and an estimation of the long axis of the femur. Inclination angles were determined from sagittal MRIs by obtaining the angle between a line parallel to the anterior fibers of the ACL and a line perpendicular to an estimation of the long axis of the tibia. ACL reconstructions were grouped by surgical technique, transtibial or tibial tunnel independent, and as either falling inside or outside an anatomic range as defined on 3D CT.

**RESULTS:** Patients that had tunnel positions within an anatomic range had a statistically significant larger femoral tunnel angle (39.3° ± 4.2) and smaller inclination angle (49.5° ± 2.7) than patients that fell outside an anatomic range (17.2° ± 12.5) and (62.3° ± 7.8)(p<0.001). Patients in the tibial tunnel independent group had statistically significant larger femoral tunnel angle (37.6° ± 9.3) and smaller inclination angle (51.8° ± 6.5) than in the transtibial group (14.2° ± 9.3°) and (63.5° ± 7.2°)(p<0.001). Posterior to anterior femoral tunnel position was negatively correlated with femoral tunnel angle (p<0.001, r = 0.78) and positively correlated with inclination angle (p<0.001, r = 0.74). Based on a ROC curve, a femoral tunnel angle of 32.7° (100% sensitivity and 85% specificity) and inclination angle of 55° (100% sensitivity and 87.5% specificity) was determined to distinguish ACL reconstructions that fell either within or outside an anatomic range on 3D CT.

**DISCUSSION AND CONCLUSION:** Femoral tunnel angle and inclination angle can be reliably determined from posterior to anterior flexion weight bearing radiographs and sagittal MRI, and provide a useful metric for characterizing femoral tunnel position after SB ACL reconstruction.

**Figure 1 - Location of all 50 single bundle reconstructions: A) femoral tunnel and B) tibial tunnel. C) Average femoral tunnel placement of transtibial and tibial independent techniques. D) Average tibial tunnel placement of transtibial and tibial tunnel independent techniques.**

**Figure 2 - A) Inclination angle technique. B) Femoral tunnel angle technique.**
INTRODUCTION: Anterior cruciate ligament (ACL) double bundle technique has become popular in recent times supported by many biomechanical studies that suggest that it may be beneficial to reconstruct both bundles of ACL in order to better restore normal anterior translation and rotation. The purpose of our study was to compare single and double bundle ACL reconstruction to investigate if the above mentioned statement could be clinically demonstrated.

METHODS: Between July and October 2005 a consecutive series of 60 patients with chronic anterior knee instability had their ACL reconstructed by the senior author. The patients were randomly assigned to two groups for surgery. Group A: single bundle ACL reconstruction with hamstring, tibial fixation with a staple and biodesic, femoral tunnel at 10.30-13.30 and endobutton fixation. Group B: double bundle ACL reconstruction with hamstrings (according to F. Fu technique PL femoral bundle from medial portal), tibial fixation with one biodesic in each of the two tunnels + one single staple for both grafts, femoral fixation with two endobuttons. Patients with condral lesions grade 3 or 4 according to Outerbridge were not included in the study. Associated surgery such as meniscectomy or meniscal suture were comparable in both groups. Rehabilitation protocol was the same for both groups. Groups are similar for age, sex, work and sport activity. No significant complications after surgery in both groups. Patients were evaluated before surgery, at one year, at 44 months and at 66 months after surgery with the IKDC scale, the Lysholm score, the KT-1000 arthrometer, R.O.M. and hop test (% of normal knee). X-rays were taken and compared with those taken before surgery to check degenerative changes according to Fairbanks scale. Three patients have been excluded from the study because of reinjury and four didn’t come to control. Fifty-three patients (88.33%) were available for the study. Evaluation was done by an independent surgeon not involved in the study. Statistical analysis of the results were calculated according to standard methods, including frequencies, means and standard deviations. Statistical significance was set at P<.001.

RESULTS: Results of the study are as follows: IKDC score, difference between Group A and Group B P=.076, Lysholm P=.053, R.O.M. P=.008, KT-1000 arthrometer P=.048, Hop test P=.064. X-rays for degenerative changes P=.011. IKDC functional groups showed an improvement after surgery as compared with the preoperative surgery in both group A and B with P<.001. In all parameters that have been studied the differences between Group A (single bundle) and group B (double bundle) were not statistically significant.

DISCUSSION AND CONCLUSION: Despite the encouraging data of biomechanical studies and other clinical investigations, there is no evidence in our study that anatomic double bundle ACL reconstruction has a better outcome in term of function and prevention of arthritis compared with single bundle reconstruction. On the other side, other aspects should be taken into consideration such as time spent in the OR and more hardware (more costs) and possible difficulties in revision in the double bundle technique. We believe that more studies, especially long term randomized prospective studies with new easy to use devices to evaluate rotation, and gait analysis are required before choosing a double bundle technique in ACL reconstruction.
INTRODUCTION: Autologous chondrocytes implantation or microfracture is currently used to repair articular cartilage defect; however, there are several limitations such as damage of healthy tissue, limitation of cell number or replication potential, or quality of the repair tissue, isolated and invasive collecting method. On the other hand, there is umbilical cord blood derived in this phase 3 clinical trial, the efficacy and collecting method. On the other hand, there is umbilical cord blood derived in this phase 3 clinical trial, the efficacy and safety of the mesenchymal stem cell (MSC)-hyaluronate composite to repair the articular cartilage defect of knee joint.

METHODS: At 10 centers, 103 patients with ICRS grade IV chondral defect were enrolled for this study. Mean age of the patients was 63.5. Through randomization process, 50 patients were administered with MSC composite and 53 patients were treated with microfracture as a control group. Arthroscopy was performed at 48 weeks post operatively to assess the ICRS grade for primary clinical outcome. Clinical and functional knee evaluations were performed using the International Knee Documentation Committee (IKDC) subjective score, the Western ON and McMaster Universities Osteoarthritis (WOMAC) index and the 100mm visual analogue scale (VAS). Biopsy was also taken at 48 weeks during the arthroscopy.

RESULTS: Patient population with at least one ICRS grade improvement was higher in the MSC group (97.67%, 42/43 patients) than the microfracture groups (71.74%, 33/46 patients). The difference between the two groups was 25.94% [95% CI: 12.17%~39.70%] (p < 0.001).). The ICRS scores was also higher in the MSC treatment group (8.37±2.26 points. Median = 9) than the microfracture group (6.43±3.51, Median = 7), which was also statistically significant (p < 0.05). More hyaline cartilage portion was observed in the MSC group (88.4%, 38/43 patients than the microfracture group (79.6%). The VAS scale on pain, IKDC subjective score and WOMAC index were both significantly decreased in each group, however, they did not show difference between the groups in one year. There was no case of serious or unexpected adverse event in both groups.

DISCUSSION AND CONCLUSION: MSC-hyaluronate composite is safe and effective to repair articular cartilage defect of the knee, with some evidence of better repair than repair with microfracture.

PAPER NO. 272

Comparison of Efficacy and Safety of Mesenchymal Stem Cell Composite vs. Microfracture for Cartilage Repair

Chul Ha, MD, Seoul, Republic of Korea
Seongil Bin, MD, PhD, Seoul, Republic of Korea
Myung-gu Kim, MD, Incheon, Republic of Korea
Beom Lee, Incheon, Republic of Korea
Jae-doo Yoo, Prof, Seoul, Republic of Korea
Choong Choi, MD, Seoul, Republic of Korea
Jung-ro Yoon, Seoul, Republic of Korea
Wonil Oh, MD, PhD, Seoul, Republic of Korea
Hong-chul Lim, MD, Seoul, Republic of Korea

INTRODUCTION: Autologous chondrocytes implantation or microfracture is currently used to repair articular cartilage defect; however, there are several limitations such as damage of healthy tissue, limitation of cell number or replication potential, or quality of the repair tissue, isolated and invasive collecting method. On the other hand, there is umbilical cord blood derived in this phase 3 clinical trial, the efficacy and safety of the mesenchymal stem cell (MSC)-hyaluronate composite to repair the articular cartilage defect of knee joint.

METHODS: At 10 centers, 103 patients with ICRS grade IV chondral defect were enrolled for this study. Mean age of the patients was 63.5. Through randomization process, 50 patients were administered with MSC composite and 53 patients were treated with microfracture as a control group. Arthroscopy was performed at 48 weeks post operatively to assess the ICRS grade for primary clinical outcome. Clinical and functional knee evaluations were performed using the International Knee Documentation Committee (IKDC) subjective score, the Western ON and McMaster Universities Osteoarthritis (WOMAC) index and the 100mm visual analogue scale (VAS). Biopsy was also taken at 48 weeks during the arthroscopy.

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DISCUSSION AND CONCLUSION: MSC-hyaluronate composite is safe and effective to repair articular cartilage defect of the knee, with some evidence of better repair than repair with microfracture.

PAPER NO. 273

Signal Homogeneity on Cartilage T2 Maps as a Predictive Image Biomarker for Rapid Symptomatic Progression of OA

Kenneth Urish, MD, PhD, Hershey, PA
Matthew G. Keffalas, BS, Woburn, MA
John R. Durkin, MS, Pittsburgh, PA
David J. Miller, University Park, PA
Constance R. Chu, MD, Pittsburgh, PA
Timothy J. Mosher, MD, Hershey, PA

INTRODUCTION: There is great interest in using quantitative magnetic resonance imaging (qMRI) to identify degenerative changes of osteoarthritis (OA) in cartilage. The objective of this study was to use qMRI to identify a series of image metrics on knee MRI that can be used to identify early detection and progression of OA in asymptomatic individuals. In normal cartilage, there is a spatial distribution of cartilage MRI T2 values that is strongly influenced by the highly anisotropic organization of the collagen matrix and regional variation in cartilage water content. We hypothesize that loss of the normal spatial distribution of cartilage MRI T2 values could be used to predict symptomatic disease progression.

METHODS: The Osteoarthritis Initiative (OAI) was used to select control and rapid OA progression populations of knee cartilage T2 maps. The control population from the OAI was used for collecting asymptomatic, healthy individuals (n=89). The incidence cohort was used to identify a rapid progression population of OA prior to symptomatic or radiographic evidence of OA. This change in T2 signal homogeneity could be used to predict symptomatic disease progression.

RESULTS: Patient population with at least one ICRS grade improvement was higher in the MSC group (97.67%, 42/43 patients) than the microfracture group (71.74%, 33/46 patients). The difference between the two groups was 25.94% [95% CI: 12.17%~39.70%] (p < 0.001).). The ICRS scores was also higher in the MSC treatment group (8.37±2.26 points. Median = 9) than the microfracture group (6.43±3.51, Median = 7), which was also statistically significant (p < 0.05). More hyaline cartilage portion was observed in the MSC group (88.4%, 38/43 patients than the microfracture group (79.6%). The VAS scale on pain, IKDC subjective score and WOMAC index were both significantly decreased in each group, however, they did not show difference between the groups in one year. There was no case of serious or unexpected adverse event in both groups.

DISCUSSION AND CONCLUSION: MSC-hyaluronate composite is safe and effective to repair articular cartilage defect of the knee, with some evidence of better repair than repair with microfracture.
METHODS: Cell Migration Assay: Mesenchymal stem cells [MSCs] were cultured and plated onto transwell membranes. The lower chambers contained SDF or S1P at three concentrations, or serum-free medium as a negative control, and serum as a positive control. Chambers contained SDF or S1P at three concentrations, or serum as a local control. Five rats in each group were sacrificed at either four or eight weeks post implantation, after which the knees were analyzed by histology for the type of healing.

RESULTS: Cell migration assay results demonstrated a dose dependent increase in chemoattraction with both molecules demonstrating significant homing on MSCs. Initial in vivo results show that compared to control or scaffold alone, both SDF and S1P coated scaffolds result in robust resurfacing of cartilage defects with white to hyaline blue smooth surfaces. Control defects were characterized by clot filled tissue with irregular articular surfaces and large cyst formation.

DISCUSSION AND CONCLUSION: Structural changes in knee cartilage of asymptomatic individuals with no radiographic signs of OA measured by quantifying signal homogeneity on T2 maps predict the later progression of clinical OA symptoms. For most individuals, this loss of signal heterogeneity primarily occurs in only one of the three main knee compartments suggesting that on an individual basis one of the compartments plays a dominant role in predicting OA progression.

PAPER NO. 274

◆ Novel Strategy to Enhance Microfracture Surgery:
Use of SDF-1 and Sphingosine in Isolated Cartilaginous Defects
Noah Chinitz, MD, New York, NY
Anthony A. Catanzano, Manhasset, NY
Pasquale Razzano, MS, Manhasset, NY
Nicholas A. Sgaglione, MD, Great Neck, NY
Daniel A. Grande, PhD, Manhasset, NY

INTRODUCTION: When the knee undergoes a traumatic displacement of a section of articular cartilage, the resultant fibrocartilaginous scar, comprised mainly of type I collagen, has suboptimal properties to native articular cartilage, made primarily of type II collagen. The microfracture procedure creates vascular access channels to allow for clot to ensure the replacement of the defect with fibrocartilage. Stromal derived growth factor 1 (SDF) and sphingosine-1-phosphate (S1P) are two chemoattractant molecules having associations with cells of the hematopoietic lineage. Hypothesis: SDF and S1P are both chemoattractive to mesenchymal stem cells, and SDF and S1P-coated collagen scaffolds can lead to the regeneration of hyaline cartilage at the site of cartilaginous defects in the rat knee.

METHODS: Cell Migration Assay: Mesenchymal stem cells [MSCs] were cultured and plated onto transwell membranes. The lower chambers contained SDF or S1P at three concentrations, or serum-free medium as a negative control, and serum as a positive control.

The transwells were incubated to allow cell migration toward the agents in the lower chambers. Cells that had migrated through the membrane were counted. SDF / S1P Scaffold Coating: Collagen scaffolds were coated with SDF and/or S1P using a proprietary dip coating process. In Vivo Cartilage Repair: 40 Sprague-Dawley rats underwent bilateral medial parapatellar arthrotomy. A 1.6mm circular defect was created down to bleeding bone. In one defect a scaffold was placed, and the contralateral empty lesion served as a local control. Four groups of 10 rats were studied: scaffolds containing SDF, S1P, SDF + S1P, or nothing. Five rats in each group were sacrificed at either four or eight weeks post implantation, after which the knees were analyzed by histology for the type of healing.

RESULTS: Cell migration assay results demonstrated a dose dependent increase in chemoattraction with both molecules demonstrating significant homing on MSCs. Initial in vivo results show that compared to empty control or scaffold alone, both SDF and S1P coated scaffolds result in robust resurfacing of cartilage defects with white to hyaline blue smooth surfaces. Control defects were characterized by clot filled tissue with irregular articular surfaces and large cyst formation.

DISCUSSION AND CONCLUSION: We successfully demonstrated the strong dose dependent chemoattraction of SDF and S1P on marrow derived MSCs, the cell population capable of promoting good hyaline repair in the context of microfracture chondroplasty. We show improved performance of our scaffolds in preliminary in vivo testing. It is envisioned that such a strategy could be easily incorporated into arthroscopic surgery when performing microfracture.
INTRODUCTION: The ability to predict those individuals most at risk for ACL injury would help to mitigate the number of anterior cruciate ligament (ACL) injuries sustained in the population and likely reduce the number of individuals who go on to develop post-traumatic osteoarthritis. Cadets at the U.S. Military Academy at West Point follow a highly active and extremely regimented lifestyle that includes baseline medical examinations to ensure that no injuries have occurred prior to entering the Academy and prior to graduation at the end of four years. All cadets have serum samples drawn upon entering West Point and prior to graduation. The objective of this study was to assess the relationship between the pre-injury levels of serum biomarkers for cartilage turnover and the subsequent likelihood of ACL rupture.

METHODS: We conducted a case control study to address the stated objective. Forty-five ACL injured cases and 45 controls matched for sex, age, height, and weight were studied. In addition to the matching criteria, controls had no history of major joint injury before or during their time at West Point. Baseline pre-injury serum samples were obtained for all cases and controls from the Department of Defense Serum Repository. Samples were assessed for two serum biomarkers of cartilage synthesis (CPII and CS846) and two markers of cartilage degradation (C1,2C and C2C) using commercially available ELISA kits. All ELISAs were performed in triplicate. Conditional logistic regression models were used to analyze the data.

RESULTS: Univariate results suggest that both biomarkers for cartilage degradation (C1,2C and C2C) were significantly associated with the subsequent likelihood of ACL injury. On average, a 1 ng/mL increase in serum C2C and C1,2C levels at baseline was associated with being 9.1 (OR=9.12, 95% CI: 2.55, 32.63, p=0.001) and 4.2 (OR=4.22, 95% CI: 1.70, 10.45, p=0.002) times more likely to sustain an ACL injury, respectively. Baseline serum CPII levels were also associated with subsequent ACL injury. On average, a 1 ng/mL increase in serum CPII at baseline was associated with being over 19 (OR= 19.43, 95% CI: 3.50, 107.82, p=0.001) times more likely to sustain a subsequent ACL injury. Baseline serum CS846 levels approached significance (OR= 0.35, 95% CI: 0.11, 1.13, p=0.080). Multivariable models suggest that C2C, CPII and CS846 levels at baseline are important factors associated with subsequent ACL injury.

DISCUSSION AND CONCLUSION: Predicting those individuals at risk for ACL injury is desirable as it lends an opportunity to administer injury prevention programs to at-risk populations. Serum biomarkers are attractive as they are easily collected and studied. This study has defined a heretofore unknown association between biomarkers of articular cartilage turnover and the risk of subsequent ACL injury. Pre-injury differences in serum levels of biomarkers of cartilage turnover suggest that bone and cartilage metabolism in those that go on to tear their ACL may be different when compared to a matched control group with no history of major joint injury. These differences may be reflective of different pre-injury biochemical and/or biomechanical risk profiles that subsequently impact both cartilage metabolism and ACL injury risk. Acknowledgements: This study was aided by a grant from the Orthopaedic Research and Education Foundation. The views and opinions expressed are those of the author(s) and do not reflect the official policy of the Army, Department of Defense or the U.S. Government.
INTRODUCTION: The current surgical techniques in osteochondral defects repair lead to fibrocartilage formation combined with poor subchondral regeneration, often associated to joint stiffness and/or pain. The ideal osteochondral graft should be an off-the-shelf product; this is the research direction and the reason why the new biomaterials proposed in recent years to repair osteochondral defects should induce an “in situ” cartilage regeneration starting at the moment of implantation into the defect site. We performed a clinical pilot study using a newly developed nanostructured scaffold to treat chondral and osteochondral lesions of the knee; its safety and manageability, as much as the surgical procedure reproducibility and the clinical outcome, were evaluated in order to test its intrinsic potential without any cells culture aid.

METHODS: This osteochondral scaffold was obtained by enucleating equine collagen type 1 fibrils with hydroxyapatite nanoparticles in three different layers with three different gradient ratios at physiological conditions. Thirty patients (9F, 21M, mean age 29.3yy) affected by either chondral or osteochondral lesions of the knee (eight medial femoral condyles, five lateral femoral condyles, 12 patellae, eight femoral trochleas) underwent the scaffold implantation from January to July 2007. Size of the lesion was in between 2 and 6 squared cm. All patients and their clinical outcome were analyzed prospectively at six, 12, 24, 36 and 48 months using the cartilage standard evaluation form as proposed by ICRS and an high resolution MRI.

RESULTS: We detected statistically significant scores improvement and function recovery comparing the pre-operative and the follow-up parameters. Moreover, we noticed a further improvement from 12 to 24 months follow up (IKDC subj. from 71.54 to 76.54: p < 0.05) while the good results gained at two years were confirmed at three and four years follow-up evaluation. TEGNER score improved at 12 months (p < 0.05) and reMEd stable up to four years. The MOCART scoring scale used to analyze the MRIs showed complete filling of the cartilage defect in 80% of the group.

DISCUSSION AND CONCLUSION: This new minimally invasive one-step surgical approach to treat osteochondral defects seems to be an easy and effective procedure. The results obtained are very encouraging and this procedure shows satisfactory outcomes even in wide osteochondral lesions.
objective analysis revealed: 0 A, 3 B, 40 C and 10 D preoperatively while at final follow up 70% scored A or B. Tegner score at final follow up (80%) showed a decline in sport activity level (Tegner 5). Only 13 patients could continue at the previous level of sports.

DISCUSSION AND CONCLUSION: Over the 10 to 15 year follow-up period (average, 13.2 years), athletic patients who underwent the microfracture procedure for full thickness chondral defects, without associated meniscus or ligament pathology, showed statistically significant improvement in function and indicated that they had less pain. However there has been a general decline in sports activity with time. Although the activity level of athletes with respect to sports had declined, patients showed significant improvement in function and decrease in pain. We believe microfracture can be a good option to treat chondral defects in active individuals but competitive athletes should be advised that improvement seen would decline with time.

PAPER NO. 279
◆Autologous Cartilage Tissue Implantation Compared to Microfracture: A Prospective, Randomized Clinical Trial

Dennis C. Crawford, MD, Portland, OR
Thomas M. DeBerardino, MD, Farmington, CT
Riley J. Williams, MD, New York, NY

INTRODUCTION: This study compares the clinical efficacy of an autologous cartilage tissue implant (ACTI) to microfracture (MF) in a multi-site prospective randomized FDA Phase II trial of a tissue-engineered, bio-implant for treating knee cartilage injuries.

METHODS: Thirty patients were randomized two-to-one, two ACTI for each microfracture, at arthroscopic confirmation of grade III ICRS lesion(s). Microfracture or cartilage biopsy was performed. The ACTI, produced by seeding collagen I matrix scaffold with autogenous chondrocytes and bioreactor treatment, was implanted six weeks post-arthroscopic biopsy. Standard evaluations applied validated clinical outcomes measures.

RESULTS: Three, six, 12 and 24 month data is reported with a mean of 26 months (±2) for all patients (21ACTI:9MF). Mean improvement seen would decline with time.

DISCUSSION AND CONCLUSION: The results of this study demonstrated that local control of gene expression was possible following IA injection of AAV in a cartilage injured joint and 2) to test the hypothesis that Dox alone will improve cartilage repair following osteochondral defect (OCD) formation.

METHODS: For Aim-1, 12 Sprague Dawley (SD) rats received an 1.5mm OCD in the trochlear groove of the right knee. These rats were then divided into two groups. To characterize the stability and localization of transgene expression, six rats received bilateral injection of AAV-CMV-Luciferase (Luc) to characterize the controllability of transgene expression, the other six rats received bilateral injection of AAV-tetracycline response element (TRE)-Luc. In this group gene expression was induced by the addition of Dox into the drinking water for one week. Luciferase expression was evaluated in both groups over the six months using an imaging system. At sacrifice the knee joints were opened and imaged using the same technique to further localize the signal within the IA structures. For Aim-2, 18 SD rats received OCDS in the trochlear groove of the right knee. The animals were divided into three groups, receiving either zero, four or 12 weeks of Dox administration into the drinking water. Following sacrifice at 12 weeks, repair tissue was examined grossly and graded using a modified ICRS grading scale. Repair tissue was then sectioned for histology and quantitatively analyzed.

RESULTS: For Aim-1, luciferase bioluminescence was detected as early as seven days and reMed stable for the entire study period. The signal was localized to the tissue in the vicinity of the OCD on the injured side. Animals that received the controllable AAV-TRE-Luc vector showed a significant upregulation of gene expression with the addition of Dox that returned to baseline following its removal. For Aim-2, the animals that received Dox for 12 weeks post-op had significantly higher mean ICRS scores than the other two groups (p=0.025). Quantitative histologic analysis of the repair tissue showed similar repair tissue fill and cellularity.

DISCUSSION AND CONCLUSION: The results of this study demonstrate that localized and persistent gene expression is possible following IA injection into a cartilage injured joint. Furthermore, this is a novel demonstration of in vivo, external control of gene expression following OCD. In addition to providing controllability of in vivo transgene expression, our data shows that oral administration of Dox does not delay cartilage repair and potentially improves the gross repair. The ability to achieve stable yet controllable, long-term IA transgene expression after a single injection of AAV into a cartilage-injured joint is of high potential clinical utility. Lastly, Dox is a promising agent for external regulation of in vivo transgene expression to improve the safety and utility of gene therapy strategies to enhance cartilage repair.
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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

INTRODUCTION: Current articular cartilage restoration modalities have drawbacks such as donor-site morbidity, two-stage surgery and fibrocartilaginous repair. We sought to evaluate the effects of genetic engineering and differentiation medium on scaffold-free neocartilage formation in-vitro to develop a superior off-the-shelf graft using juvenile human chondrocytes (jCh).

METHODS: Articular cartilage was harvested from individuals (<7yo) undergoing routine amputation. jCh were isolated, expanded and transduced with adenoviral vectors for bone morphogenetic protein-2 (AdBMP2). jCh were suspended, centrifuged and grown for two weeks to form neocartilage. For part one, treatment conditions compared transduction vs. no transduction (naïve) and standard media vs. chondrogenic differentiation media (CDM). For part two, the ratio of transduced to non-transduced jCh was varied (0:100%, 10:90%, 25:75%, 50:50%, 75:25%, 100:0%) to form neocartilage.

RESULTS: In standard media, AdBMP2-transduced jCh resulted in larger diameter, increased mass and histologically superior (p ≤ 0.0035) neocartilage than naïve jCh. Compared to standard media, CDM improved diameter, weight, histology and collagen type-II expression (p ≤ 0.0081) regardless of transduction (Figure 1). With CDM, transduction of 10%, 25%, or 50% of jCh with AdBMP2 produced superior weight, histology and collagen type-II expression compared to naïve jCh and 75% or 100%-transduced jCh (p≤0.044) (Figure 2). Soluble BMP2 production tended to increase with greater proportions of AdBMP2-transduced jCh (p=0.03). Chondrocyte viability was reduced in neocartilage with ≥50% proportion of transduced jCh (p=0.035). DISCUSSION AND CONCLUSION: We demonstrated that low proportions of transduction were superior to high levels or no transduction and that jCh grown in CDM and genetically engineered to express elevated soluble BMP2 produced potential neocartilage grafts (Figure 3) after a short incubation period.

PAPER NO. 282
Higher Activity Level after Mosaicplasty than Microfracture for Cartilage Defects of the Knee
Aaron J. Krych, MD, Rochester, MN
Heather W. Harnly, MD, East Brunswick, NJ
Scott A. Rodeo, MD, New York, NY
Russell F. Warren, MD, New York, NY
Thomas L. Wickiewicz, MD, New York, NY
Riley J. Williams, MD, New York, NY

INTRODUCTION: Limited information exists directly comparing the outcome of osteochondral autograft transfer mosaicplasty (OAT) and microfracture (MFX) for the treatment of cartilage defects in the knee. We hypothesized that patients treated with OAT or MFX for symptomatic, 1-6 cm² chondral defects of the femoral condyles will have similar clinical outcomes. We designed a prospective comparison study to specifically determine if (1) clinical outcome was similar between patients treated with OAT and MFX, as measured with Short Form-36 (SF-36) scores, (2) knee function was similar between patients treated with OAT and MFX, as measured by the activities of daily living scale of the Knee Outcome Survey (KOS) and by the International Knee Documentation Committee (IKDC) score, and (3) activity levels were similar between patients treated with OAT and MFX, as measured by Marx activity scores.

METHODS: Ninety-six patients with full thickness cartilage defects of the femoral condyles were treated with either OAT (n=48) or MFX (n=48). For each patient in the OAT group, a control patient receiving microfracture was matched from our institutional cartilage registry for gender, lesion location and lesion size. Patients were prospectively evaluated at baseline, one,
two, three and five years by validated outcome measures including SF-36 scores, IKDC scores, KOS activities of daily living scale and Marx Activity Level scores. No significant baseline score differences existed between the two groups. Intra-group and inter-group comparison between parameters before and after mosaicplasty or microfracture was tested with use of the paired test; only two-tailed tests were used and P values of < 0.05 were considered significant.

RESULTS: In both groups, 32 patients were male (67%) and 16 patients were female (33%). The average age of patients at the time of surgery was 29.7 (range 15-49) for the OAT group versus 32.5 (range 15-46) for the MFX group. The mean body mass index (BMI) for patients in the OAT group was 25.2 (range 18-36) versus 25.5 (range 21-31) in the MFX group. In both groups there were 27 chondral lesions of the medial femoral condyle, 16 lateral femoral condyle and five trochlea. The average size of the chondral defect in the OAT group was 265 mm² (range 100-625 mm²), and 255 mm² (range 100-625 mm²) in the MFX group. At the latest follow up, both groups demonstrated significant increases in SF-36 scores, KOS activities of daily living scale and IKDC scores compared to baseline (all p< .05). In comparing the two groups, there was no significant difference in these scores at any time point in the study. However, for Marx activity scores, the OAT group demonstrated significantly greater improvement from baseline to the two (p=0.001), three (p=0.03) and five year (p=0.02) endpoints when compared to the MFX group (Figure 1).

DISCUSSION AND CONCLUSION: In the present prospective comparative study, we compared the MFX and OAT surgical techniques for symptomatic chondral lesions of the femoral condyles and matched groups for patient gender, location of lesion and size of lesion. We found that patients in both groups had a similar improvement in general health outcome and knee function at mid-term follow up. However, patients who had an autologous osteochondral mosaicplasty maintained a superior level of athletic activity compared to those who had a microfracture.

![Change in Marx Activity Level Over Time](image)

**PAPER NO. 283**

**Knee Chondrolysis After Surgery Following Intra-articular Bupivacaine Infusion: Series of 16 Knees**

Frank R. Noyes, MD, Cincinnati, OH

Cassie M. Fleckenstein, Cincinnati, OH

Sue Barber-Westin, Fort Myers, FL

**INTRODUCTION:** This is the largest series reported to date of severe chondrolysis after surgery caused by a continuous intra-articular (IA) pain pump bupivacaine infusion. Over five years, 16 patients with severe disabling knee symptoms were evaluated. We report the patient factors, extent of pathology and treatment after this devastating complication.

**METHODS:** The medical records of 16 patients with chondrolysis afterkneesurgery were reviewed and their clinical course determined.

All were referred for treatment of symptoms with daily living activities. A comprehensive physical examination with radiographs, and review of MRI and treatment records were conducted. Articular cartilage deterioration was documented through operative notes and radiographic criteria (IKDC). Knee symptoms and function was assessed with the Cincinnati Knee Rating System.

**RESULTS:** There were 13 females and three males whose ages ranged from 14-42 years. The original procedures included 13 ACL reconstructions, one meniscus repair, one tibial tubercle osteotomy and one arthroscopy. An intra-articular high flow volume pump (200-270 mL, 4 mL/hr) was used in nine patients, a low flow volume pump (90-120 mL, 2 mL/hr) was used in five patients, and in two the flow rate was not documented. The pump was filled with 0.5% bupivacaine in all cases and in seven knees, 1,200,000 epinephrine was added. Five patients also received an intra-articular bolus injection of bupivacaine with morphine and epinephrine at the conclusion of the procedure. The pumps were set to infuse medication for 48 hours in 12 patients, 72 hours in two patients, 96 hours in one patient, and the time was unknown in one patient. The mean time between the operative procedure and onset of symptoms was nine months (range, 3-24 months). In seven knees, all three of the knee compartments showed severe articular cartilage deterioration; in five knees, two compartments had deteriorated; and in four knees, one compartment had deteriorated. The affected compartments were the patellofemoral in 14 knees, medial tibiofemoral in 14 knees, and lateral tibiofemoral in seven knees, which was not related to a high or low flow rate. This suggests the position of the catheter and path of drug flow effected the compartment involved. After the index surgery, an additional 40 operative procedures were done a mean of 25 + 15 months in 15 patients, including 14 arthroscopic debridements, seven chondroplasties, two cartilage restoration procedures, two high tibial ostetomies, two ACL revision reconstructions, one total knee replacement and one partial femoral replacement. The menisci were intact at the time of the first follow-up arthroscopic debridement in 10 knees and required partial removal in four knees. In two other knees, partial meniscectomy had been performed during the index operation.

**DISCUSSION AND CONCLUSION:** Severe knee chondrolysis following surgery occurred in 16 knees after use of either a high or low flow pain pump with bupivacaine, producing disabling knee symptoms. A variety of operative procedures that attempted to alleviate symptoms were ineffective and all but one patient are delaying total knee replacement due to age-related factors. There was a relatively short period of time in the majority of patients from the index operative procedure to the onset of significant symptoms. No other factors such as thermal probe, infection, chemicals or foreign bodies were implicated. The menisci often appeared normal throughout the initial course of treatment (10 knees). Patients often presented with severe involvement of one to two knee compartments within months after pain pump use in which the diagnosis of this causal effect was not considered. The true incidence of knee chondrolysis is unknown. We strongly advise against the use of IA pain pumps after knee surgery.
PAPER NO. 284

How Reliable is the Radiographic Assessment of Healing of Osteochondritis Dissecans?

Shital Parikh, MD, Cincinnati, OH
Marcus Allen, Redford, MI
Eric Wall, MD, Cincinnati, OH
Tal Iaor, MD, Cincinnati, OH
Andrew M. Zbojniewicz, MD, Cincinnati, OH
Megan May, MD, Houston, TX
Gregory D. Myer, PhD, Cincinnati, OH
Emily A. Eismann, MS, Cincinnati, OH

INTRODUCTION: The current literature supporting treatment strategies for osteochondritis dissecans (OCD) has limited prognostic utility. In addition there is currently no gold standard for an OCD “healing” outcome. Accurate and reliable determination of OCD healed status based on radiographs would be a valuable advancement in the development of evidence guiding the treatment of OCD. The purpose of the study was to determine interrater and intrarater reliability in the assessment of radiographic healing of OCD lesions of the knee.

METHODS: Using a hospital database, 39 consecutive patients (42 knees) with OCD of the knee, who were treated conservatively for at least six months, were identified. The average age of these patients was 12 (±2.4) years. Two radiographs taken six months (± 1 month) apart were then selected and transferred to a presentation slide using lossless compression method (Fig A,B). A total of 102 slides were thus prepared with each slide containing two similar radiographic views from the same patient (total of 34 notch, 34 AP and 34 lateral views) taken six months apart. These slides were then categorized by four blinded reviewers (one orthopaedic surgeon, one orthopaedic fellow, two musculoskeletal radiologists) as healed, not healed or unable to evaluate the OCD lesion. Three reviewers repeated their assessment three weeks after their first read. Statistical analyses were performed using kappa coefficient and percentage agreement. Chi-square tests ($\chi^2$) were used to determine if there was a significant difference between the raters in the percentage of patients rated in each category.

RESULTS: The OCD lesion categorization demonstrated insufficient interrater reliability with a kappa of 0.44 and 63% agreement on the first read and a kappa of 0.42 and 61% agreement on the second read. On the first rating, all raters agreed only 40% of the time, and three of four raters agreed 70% of the time. The proportion of ratings in each category differed significantly between the raters on their first ($\chi^2 = 26.75, p < 0.001$) and second ratings ($\chi^2 = 20.90, p < 0.001$). The notch view had the highest interrater reliability with kappa of 0.63 and 76% agreement, and the lateral view had the lowest interrater reliability with kappa of 0.29 and 53% agreement.

DISCUSSION AND CONCLUSION: The radiographic assessment of OCD lesion demonstrated insufficient interrater reliability, i.e. there was no significant agreement between the reviewers on the ‘healing’ status of an OCD lesion on radiographic assessment. We suggest that standardization of radiographic views to include a notch view, and defining standard criteria to assess healing is needed to consistently evaluate OCD lesions of the knee in children.

PAPER NO. 285

Survivorship of Osteoarthritic Knee After Microfracture: Minimum 10-year Follow Up

Dae K. Bae, MD, Seoul, Republic of Korea
Sang Jun Song, Seoul, Republic of Korea
Kyoung Ho Yoon, MD, Seoul, Republic of Korea
Jong Ho Kang, MD, Seoul, Republic of Korea
Jung Keun Choi, MD, Seoul, Republic of Korea

INTRODUCTION: The purpose of this study was to evaluate survivorship and clinical results of microfracture in patients with degenerative osteoarthritic knee at minimum 10 years follow up. We also analyzed factors affecting the length of time to undergo total knee arthroplasty (TKA) after microfracture.

METHODS: Between March 1998 and February 2001, 142 consecutive patients (155 knees) diagnosed with moderate degenerative osteoarthritis had undergone arthroscopic microfracture. Out of 155 knees, 134 knees (120 patients) had follow-up data at minimum 10 years postoperatively. Their mean age at the time of operation was 61.3 years (40-75 years) and mean period of follow up was 11.2 years (10-12.9 years). All knees had a full-thickness chondral defect of Outerbridge grade IV on medial compartment. Survivorship was defined as not requiring TKA after microfracture. We evaluated possible factors affecting survivorship including gender, age, body mass index (BMI), the size of cartilage defect on medial femoral condyle (MFC) and medial tibia condyle (MTC), the presence of meniscus tear and the severity of preoperative varus deformity. Varus deformity was assessed in 78 knees by using the mechanical axis angle (MAA) and the mechanical axis percentage (MA%) on orthoroentgenogram. MAA was defined as the angle between femoral and tibial mechanical axes. MA% was defined as the percentage in which the mechanical axis (Misculicz line) bisects the total width of the tibia. The clinical result was assessed to the Knee Society score (KSS). Kaplan-Meier method and Cox proportional-hazard model was used to analyze survivorship and to identify predictors to have effect on survivorship.

RESULTS: Survivorship was 89% at five years and 61.9% at 12 years (fig 1). Fifty-four patients proceeded to TKA at a mean of 81 months (range: 15-136 months) after microfracture. Gender (p=0.411), age (p=0.854), the presence of meniscus lesions (p=0.316) and BMI (p=0.194) didn’t have effect on survivorship of microfracture. The size of cartilage defect, MAA and MA% was related to the length of time to undergo knee arthroplasty after microfracture. Survivorship of group with less than 2cm$^2$ in the size of cartilage defect and less than 5 degree in varus malalignment affected the likelihood of long-term survivorship after microfracture. Microfracture procedure in patients with moderate degenerative osteoarthritis was 61.9% at minimum 10 years follow up. The size of cartilage defect and the severity of varus deformity affected the likelihood of long-term survivorship after microfracture. Microfracture procedure in degenerative osteoarthritic patients with in less than 2cm$^2$ in the size of cartilage defect and less than 5 degree in varus malalignment seem to have improvement of clinical result at the long term follow up and delay the time to undergo knee arthroplasty after microfracture.
Distinct Gene Expression Patterns in Surface, Middle, and Deep Zones of Bovine Articular Cartilage

Derek Amanatullah, MD, Sacramento, CA
Shintaro Yamane, PhD, Sacramento, CA
A. Hari H. Reddi, PhD, Sacramento, CA

INTRODUCTION: The regeneration of articular cartilage remains a challenge and is an unmet clinical need in orthopaedic surgery. Since hyaline articular cartilage will not heal spontaneously, these lesions eventually lead to degenerative joint disease. A complete understanding of the responsive cells, inductive signals and extracellular scaffolding required for the recapitulation of embryonic development and morphogenesis (i.e., regeneration) remain elusive. METHODS: The superficial zone of bovine stifle joint femoral condyle articular cartilage (~100 µm) was harvested using a dermatome. An osteochondral plug was removed using a coring reamer and middle and deep zone articular cartilage (1.25 mm) were removed from each plug using a custom jig. Total mRNA was extracted, and after cRNA probe labeling, bovine genome array analysis was performed. Data analysis was performed using the dChip MFC Application v1.0.0.1. The results of the dChip comparison between the gene expression of the superficial and middle zone articular cartilage was input into analysis software to evaluate the changes in canonical signaling pathways as well as any cellular processes and networks involved. RESULTS: Microarray analysis of superficial and middle zone articular cartilage reveal 52 differentially expressed genes greater than 10-fold and 114 differentially expressed genes greater than five-fold. However, there were no genes identified with a greater than five-fold change in expression when comparing middle and deep zone articular cartilage. Changes in the gene expression of the TGF-β superfamily pathway play a critical role in cartilage differentiation. The expression of two bone morphogenetic proteins (BMPs), BMP4 and BMP5, were reciprocally expressed between the superficial and middle zones of articular cartilage. The expression of inhibin, beta a (INHBA), a member of the TGF-β superfamily and traditional inhibitor of FSH, as well as TGF-β3 were elevated 17.1- and 2.2-fold, respectively, in the superficial zone of articular cartilage. Changes in the gene expression of the Wnt pathway play a critical role in cartilage differentiation as well. The expression of known GSK3β inhibitory DKK1 was increased in superficial zone articular chondrocytes by 2.4-fold. The middle zone articular chondrocytes had an increased expression of several Wnt pathway inhibitors, including, FRZB, FZD1, and FZD9. Interestingly, we found no changes in the gene expression of genes involved in the hedgehog (Hh) pathway.

DISCUSSION AND CONCLUSION: The changes in gene expression between the superficial, middle and deep zones of articular cartilage reveal several key findings that will be critical to articular cartilage tissue engineering and regeneration. However, comparing the middle and deep zones of articular cartilage, only seven genes were changed out of 23,000 genes on the bovine genome array and no gene was changed more than five-fold suggesting these two zones appear more similar than anticipated. In contrast, when comparing the middle and superficial zones of articular cartilage 1,471 genes were changed suggesting that these zones are remarkably distinct. Our results characterize the superficial and middle zone of articular chondrocyte as highly specialized cell types and suggest that these cell types are distinct and that the specific analysis of these highly specialized cells must be required before routine cartilage regeneration becomes a reality.
Recent Trends in Arthroscopic Versus Open Rotator Cuff Repair and Acromioplasty in the United States

Alan Zhang, MD, Los Angeles, CA
Stephanie Ngo, BS, Los Angeles, CA
Jessica Ellerman, MD, Santa Monica, CA
Jeffrey C. Wang, MD, Santa Monica, CA
Sharon L. Hame, MD, Los Angeles, CA
Seth C. Gamradt, MD, Los Angeles, CA

INTRODUCTION: The treatment of shoulder pain due to rotator cuff tear and subacromial impingement has been controversial. In the past, the traditional surgical treatment of rotator cuff tears has been an open procedure, however, there has been a movement towards arthroscopic procedures over the last two decades. Recently, the necessity of acromioplasty in conjunction with rotator cuff repair has also been debated. The purpose of this study was to identify current trends in surgical treatment of rotator cuff tears across gender, age and region in the United States. We aimed to assess the extent to which surgeons have converted to arthroscopic rotator cuff repair and to identify current trends in the performance of an acromioplasty in the setting of rotator cuff repair.

METHODS: For the years 2004 through 2009, patients who underwent open rotator cuff repair (CPT codes 23410, 23412, 23420), arthroscopic rotator cuff repair (CPT code 29827) and in combination with acromioplasty (CPT codes 23415, 29826) were identified using a publicly available insurance record database. The type of procedure, date, gender, region of the country were identified for each patient. Logistic regressions and chi square tests were used to determine statistical significance.

RESULTS: In the database, there were 151,866 rotator cuff repair procedures identified from 2004-2009. There were 91,885 males (60%) and 59,981 females (40%). Patients aged 50-59 years showed the most rotator cuff repairs (42%) followed by those aged 40-49 years (28%). Overall, there were 98,174 arthroscopic rotator cuff repairs (65%) and 53,692 open repairs (35%). However, the annual number of arthroscopic procedures significantly increased (48.8% in 2004 vs. 74.3% in 2009) while the annual number of open procedures significantly decreased (51.2% in 2004 vs. 25.7% in 2009) (P<0.0001). Acromioplasty was performed in conjunction with arthroscopic rotator cuff repair overall in 47.3% of cases without significant change between 2004 and 2009 data. All regions of the U.S. showed similar surgical trends and trends for gender and age distributions.

DISCUSSION AND CONCLUSION: Our analysis shows that the majority of rotator cuff repairs in the U.S. are now performed arthroscopically (over 74%) and there has been a recent steady decline in performance of open rotator cuff repair. This trend is likely the result of improved arthroscopic rotator cuff repair technology and change in surgeon preference. Acromioplasty is performed with rotator cuff repair about half of the time and the rate of acromioplasty has not changed since 2004. This database study shows surgeon preference for open rotator cuff repair continues to decline in the United States. This trend toward an increase in arthroscopic surgery was consistent across age, gender and region in the United States.

Factors Most Closely Associated with Functional Outcomes in Rotator Cuff Repair

Vasili Karas, BS, Chicago, IL
Elizabeth S. Tetteh, MD, Chicago, IL
Emery Lin, BA, Chicago, IL
Richard C. Mather, III, MD, Traverse City, MI
Anthony A. Romeo, MD, Chicago, IL
Nikhil N. Verma, MD, Chicago, IL
Brian J. Cole, MD, Chicago, IL

INTRODUCTION: Reduction in pain and restoration of strength are the two primary goals of rotator cuff repair. The objective of this study was to determine if subjective (pain) or objective (strength) measures correlate to patient satisfaction, functional outcomes, validated disease specific outcome measures and general quality of life metrics. We hypothesize that both overall satisfaction and quality of life metrics will correlate more closely to a decrease in pain rather than an improvement in strength. Conversely, validated functional outcome scores will more closely correlate with strength rather than pain.

METHODS: We performed a retrospective review of patient data from a level I randomized controlled trial on the effect of acromioplasty in rotator cuff repair. Pre and post-operative data was collected and outcomes at one year were examined. Pain and strength were the primary predictive variables. Strength was measured in an isometric fashion using a digital dynamometer by independent observers. Pain was measured by VAS scale. The degree of correlation among strength, pain and three primary groups of outcomes was examined. These groups were: 1) validated, disease-specific outcome measures including the American Shoulder and Elbow Surgeons score (ASES), the Constant score (CS) and Simple Shoulder Test (SST); (2) general quality of life measured by the SF-12; and (3) measurement of perceived utility by the SF6-D. The degree of change in pain and strength was compared to patient and disease specific characteristics including sex, age, worker’s compensation status and tear size. The extent of correlation was assessed using Spearman’s rank correlation with correlation coefficients of >0.50, 0.35-0.50 and <0.35 considered strong, moderate and weak, respectively with <0.05 considered statistically significant.

RESULTS: Change in strength (forward flexion) correlated with two outcomes, change in SF-12 (0.327) and SST (0.395). Change in pain was correlated only with the change in the ASES. Postoperative SF6-D correlated positively (0.35) with a change of strength in forward flexion and negatively (-0.42) with a change in VAS score.

DISCUSSION AND CONCLUSION: Our results suggest that
increases in strength correlate with improvements in general quality of life (SF-12) for patients who undergo rotator cuff repair. Perceived utility (SF6-D) correlated moderately with, an increase in strength as well as a decrease in pain. Among validated outcome measures, pain correlates with the ASES and strength with the SST. Of note, overall correlations were weak and no validated outcome measure correlated with both strength and pain. This finding suggests these outcome measures may be unable to capture basic treatment effects and development of novel, more accurate measures may be indicated.

PAPER NO. 469
Early Mobilization Following Mini-Open Rotator Cuff Repair

Robert Balyk, MD FRCS(C), Sherwood Park, AB, Canada
Matthew Souster, MD, Edmonton, AB, Canada
Charlene Luciak-Corea, Edmonton, AB, Canada
Fiona Styles-Tripp, PT, Edmonton, AB, Canada
Martin Bouliane, Edmonton, AB, Canada
Jeff Bury, MD, Edmonton, AB, Canada
Robert R. Glasgow, MD, FRCS, Edmonton, AB, Canada
Lauren Beaupre, PhD, Edmonton, AB, Canada
David M. Sheps, MD, Edmonton, AB, Canada

INTRODUCTION: Mini-open rotator cuff repair (MORCR) is a common treatment for rotator cuff (RC) disease. Traditional shoulder rehabilitation supports immobilization for the initial six postoperative weeks to promote tendon healing. However, delayed range of motion (ROM) may slow the return of shoulder ROM, increase the risk of stiffness and disrupt patients' quality of life. The effect of early motion and the subsequent effect on clinical outcomes are unknown in humans. Our objective is to evaluate the clinical outcomes following MORCR treated with early ROM compared to those who followed the standard immobilization protocol.

METHODS: A total of 187 patients with radiographically-confirmed full-thickness RC tear underwent a MORCR performed by fellowship-trained upper extremity surgeons (n=6). Subjects were randomized to one of two treatment groups following a preoperative assessment of shoulder pain, ROM, abduction strength and health-related quality of life (HRQL) using a disease-specific measure. During the first six postoperative weeks, subjects randomized to early mobilization (n=97) self-weaned from the shoulder immobilizer and performed painfree active ROM for activities of daily living (ADLs) while the standard immobilization group (n=90) wore a sling. Both groups completed identical rehabilitation protocols after six weeks. Shoulder ROM and pain were assessed at six weeks and three months postoperatively. At six months, subjects had their abduction strength and HRQL assessed in addition to shoulder pain and ROM.

RESULTS: The two groups were similar preoperatively in power, ROM, HRQL and pain (p>0.10). Six-week ROM comparisons demonstrated that the early mobilization group had increased abduction (p=0.03), flexion (p=0.01) and scaption (p=0.003), but these differences disappeared by three months (p>0.32). There was no difference in power (p=0.85) or HRQL (p=0.72) between groups at six months.

DISCUSSION AND CONCLUSION: Patients who performed painfree active ROM for ADLs had no significant difference in power, ROM, HRQL or pain at six months compared to those who were immobilized for six weeks following MORCR. Early ROM did not show any significant benefits for minimizing long-term stiffness and pain, but clinically there was no compromise of their postoperative shoulder power or HRQL. Consideration should be given to allow patients to start actively using their shoulder within the first six weeks following a MORCR.

PAPER NO. 470
Immobilization in External Rotation Following Primary Shoulder Dislocation: A Meta-analysis

Daniel Whelan, MD, Toronto, ON, Canada
Stephanie N. Kletke, BS, Toronto, ON, Canada
Bruce S. Miller, MD, Ann Arbor, MI

INTRODUCTION: Anterior shoulder dislocations are common traumatic injuries that often result from sports participation. The recurrence rate following primary anterior shoulder dislocation is high, especially in active, young individuals. Recent studies have suggested external rotation immobilization as a method to reduce the rate of recurrence of shoulder dislocation in comparison to the traditional sling immobilization. The primary aim of this review was to assess and summarize evidence from randomized controlled trials (RCTs) on the effect of internal (IR) versus external rotation (ER) immobilization on the rate of recurrence following primary anterior shoulder dislocation.

METHODS: Medline, Cochrane and Embase databases were searched using an identical search string. RCTs of Levels of Evidence I or II comparing internal versus external rotation immobilization were identified, and a total of three articles were selected after an initial screening process. A Pubmed search was also performed using the keywords “primary shoulder dislocation external rotation immobilization”; 16 repeat articles were obtained, two further articles were excluded, and one was selected for the meta-analysis. Next, a search was done of available proceedings from professional meetings, which produced two further abstracts that were included in the review, for a total of six studies.

RESULTS: Six randomized controlled trials (n=561) were included in the review; four studies contained published data and two studies contained unpublished data. Demographic and prognostic variables measured at baseline were similar in the pooled groups. Average age was 28.6 years in the pooled ER group and 29.0 years in the pooled sling group. One study found that ER immobilization reduced the rate of recurrence after initial anterior shoulder dislocation compared with conventional IR immobilization, whereas four studies found no significant difference between the two groups. The final study found a significant benefit of ER immobilization, but only for individuals aged 21-30 years. The recurrence rate was higher when treated with IR immobilization (82/243, 33.7%) than when treated with ER immobilization (77/262, 29.4%), and this difference was not found to be significant (p>0.25).

Immobilization in ER was associated with a relative risk reduction of 14% with confidence intervals that included equivalence (RR 0.86, 95% CI 0.66 to 1.11). Four of the six studies measured patient compliance with the randomized immobilization device. The compliance rate was higher in the ER group (177/236, 75%) versus the sling group (132/222, 59.5%). Western ON Shoulder Instability Index (WOSI) scores were pooled across two studies, and there was no significant difference between the two groups (p=0.52).

DISCUSSION AND CONCLUSION: Immobilization in ER may not be as effective as previously described in reducing the recurrence rate following primary anterior shoulder dislocation. This review suggests that there is minimal difference in the patient’s own perception of their health related quality of life following immobilization in internal versus external rotation.

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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
Outcomes After Bankart Repair in a Military Population: Predictors for Surgical Revision and Long-Term Disability

Brian Waterman, MD, El Paso, TX
Travis C. Burns, MD, San Antonio, TX
Kelly G. Kilcoyne, MD, Bethesda, MD
Brendan J. McCriskin, MD, El Paso, TX
Kenneth L. Cameron, PhD, West Point, NY
Brett D Owens, MD, West Point, NY

INTRODUCTION: Surgical stabilization for shoulder instability is common for military service members due to their unique physical demands. However, few studies have examined the factors associated with surgical failure after Bankart repair in the military population.

METHODS: All Army patients undergoing arthroscopic or open Bankart repair of the shoulder (Current Procedural Terminology codes 29806 or 23455, respectively) for diagnoses related to shoulder instability (International Classification of Disease Ninth Edition code 718.31, 718.81, 831.00) were isolated from the Military Health System Management Analysis and Reporting Tool (M2) between 2003 and 2010. Demographic variables including age and gender were extracted, as were surgical variables including treatment facility volume, patient status (inpatient vs. outpatient) and type of surgical procedure (open vs. arthroscopic). Rates of surgical failure, defined as subsequent revision surgery or medical discharge with persistent shoulder disability, were recorded from the electronic medical record and U.S. Army Physical Disability Agency database. We calculated standard descriptive statistics including means and standard deviations (SD) for continuous variables and counts and frequencies for categorical variables. Initially, we evaluated the importance of factors associated with failure using univariate t-tests and chi square tests for continuous and categorical variables, respectively. Variables that were associated with failure were then carried forward into a multivariable logistic regression model with failure as the outcome.

RESULTS: A total of 3,854 patients underwent Bankart repair during the period of study, with 3,230 (84%) of procedures performed arthroscopically and 624 (16%) performed open. The majority of these stabilizations were performed on an outpatient basis (n=3255; 84%), compared with 599 (16%) who received inpatient care. Patients were predominately male (n=3531; 92%), with females representing only 8% (n=323). The mean age of the cohort was 28.0 years (SD=7.5). A total of 193 (5.0%) of patients underwent revision stabilization during this timeframe, while 237 (6.2%) patients were medically discharged with complaints of shoulder instability resulting in a total combined failure rate of 8.6% (n=330). Univariate analyses showed no significant effect for gender; however, younger age, higher facility volume, open repair and inpatient status were significant factors associated with subsequent failure. Multivariable analyses controlling for these factors confirmed that all factors except facility volume were independently associated with failure. In adjusted analyses, for every one year increase in age there was a 7% decrease in the likelihood of failure (OR=0.93, 95%CI:0.91, 0.95, p<0.001). Furthermore, patients undergoing an arthroscopic repair were 50% less likely to experience a subsequent failure when compared to patients treated with an open procedure (OR=0.50, 95%CI:0.35, 0.72, p<0.001). Finally, those who underwent outpatient procedures were 41% less likely to have a subsequent failure when compared to those receiving inpatient care (OR=0.59, 95%CI:0.41, 0.85, p=0.005).

DISCUSSION AND CONCLUSION: Patients with arthroscopic Bankart repair had a 50% lower failure rate than patients receiving open procedures for shoulder instability. Similarly, young age remains a significant risk factor for surgical failure after Bankart repair, while facility surgical volume did not appear to be significant after controlling for patient age. Despite advances in surgical technique, nearly one in 10 military service members failed surgical management in the current study.

The Effect of Platelet-Rich Fibrin Matrix on Rotator Cuff Healing in a Rat Model

Saqib Hasan, BS, New York, NY
Samir Nayar, MD, Amherst, NY
Kunal Kalra, MD, New York, NY
Meredith Mayo, BA, Atlanta, GA
Martin Quirno, MD, New York, NY
Laith M. Jazrawi, MD, New York, NY
Eric Strauss, MD, New York, NY

INTRODUCTION: Healing following a rotator cuff repair occurs via fibrous scar tissue formation that is structurally and biomechanically different from native tissue. Failure to recapitulate the normal morphology of the tendon-bone enthesis has been theorized to contribute to structural failure of repairs. Platelets have long been shown to play an instrumental role in the normal healing response via the local secretion of growth factors and recruitment of reparative cells. The use of autologous platelet-rich fibrin matrix (PRFM) provides a sustained vehicle of growth factor delivery to augment tendon-bone healing post-surgical repair. The purpose of the current study was to determine if the application of platelet-rich fibrin matrix could improve regeneration of the tendon-bone insertion site in a rat rotator cuff repair model.

METHODS: Twenty-four Lewis in-bred rats underwent bilateral tenotomy and repair of the supraspinatus tendon. Six separate specimens were used for PRFM harvest. Trans-osseous rotator cuff repairs were performed on one shoulder without PRFM with the repair site augmented with PRFM on the contralateral shoulder. Animals were sacrificed at two-week and four-week time intervals for biomechanical and histological analysis of the structural and cellular properties of the tissue at the repair site. Based on pre-study power analysis, nine specimens were used for histological testing and three for histological analysis to achieve a power of >0.80 at α = 0.05. The mean differences in our parameters were analyzed for significance with α = 0.05 using a paired Student t-test.

RESULTS: At two weeks, there was a significant increase in ultimate load to failure (N) in the PRFM group (6.7 N +/- 1.7) as compared to the control group (4.3 N +/- 1.4). However, this increase was no longer realized at the four-week time interval. A non-significant increase in cross-sectional area of the tendon repair site was noted to be present in the PRFM group at two weeks (7.1 mm² +/- 0.8) and four weeks (9.2 mm² +/- 1.2) compared to the control group at two weeks (6.7 mm² +/- 0.8) and four weeks (7.5 mm² +/- 1.1). On histological analysis, statistically significant increases in collagen organization were seen in the control group when compared to the PRFM group at four weeks, but not at two weeks. In addition, statistically significant greater areas of new cellular properties of the tissue at the repair site. Based on pre-study power analysis, nine specimens were used for histological testing and three for histological analysis to achieve a power of >0.80 at α = 0.05. The mean differences in our parameters were analyzed for significance with α = 0.05 using a paired Student t-test.

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cartilage formation were observed for the control group at both two weeks and four weeks when compared to the PRFM group. 

**DISCUSSION AND CONCLUSION:** The addition of platelet-rich fibrin matrix to augment rotator cuff repair in a rat model resulted in increases in cuff strength at two weeks but not at four weeks. Additionally, PRFM did not significantly improve collagen formation at the enthesis site and may, conversely, have an inhibitory role.

**PAPER NO. 473**

**History of Shoulder Instability and Subsequent Injury during Four Years of Follow-up: A Survival Analysis**

*Brett D Owens, MD, West Point, NY*

*Michele L. Duffey, MS*

*Thomas M. DeBerardino, MD, Farmington, CT*

*Sally B. Mountcastle, PhD, Sammamish, WA*

*Bradley J. Nelson, MD, Minneapolis, MN*

*Steven J. Svoboda, MD, West Point, NY*

*Kenneth L. Cameron, PhD, West Point, NY*

**INTRODUCTION:** Little is known about the risk factors for glenohumeral joint instability. We hypothesized that a prior history of instability would be a significant risk factor for subsequent injury.

**METHODS:** We conducted a prospective cohort study over a four-year period within a high risk group of young athletes to address the research hypothesis. Subjects were freshmen entering a U.S. Service Academy in June of 2006. Part of the baseline assessment included documenting a prior history of instability upon entry into the study. All subjects were followed for subsequent glenohumeral joint instability events until graduation in May of 2010. The primary outcome of interest in this study was time to glenohumeral instability event during the follow-up period. We examined injury outcomes for any instability, anterior instability and posterior instability events. Cox proportional hazards regression models were used to analyze the data with shoulder as the unit of analysis.

**RESULTS:** Baseline data for a prior history of glenohumeral joint instability were available for 1,424 shoulders, of which 126 had a prior history. Time to a subsequent instability event was available for 1,420 (99.7%) shoulders during the follow-up period, with 46 (39 anterior and seven posterior) instability events documented. Subjects with a prior history of instability were over five times (HR=5.38, 95% CI: 2.90, 9.96, p < .001) more likely to sustain an acute (anterior or posterior) instability event during follow up. Similar results were observed in multivariable models after controlling for sex, race and generalized joint hypermobility.

**DISCUSSION AND CONCLUSION:** Despite meeting the rigorous physical induction standards for military service, subjects with a prior history of instability events documented. Subjects with a prior history of instability were over five times (HR=4.60, 95% CI: 0.89, 23.71, p = .068) more likely to experience a subsequent anterior instability event and posterior instability event during follow up. Survival estimates by group are presented in Figure 1. Subjects with a history of instability were also 5.6 times (HR=5.39, CI: 2.87, 10.88, p < .001) more likely to experience a subsequent anterior instability event and 4.6 times (HR=4.60, 95% CI: 0.89, 23.71, p = .068) more likely to experience a posterior instability event during follow up. Similar results were observed in multivariable models after controlling for the influence of sex, race and generalized joint hypermobility.

For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
Gregory P. Nicholson

80.8 (range 10.0 to 100.0, SD 20.0). The mean post-operative and labral repair (one). The mean post-operative SANE score was distal clavicle excision (10), anteroinferior stabilization (two) repair included subacromial decompression (34), biceps tenodesis. Concomitant procedures performed at the time of rotator cuff surgery included 38% (12/32) of these related to an athletic event.

RESULTS: A total of 60% (32/53 of the patients had a traumatic Shoulder and Elbow Society (ASES). Revision surgery or post-operative SANE (p = .012) scores at the time of final follow up. Excluding partial repairs, the UCLA score improved from 16.4 to 29.8 in the group I compared to 15.2 to 32.8 in group II (p = .007), and pain improved from 6.2 to 1.5 in group I compared to 6.8 to 0.5 in group II (p = .033). At final follow up, patients in group I rated their shoulder as 84.4% of normal compared to 93.5% of normal in group II (p = .006). In multivariate analysis of complete repairs a double-row repair was 4.9 times more likely to lead to a good or excellent UCLA functional outcome (95% CI, 1.3 - 18.8; p = .021).

DISCUSSION AND CONCLUSION: A good or excellent long-term functional outcome can be achieved in the majority of cases with ARCR of massive RCTs. Preoperative active external rotation past neutral and a complete repair are associated with improved long-term functional outcome. While this study was retrospective and non-randomized, a double-row repair improved the functional outcome of massive RCTs. Given the known high risk of recurrence following repair of massive RCTs and the knowledge that functional outcome is related to recurrence, our data suggests that when there is sufficient tendon mobility a double-row repair should be performed for massive RCTs.

PAPER NO. 475
Arthroscopic Primary Rotator Cuff Repairs in Patients under the Age of 45
Emery Lin, BA, Chicago, IL
Aman Dhawan, MD, Manalapan, NJ
Seth Sherman, MD, Columbia, MO
Kevin C. McGill, MD, MPH, Royal Oak, MI
Matthew T. Provencher, MD, San Diego, CA
Gregory P. Nicholson, MD, Chicago, IL
Brian J. Cole, MD, Chicago, IL
Anthony A. Romeo, MD, Chicago, IL
Nikhil N. Verma, MD, Chicago, IL

INTRODUCTION: Rotator cuff tears are a common cause of shoulder pain. However, to date, the majority of reports following outcomes of arthroscopic rotator cuff repair have been described in patients over 50. The purpose of this study is to evaluate the mechanism of injury and clinical outcomes following arthroscopic primary repair of full-thickness rotator cuff tears in patients under the age of 45. We hypothesized that patients under the age of 45 would have similar improvements in pain and function as compared to an older population.

METHODS: A total of 70 consecutive patients were reviewed in a multicenter (two) retrospective study. Fifty-three patients, with a mean age of 37.5 years (range 16.2 to 44.9 years), were available for follow up at a mean of 35.8 months (range 13.8 to 59.1 months). Exclusion criteria included patients with revision procedures, repair of partial tears and follow up less than 12 months. Follow-up examinations included range of motion testing and clinical outcome measures including Single Assessment Numeric Evaluation (SANE) and American Shoulder and Elbow Society (ASES). Revision surgery or post-operative ASES score less than 50 were considered failure criteria.

RESULTS: A total of 60% (32/53) of the patients had a traumatic etiology, with 38% (12/32) of these related to an athletic event. Concomitant procedures performed at the time of rotator cuff repair included subacromial decompression (34), biceps tenodesis (24), acromioplasty (17), coracocapitular ligament release (five), distal clavicle excision (10), anteroinferior stabilization (two) and labral repair (one). The mean post-operative SANE score was 80.8 (range 10.0 to 100.0, SD 20.0). The mean post-operative ASES score was 84.6 (range 21.6 to 100.0, SD 16.8), with two patients recording ASES scores less than 50 (21.7 and 41.7) at final follow up. In the 38 patients available for clinical follow-up exam, forward flexion improved from 158.7 (range 45 to 180, SD 33.2) to 168.4 (range 120 to 180, SD 17.3, p<.014). No significant change in external rotation was noted. At the time of follow up, zero patients had undergone revision surgery. Two patients (4.0%) were considered failures based on poor clinical outcome scores.

DISCUSSION AND CONCLUSION: The results of this study indicate that arthroscopic primary rotator cuff repair of full thickness tears in patients younger than 45 provides reliable pain relief and restoration of shoulder function in this unique patient population. Longer-term studies are required to determine if similar results are maintained in young rotator cuff patients over time.

PAPER NO. 476
Pelvic Stability and Scapular Kinematics in Youth Baseball Pitchers
Michael P. Beckett, MD, Santa Monica, CA
Christopher R. Ropiak, MD, Scotch Plains, NJ
Karen J. Mohr, PT, Los Angeles, CA
Orr Limpisvasti, MD, Anaheim, CA

INTRODUCTION: Hip abduction strength, hip range of motion (ROM) and scapular kinematics are necessary components to the throwing kinetic chain. Each is vital for the initiation and transfer of energy from the lower body to the upper extremity. Any break in this chain due to weakness, decreased ROM or scapular dyskinesis may increase stress and torque on upper extremity structures possibly leading to poor throwing mechanics and increased incidence of shoulder, elbow and knee injuries. We will evaluate hip and core strength, hip ROM and scapular kinematics in asymptomatic youth baseball pitchers--a significant at-risk population for shoulder and elbow injuries. Secondly, we will assess any link between scapular dyskinesis and hip abduction weakness or hip ROM deficits.

METHODS: A total of 150 youth baseball pitchers, aged 7-18 were tested. Scapular function/dyskinesis and pectoralis minor tightness were assessed, both according to Kibler’s protocol. Hip abductor strength was measured using a handheld digital dynometer in the side-lying position with the pelvis stabilized and by performing a single leg squat test. Hip ROM was measured using a handheld goniometer in the prone position with the pelvis stabilized. RESULTS: There were abnormalities with scapular dyskinesia in both the dominant and non-dominant shoulders. More normal kinematics were seen in the youngest age groups, with pathology mostly noted in the non-dominant shoulder. There is an increasing incidence of scapular dyskinesia in the dominant arm with increasing age. Almost all of the pitchers in all age groups had hip abductor weakness and failed the single-leg squat test with an almost 100% incidence in kids under 14. There was a slightly decreasing incidence with increasing age. DISCUSSION AND CONCLUSION: Scapular dyskinesia and pectoralis minor tightness were more prevalent with increasing age. This may be due to overuse or more per year. These breaks in the throwing kinetic chain may increase stress and torque on upper extremity structures possibly leading to poor throwing mechanics and increased incidence of shoulder, elbow and knee injuries. We will evaluate hip and core strength, hip ROM and scapular kinematics in asymptomatic youth baseball pitchers–a significant at-risk population for shoulder and elbow injuries. Secondly, we will assess any link between scapular dyskinesis and hip abduction weakness or hip ROM deficits.

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The Biomechanical Stability of Distal Clavicle Excision vs. Acromioclavicular Joint Resection

Nikhil Pandhi, DO, Farmington, MI
Amanda Esquivel, PhD, Warren, MI
Jeffrey S. Staron, MD, Munster, IN
Jason D. Hanna, MD, Fort Wayne, IN
Stephen E. Lemos, MD, PhD, Warren, MI

INTRODUCTION: A variety of conditions such as osteoarthritis, trauma and osteolysis affect the acromioclavicular (AC) joint, leading to persistent pain. Surgical treatment is often suggested if conservative treatment does not provide sufficient pain relief. Surgical treatment of choice is distal clavicle excision (DCE), often arthroscopically. A post-operative complication associated with DCE is instability, leading to persistent AC joint pain. Various studies have shown that under-resection of the AC joint may also result in AC joint pain postoperatively. It would therefore be advantageous to preserve AC ligament insertion sites while avoiding under-resection. The purpose of this study was to determine the strength and stiffness after both distal clavicle excision (DCE) and symmetric acromioclavicular joint resection (ACJR) during simulated physiologic loading. METHODS: Twenty matched, fresh-frozen human cadaveric shoulders were randomly assigned to one of two groups: DCE (10 mm of distal clavicle, n=10) and ACJR (5 mm of distal clavicle and 5mm of acromion, n=10). Prior to resection, the stability of each AC joint was tested. The specimens were preconditioned in the AP plane using a servohydraulic materials testing machine. Specimens were loaded in the AP plane at 70 N for 10 cycles to determine anteroposterior translation prior to resection; this was repeated after resection. Mean displacement was recorded for each specimen. The AC joint capsule and superior stabilizing ligaments were preserved during the resections. The specimens were then loaded at 2 mm/s in the AP plane until clinical failure which was defined as 15 mm of displacement. Peak load and stiffness were compared using a paired t-test (p<0.05). RESULTS: The peak load to failure for the DCE and ACJR groups was 387.8 N and 468.5 N. The ACJR group was significantly stronger (p=0.035). The average stiffness for each group was 35.2 N/mm (DCE) and 37.4 N/mm (ACJR). There was no significant difference in stiffness between the groups (p=0.11). There was no significant difference in the anteroposterior translation before and after resection for either group (p>0.05). DISCUSSION AND CONCLUSION: The superior, inferior, anterior, posterior ligaments and capsule of the acromioclavicular joint, along with the coracoclavicular ligaments (conoid and trapezoid), provide the vast majority of its stability. Both DCE and ACJR can disrupt these crucial structures, leading to a post-operative complication of increased AC joint laxity, instability and subsequent pain, which may require additional surgery for stabilization. In this cadaveric study, symmetric resection of both the clavicle and acromion created a more stable joint than resection of the distal clavicle alone when loaded in an anterior to posterior direction. Horizontal instability is well documented after over resection of the distal clavicle. Symmetric AC joint resection also increases the likelihood of preservation of the trapezoid ligament, which has been shown to be compromised with the traditional 1 cm DCE or even greater over-resection. The results of this study are supported by the attempt to create a more “anatomic” resection to preserve optimal native anatomy of the AC joint while still treating the pathologic condition. This is a proof-of-concept study that will lead to a future clinical trial examining the outcomes in patients who receive either surgical treatment.

Prediction of In-season Shoulder Injury from Preseason Testing in D1 Collegiate Football Players

Marisa Pontillo, PT, DPT, Philadelphia, PA
Brian Sennett, MD, Philadelphia, PA
Bryan Spinelli, PT, Philadelphia, PA

INTRODUCTION: Collegiate football is a high-demand sport in which shoulder injuries account for approximately 20% of injuries. Although many are traumatic in nature, some are due to repetitive stresses and those at risk could potentially be identified prior to a season. The purpose of this study is to investigate if a relationship exists between various pre-season testing measures and whether an injury was sustained that following season. METHODS: Twenty-six collegiate football players (mean age = 19.6 years, range = 18-22 years; mean body mass index (BMI) = 28.8; 15 offensive and 11 defensive players; 23 right-hand dominant) were examined prior to their fall season. Pre-season testing consisted of an outcome score (Penn Shoulder Score); a rotational profile for shoulder range of motion (ROM); isometric strength by hand-held dynamometer for external rotation at 90 degrees (ER) and forward elevation (FE) in the plane of the scapula; fatigue testing in three positions, and the Closed Kinetic Chain Upper Extremity Stability test (CKCUEST). The fatigue testing consisted of scaption, standing cable press, and prone-Y, utilizing a percentage of body weight as resistance, measuring repetitions to fatigue. Data collected post-season included which athletes sustained shoulder injuries, side injured, and type of injury. PASWStatistics18 was used for statistical analysis. Data was divided into left and right shoulders. Logistic regression was used to determine if the testing measures predicted injury on a specified side for each subject. RESULTS: Three athletes sustained left shoulder injuries and three sustained right shoulder injuries during the season. For both the left and right shoulders, when the predictor variables were considered together, they significantly predict whether that player would sustain an injury the following season (p<0.05). The variables which individually were significantly correlated to injury were FE strength, prone-Y to fatigue, and the CKCUEST on the right; on the left, only the CKCUEST was significant, with a trend with scaption. DISCUSSION AND CONCLUSION: Using a battery of strength, fatigue and functional testing may be helpful in identifying football players pre-season who are at a higher risk for sustaining a shoulder injury. This information can be used to optimize pre-season testing and implementation of injury prevention programs.
METHODS: Twenty matched, fresh-frozen human cadaveric shoulders were randomly assigned to one of two repair groups: simple suture repair and vertical mattress repair. A pressure mapping sensor was placed on the intact glenoid surface. A baseline measurement was taken for each specimen using a materials testing machine applying loads of 220N and 440N (3X for each load) through the humeral head. Pressure was recorded for 0, 45, and 90 degrees of shoulder abduction. After creation of the Bankart lesion and repair, the pressure testing protocol was repeated. Mean contact pressure over the entire surface and peak force of the most loaded senson were recorded. The repairs were then loaded to failure and peak load, and stiffness were recorded. Data comparing intact to repair were analyzed by repeated measures ANOVA and data comparing the two repairs were compared by paired t-test (p<0.05).

RESULTS: There was a significant (p<0.05) increase in contact pressure and the peak pressure after repair for both groups at 90 degrees abduction at both 220 N (Table 1) and 440 N (Table 2) of force. There was a significant increase in peak pressure after repair for both groups at 45 degrees abduction and 220 N of force. There was no significant difference between the two repair groups. There was no significant difference in peak load between the simple group (356 N) and the vertical group (396 N). There was no significant difference in stiffness between the simple group (38 N/mm) and the vertical group (40 N/mm).

DISCUSSION AND CONCLUSION: Surgical procedures have the potential to change the contact pressure and peak forces inside the glenohumeral joint. Greis et al. investigated changes in articular contact area and pressures across the glenohumeral joint with progressive loss of the labrum and glenoid. They found a decrease in contact area and increase in mean contact pressure with the loss of the anteroinferior labrum. These alterations result in changes in joint loading mechanics and can ultimately hasten the degenerative process at the articular surface. In our study, we found no significant difference in peak pressures and mean contact pressures between the simple repair group and the vertical repair group. This would suggest that pressure patterns may not be affected if the knot for a labral repair is placed on the articular surface versus outside the articular surface. We did find a significant increase in peak pressure and mean contact pressure in both repair groups which could lead to early degenerative changes in the joint. Joint loading properties can be affected by alterations in the contact pressures within the glenohumeral joint. These alterations can occur after repairs to the labrum.

Table 1: Mean contact pressure and peak contact pressure before and after repair – 220 N (*significantly elevated from intact joint)

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<td>Simple Repair</td>
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Table 2: Mean contact pressure and peak contact pressure before and after repair – 440 N (*significantly elevated from intact joint)

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*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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
Long-term Results of Arthroscopic Meniscectomy: A Minimum 20 Years of Follow Up

Wojciech Widuchowski, MD, PhD, Piekary Slaskie, Poland
Ryszard Faltus, PhD, Piekary Slaskie, Poland
Piotr Lukasik, MD, PhD, Chorzow, Poland
Grzegorz Kwiatkowski, Piekary Slaskie, Poland
Bogdan Koczy, MD, Piekary Slaskie, Poland
Jerzy Widuchowski, MD, Katowice, Poland

INTRODUCTION: We aimed to evaluate to what extent arthroscopic meniscectomy has an impact on clinical outcomes and osteoarthritis (OA) progression in long-term follow up. METHODS: A total of 157 patients with isolated meniscal lesion and performed arthroscopic meniscectomy (160 knees) were included in this study. There were 110 medial and 50 lateral meniscal lesions. A total portion of 64% of all lesions were longitudinal (including bucket-handle lesions) and in 91% of cases they were traumatic lesions. The posterior portion of medial meniscus and mid portion and posterior portion of lateral meniscus were the most frequent localization of lesions. The meniscus rim was left intact during the surgery and meniscectomy was considered as partial or subtotal. The average age at time of surgery was 31 years (range; 16-50) and the average follow-up period was 22 years (range; 20-25). Clinical evaluation of the results are based on established scores (Lysholm, Tegner, IKDC). Radiographic evaluation was performed according to Kellgren-Lawrence scale. RESULTS: A total of 120 of initial 160 patients (75%) could be evaluated at follow up. According to IKDC score, 83% of patients had normal (A) or nearly normal (B) knee joints, 13% were abnormal (C) and 4% severely abnormal. The mean Lysholm and Tegner score were 87.8 and 5.9, respectively. Return to sports occurred in 70% cases, 20-25 years later. Comparing to preoperative status, in 50% of 120 patients osteoarthritic changes were observed at follow up: 31% of K-L1, 15% of K-L2 and 4% of K-L3. Lateral and subtotal meniscectomy resulted in more frequent and severe OA comparing to medial and partial meniscectomy (p = 0.002).

DISCUSSION AND CONCLUSION: Satisfactory clinical subjective and objective results may be obtained after arthroscopic meniscectomy with long-term follow up. An isolated tear treated by meniscectomy is associated with higher risk of radiographic and symptomatic tibiofemoral OA. Medial meniscectomy and partial resection is associated with less radiographic OA than lateral and subtotal meniscectomy. However, the development and progression of osteoarthritis seems to be influenced by other local and systemic factors. Limited partial meniscectomy may be reliable treatment when surgical repair of meniscal lesions is not possible.

MRI Based Topographic Differences between Normal and Recurrent Patellofemoral Instability Patients

Michael D. Charles, BS, BA
Sean Haloman, MD, Seattle, WA
Lina Chen, MD, Catonsville, MD
Samuel R. Ward, PhD, La Jolla, CA
Donald C. Fithian, MD, El Cajon, CA
Robert Afra, MD, Solana Beach, CA

INTRODUCTION: Plain films and CT based imaging were the first to establish measurements that evaluated patellar instability. Limited research has shown MRI’s efficacy in evaluating these established measurements. The aim of this study is to identify morphological differences between normal knees and those with patellofemoral instability on MRI imaging in order to determine what measurements are significant and the value at which each measurement signifies pathology. METHODS: This was a retrospective review of 82 patients with no patellofemoral history and 42 patients with recurrent patellar instability. Normals had no present symptoms or history of patellofemoral complaints and an exam negative for patellar grind, facet tenderness, and apprehension. Patients with patellar instability must have a history with at least two frank patellofemoral joint dislocations (PFJD). MRI images were obtained with a non-weight bearing knee in full extension. Patellar tilt was evaluated on axial slices and patellar station was measured on sagittal images. Trochlear morphology was assessed on axial images at the proximal and distal trochlea. RESULTS: All measurements of patellar tilt were found to be significantly different between the two groups and reflected an increase in the lateral rotation of the patella in patients with instability. For patellar station, only Insall Salvati (control: 1.08 ± 0.02; PFJD: 1.23 ± 0.05) and Canton Deschamps (control: 1.13 ± 0.02; PFJD: 1.34 ± 0.08) ratios proved to be significantly different. Trochlear morphology had numerous measurements that proved significantly different proximally and distally. These included classic measurements like sulcus angle (control: 148.48 ± 0.94; PFJD: 164.61 ± 2.85 at first cut) and lateral trochlear inclination (control: 21.27 ± 0.63; PFJD: 13.31 ± 1.36 at first cut) and less established measurements like ETTT (control 1.51 ± 0.05; PFJD: 2.11 ± 0.17), a measurement of facet asymmetry. Only lateral condylar height lost significance between proximal and distal measurements. Trochlear groove thickness proved to be not significant at either point along the trochlea. The difference between Normals and PFJDs was greater on average at the proximal trochlea. DISCUSSION AND CONCLUSION: This study helps to clarify the contributing factors to patellofemoral instability and their radiographic measurements. The greater difference between the groups at proximal measurements reflects the importance of the proximal trochlea in the stabilizing the patella through the initial 30° of flexion. The findings reveal that the well-studied measurement of trochlear groove depth may be more a result of failure to form the condyles than a failure of groove formation. Analysis of the specific abnormalities that influence each patient’s patellar instability can guide a surgeon to the most effective intervention (i.e. trochleoplasty versus tibial osteotomy versus lateral release).
INTRODUCTION: This study was performed to compare clinical outcomes of the modified Brostrom procedure using suture bridge technique vs. bone tunnel technique for chronic ankle instability in high-demand athletes. METHODS: Thirty-two patients were followed up for more than two years after modified-Brostrom procedure for chronic lateral ankle instability. Patients were comprised of 16 track sports, eight basketball, five soccer and three taekwondo athletes. Eighteen procedures with suture bridge technique and 14 procedures with bone tunnel technique were performed by one surgeon. The mean age was 23.6 years, and the mean follow-up period was 2.5 years. The clinical evaluation was performed according to the Karlsson scale and Sefton grading system. As the evaluation for mechanical stability, the measurement of talar tilt angle and anterior talar translation was performed through stress radiographs.

RESULTS: The Karlsson scale had improved significantly from preoperative average 45.5 points to 91.6 points in suture bridge group, from 46.8 points to 88.4 points in bone tunnel group. There were seven excellent, nine good, and two fair results according to the Sefton grading system in suture bridge group, and five excellent, seven good, two fair results in bone tunnel group. Therefore, 16 cases (89%) in suture bridge group and 12 cases (86%) in bone tunnel group achieved satisfactory results. Talar tilt angle had improved significantly from preoperative average 16.3° to 4.7° at postoperative three months, to 5.5° at final follow up in suture bridge group; from average 15.8° to 6.1° at postoperative three months, to 6.3° at final follow up in bone tunnel group. There was significant difference on talar tilt angle in early postoperative period (p=0.026).

DISCUSSION AND CONCLUSION: No significant differences, except for talar tilt angle in early postoperative period, existed in clinical and functional outcomes between two techniques for ligament reattachment. Both modified Brostrom procedures using the suture bridge and bone tunnel technique seem to be effective treatment methods for chronic ankle instability in high-demand athletes. The suture bridge technique has an advantage of more mechanical stability in early rehabilitation period.
Previous Partial Meniscectomy Increases Incidence of Chondrosis at Revision ACL Reconstruction in MARS Cohort

Robert H. Brophy, MD, Chesterfield, MO
Tal S. David, MD, San Diego, CA
Robert G. McCormack, MD, New Westminster, BC, Canada
Jon K. Sekiya, MD, Ann Arbor, MI
Steven J. Svoboda, MD, West Point, NY
Laura J. Huston, MS, Nashville, TN
Amanda Haas, MA, Saint Louis, MO
Rick W. Wright, MD, Saint Louis, MO

INTRODUCTION: Knees undergoing revision anterior cruciate ligament (ACL) reconstruction typically have more intra-articular injuries than knees undergoing primary reconstruction. The association between prior meniscal surgery and the incidence of articular cartilage lesions at the time of revision ACL reconstruction has not been well studied in the literature. The purpose of this study was to test the hypothesis that the incidence of articular cartilage lesions at the time of revision ACL reconstruction would be higher in knees with a history of previous partial meniscectomy but not in knees with a history of previous meniscal repair. METHODS: Data from the prospective Multicenter ACL Revision Study (MARS) cohort was reviewed to determine the history of prior meniscal surgery (partial meniscectomy/repair) and the presence of grade II, III and IV chondral lesions at revision ACL reconstruction. The association between previous meniscal surgery and the incidence of chondral lesions was examined for the entire knee, the same compartment, and the patellofemoral compartment. RESULTS: The cohort included 725 ACL revision surgeries. Median patient age was 26 (range 12-63). A total of 421 patients (58%) were male. Based on the highest grade chondral lesion in the entire knee (medial, lateral or patellofemoral compartments), knees with previous partial meniscectomy were more likely to have high grade lesions than knees with no previous meniscal surgery (p<0.0001) or previous meniscal repair (p=0.0001). There was no difference between knees without previous meniscal surgery and knees with previous meniscal repair (p=0.9).

Although this association may reflect underlying differences in the knee at the time of prior surgery, it does suggest that meniscal repair is preferable when possible at the time of ACL reconstruction.

PAPER NO. 546

The Effect of Femoral Tunnel Position on Medial Patellofemoral Ligament (MPFL) Reconstruction

Joanna M. Stephen, MSc, London, United Kingdom
Deiary F. Kader, MD, FRCS (ORTHO), FRCS, Newcastle Upon Tyne, United Kingdom
Punyawan Lumphapong, MSc, London, United Kingdom
David Deehan, MD FRCS, England, United Kingdom
Andrew A. Amis, London, United Kingdom

INTRODUCTION: The aim of this study was to determine the effect of altering femoral tunnel position on medial patellofemoral ligament (MPFL) length change patterns and patellofemoral joint contact pressures when undertaking MPFL reconstruction. METHODS: Eight fresh frozen cadaveric knees were prepared and placed on a customized testing rig, where the femur was fixed but the tibia could be moved freely from 0-90° flexion. Individual quadriceps heads and the iliotibial tract were separated and physiologically loaded with 205N using a weighted pulley system. The origin and insertion of the MPFL were determined and marked with eyelets securely fixed to the femur and patella. Two further femoral eyelets were inserted 5mm proximal and 5mm distal to the eyelet in the femoral origin along the bony axis of the posterior femoral cortex. A single monofilament suture was then passed along the fibres of the MPFL with the anterior end fixed to the patellar eyelet and the posterior end passing through the femoral MPFL origin eyelet and continuing to attach to a linear variable displacement transducer. The ligament length changes were measured throughout the flexion range for the central, proximal and distal graft tunnel positions. Patellofemoral contact pressures were measured throughout flexion range at 10° intervals, using pressure sensitive film inserted between the patella and trochlea. The MPFL was then ruptured and transducer and pressure measurements repeated prior to reconstruction of the MPFL using a double strand gracilis tendon graft. Measurements were then recorded for reconstruction with the graft positioned in central, proximal and distal tunnels. Statistical analysis was undertaken using a repeated-measures ANOVA, Bonferroni post hoc analysis and paired t-tests. RESULTS: The central fibers of the intact MPFL were isometric within 2mm. MPFL rupture resulted in a significant increase in length between the patellar and femoral attachments from 10°-50° knee flexion (P<0.05), a significant decrease in peak medial facet contact pressures at 0°-30° and 90°, and an increase in lateral facet contact pressures at 10°-30° (P <0.05). Tunnel position had a significant effect on length change patterns of the MPFL (P <0.05). Anatomically placed MPFL reconstruction resulted in restoration of intact medial and lateral joint contact pressures (P >0.05), but femoral tunnels positioned 5mm proximal or 5mm distal resulted in significant increases in peak medial pressures during knee flexion or extension, respectively (P <0.05). DISCUSSION AND CONCLUSION: MPFL rupture resulted in increased length between the patella and femur and increased lateral patellofemoral joint contact pressures, implying lateral maltracking. MPFL length pattern and contact pressures were restored with an anatomically positioned ligament reconstruction. However, femoral tunnels positioned too proximal or distal resulted in significantly higher medial joint contact pressures. The importance of correct femoral tunnel position in restoring normal patellofemoral joint kinematics...
and articular cartilage contact stresses is therefore evident.

PAPER NO. 547
The Result of Meniscus Allograft Transplantation Using Bone Fixation: 110 Cases with Minimum Two-Year Follow Up
Seongil Bin, MD, PhD, Seoul, Republic of Korea
Jongmin Kim, MD, Seoul, Republic of Korea

INTRODUCTION: Larger series with objective evaluation is necessary in order to verify the effect of meniscus allograft transplantation (MAT). We hypothesized that MAT would relieve pain and improve function of involved knee joint and objective evaluation would provide evidences to judge the integrity of the allograft. METHODS: One-hundred-fifteen knees underwent MAT from December 1996 to February 2009. Among these 110 knees (95.7%) were available for follow up for more than two years and were enrolled in this study. There were 83 cases of lateral meniscus allograft transplantation and 27 cases of medial meniscus allograft transplantation. The modified Lysholm score and the Knee Society pain score were utilized to evaluate clinical outcome. All knees underwent magnetic resonance imaging (MRI) or second look arthroscopy or both postoperatively. The integrity and position of the allografts were evaluated on postoperative MRI. Status of allograft was classified according to clinical and objective evaluations into three grades: satisfactory, fair, and poor. RESULTS: The mean follow-up duration was 49.4 months. Clinical improvement was achieved in 104 knees. Mean preoperative modified Lysholm score was 72.7 which increased to 92.3 at final follow up (P < 0.001). Mean preoperative Knee Society pain score was 32.5 which increased to 47.7 at final follow up (P < 0.001). Postoperative MRI alone was conducted in 90 knees; second look arthroscopy alone in 24 knees; and both examinations in 18 knees. In MRI examination, 12 gross tears and six small tears in the allograft were identified. Mean extrusion of the allograft was 3.7 mm and mean relative percentage of extrusion was 42.6%. Six gross tears and one small flap tear were identified in second look arthroscopy. According to classification criteria that consisted of clinical outcome, MRI and second look arthroscopy, the allografts were graded as satisfactory in 90 cases (81.8%); fair in eight cases (7.3%) and poor in the other 12 cases (10.9%). DISCUSSION AND CONCLUSION: MAT using bone fixation resulted in significant symptomatic and functional improvement. MAT with bone fixation technique is considered to be an effective treatment for symptomatic, totally meniscectomized knee.

PAPER NO. 548
Outcomes of Fasciotomy in Chronic Exertional Compartment Syndrome of the Leg in an Active Patient Population
Brian Waterman, MD, El Paso, TX
Matthew Laughlin, DO, El Paso, TX
Kenneth L. Cameron, PhD, West Point, NY
Brett D Owens, MD, West Point, NY

INTRODUCTION: Chronic exertional compartment syndrome (CECS) of the leg is a frequent source of lower extremity pain in military personnel, competitive athletes, and runners. While small case series exist, no previous study has rigorously evaluated the rates of return to full activity, persistent disability, and surgical revision after operative management in a large, physically active population. METHODS: Individuals undergoing surgical fasciotomy of the anterior, lateral, or posterior compartments (Current Procedural Terminology codes 27600, 27601, and 27602) for non-traumatic compartment syndrome of the lower extremity (International Classification of Disease Ninth Edition code 729.72) were isolated from the Military Health System Management Analysis and Reporting Tool (M2) between 2003 and 2010. Demographic variables including age, sex, and rank were extracted, and rates of postoperative complications, activity limitations, and revision surgery or medical discharge were recorded from the electronic medical record and U.S. Army Physical Disability Agency database. RESULTS: A total of 611 patients underwent 754 surgeries during the study period. Average patient age was 28.0 years old and males comprised 91.8%. Nearly 77% of surgeries involved anterior and lateral compartment releases, while 19.8% addressed anterior, lateral, and posterior compartments and 2.2% addressed posterior compartments alone. Of all surgeries, approximately 44.7% of patients reported symptom recurrence and 27.7% were unable to return to full activity. Additionally, 15.7% had documented surgical complications, at least 5.8% underwent surgical revision, and 17.3% were referred for medical discharge due to CECS. Rates of surgical failure were not increased with four-compartment fasciotomy. DISCUSSION AND CONCLUSION: CECS is a significant contributor to lower extremity disability in the military population. Nearly half of all service members undergoing fasciotomy reported persistent symptoms and one in five individuals fails surgical interventions.

PAPER NO. 549
Radiofrequency Stimulation of Meniscal Injury in the Avascular Zone: Potential Healing
Christopher S. Lee, MD, Los Angeles, CA
James P. Tasto, MD, San Diego, CA
Sakae Sano, MD, Matsudo City, Chiba, Japan
David Amiel, PhD, La Jolla, CA

INTRODUCTION: Meniscal repair in the white-white zone has a high incidence of failure due to poor vascularity. Radiofrequency application has been shown to increase the angiogenic capabilities of fibroblasts in chronic tendinopathies. The purpose of this study was to evaluate the effect of radiofrequency (RF) stimulation, in conjunction with suture repair, on the healing of tears in the white-white zone of the meniscus. METHODS: Fifty-four New Zealand white rabbits underwent surgically induced meniscal injuries within the avascular (white-white) region. Rabbis were then divided into three treatment

*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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
groups: no repair (N=6), suture repair only (N=15) and suture repair in conjunction with RF treatment (N=33). Radiofrequency was applied using a 0.8 mm radiofrequency wand at level 4 for 500 milliseconds. Rabbits were then sacrificed at nine, 28 and 84 days for gross, histological and biochemical examination by two blinded observers. Biochemical analyses included evaluation of cell proliferation (3H-thymidine) as well as mitogenic (IGF-1, bFGF) and angiogenic (VEGF, αV) factors.

RESULTS: Of specimens repaired with radiofrequency combined with suture, 19 (38%) showed increased gross morphologic and histological healing compared to those treated without RF. Two meniscal explants in the RF treatment group demonstrated complete histological healing. No significant healing was seen in specimens that had either no repair or repair with suture alone. With regards to biochemical testing, at nine days, the rate of 3H-thymidine for meniscal tears treated with suture repair combined with RF was 590±80 cpm/mg dry tissue. This value was approximately 40% greater than the menisci treated with suture repair only, which had a value of 380±30 cpm/mg (p < 0.05). Normal, unrepaird meniscal tissue had a 3H-thymidine incorporation rate of 250±35 cpm/mg. Semiquantitative RT-PCR analysis showed that at nine days post-repair, the RF-treated menisci had significantly increased mRNA expression of IGF-1, bFGF, VEGF and αV relative to untreated repairs (p < 0.05). By day 28 and 84, the levels appeared equivalent between all treatment groups (p < 0.05).

DISCUSSION AND CONCLUSION: This study demonstrated that radiofrequency application to suture repair of white-white zone meniscal tears led to a significantly increased healing response both in vitro and in vivo. Although the mechanism by which RF stimulation improved the healing response is not completely understood, our biochemical analysis suggests that RF may enhance local cellular proliferation as well as the mitogenic and angiogenic capabilities of meniscal fibroblasts. Radiofrequency application could be a potential tool for avascular meniscal repair.

Figure 1. (A and B) Gross and histological specimens 84 days following suture repair of a white-white zone meniscal tear. There is no healing and there is instability of the lesion to stress. (C and D) White-white zone meniscal tear treated with radiofrequency combined with suture repair. There is complete gross and histological healing at 84 days.

PAPER NO. 550
Adverse Events in Medial Opening Wedge High Tibial Osteotomy: A Retrospective Study of 323 Cases
Robin Martin, MD, London, ON, Canada
Trevor B. Birmingham, PhD, London, ON, Canada
Kevin Willits, MD, London, ON, Canada
Robert R. Litchfield, MD, London, ON, Canada
Marie-Eve LeBel, MD, London, ON, Canada
Robert Giffin, MD, London, ON, Canada

INTRODUCTION: To examine adverse events and their risk factors in medial opening wedge high tibial osteotomy (MOW HTO).

METHODS: All patients receiving MOW HTO at our center from September 2005 to August 2009 were included in this retrospective cohort study, with evaluations at two, six, 12 weeks, six months and one year. Surgical and postoperative adverse events and their hypothesized risk factors were defined a priori. Medical records and x-rays were reviewed by an independent observer.

RESULTS: A total of 323 consecutive patients (242 males) were evaluated (age=46±9, BMI=30±4.5). Some 82% (n=265) had ASA scores of 1 or 2, 20% (n=65) were active smokers and 4% (n=13) had diabetes. Data from 7% (n=23) were unavailable at one year. Mean follow up was 24 months [min 12; max 52]. Some 16% (n=52) of MOW HTOs were combined with ACL reconstruction and 1% (n=3) with multi-ligament reconstruction. A non locking Puddu plate was used in 80% (n=259), a locking plate in 17% (n=56) and a PEEK plate in 3% (n=9). Mean wedge size was 12±3mm. A total of 94% (n=303) were filled with cancellous allograft. Adverse events not requiring treatment were undisplaced lateral tibial plateau fracture (3%; n=9), displaced (>2mm) lateral hinge fracture (6%, n=18), delayed wound healing (6%, n=18) and hematoma (3%; n=9). Adverse events requiring non-operative management but not affecting outcome were cellulitis (10%; n=32), post-op stiffness (1%; 4/314), DVT (1%; 4/314). DVT (1%; 4/314). RSD (1%; 4/314), delayed union (12%; 38/317) and limited hardware failure (one broken screw; 4%; 12/301). Severe adverse events requiring revision surgery and/or affecting outcome were deep infection (2%; 5/301), neuropathic pain (1%; 3/314), aseptic non union (3%; 10/317) and severe hardware failure with loss of correction (1%; 2/301). Revision surgery rate was 3% (10/300). Multivariable logistic regression showed that risk factors for severe adverse outcomes were diabetes (OR:16; 95%CI:4-65), active smoking (OR:6; 95%CI:2-18), non compliance with partial weight bearing (OR:6; 95%CI:1-30) and displaced lateral hinge fracture (OR:9; 95%CI:2-43).

DISCUSSION AND CONCLUSION: This comprehensive review suggests the rate of adverse events in MOW HTO requiring revision surgery and/or affecting outcome is low (7%). Attempts should be made to control identified risk factors for these events preoperatively and at time of surgery.
The treatment of Meniscus Horizontal Tear

Joon Kyu Lee, MD
Sahnghoon Lee, MD, Seoul, Republic of Korea
Jang, MD, Seoul, Republic of Korea
Yoon Whan Roh, MD, Seoul, Republic, of Korea
Sae Hyung Chun, MD, Seoul, Republic of Korea
Sang Cheol Seong, MD, Seoul, Republic of Korea
Myung Chul C. Lee, MD, Seoul, Republic of Korea

INTRODUCTION: Meniscus horizontal tears are usually associated with degeneration. Because there is no disruption in the continuity of circumferential fibers, load bearing, shock absorbing functions are largely preserved. In this study, we tried to find out the factors to successful conservative and arthroscopic treatments of meniscus horizontal tear, respectively.

METHODS: A total of 166 meniscus horizontal tear patients without combined ligament injury, other types of meniscus tear such as longitudinal, radial, flap, complex were included in this study. Patients who had non-arthroscopic surgeries or operations at other hospital were excluded. All patients were followed up for minimum of two years. We generally recommended arthroscopic surgery to patients with definite mechanical symptoms (positive McMurray test, locking, giving way, clicking). Factors considered were age, gender, joint line tenderness, mechanical symptom, widest tear gap width on MRI sagittal view, grade of joint arthritis (International Cartilage Repair Society (ICRS) grade), combined root tear, discoid meniscus, tear site, and joint alignment on X-ray. Chi square test and multiple logistic regression analysis were done to determine the factors that lead to successful conservative and arthroscopic treatment, respectively.

RESULTS: The patients whom we recommended arthroscopic operation were younger (patients over 60 compared to patients under 50, p value = 0.022, odds ratio: 0.132, 95% confidence interval: 0.031 - 0.568) and had wider tear gap (widest gap width more than 1.5mm compared to widest gap width less than 1.0mm, p value < 0.001, odds ratio: 49.130, 95% confidence interval: 9.071 - 266.082). Combined root tear was the only meaningful factor that led to failure of the conservative treatment (p value = 0.025, odds ratio: 2.860, 95% confidence interval: 1.140 - 7.175). Another factor that could be considered was joint line tenderness (p value = 0.136, odds ratio: 2.179, 95% confidence interval: 0.782 - 6.072). ICRS grade was the only significant factor that led to the failure of arthroscopic meniscectomy (ICRS grade 3 or more compared to ICRS grade 0, p value = 0.035, odds ratio: 33.383, 95% confidence interval: 1.288 - 864.902).

DISCUSSION AND CONCLUSION: Meniscus horizontal tear patients with combined root tear and joint line tenderness did not respond well to conservative treatment. Patients with advanced arthritis had poor outcomes after arthroscopic meniscectomy. When deciding the treatment option for meniscus horizontal tear, other factors should be considered thoroughly in addition to mechanical symptom.

TABLE I. ADVERSE EVENTS

<table>
<thead>
<tr>
<th>CLASS I: no treatment</th>
<th>no impact on the outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>• undisplaced lateral tibial plateau fracture 2.8% (9/323)</td>
<td></td>
</tr>
<tr>
<td>• Displaced (≥2mm) lateral hinge fracture 5.6% (18/323)</td>
<td></td>
</tr>
<tr>
<td>• Hematoma 2.8% (9/323)</td>
<td></td>
</tr>
<tr>
<td>• Delayed wound healing 5.6% (18/323)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS II: medical treatment</th>
<th>no impact on the outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cellitis 9.6% (51/522)</td>
<td></td>
</tr>
<tr>
<td>• Post-op stiffness 1.3% (4/314)</td>
<td></td>
</tr>
<tr>
<td>• DVT † 1.3% (4/314)</td>
<td></td>
</tr>
<tr>
<td>• CRPS type 1 † 1.3% (4/314)</td>
<td></td>
</tr>
<tr>
<td>• Delayed union 12.0% (38/317)</td>
<td></td>
</tr>
<tr>
<td>• Limited hardware failure – no LOC * 4.0% (12/301)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS III: revision surgery required and/or impact on final outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Neurovascular injury 0% (0/323)</td>
</tr>
<tr>
<td>• Intracapsular screw 0% (0/323)</td>
</tr>
<tr>
<td>• Compartment syndrome 0% (0/323)</td>
</tr>
<tr>
<td>• Deep infection 1.7% (5/301)</td>
</tr>
<tr>
<td>• CRPS type 2 † 1.0% (3/314)</td>
</tr>
<tr>
<td>• Aseptic non union 3.2% (10/317)</td>
</tr>
<tr>
<td>• Hardware failure with LOC * 0.7% (2/301)</td>
</tr>
<tr>
<td>TOTAL 6.6%</td>
</tr>
</tbody>
</table>

TABLE II. RISK FACTORS FOR ADVERSE EVENTS

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>Odds ratio</th>
<th>95%CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>EITHER DELAYED UNION OR NON UNION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASA 3</td>
<td>5.2</td>
<td>1.6-16.7</td>
<td>0.037</td>
</tr>
<tr>
<td>Puddle plate</td>
<td>9.8</td>
<td>2.2-42.8</td>
<td>0.002</td>
</tr>
<tr>
<td>Undisplaced fracture lateral hinge</td>
<td>4.8</td>
<td>2.1-10.7</td>
<td>0.036</td>
</tr>
<tr>
<td>Wedge size &gt; 15mm</td>
<td>7.4</td>
<td>2.2-24.9</td>
<td>0.001</td>
</tr>
<tr>
<td>Female gender</td>
<td>2.4</td>
<td>1.1-5.2</td>
<td>0.031</td>
</tr>
<tr>
<td>CLASS II ADVERSE EVENTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASA 3</td>
<td>2.5</td>
<td>1.1-6.0</td>
<td>0.022</td>
</tr>
<tr>
<td>Undisplaced lateral hinge fracture</td>
<td>2.2</td>
<td>1.2-4.2</td>
<td>0.025</td>
</tr>
<tr>
<td>Wedge size &gt; 15mm</td>
<td>3.5</td>
<td>1.4-8.9</td>
<td>0.008</td>
</tr>
<tr>
<td>CLASS III ADVERSE EVENTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active smoker</td>
<td>5.8</td>
<td>1.9-18.0</td>
<td>0.011</td>
</tr>
<tr>
<td>Diabetes</td>
<td>16.4</td>
<td>4.1-66.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Noncompliance</td>
<td>6.3</td>
<td>1.3-30.0</td>
<td>0.020</td>
</tr>
<tr>
<td>Displaced lateral hinge fracture</td>
<td>9.2</td>
<td>2.0-42.8</td>
<td>0.020</td>
</tr>
<tr>
<td>REVISION SURGERY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>15.2</td>
<td>4.7-49.2</td>
<td>0.0037</td>
</tr>
</tbody>
</table>

* 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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
INTRODUCTION: Fifty-five patients without a medial meniscus tear underwent a phase I/II double blind controlled study evaluating the safety and efficacy of an allographic mesenchymal stem cell (MSC) drug injection. The purpose of this study was to evaluate the effect of an MSC injection on meniscus regeneration and osteoarthritis (OA) progression.

METHODS: Fifty-five patients at seven institutions underwent a randomized prospective double blind trial. Under Institutional Review Board approval, a single superior lateral knee injection was given to the 7-10 day post-operative meniscectomy patients after aspiration. Patients were computer randomized to one of three single MSC injection groups: low dose (50 million cells), high dose (150 million cells) and a hyaluronic acid (HA) placebo. Hyaluronic acid was the carrier for the MSC injections. Patients were followed for safety, pain, articular cartilage progression/improvement, and meniscus regeneration. Timed intervals out to two years evaluated these parameters along with sequential MRI evaluations reviewed by centralized independent blinded musculoskeletal radiologists.

RESULTS: OA patients receiving MSCs experienced a statistically significant reduction in pain compared to those receiving the control. Patients receiving the control were 3.5 times more likely to experience degenerative bone changes associated with OA as compared to those receiving MSCs. The effects were dose dependent and pain scores following treatment. Subchondral sclerosis and osteophyte formation were reported in 21% of patients receiving the control, but only in 6% of MSC treated patients. No serious adverse events at the two-year follow up. MRI meniscus volume regrowth by digital analysis showed wide variability and no statistical improvement ($p = 0.05$).

DISCUSSION AND CONCLUSION: The single MSC injections demonstrated a significantly higher initial displacement than the other methods tested ($p = 0.04$). No significant difference was found among the methods in response to cyclic loading. The inside-out FiberWire repair demonstrated the highest load-to-failure (120.8 ± 23.5 N) and was significantly higher than both the Meniscal Cinch (64.8 ± 24.1 N, $p < 0.001$) and the Ultra Fast-Fix (88.3 ± 14.3 N, $p = 0.002$). It was not significantly higher than the inside-out Ultrabraid suture repair (98.8 ± 29.2N). The inside-out FiberWire repair had the highest stiffness (28.7 ± 7.8 N/mm). It was significantly higher than the Meniscal Cinch (18.0 ± 8.8 N/mm, $p = 0.01$). The most common mode of failure in all methods was suture failure.

DISCUSSION AND CONCLUSION: An inside-out suture repair affords surgeons the best overall biomechanical characteristics of the devices tested (initial displacement, response to cyclic loading, and load to failure). For an all-inside repair, the Ultra Fast-Fix reproduces the characteristics of its matched inside-out suture repair more closely than the Meniscal Cinch. Clinical Relevance: Initial displacement demonstrates the degree of contact at the level of the repaired tear. This is difficult to evaluate arthroscopically and hence needs to be evaluated in biomechanical testing.

<table>
<thead>
<tr>
<th>Outcome Measurement</th>
<th>FiberWire 2-0</th>
<th>Meniscal Cinch</th>
<th>Ultra Fast-Fix</th>
<th>Ultrabraid No. 0</th>
<th>p value ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Displacement</td>
<td>9.37 ± (1.02)</td>
<td>7.06 ± (3.11)</td>
<td>9.49 ± (4.09)</td>
<td>9.72 ± (3.49)</td>
<td>0.03</td>
</tr>
<tr>
<td>Increase in Elongation</td>
<td>1 to 200</td>
<td>0.02 ± (0.20)</td>
<td>0.36 ± (0.16)</td>
<td>0.36 ± (0.12)</td>
<td>0.13 ± (0.14)</td>
</tr>
<tr>
<td></td>
<td>1 to 300</td>
<td>0.35 ± (0.14)</td>
<td>0.36 ± (0.13)</td>
<td>0.45 ± (0.22)</td>
<td>0.36 ± (0.14)</td>
</tr>
<tr>
<td></td>
<td>1 to 500</td>
<td>0.45 ± (0.14)</td>
<td>0.34 ± (0.22)</td>
<td>0.57 ± (0.29)</td>
<td>0.65 ± (0.42)</td>
</tr>
</tbody>
</table>

PAPER NO. 554

Arthroscopic-assisted Brostrom-gould Procedure for Chronic Ankle Instability: A Long-Term Follow Up

Caio A. Nery, MD, Sao Paulo, Brazil
Fernando C. Raduan, MD, Sao Paulo, Brazil
Angelo Del Buono, MD, Rome, Italy
Inacio D. Asaumi, Sao Paulo, Brazil
Nicola Maffulli, London, United Kingdom

INTRODUCTION: Lateral ankle sprains account for 85% of ankle lesions. Hypothesis: Combined open and arthroscopic procedures could improve the diagnosis and management of intra-articular lesions, and allow us to perform minimally invasive anatomical reconstruction of the lateral ligament complex. Study Design: Retrospective case series study.
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For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

METHODS: Forty consecutive patients underwent ankle arthroscopy for recurrent (two or more episodes) lateral ankle instability unresponsive to conservative measures. The clinical diagnosis of mechanical instability was confirmed at imaging (plain radiographs and MRI) and arthroscopic assessment. All patients underwent arthroscopic Broström-Gould repair for management of lateral ankle instability; secondary lesions were also managed. Postoperatively, the AOFAS score was administered to assess the functional status, clinical examination and conventional radiographs were performed in all patients.

RESULTS: Thirty-eight patients were reviewed at an average postoperative follow up of 9.8 years. The mean AOFAS score was 90 (range 44 to 100) at the last follow up. No significantly different outcomes were found in patients who had undergone microfractures formanagement of Grade III-IV cartilage lesions compared to patients with no cartilage lesions. Postoperative AOFAS were graded as excellent and good in almost all patients (94.7%). Concerning the failure rate, two patients (5.3%) reported low AOFAS score: one patient underwent soft tissue removal for anterior impingement, and one received simultaneous medial ankle instability repair.

DISCUSSION AND CONCLUSION: The arthroscopic Broström-Gould assisted technique could be a viable alternative to gold standard Broström-Gould procedure for anatomical repair of chronic lateral ankle instability and management of intra-articular lesions. Prospective randomized controlled trials are needed.

PAPER NO. 555

The Effect of Arthroscopic Partial Medial Meniscectomy on Tibiofemoral Position and Stability
Scott R. Hadley, MD, New York, NY
Sally Arno, MSc, New York, NY
Kirk A. Campbell, MD, New York, NY
Christopher Bell, MSc, New York, NY
Michael P. Hall, MD, Manhattan Beach, CA
Orrin H. Sherman, MD, New York, NY
Peter S. Walker, PhD, New York, NY

INTRODUCTION: The purpose of this study was to determine if partial meniscectomy of the posterior horn of the medial meniscus could significantly increase tibiofemoral laxity in the presence of intact cruciate ligaments. METHODS: Five cadaveric knees were dissected to the capsule, preserving all ligaments and the quadriceps tendon. Each specimen was first tested on a rig where the anteroposterior (AP) position of the medial femoral condyle could be obtained with fiducial points while a range of forces (compression, shear and torque) were applied from full extension to 90° flexion. A 3 Tesla MRI was then performed for baseline measurements of the meniscus prior to partial meniscectomy. Arthroscopic partial medial meniscectomy aimed at 30% of the posterior horn was then performed, followed by repeat laxity testing and MRI scan. The sequence was then repeated for arthroscopic partial meniscectomy aimed at 60% and 100% of the posterior horn of the medial meniscus. The surfaces of the femur and tibia were digitized, creating a solid body model that could be transformed onto the fiducial points from each testing scenario. The AP position of the medial condyle was measured in each transformed state by determining the distance from the medial end-point of the circular axis to the posterior edge of the tibia. Tibiofemoral laxity was then calculated as the difference in position between anterior and posterior shear (AP Laxity) as well as between internal and external torque (Rotational Laxity).

RESULTS: MRI analysis demonstrated that 22% ± 9% of the original width of the posterior horn was removed at the first resection, 46% ± 11% at the second resection and full removal at the third resection (Figure 1). After 22% resection, no significant difference in AP laxity was observed. A statistically significant increase in AP laxity was observed with 46% resection under higher compressive loads (500N) compared to the intact meniscus. After full resection, significant increases in AP laxity were observed under lower compressive loads (50N) compared to the intact, 22% and 46% resections. Statistically significant posterior displacement of the medial femoral condyle was seen after both 46% and full resection of the posterior horn. (Figures 2 and 3).

DISCUSSION AND CONCLUSION: Partial meniscectomy equal to or greater than 46% resection of the posterior horn of the medial meniscus can increase AP laxity of the medial compartment under higher loads, although the magnitude was small. Such large resections can also result in increased posterior displacement similar to that of full resection of the posterior horn. This position change may lead to abnormal cartilage loading and early osteoarthritis.
INTRODUCTION: Most tests for labral pathology are currently done in the supine position. We have developed the "twist test," which is done with the patient standing and can evaluate the patient in functional, weight bearing position. The purpose of this study is to compare its reliability to arthroscopy and MR arthrogram.

METHODS: Between June 2009 and August 2010, 371 patients had the twist test performed. Of these, 247 had an MR arthrogram (MRA) of the affected hip. A labral tear, degeneration, fraying and paralabral cyst were considered as a positive MRA. A total of 110 of the total 371 patients underwent arthroscopic surgery. Post-operative surgical notes were examined and presence of labral tear were noted and compared to twist test. The twist test is done with the patient facing the examiner, toes pointing forward. The patient bends their knees to 30 degrees and performs a windshield wiper like action with maximal excursion to the left and right. If the patient tolerates this, then the patient first gets on the unaffected leg, again with the knee bent at 30 degrees, and "does the twist" one-legged, with the examiner holding their hands gently for balance. The test is then repeated on the affected hip. A positive test is groin pain on the affected hip, apprehension with performing the test on the affected hip, or gross range of motion deficits on the affected hip compared with the unaffected side (>50%).

RESULTS: Among 160 patients with positive twist test, 154 patients had positive MRA and six had negative MRA. Among 87 patients with negative twist test, 72 had positive MRA and 15 had negative MRA. In comparison with MRA, the sensitivity and specificity of twist test for labral injury were 68.14% and 71.5% respectively. Positive predictive value (PPV, precision) of twist test for diagnosis of labral lesion was 96.25% and the accuracy was 68.4%. We then determined the sensitivity of the twist test compared with arthroscopy results. Of the 110 patients who underwent surgical intervention, 100% exhibited labral tears. Of those 110 patients with surgically confirmed labral tears, 80 of them exhibited a positive twist test, resulting in a sensitivity of 72.7%

DISCUSSION AND CONCLUSION: Accurate diagnosis of a labral tear is necessary for treatment planning. This study shows that twist test can support clinical decision making when considering labral pathology as a differential diagnosis because of its high PPV (96.25%). This test can be beneficial for ruling out labral pathology. An added benefit is that this test is quick to perform, so it could be incorporated into a general sports physical screening examination.

PAPER NO. 662

Back Pain Prior to Hip Arthroscopy for Femoroacetabular Impingement Predicts Inferior Results

Itamar Botser, Chicago, IL
Rima Nasser, MD, Chicago, IL
Benjamin Domb, MD, Westmont, IL

INTRODUCTION: The hip and the spine are intimately related anatomically and functionally, and their respective disorders may present with overlapping symptomatology. Information on the impact of comorbidities on outcome and satisfaction after hip arthroscopy is lacking. A problem in one area could potentially cause or aggravate problems in the other. The hypothesis of this study was that hip surgery for femoroacetabular impingement (FAI) would have inferior results in patients with a history of low back pain.

METHODS: Between February 2008 and April 2010, data was prospectively collected for all patients undergoing arthroscopic surgery for FAI. Exclusion criteria were previous surgery on the same hip other than diagnostic hip arthroscopy, Tonnis arthritic grade 2 or 3, and previous hip condition such as AVN, LCPD, or DDH. Any history of back pain was recorded and the type of pain and duration were noted. A total of 116 hips (112 patients) met the inclusion/exclusion criteria. Ninety-one patients had no history of back pain, while 25 had a positive history of back pain. Radiographic and intraoperative findings and procedures were recorded. All patients were assessed pre- and post-operatively using the modified Harris Hip Score (mHHS), the Non-Arthritic Hip Score (NAHS), and the visual analog pain scale (VAS). Post-operatively, patients were asked for their satisfaction from the surgery on a scale from 0 to 10.

RESULTS: There was no difference in the radiographic findings pre- and post-operatively, or the intra-operative findings and procedures between the two groups. Pre-operative clinical scores (mHHS and NAHS) trended lower for the back pain group; pain level (VAS) was similar between the groups. At mean follow-up of 14.5 months (11 to 30 months), all scores were significantly improved, and there was no difference in relative improvement between patients with or without back pain. However, the absolute clinical scores (mHHS and NAHS) were significantly lower for the back pain group (p=0.01 and 0.02, respectively); the pain level (VAS) trended lower as well (p=0.07). Moreover, patients with back pain were significantly less satisfied with the result of the surgery (p=0.01) (Figure 1).

DISCUSSION AND CONCLUSION: FAI patients with and without a history of low back pain improve significantly after arthroscopic treatment. Although those with back pain have equivalent relative improvement, their absolute clinical results and satisfaction are inferior compared to patients without back pain. Hence, the patients’ and surgeon’s expectations for FAI surgery should be adjusted accordingly when back pain is present.
Impact of Hip Arthroscopy for Femoroacetabular Impingement on Quality of Life

Ajay Malviya, MD, Newcastle Upon Tyne, United Kingdom
Giles H. Stafford, FRCS, London, United Kingdom
Richard N. Villar, MD, Cambridge, United Kingdom

INTRODUCTION: The benefit of hip arthroscopy for the treatment of femoroacetabular impingement (FAI) on quality of life (QoL) needs further exploration.

METHODS: We prospectively collected data on 611 patients, the largest series reported, who underwent hip arthroscopy for FAI over a period of five years under the care of a single surgeon. The minimum follow up was one year with a mean follow up of three years. The responses to the Harris hip score were translated using Rosser index matrix, to QoL score.

RESULTS: The mean QoL score increased from 0.946 (-1.486 to 0.995) to 0.974 (0.7 to 1) at one year after surgery (p<0.001). It was noted that the mean QoL score in males was significantly (p<0.001) better than females, both before surgery and at one year after surgery; although the mean change in the QoL score was not statistically different (M=0.02, F=0.04; p=0.12). Linear regression analysis revealed that the significant predictors of change in QoL score were pre-operative QoL score (p<0.001) and the gender (p=0.02). The change in QoL score showed moderate (p=-0.66; p<0.001) negative correlation with the pre-operative QoL score. The QoL scores improved in 74.5%, reMed unchanged in 15.6%; while it deteriorated in 9.9% of the patients at one year after surgery.

DISCUSSION AND CONCLUSION: In a prospective, consecutive series of 611 patients, the largest reported to date, we have found that arthroscopic surgery for FAI improves the QoL in 75% of the patients. The pre-operative QoL score and gender were significant predictors of the change in QoL.

Prevalence of Hip Pathology in Asymptomatic Subjects: An MRI Prospective Investigation

Brad Register, MD, Athens, GA
Andrew T. Pennock, MD, San Diego, CA
Marc J. Philippon, MD, Vail, CO
Charles P. Ho, MD, PhD, Vail, CO
Ashur Lawand, MD, Atlanta, GA
Colin Strickland, MD, Aurora, CO
Karen K. Briggs, MPH, Vail, CO

INTRODUCTION: Previous studies have shown a high prevalence of hip pathology in athletes with groin pain, however, the prevalence of abnormal MRI findings in an asymptomatic population has yet to be defined. The purpose of this study was to assess a cohort of asymptomatic individuals to determine the prevalence of hip pathology.

METHODS: Forty-five volunteer subjects with no history of hip pain, symptoms, injury, or surgery were recruited for enrollment in this Institutional Review Board-approved study. Patients underwent a unilateral MRI scan. The extremity side evaluated by MRI was selected randomly. All MRI scans were reviewed by three separate fellowship-trained musculoskeletal radiologists. The scans were mixed randomly with 19 scans from symptomatic patients to blind the radiologists to the possibility of patient symptoms. The imaging findings were tallied by consensus.

RESULTS: The average volunteer age was 37.8 years (range 15 to 66). There were 60% males and 40% females. Labral tears were identified in 69% of hips, chondral defects in 24%, ligamentum teres tears in 2.2%, labral/paralabral cysts in 13%, acetabular bone edema in 11%, fibrocystic changes of the head neck junction in 22%, rim fractures in 11%, subchondral cysts in 16%, and osseous bumps in 20%. Subjects over the age of 35 were 13.7 [95% CI: 2.4 to 80] times more likely to have a chondral defect and 16.7 [95%CI: 1.8 to 158] times more likely to have a subchondral cyst compared to those subjects 35 or younger. No other joint pathology was associated with age. Male subjects were 8.5 [95% CI: 1.2 to 56] times more likely to have an osseous bump compared to female subjects. No other joint pathology was associated with gender.

An MRI Prospective Investigation of the Proximal Femur in Asymptomatic Pediatric and Adolescents

Karl-Philipp Kienle, Germany
Yi-Meng Yen, MD, Boston, MA
Sarah Bixby, MD, Boston, MA
Adam Nasreddine, BS, MA, Boston, MA
Young Jo Kim, MD, Boston, MA

INTRODUCTION: Femoroacetabular impingement (FAI) is an increasingly recognized diagnosis that predisposes individuals to early osteoarthritis of the hip. Previous studies have reported on the high prevalence of FAI in asymptomatic adult patients, though little is still known about the etiology and development of morphologic abnormalities in children and adolescents that may lead to FAI. This study investigates the morphologic development of the proximal femur in asymptomatic pediatric patients and identifies the prevalence of deformities that may predispose to FAI.

METHODS: Radiology records from 01/2008 to 06/2010 were retrospectively reviewed to identify patients between 12 and 18 years who underwent a multidetector CT (MDCT) scan of the pelvis for suspected appendicitis. Patients with history of hip pain or hip-related problems were excluded. Eighty-five patients, mean age 15 years (range, 12-18), 111 (65%) females were included in this study. Thin-section axial CT images were reformatted into radial planes aligned along the axis of the femoral head and neck and rotated in 45 degree increments from anterior to superior. Reformats were performed on bilateral hips for each patient. Alpha angle, head-neck offset, radius of the femoral neck and femoral head measurements were computed on anterior, superior, and anterior-superior positions (Table 1). Alpha angles greater than 55 degrees in any plane were considered as a potential for cam impingement. A majority of the measured anterior offset of the femoral head-neck junction were less than the 8 mm commonly used in the adult population. Therefore, we considered a patient as having a decreased offset when the measured offset was less than the mean offset minus two standard deviations. (Table 1)

RESULTS: The 170 hip joints demonstrated that the average radius of the femoral head was 2.24 mm with average increase of 0.3 mm and average anterior-offset of 6.70 mm (range, 1.30-11.30)
and posterior offset was 7.50 mm (range, 3.90-10.90). Sixteen (9.4%) of patients had a decreased offset. Fifty-two (30.5%) of the patients had an alpha angle greater than 55 degrees in the anterior, antero-superior, or superior positions. This slightly increased with age. (Table 2) DISCUSSION AND CONCLUSION: This study demonstrates that the bony characteristics of the proximal femur predisposing to FAI can occur in patients as young as 12 years old slightly increasing with adolescence and is comparable in incidence compared to adults.

Table 1. Femur characteristics in asymptomatic pediatric and adolescent patients

<table>
<thead>
<tr>
<th>Position</th>
<th>Mean</th>
<th>Range</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Angle</td>
<td>42.8</td>
<td>27.3-71.8</td>
<td>7.59</td>
</tr>
<tr>
<td>Superior</td>
<td>40.4</td>
<td>13.1-82.3</td>
<td>6.88</td>
</tr>
<tr>
<td>Anterior/Superior</td>
<td>50.9</td>
<td>29.6-80.7</td>
<td>9.57</td>
</tr>
<tr>
<td>Head/Neck Offset</td>
<td>6.7</td>
<td>1.3-11.3</td>
<td>1.85</td>
</tr>
<tr>
<td>Posterior</td>
<td>7.5</td>
<td>3.9-10.9</td>
<td>1.35</td>
</tr>
<tr>
<td>Head Radius</td>
<td>21.2</td>
<td>18.3-26.0</td>
<td>1.69</td>
</tr>
<tr>
<td>Superior</td>
<td>21.2</td>
<td>18.3-26.5</td>
<td>1.71</td>
</tr>
<tr>
<td>Neck Radius</td>
<td>12.2</td>
<td>9.1-17.2</td>
<td>1.44</td>
</tr>
<tr>
<td>Superior</td>
<td>13.3</td>
<td>8.9-19.0</td>
<td>1.74</td>
</tr>
</tbody>
</table>

Table 2. Changes in Bone Characteristics by age

<table>
<thead>
<tr>
<th>Years</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
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<tbody>
<tr>
<td>Abnormal alpha &gt; 55 degrees</td>
<td>6 (30)</td>
<td>5 (21)</td>
<td>7 (25)</td>
<td>8 (33)</td>
<td>6 (23)</td>
<td>8 (33)</td>
<td>12 (50)</td>
</tr>
<tr>
<td>Head/Neck Offset (&lt; Mean - 2SD)</td>
<td>1 (5)</td>
<td>4 (17)</td>
<td>3 (11)</td>
<td>0 (0)</td>
<td>5 (19)</td>
<td>3 (12)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Anterior Head Radius</td>
<td>Mean (SD)</td>
<td>19.9 (0.95)</td>
<td>20.8 (0.86)</td>
<td>21.9 (1.38)</td>
<td>21.4 (1.64)</td>
<td>21.2 (1.89)</td>
<td>21.6 (1.66)</td>
</tr>
<tr>
<td>Anterior Neck Radius</td>
<td>Mean (SD)</td>
<td>11.8 (1.91)</td>
<td>12.0 (1.42)</td>
<td>12.8 (1.42)</td>
<td>12.2 (1.11)</td>
<td>11.9 (1.35)</td>
<td>12.3 (1.97)</td>
</tr>
</tbody>
</table>

PAPER NO. 666

Femoral Nerve Blocks are Effective for Post-operative Pain Control after Hip Arthroscopy

James P. Ward, MD, Hoboken, NJ
David Albert, New York, NY
Robert Altman, MD, New York, NY
Andrew D. Rosenberg, MD, New York, NY
Germaine Cuff, RN, New York, NY
Rachel Y. Goldstein, MD, New York, NY
Thomas Youm, MD, New York, NY

INTRODUCTION: Hip arthroscopy has increased as a diagnostic and therapeutic tool in recent years. Since the majority of the procedures are performed as ambulatory procedures, adequate peri-operative pain control is paramount for timely discharge of patients and successful outpatient rehabilitation. This study will evaluate the utility of femoral nerve blocks in post-operative pain control after hip arthroscopy. METHODS: Forty consecutive patients scheduled for hip arthroscopy were randomized into two groups for post-operative pain control. Half were to receive routine intravenous narcotics for pain scores of seven or above in the post-anesthesia care unit (PACU), the other half were to receive a femoral nerve block in the PACU for the same pain scores. Data was compared with respect to patient sex, age, nausea, overall satisfaction with analgesia, and duration of time in the PACU. RESULTS: Thirty-six patients had initial pain scores of seven or greater. Sixteen were randomized to receive post-operative morphine, and 20 to receive a femoral nerve block. There were no significant differences between the two groups with respect to sex or age of the patients. Patients who received morphine had a significantly longer time to discharge from the PACU (216 minutes) than the femoral nerve block group (177 minutes). The morphine group was also significantly more likely to report post-operative nausea (75%) than the femoral nerve block group (10%). Patients receiving femoral nerve blocks were significantly more likely to be satisfied with their post-operative pain control (90%) than those who had received morphine (25%). All of the patients receiving femoral nerve block stated that they would have the block again if they needed another hip arthroscopy. DISCUSSION AND CONCLUSION: We conclude that, by all criteria studied, a femoral nerve block is an excellent alternative to routine narcotic pain medication in patients undergoing hip arthroscopy.

PAPER NO. 667

Traction Injury Risk in Hip Arthroscopy-Duration or Amount? An Intraoperative Nerve Monitoring Study

Jessica J. Telleria, MD, Seattle, WA
Marc Safran, MD, Redwood City, CA
John N. Gardi, PhD, San Francisco, CA
James M. Glick, MD, Hillsborough, CA

INTRODUCTION: The reported incidence of nerve injury during hip arthroscopy ranges from 0 to 27.3% and may be under-reported. Most surgeons advocate limiting the traction weight and time to 50 pounds and two hours, respectively. While these practices are widely accepted by the orthopaedic community, to date these parameters have been based on general consensus rather than experimental evidence. Therefore, we prospectively studied nerve injury using intra-operative nerve monitoring to identify the incidence, pattern and pre-disposing factors for sciatic nerve traction injury during hip arthroscopy. METHODS: During 1998 - 2001, the motor (MEP) and/or somatosensory (SEP) evoked potentials were recorded in 76 patients undergoing routine hip arthroscopy in the lateral position. Sixteen subjects were excluded due to incomplete data. Changes in the posterior tibial and common peroneal nerves were evaluated to assess the effects of traction intensity and time on nerve dysfunction. Baseline electromyographic (EMG) values were recorded prior to the start of the procedure, and the contralateral non-operative limb was continuously monitored to serve as a control. Nerve dysfunction was defined as a 50% reduction in amplitude of SSEPs or MEPs or a 10% increase in latency of the SSEPs; nerve injury was defined as a clinically apparent neurologic deficit in sensory or motor function. When the EMG indicated nerve dysfunction the surgeon was immediately notified, followed by reevaluation of the vital signs, depth of anesthesia, patient position and technical troubleshooting. Traction time and weight were continuously monitored with a custom footplate tensiometer. RESULTS: Of the 60 patients (31 females, average age 37 years, range 16 - 61), 35 (58.3%) experienced intra-operative nerve dysfunction and four (6.7%) sustained a clinical nerve injury, none of which were permanent. The average maximum traction weight in patients who did and did not have nerve dysfunction was 84.0 pounds (range, 50-125) and 72.6 pounds (range, 50-100),
respective (age/sex adjusted; p = 0.04; 95% confidence interval, 1.01 -1.08). The average total traction time in patients who did and did not have nerve dysfunction was 96 minutes (range, 42-240) and 82 minutes (range, 38-160), respectively (age/sex adjusted; p = 0.20). The odds of nerve dysfunction increased 4% with every one-pound increase in the traction intensity (odds ratio [OR], 1.04) and decreased 2% for every additional minute spent at maximum traction (OR, 0.98). Age and sex were not statistically significant risk factors. Following the removal of traction six of the 35 patients who experienced nerve dysfunction returned to baseline EMG levels within five minutes (17.1%), 19 patients by 15 minutes (54.3%) and 21 patients by 30 minutes (60.0%); in 14 (40.0%) patients removal of traction did not result in full return of EMG amplitude or latency to baseline range by the end of nerve monitoring.

DISCUSSION AND CONCLUSION: The incidence of nerve changes on SSEPs and MEPs are far more common than clinically identified. The maximum traction weight is the greatest risk factor for traction-related sciatic nerve dysfunction during hip arthroscopy; total traction time was not a risk factor. This study did not identify a discrete threshold of traction weight or traction time that puts patients at a higher risk for nerve dysfunction. Surgeons should attempt to minimize traction time and intensity during hip arthroscopy to decrease the risk of iatrogenic sciatic nerve damage.

PAPER NO. 668
The Effect of Capsulotomy on Hip Stability
Christopher O. Bayne, MD, Chicago, IL
Robert A. Stanley, BA, Chicago, IL
Peter Simon, MS, Chicago, IL
Alejandro Espinoza, PhD, Chicago, IL
Nozomu Inoue, MD, Chicago, IL
Shane Nho, MD, Chicago, IL

METHODS: Thirteen fresh frozen cadaveric hip specimens were mounted in a custom testing apparatus and an external rotation torque of 0.588 Nm was applied under static load. A motion tracking system was used to record the experimental kinematics, post-process translation, and rotation data for each specimen under four conditions: (1) Neutral flexion with capsule intact. (2) Neutral flexion with transverse capsulotomy. (3) Maximum flexion with capsule intact. (4) Maximum flexion with transverse capsulotomy. Each specimen underwent CT scanning prior to testing. DICOM images were imported into software and the femoral head centroid was calculated based on segmented 3D model of the femur.

RESULTS: We compared femoral-acetabular motion caused by an applied external rotation torque for each testing condition in terms of translation and rotation in the x, y and z planes. We analyzed the data using both analysis of variance (ANOVA) and nonparametric analysis. After evaluation of rotation in the z plane in maximum flexion, the intact hip rotated less than hips with transverse capsulotomy (p-value=.0362).

DISCUSSION AND CONCLUSION: The presence of transverse capsulotomy appears to permit increased rotation in maximum flexion compared to hips with intact capsules. We believe that larger studies are warranted to further examine how capsular integrity affects hip stability.

PAPER NO. 669
Relationship Between Tears of the Ligamentum Teres and Acetabular Undercoverage
Benjamin Domb, MD, Westmont, IL
Dorea E. Martin, BS, Westmont, IL
Itamar Botser, Chicago, IL

INTRODUCTION: Although the function of the ligamentum teres remains a subject of research, it is thought to play a role in stability of the hip joint. We hypothesized that hips with less inherent bony stability would be more dependent on the ligamentum as a secondary stabilizer, and would be more likely to have ligamentum tears. The purpose of this study was to examine the relationship between ligamentum teres tears and acetabular radiographic architecture.

METHODS: All patients less than 50 years old who underwent hip arthroscopy between June 2009 and February 2011 were prospectively studied. The exclusion criteria were Tonnis arthritic grade >1 and traumatic high-energy mechanisms of injury. Radiographic data were measured preoperatively on an AP pelvis view, including acetabular inclination (AI), lateral center edge angle (LCEA), magnitude of crossover sign, and ischial spine prominence. A stability index (SI) was defined as SI = [LCEA - AI]. Hips were divided into three groups: 1) high stability: SI > 38°; 2) medium stability: SI: 16<SI<38; and 3) low stability: SI < 16°. The presence of tears of the ligamentum teres was recorded at the time of arthroscopy.

RESULTS: Of the 360 hips (317 patients) included in the study, 170 (47%) had a partial or full thickness ligamentum tear. Patients with tears were significantly older than patients without tears (p<0.0001), with averages of 35.1 and 29.8 years, respectively. Radiographically, patients with tears had less acetabular retroversion, as reflected by lower ischial spine prominence values and lesser crossover signs (p=0.01 and <0.001, respectively). Intraobserver reliability coefficients were 0.91 and 0.79 for acetabular inclination and center edge angles, respectively. Using the stability index classification, 557 hips (15%) were classified as high stability, 260 (72%) as medium stability, and 45 (13%) as low stability. Low stability hips were 1.74 times more likely to have a ligamentum tear than high stability hips (Figure 1).

Clinical exam. should consider this diagnosis based on both patient history and frequent cause of proximal hamstring ruptures; therefore surgeons DISCUSSION AND CONCLUSION: Acute surgical repair allows undergoing proximal hamstring repair (mean: 1.2, range: 0 to 4). other orthopedic surgeons) or healthcare professionals before average consulted with more than one physician (including to patients with sciatic nerve paresthesia (n = 24). Patients on not have statistically significant score differences when compared post-operative nerve complaints (i.e. tingling in thigh or foot) did hamstring scores were not significantly different. Patients without had higher LEFS scores when compared to patients with chronic outcome following surgery. Patients with acute injuries (n= 38) (n = 27). Most patients (98%, n = 47) were satisfied with their trauma (n =1) or falls with eccentric hip flexion and knee extension included water/snowskiing (n =10), sports related injuries (n =10), tears, and 4.2% (n =2) were 1 tendon tear. Mechanism of injury modifies the natural course of this pathology and if pain relief remains in time. PAPER NO. 670 Functional Outcomes following Proximal Hamstring Repair Ashwin Rangavajjula, BS, Philadelphia, PA Steven B. Cohen, MD, Media, PA Dharmesh Vyas, MD, Pittsburgh, PA James P. Bradley, MD, Pittsburgh, PA INTRODUCTION: Proximal hamstring rupture is a commonly misdiagnosed and debilitating injury if acute surgical intervention is not performed. There is a paucity of literature assessing functional levels following repair with validated outcomes measures. Our study evaluates patient-reported function, strength, neurovascular issues, and patient history using the Lower Extremity Functional Scale (LEFS), the Marx Activity Scale, and a proximal hamstring questionnaire (maximum score: 100). METHODS: We retrospectively reviewed proximal hamstring repairs performed by the two senior surgeons using consistent surgical technique with five bioabsorbable anchors on the ischial tuberosity. A phone survey was administered to obtain outcome measures. Inclusion criteria were acute and chronic proximal hamstring tears that had at least 12 months of postoperative follow up. RESULTS: A total of 48 patients with a mean age of 48.2 (range: 17 to 66 years) and a mean follow up of 28.9 months (range: 12 to 77 months) completed the questionnaire. Of the 48 patients, 75% (n =36) were complete 3 tendon tears, 20.8% (n =10) were 2 tendon tears, and 4.2% (n =2) were 1 tendon tear. Mechanism of injury included water/snowskiing (n =10), sports related injuries (n =10), trauma (n =1) or falls with eccentric hip flexion and knee extension (n =27). Most patients (98%, n =47) were satisfied with their outcome following surgery. Patients with acute injuries (n= 38) had higher LEFS scores when compared to patients with chronic injuries (n= 10) (p<0.05), but the Marx Activity score and proximal hamstring scores were not significantly different. Patients without post-operative nerve complaints (i.e. tingling in thigh or foot) did not have statistically significant score differences when compared to patients with sciatic nerve paresthesia (n = 24). Patients on average consulted with more than one physician (including other orthopedic surgeons) or healthcare professionals before undergoing proximal hamstring repair (mean: 1.2, range: 0 to 4). DISCUSSION AND CONCLUSION: Acute surgical repair allows excellent lower extremity function after repair of proximal hamstring ruptures. Eccentric hip flexion and knee extension is the frequent cause of proximal hamstring ruptures; therefore surgeons should consider this diagnosis based on both patient history and clinical exam.
RESULTS: Sixteen of 18 and 10/18 college players and 16/21 and 14/21 minor league hockey players were available at one- and two-year follow up, respectively. Among 13 players with labral tears on initial MRI and available at two years, 76.9% had no hip or groin symptoms. None of three “symptomatic” players missed any games or sought treatment. Four of five players with labral tears on initial MRI were asymptomatic at one year but were not available at two years. The other player had “sore hips” bilaterally but did not pursue treatment at the time of follow up. Only one athlete had hip/groin pain that required treatment and/or cessation from hockey: that player had “other tendinosis” but no labral pathology.

DISCUSSION AND CONCLUSION: Although common on MRI among asymptomatic hockey players, hip labral tears often do not produce significant symptoms within two years.

PAPER NO. 673

Novel 3-D Quantification and Classification of Cam Lesions in Patients with Femoroacetabular Impingement

Adam B. Yanke, MD, Chicago, IL
Robert A. Stanley, BA, Chicago, IL
Hyun Kim, BS, Chicago, IL
Richard W. Kang, MD, Chicago, IL
Alejandro Espinosa, PhD, Chicago, IL
Charles A. Bush-Joseph, MD, Chicago, IL
Nozomu Inoue, MD, Chicago, IL
Shane Nho, MD, Chicago, IL

INTRODUCTION: Femoroacetabular impingement (FAI) can lead to labral injury, osseous changes, and even osteoarthritis (1,2). Though our understanding of FAI continues to improve, no study has been able to classify and describe femoral cam lesions toward the goal of obtaining clinically applicable results. Due to inconsistency of the alpha angle (3) and radiographic evaluation (4), we focused on the application of CT data to develop a novel, automated method to describe aberrancies in the topography of the femoral head and the head-neck junction. Furthermore, this will also yield sub categorization into zones based on a modification of the Ilizarov (5) grid for cartilage lesions, along with a “clock face” description.

METHODS: Institutional Review Board approval was given for retrospective analysis of the pre-operative CT scans for nine patients (seven female, two males, ages between 17-51) who underwent hip arthroscopy for FAI. The patients’ DICOM data was segmented. The resulting 3D femoral and acetabular models converted to point-clouds and analyzed with a custom written visual C++ with MFC routine. To find the gravity center of the femoral head, a virtual point near the gravity center was moved ± 5mm in x,y,z directions in 0.1mm increments until the standard deviation of the distance to each point on the surface became the smallest. From this point, a virtual sphere was created that mimicked the contour of the femoral head. Then the cam lesion was quantified three dimensionally using the distance from cam lesion’s surface to the centroid of femoral head, yielding an “atlas view” and a “globe view” as described in Figure 1a-d. The modified zoning method was then applied yielding data for regions 1 through 9. The mean bump height, volume, location on the clock face, and relative zoning were all calculated. Zonal differences were analyzed using ANOVA with post-hoc Tukeys test with significance set at p<0.05.

RESULTS: As seen in Figure 1a, when looking axially at the femur, one notices an abnormality of the alpha angle at the red arrow as compared to the blue. When applying the globe view to this (Fig 1b), the extent of the lesion becomes apparent and using the atlas view (Fig 1d), one sees the lesion span from 12 o’clock to almost 4 o’clock. The lesion was quantified on the atlas view to have an average height of 2mm and volume of 1175mm³. Furthermore, when applying the Ilizarov coordinates, the height of the lesion in sector 9 is significantly larger than the other areas. When looking at all samples, the average lesion volume was 451±352mm³ and the lesion height was 1.15±0.4mm. The average distribution on the clock face was from 1:45±4 hours to 3:00±30 minutes with an average span of two hours and 45 minutes or 74 degrees. The zone with the largest height was region 9 followed by region 8 on average (Fig 1e).

DISCUSSION AND CONCLUSION: This study developed a novel approach to objectively visualize cam lesions in patients with FAI. Beyond visualization, one can also determine the lesion’s height and volume. While the Ilizarov method is limited, as it was originally described for cartilage defects, we are developing a new system to classify cam lesions specifically. Further studies are currently underway to expand the model to the femoral neck.
gender, larger alpha angle, and increased length of preoperative symptoms. If patients with hip pathology seek treatment at an earlier age and earlier onset of symptoms, the prevalence of cartilage defects may be reduced.

PAPER NO. 675
The Alpha Angle and Head-Neck Offset Ratio in the Diagnosis of FAI: Do They Agree?
Jeffrey Nepple, MD, Shrewsbury, MO
Ira Zaltz, MD, Royal Oak, MI
Young Jo Kim, MD, Boston, MA
John M. Martell, MD, Chicago, IL
Michael B. Millis, MD, Boston, MA
Daniel J. Sucato, MD, Dallas, TX
John C. Clohisy, MD, Saint Louis, MO

INTRODUCTION: Clinical and radiographic strategies for diagnosing cam-type femoroacetabular impingement (FAI) continue to evolve. The agreement between and sensitivity of commonly used radiographic parameters of cam-type FAI [alpha angle and head-neck offset (HNO) ratio] has not been fully investigated. The purpose of our study was to establish the correlation between and sensitivity of radiographic parameters of cam-type FAI.

METHODS: Forty-one hip preservation patients with a complete radiographic series, including an AP pelvis, 45° Dunn, frog-leg lateral, and crosstable lateral views, were identified. Radiographs were analyzed utilizing novel computer-assisted measurement software. Radiographic measurements included the alpha angle and HNO ratio. An alpha angle greater than 50° and a HNO ratio less than or equal to 0.17 were considered abnormal.

RESULTS: Ninety-six radiographs (59.5%) had cam-type deformity (an abnormal alpha angle or HNO ratio), including 49 (29.9%) with both. Abnormal alpha angle and HNO ratio were significantly correlated (p<0.001) with a Pearson correlation coefficient of -0.456 (p<0.001). Classification using the alpha angle and HNO ratio together for diagnosing cam FAI. The alpha angle should be viewed as a parameter of asphericity, while the HNO ratio is a parameter of offset.

PAPER NO. 781
The Chondrotoxicity of Single-Dose Local Anesthetic Injections
Jason L. Dragoo, MD, Redwood City, CA
Hillary Braun, Redwood City, CA
Hyeon Joo Kim, PhD
S. R. Golish, MD, PhD, Ridgefield, WA

INTRODUCTION: The chondrotoxicity of continuously administered or multiple injections of local anesthetics has been widely documented. The purpose of this study was to determine whether single-dose injections of three commonly used local anesthetics are also chondrotoxic.

METHODS: Human chondrocytes were seeded at a density of 0.5 X 10^6 cells/well in six-well plates. A bioreactor was used to simulate normal joint fluid metabolism. The clinically acceptable dose of 10 cc was adjusted to account for decreased cartilage surface area of experimental conditions versus human knee, and for the prevalence of cartilage defects. Three anesthetics were tested: 1% lidocaine, 0.25% bupivacaine and 0.5% ropivacaine. Each medication was delivered to the chondrocytes over the average duration of chemical action. Cell viability was assessed with a two-color fluorescence assay.

RESULTS: Chondrocytes treated for three hours with 1% lidocaine demonstrated a significant decrease in viability (7.60% cell death ± 1.8%) when compared with those in the control medium (2.83 ± 1.8%, P<0.001). Compared with appropriate controls, neither 0.25% bupivacaine nor 0.5% ropivacaine appeared to be chondrotoxic (p=1.00, p=1.00 respectively).

DISCUSSION AND CONCLUSION: A single dose of 1% lidocaine is significantly chondrotoxic. Single-dose administrations of 0.25% bupivacaine and 0.50% ropivacaine did not show signs of chondrotoxicity.

PAPER NO. 782
Shockwave Therapy Enhances Tendon-Bone Healing in Anterior Cruciate Ligament Reconstruction
Ching-Jen Wang, MD, Kaohsiung, Taiwan
Jih-Yang Ko, MD, Niao Sung Hsiang, Taiwan
Chung-Cheng Huang, Kaohsiung, Taiwan

INTRODUCTION: The tendon-bone healing in anterior cruciate ligament (ACL) reconstruction remains controversial. Some studies demonstrated the phenomenon of ligamentization after implantation of tendon autograft into a bone tunnel. However, other studies showed the opposite results and concluded that metaphyseal bone and tendon do not heal together. Extracorporeal shock wave therapy (ESWT) has been shown to enhance tendon-bone healing after ACL reconstruction in rabbits. We hypothesized that ESWT may improve ACL surgery in human subjects.

METHODS: Thirty-four patients (34 knees) were randomized into ESWT and control groups with 17 patients (17 knees) in each group. The ESWT group underwent arthroscopic single-bundle ACL reconstruction and received ESWT to the midtibia tunnel after surgery. The control group received ACL surgery without ESWT. The evaluations included Lysholm score, International Knee Documentation Committee (IKDC) score, KT-1000 arthrometer testing, radiographs, bone mineral density, and magnetic resonance imaging.

RESULTS: The ESWT group showed significantly better Lysholm scores than the control group at one year (96.67 ± 2.58 vs. 86.71 ± 10.58; P=.043) and two years (97.92 ± 2.43 vs. 89.27 ± 8.09; P<.001) postoperatively. No significant differences were noted in the IKDC subjective between the ESWT and control groups at one year (58.64 ± 6.38 vs. 53.31 ± 10.57) and two years (63.78 ± 5.74 vs. 58.0 ± 9.36) postoperatively (both P>.05). The KT-1000 arthrometer values of anterior-posterior laxity of the knee in the ESWT group were significantly better than those of the control group at two years postoperatively (2.40 ± 0.91 vs. 3.47 ± 1.25; P=.041). The size of the middle third tibia tunnel on radiographs was significantly smaller in the ESWT group at two years after treatment (P=.016). No discernible difference was noted in bony appearance and bone mineral density values between the two groups. On magnetic resonance imaging, the ESWT group showed significantly better integration of tendon graft to bone marrow and lower tibial tunnel enlargement as compared with the control group (all P<.05).

DISCUSSION AND CONCLUSION: Many factors may influence the healing of tendon to bone including the application of bone morphogenetic protein (BMP), periosteum augmentation, calcium-phosphate ceramics, granulocyte colony-stimulating factor, hyperbaric oxygen therapy and gene transfer. Some
reported limited success, but none showed universal results. Many studies showed that physical factors such as continuous passive motion (CPM) and ESWT can enhance the healing of periosteal and free tendon autografts to bone. The results of the current study showed that application of ESWT to the bone tunnel significantly enhanced the early tendon-bone healing and decreased the tibia tunnel enlargement after anterior cruciate ligament reconstruction in the short-term. ESWT-treated knees showed better Lysholm functional scores and A-P laxity of the knee, but not the IKDC subjective scores than the control. Long-term results are needed to confirm the efficacy of ESWT in ACL reconstruction.

PAPER NO. 783

Opioids as an Alternative to Amide-type Local Anesthetics for Intraarticular Application

Joern Kircher, MD, Duesseldorf, Germany
Monika Herten, PhD, Duesseldorf, Germany
Irina Ickert, Duesseldorf, Germany
Christoph Ziskoven, Diisseldorf, Germany
Ruediger Krauspe, MD, Duesseldorf, Germany

INTRODUCTION: Several authors have investigated the cytotoxic effects of amide-type local anesthetics (LA) on chondrocytes (Karpe 2007, Dragoa 2008, Chu 2008, Peger 2008, Gomoll 2009, Lo 2009). Dilution effects during intraarticular application and degradation effects on human chondrocytes also after single-shot application have not been thoroughly investigated yet. The hypotheses are that single-shot application of LA is significantly cytotoxic on human chondrocytes and that opioid drugs are harmless without relevant cytotoxicity and therefore can replace LA. METHODS: Human cartilage cells were cultivated in monolayer until confluence in alginate beads (1.2% alginate, 4x106 cells/ml) (n=5). The cells were harvested from non-weight bearing parts of the knee joint in patients during arthroscopy for meniscus surgery. Exclusion criteria were the presence of remarkable degenerative changes, infections, previous surgery, alignment failure or cruciate ligament rupture. Staining with Safranine O, Alcian blue and Dimethylmethylene blue. Immunocytochemistry Collagen-II characterization. After 16d of cell culture exposure to bupivacaine 0.5%, ropivacaine 0.75%, morphine 0.5mg/ml and NaCl as control for 15, 30, 60 and 240 min. Washing three times with NaCl/medium and cultivation for another 3d in medium. Assessment of cell viability by assay. RESULTS: We observed a clear ranking order in regard to the cytotoxic potency: bupivacaine > ropivacaine > morphine. Bupivacaine reduces cell viability compared to control after 15 min exposure to 50%, to 20% after 30 min, to 0.2% after 60 min; after 240 min there are no more viable cells detectable. Ropivacaine shows 100% viability after 15 min, 82% after 30 min; 70% after 60 min and 10% after 240 min. Incubation with bupivacaine 0.25% and ropivacaine 0.375% for 15 min reduces cell viability about 32% and 9%. Cell viability after exposure to morphine is comparable to the control: 90% after 15 min, 85% after 30 min, 83% after 60 min and 81% after 240 min. DISCUSSION AND CONCLUSION: With this in vitro-simulation of the effect of a single-shot intraarticular application of morphine versus LA on human chondrocytes we were able to show a significant and relevant cytotoxic effect of LA in contrast to morphine. Intraarticular application of LA is not recommended for routine use and for single-shot injections. This study confirms morphine to be the less cytotoxic analgesic drug for intraarticular application. Further investigations are necessary to prove the harmlessness for continuous application via pain pumps. Alternative opioid drugs are under investigation for clinical intraarticular use.

PAPER NO. 784

Ongoing Positive Effect of Platelet Rich Plasma in Lateral Epicondylitis After Two Years: A RCT

Taco Gosens, MD, Goirle, Netherlands
Brenda den Oudsten, PhD, Tilburg, Netherlands
Joost Peerbooms, Seacliff, Australia

INTRODUCTION: Platelet rich plasma (PRP) has shown to be a general stimulation for repair and one year results showed promising success percentages. The objective was to determine the effectiveness of PRP compared with corticosteroid injections in patients with chronic lateral epicondylitis with a two-year follow up in a double-blind randomized controlled trial with a two-year follow up between May 2006 and January 2008. The trial was conducted in two teaching hospitals in the Netherlands. METHODS: One hundred patients with chronic lateral epicondylitis were randomly assigned to the PRP group (n=51) or in the corticosteroid group (n=49). A leucocyte-enriched PRP was used in this study. Randomization and allocation to the trial group were carried out by a central computer system. Patients were randomized to receive either a corticosteroid injection or an autologous platelet concentrate injection through a peppering needling technique. The primary analysis included Visual Analogue Scale (VAS) pain scores and Disabilities of the Arm, Shoulder, and Hand Outcome (DASH) scores. RESULTS: With regard to pain, 60 out of 100 (60%) patients were successfully treated. Compared with the corticosteroid group (n = 21; 42.8%), patients in the PRP group were more often treated successfully (n =39; 76.5%) (p<.0001). With regard to disability, 56 out of 100 (56.0%) patients were successfully treated. Compared with the corticosteroid group (n = 19; 38.7%), patients in the PRP group were more often treated successfully (n =37; 72.5%) (p<.0001). Success was defined as a reduction of 25% on VAS or DASH scores without a re-intervention after two years. There were no complications related to the use of PRP. DISCUSSION AND CONCLUSION: Treatment of patients with chronic lateral epicondylitis with PRP reduces pain and increases function significantly, exceeding the effect of corticosteroid injection even after a follow up of two years. Future decisions for application of the PRP for lateral epicondylitis should be confirmed by further follow up from this trial and should take into account possible costs and harms as well as benefits.

PAPER NO. 785

Increasing Platelet Concentration in Platelet Rich Plasma Inhibits ACL Cell Function

Ryu Yoshida, BS, Boston, MA
Mingyu Cheng, PhD, Medford, MA
Martha M. Murray, MD, Boston, MA

INTRODUCTION: The use of platelet rich plasma (PRP) for orthopedic applications, including treatment of anterior cruciate ligament (ACL) injuries, has gained much interest. Collagen-PRP composites have been shown to stimulate ACL healing at early time points in large animal models. However, there is limited knowledge about the optimal concentration of platelets in PRP. In this study, we examined whether varying platelet concentrations of PRP would affect ACL cell proliferation and collagen production. METHODS: Porcine ACL fibroblasts were cultured on three-dimensional collagen scaffolds with saline, platelet-poor plasma (PPP) and PRP with 1X to 5X the systemic concentration of platelets. ACL cell proliferation, collagen gene expression and apoptosis were measured at day 14 using...
RESULTS: In all the experiments, the 5X PRP had the poorest effect on ACL cells. The 5X group had the least ACL cell proliferation and collagen production (significantly less than 1x PRP, p<0.05). Cells treated with PPP had the most ACL cell proliferation, and ACL cells treated with 1X PRP had the highest type I and type III collagen expressions and least number of apoptotic cells. (All figures shown as mean±SD, n=5 for MTT assay. n=4 for all other data.) DISCUSSION AND CONCLUSION: Our in vitro results suggest that higher concentrations of platelets in PRP (5X) are not necessarily beneficial for ACL healing.

INTRODUCTION: Injection of anesthetics and steroids is commonly employed in the management of tendinitis. Previous studies have demonstrated that local anesthetics have cytotoxic effects on chondrocytes and have also been implicated in post-arthroscopic glenohumeral chondrolysis. The effect of anesthetics and steroids on tendon health and viability remains largely unknown. We aim to compare the cytotoxic nature of lidocaine and ropivacaine in conjunction with dexamethasone on cultured bovine tenocytes.

METHODS: Tenocytes were harvested and cultured from the patellar tendons of bovine calves. Cultured cell lines were then subjected to one of 10 different conditions (12 samples/condition). Cells were subjected to (1) Normal Saline (NS), (2) 1% Lidocaine, (3) 2% Lidocaine, (4) 0.2% Ropivacaine, (5) 0.5% Ropivacaine, (6) Dexamethasone (Dex), (7) 1% Lidocaine+Dex, (8) 2% Lidocaine+Dex, (9) 0.2% Ropivacaine+Dex, (10) 0.5% Ropivacaine+Dex for 30 minutes and then allowed to recover in regular media for 24 hours. Treated cells then underwent viability assay and fluorescence-activated cell sorting (FACS) for live/dead cell counts. Statistical Analysis: viability assay results are exhibited as mean luminescence (representing relative cell viability) +/- standard error. FACS data is shown as the percentage of dead cells seen in the overall cell sorting. Statistically significant differences were determined with the Student t test with significance set at p<0.05.

RESULTS: We found decreased cell viability with increasing concentrations of local anesthetics. All anesthetic treatment groups were statistically different from our normal saline control (p<.05) except 0.2% ropivacaine (p=.07). The greatest overall decrease in cell viability was seen with 2% lidocaine; 0.2% ropivacaine had the least cytotoxic effect of the anesthetics. Dexamethasone failed to demonstrate a statistically different effect than our NS control (p=.22) but when used in concert with the anesthetics, the combination proved to have a greater cytotoxic effect than when the anesthetics were used alone. FACS data counting for live/dead cell percentages showed similar results with increased dead cells with higher anesthetic concentrations. Interestingly, dexamethasone had a greater detrimental effect on cell viability and cell death when administered with ropivacaine than with lidocaine.

DISCUSSION AND CONCLUSION: As seen with bovine and human chondrocytes, local anesthetics demonstrate significant...
cytotoxic effects on bovine tenocytes. Tenocyte exposure to lidocaine and ropivacaine exhibited a dose dependent response with decreased cell viability and increased cell death with increased anesthetic concentrations. Dexamethasone further potentiated this effect when exposed with the anesthetic. This data suggests the injection of local anesthetics and steroids may be detrimental to tenocyte viability and overall tendon health. Figure 1. (Section 1) Tenocyte luminescence (demonstrating cell viability) 24 hours after 30-minute exposure +/- standard error. (Section 2) Dead cell percentage counts as demonstrated by FACS. (Section 3) Sample FACS readout with NS Control vs. 2% Lidocaine.

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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

PAPER NO. 787

Thermal Stress Potentiates Bupivacaine Chondrotoxicity

Samantha L. Piper, MD, San Francisco, CA
Hubert T. Kim, MD, PhD, San Francisco, CA

INTRODUCTION: Post-arthroscopic glenohumeral chondrolysis (PAGL) has been increasingly described in recent literature. While its etiology remains unknown, intra-articular local anesthetics and thermal stress from radiofrequency probes are suspected causes; both are chondrotoxic, however neither has individually been shown to cause PAGL. The effect of sequential exposure to thermal stress and local anesthetics on articular cartilage remains unknown. We hypothesize that thermal exposure will potentiate the chondrotoxic effects of bupivacaine and result in increased articular chondrocyte death compared to bupivacaine exposure alone.

METHODS: Bovine full-thickness articular cartilage explants were first treated with a range of thermal exposures to create a time/temperature/viability curve. The temperature and time combination that did not cause a significant decrease in chondrocyte viability compared to control (thermo-toxicity threshold) was determined; this was used as the thermal exposure for further experiments. Explants were then exposed to 37 or 55° C for 20 minutes in a clean water bath. Thirty minutes later, they were treated with either 0.9% normal saline or 0.5% bupivacaine for 30 minutes. Twenty-four hours after treatment, chondrocyte viability was measured using the Live/Dead Cell Viability Assay. Statistical Analysis: Results are represented by mean percentage of live cells +/- standard error. Each combination of experimental and control treatments was repeated five times and done in quintuplicate. Statistically significant differences were determined using ANOVA with a Tukey’s post-hoc analysis with significance set at p<0.05.

RESULTS: There was a temperature and time dependent decrease in chondrocyte viability after thermal exposure. For intact cartilage explants, the thermo-toxicity threshold was 55° C for 20 minutes [55° C = 52.5+/-1.1%; 37° C = 57.6+/-1.3% (p=0.23)]. At all points above this time and temperature combination, there was a significant difference in chondrocyte viability between thermal exposure and no thermal exposure groups (p<0.05). Chondrocyte viability in cartilage explants was significantly lower after treatment with thermal stress followed by bupivacaine compared to treatment with bupivacaine or with thermal stress alone [bupivacaine+55° C, 20m=0.08+/-0%; bupivacaine+37° C, 20m=47.1+/-0.8% (p<0.01); normal saline+55° C, 20m= 52.5+/-1.1% (p<0.01)] (Figure 1).

DISCUSSION AND CONCLUSION: Bupivacaine exposure up to 30 minutes following thermal exposure is significantly more chondrotoxic than bupivacaine exposure alone in bovine articular cartilage explants. This result indicates that thermal stress sensitizes chondrocytes to the toxic effects of bupivacaine, resulting in significantly more cell death, even when the exposures do not occur simultaneously.

Figure 1. Bovine articular cartilage explant viability 24 hours after 20 minute thermal exposure followed 30 minutes later by 30 minute local anesthetic exposure. (1) 37° C, Normal saline (2) 37° C, 0.5% Bupivacaine (3) 55° C, Normal saline (4) 55° C, 0.5% Bupivacaine. Live cells fluoresce green, and dead cells fluoresce red (magnification x10; calibration bar = 1 mm). Bar graph shows mean % live chondrocytes +/- standard error, * = p<0.01.
Orthovisc(R) Hinders Bovine Articular Chondrolysis Induced by Bupivacaine under Supraphysiologic Temperatures

Sen Liu, MD
Qingsong Zhang, MD, New Orleans, LA
Qiuyang Zhang, PhD, New Orleans, LA
Nelson Mead, BS, New Orleans, LA
Michael J. O’Brien, MD, New Orleans, LA
Zongbing You, MD, New Orleans, LA
Felix H. Savoie, III, MD, New Orleans, LA

INTRODUCTION: Bupivacaine has long been used to reduce immediate postoperative pain following arthroscopy in joints. It is known that supraphysiologic temperature (> 37 ºC, up to 80 ºC) can be attained inside the joint during heat-generating arthroscopic procedures. It is possible that bupivacaine may be injected into the joint when the intra-articular temperature is supraphysiologic. Supraphysiologic temperature has been known to reduce chondrocyte viability. However, it is not known whether a combination of bupivacaine and supraphysiologic temperature would further increase cytotoxicity in articular chondrocytes, and if so, what measures could protect the chondrocytes against such cytotoxicity. The specific aim of this in-vitro study was to determine if Orthovisc®, a bacterially derived sodium hyaluronate solution, could protect chondrocyte death induced by bupivacaine under supraphysiologic temperatures.

METHODS: Bovine articular chondrocytes suspended in phosphate-buffered saline (PBS) were incubated at 37ºC, 45ºC, and 50ºC for 1 h, then treated with or without 0.25% or 0.5% bupivacaine hydrochloride for one hour at room temperature. The chondrocytes were stained with a solution of 0.8 µM ethidium homodimer-1 and 0.8 µM calcein AM (acetoxymethyl ester) in PBS for 20 minutes in the dark at room temperature. The percentages of live and dead cells were obtained by counting 10,000 cells using a flow cytometry analyzer. For cell viability at six and 24 hours after treatment, the cells were washed three times with PBS to remove bupivacaine and cultured in Dulbecco’s Modified Eagle’s Medium (DMEM) containing 10% fetal bovine serum. At each time point, the cells were stained with the LIVE/DEAD kit. Representative photomicrographs were taken with a fluorescence microscope equipped with a digital camera and basic research software. We found that, one hour after treatment, supraphysiologic temperatures (45 ºC and 50 ºC) caused 9.2% and 24.8% of chondrocyte death, respectively.

RESULTS: Bupivacaine at 37ºC did not induce significant chondrocyte death, compared to the PBS control group. However, at 45ºC and 50ºC, 0.25% bupivacaine caused 21.2% and 72.4% of chondrocyte death, respectively; and 0.5% bupivacaine caused 44.3% and 61.5% of chondrocyte death, respectively. Addition of 1.5, 3.75 and 7.5 mg/ml Orthovisc (in concentration of hyaluronan) to the chondrocytes significantly inhibited chondrocyte death caused by 0.25% bupivacaine at 50ºC (P<0.05). However, addition of 3.75 and 7.5 mg/ml Orthovisc significantly inhibited chondrocyte death caused by 0.5% bupivacaine at 45ºC and 50ºC (P<0.05 and P<0.01, respectively) (Figure 1). Orthovisc’s protective effects were still observed at six (Figure 2) and 24 hours (Figure 3) after bupivacaine treatment at 45ºC. However, at 50ºC, Orthovisc could only delay the process of cell death caused by bupivacaine, but could not prevent the eventual chondrocyte death after 24 hours. DISCUSSION AND CONCLUSION: We concluded that bupivacaine under supraphysiologic temperatures could cause articular chondrocyte death and Orthovisc could prevent chondrocyte death induced by bupivacaine at or below 45ºC. This finding implies that bupivacaine can be mixed with Orthovisc for intra-articular injection to prevent bupivacaine’s potential cytotoxicity.
**Figure 2** shows the results for tensile testing at 15 weeks postoperatively, normalized for values for intact ACLs from the contralateral knees.

### Cytotoxicity of Local Anesthetics in Human Mesenchymal Stem Cells

**Ruyan Rahnama, BA, San Francisco, CA**  
**Hubert T. Kim, MD, PhD, San Francisco, CA**  
**Alfred C. Kuo, MD, San Francisco, CA**

**INTRODUCTION:** Local anesthetics are delivered intra-articularly to provide post-operative analgesia following orthopaedic procedures. However, these drugs can be toxic to cells such as articular chondrocytes, with the degree of toxicity dependent on the anesthetic. Mesenchymal stem cells (MSCs) are bone-marrow derived precursors that can form multiple tissues, including cartilage and tendon. MSCs likely play a key role in tissue healing following surgeries such as microfracture and anterior cruciate ligament reconstruction. The effects of local anesthetics on MSCs have not yet been reported. In this study, we determined the cytotoxicity of commonly used concentrations of lidocaine, ropivacaine, and bupivacaine on human MSCs.

**METHODS:** Human MSCs (Lonza) were grown in tissue culture until passage five or six, grouped into six samples per condition, and exposed to one of the following drug dilutions for 60 minutes: 1) 0.5% lidocaine, 2) 1% lidocaine, 3) 2% lidocaine, 4) 0.25% bupivacaine, 5) 0.5% bupivacaine, 6) 0.2% ropivacaine, 7) 0.5% ropivacaine. Control groups were treated with 0.9% normal saline solution. MSCs were allowed 24 hours recovery in regular growth media after treatment and viability was measured using an assay which stains live cells green and dead cells red and a viability assay which measures levels of ATP production. Statistical Analysis: Live cell counts from three independent trials were combined in an ANOVA model with trial as a random variable. Least Square Mean values ± standard error were compared. Output was reported as mean luminescence ± standard error. Statistically significant differences for multiple comparisons were determined using Tukey’s HSD test at p<0.05. RESULTS: Analysis of live cell counts indicates that clinically used 1% lidocaine is significantly more toxic than the highest tested doses of bupivacaine and ropivacaine (p<0.05; Figure 1,2). Bupivacaine and ropivacaine did not exhibit significant differences in toxicity in comparison to control conditions (p=0.22 and 0.48, respectively) or in comparison to each other (p=0.96). Additionally, analysis of individual drugs revealed a dose response for lidocaine with significantly greater cell death at higher doses (p<0.05). No significant toxicity or dose response was observed for bupivacaine and ropivacaine. Analysis of output confirmed the relative toxicity of lidocaine in comparison to bupivacaine and ropivacaine (p<0.05).

**DISCUSSION AND CONCLUSION:** Unlike the toxicity observed in human and bovine chondrocytes, commonly-used concentrations of ropivacaine and bupivacaine appear to have limited toxicity in human MSCs. However, lidocaine is significantly detrimental to MSC viability at even low concentrations, with a dose dependent increase in cell death. These data suggest that ropivacaine and bupivacaine may offer better treatment options with respect to MSC health and healing following surgery.

**Figure 2**

![Tensile Testing Load and Stiffness](chart)

**DISCUSSION AND CONCLUSION:**

**PAPER NO. 791**

**Combination Treatment using Platelet-Rich Plasma and an Angiotensin II Receptor Blocker for Muscle Contusions**

**Satoshi Terada, MD, Pittsburgh, PA**  
**Tetsuo Kobayashi, MD, Pittsburgh, PA**  
**Yutaka Mifune, MD, Kobe, Japan**  
**Koji Takayama, MD, PhD, Pittsburgh, PA**  
**Takanobu Otsuka, MD, Nagoya-City, Japan**  
**Freddie H. Fu, MD, Pittsburgh, PA**  
**Johnny Huard, PhD, Pittsburgh, PA**

**INTRODUCTION:** Muscle contusions are capable of healing; incomplete functional recovery often occurs. We have previously reported that when a safe human dose of losartan (10mg/kg/day), one of the FDA approved angiotensin II receptor blockers (ARBs), was administrated three days after injury, it can promote functional improvement, muscle regeneration and decrease fibrosis at four weeks after injury. Moreover, some reports have shown that platelet-rich plasma (PRP), which includes many kinds of growth factors, can accelerate muscle healing after injury. Our hypothesis that losartan treatment along with PRP can further accelerate the muscle healing process compared to the use of losartan or PRP treatment alone. The purpose of the current study is to investigate the potential functional improvement of contusion injured skeletal muscle in mice using both losartan and PRP in combination.

**METHODS:** The contusion injury was created on the tibialis
A Systematic Review of the Use of Platelet Concentrates on Tendon and Ligament Injuries of the Extremities

Mohamed Sukeik, MD, London, United Kingdom
Jonathan Bernheimer, London, United Kingdom
Moataz El-Husseiny, Stanmore, United Kingdom
Fares Haddad, FRCS, London, United Kingdom

INTRODUCTION: Despite its extensive use, research on the efficacy of platelet concentrates (PC) in treating orthopaedic injuries is limited. We conducted a systematic review of randomized controlled trials (RCTs) to study the use of PC in tendon and ligament injuries of extremities. Our hypothesis was that PC may improve functional outcomes, reduce pain and augment tissue healing with no significant complications due to its autologous origin.

METHODS: The Cochrane methodology for systematic reviews was implemented and outcomes measured included the effects of PC on function and pain levels, radiological assessment of healing and any associated complications. Methodological assessment was performed independently by two reviewers.

RESULTS: The literature search yielded five RCTs involving 410 patients with mean age of 40.8 years (range 18-70) for the PC treated group and 40.9 years (range 18-70) for the control group. Mean follow up was 46 weeks (range 24-104). Types of injuries included acute anterior cruciate ligament (ACL) tears in two studies, chronic achilles tendinopathy, chronic subacromial compression and chronic lateral epicondylitis of the elbow. Despite favorable results from observational studies, our study showed conflicting evidence of PC benefit for all three outcomes measured regardless of whether the injury was acute or chronic; PC was given as part of nonsurgical or surgical management and even within the two studies dealing with ACL injuries. The only significant finding was when comparing injuries affecting the upper versus lower limbs where using PC has been associated with better functional outcome and pain scores in upper limb injuries. However, there remains a lot of variability among the study protocols and administered doses to draw any firm conclusions.

DISCUSSION AND CONCLUSION: Given the limited amount and conflicting nature of the current data, the benefits of using PC in tendon and ligament injuries of the extremities remain questionable. Larger multi-centred RCTs on specific injuries that use standard operating procedures and have standardized inclusion and exclusion criteria are needed to clarify PC’s role in these types of injuries.

PAPER NO. 793
Combination Treatment using Platelet-Rich Plasma and an Angiotensin II Receptor Blocker for Muscle Contusions
Satoshi Terada, MD, Pittsburgh, PA
Shusuke Ota, MD, PhD, Shizuoka, Japan
Tetsuo Kobayashi, MD, Pittsburgh, PA
Yutaka Mifune, MD, Kobe, Japan
Koji Takayama, MD, PhD, Pittsburgh, PA
Takanobu Otsuka, MD, Nagoya-City, Japan
Freddie H. Fu, MD, Pittsburgh, PA
Johnny Huard, PhD, Pittsburgh, PA

INTRODUCTION: Muscle contusions are capable of healing; incomplete functional recovery often occurs. We have previously reported that when a safe human dose of losartan (10mg/kg/day), one of the FDA approved Angiotensin II Receptor Blockers (ARBs), was administrated 3 days after injury it can promote functional improvement, muscle regeneration and decrease fibrosis at 4 weeks after injury. Moreover, some reports have shown that Platelet-Rich Plasma (PRP), which includes many kinds of growth factors, can accelerate muscle healing after injury. Our hypothesis that losartan treatment along with PRP can further accelerate the muscle healing process compared to the use of losartan or PRP treatment alone. The purpose of the current study is to investigate the potential functional improvement of contusion injured skeletal muscle in mice using both losartan and PRP in combination. Methods: The contusion injury was created on the tibialis anterior (TA) muscle of C57BL/6 wild-type mice. All injured mice were randomly assigned to 1 of 4 groups: (1) fed plain drinking water (control group, n=10), (2) administered 10mg/kg/day of oral losartan starting 3 days (losartan group, n=10), (3) injected with 20 μl of PRP in the injured TA muscle 1 day after injury (PRP group, n=10), (4) combined treatment with both (2) and (3) (PRP/losartan group, n=10). PRP was isolated from the rat whole blood via a double centrifuge technique. The concentration of the platelets obtained in the PRP was 5.5 times higher than that of the whole blood. All animals were sacrificed at one, two and four weeks post-injury to evaluate, histologically and physiologically, muscle healing. Histological evaluation was performed using hematoxin and eosin staining to monitor the number of regenerating myofibers, and Masson’s trichrome staining was used to measure areas of fibrotic tissue within the injury sites. Immunohistochemistry was performed to evaluate angiogenesis in the injured site. Statistical analysis was performed with Scheffe’s F test as a post hoc test. Statistical significance was defined as p<0.05.

RESULTS: Injection of PRP and the administration of losartan showed an improvement in muscle strength. At 4 weeks after the injury, the control group showed significantly less specific peak twitch and tetanic forces when compared with all the other groups. Interestingly, the PRP/losartan group showed a significantly greater specific peak twitch and tetanic forces when compared to the other groups. Injection of PRP and the administration of losartan enhanced muscle regeneration and angiogenesis and decreased fibrosis formation in injured muscle. At four weeks after the injury, we observed significant increases in the number of centronucleated myofibers (regenerating myofibers) in the losartan, PRP and PRP/losartan groups when compared with the control animals, and the PRP/losartan group possessed a greater number of regenerating myofibers than all the other groups. The mean area of fibrosis in the control was greater than in the losartan, PRP and PRP/losartan groups. Moreover in the PRP/losartan group the mean area of fibrosis was less than the other groups. At both one and two weeks after injury, the PRP and PRP/losartan groups showed significantly greater angiogenesis areas.

DISCUSSION AND CONCLUSION: The combination treatment using losartan and PRP following a contusion injury can accelerate skeletal muscle healing. We observed a larger number of regenerating myofibers, greater angiogenesis, less fibrosis, and better functional recovery in the PRP/losartan group. These results suggest that the combination treatment of PRP and losartan after skeletal muscle injury could be more effective than the individual treatments alone.

PAPER NO. 792
Combination Treatment using Platelet-Rich Plasma and an Angiotensin II Receptor Blocker for Muscle Contusions
Supplementation with Platelet Rich Plasma Improves the In Vitro Formation of Cartilage

J. N. Amritha De Croos, PhD, Toronto, ON, Canada
Massimo Pettera, MD, Toronto, ON, Canada
Rita Kandel, MD, Toronto, ON, Canada
Mark Hurtig, DVM, Guelph, ON, Canada
John Theodoropoulos, MD, North York, ON, Canada

INTRODUCTION: Cartilage injuries are problematic due to a limited repair response. We have developed an in vitro method of forming cartilage on the top surface of a porous biodegradable substrate suitable for transplantation. This tissue engineering strategy replaces the damaged cartilage and restores joint congruency with hyaline-like cartilage. However, this tissue has reduced extracellular matrix (ECM) compared to native cartilage. Platelet rich plasma (PRP) has previously been used to treat various types of tendon and cartilage trauma. The successful treatment of cartilage damage using platelet rich plasma is secondary to the concentration of growth factors and clot formation in the injury site. Given its benefits, we hypothesized that PRP in place of fetal bovine serum (FBS) would improve tissue engineered cartilage making it more suitable for transplantation.

METHODS: Tissue engineered cartilage was cultured in three conditions: FBS, PRP or PPP (platelet poor plasma). PRP and PPP were prepared with blood from a mature cow collected in a syringe with citrate dextrose solution (1.3 ml per 10 cc of blood) and centrifuged at 1000 rpm for 10 minutes. The supernatant was centrifuged again at 3000 rpm for five minutes to collect the PRP. The remaining serum was centrifuged at 3000 rpm and the supernatant was centrifuged again at 3000 rpm to collect the PPP. Chondrocytes were isolated from bovine metacarpal-phalangeal articular cartilage by enzymatic digestion and seeded on top of a porous substrate (calcium polyphosphate) at a density of 160,000 cells/mm² in Ham’s F12 supplemented with 5% FBS, PRP or PPP. Media was changed every two to three days. FBS, PRP or PPP concentration was increased to 20% with the addition of ascorbic acid (100µg/ml) on Day 5. After two weeks, the samples were analyzed by histology and biochemistry. Experiments were conducted three times and results expressed as mean ± SEM. Data was analyzed by one-way ANOVA with significance assigned at p<0.05.

RESULTS: Tissue engineered cartilage cultured for two weeks with PRP formed thicker tissue compared to samples incubated with FBS or PPP (Fig 1). Biochemical data supported our histological findings with a significant increase in GAG (a measure of proteoglycan) content in samples incubated with PRP (177±25 µg GAG/mg dry wt.) compared to FBS (117±18 µg GAG/mg dry wt.) or PPP (136±26 µg GAG/mg dry wt.). Collagen content increased in samples incubated in PRP (85±9.6 µg collagen/mg dry wt.) compared to FBS (71±10.3 µg collagen/mg dry wt.) or PPP (50±10.6 µg collagen/mg dry wt.), but this increase was not significant. There were no significant differences in DNA content under the three conditions.

DISCUSSION AND CONCLUSION: Tissue engineered cartilage cultured in media supplemented with PRP had improved ECM compared to FBS and PPP cultures. The lack of significance in collagen increase may be due to the short two-week time point. These results suggest that supplementing with PRP instead of FBS yields improved tissue engineered cartilage.

For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.

*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).
INTRODUCTION: Tendinopathy is characterized by degenerative changes in tendon structure resulting in decreased biomechanical function and pain. rhPDGF-BB has been shown to improve repair in animal models of tendon rupture. The objective of this study was to characterize the ability of rhPDGF-BB to induce tendon repair in a tendinopathy (non-rupture) model. METHODS: A collagenase-induced rat Achilles tendinopathy model was used. Treatment groups (n=15 animals/group) included: (i) Vehicle control, (ii) 1.02 µg rhPDGF-BB, (iii) 10.2 µg rhPDGF-BB, and (iv) 102 µg rhPDGF-BB. Treatments were injected intratendinously seven days following the collagenase treatment. Rats were euthanized seven and 21 days post-treatment. Histopathological assessment included cell proliferation (PCNA immunostaining) and tendon thickness measurements. Uniaxial tensile testing was performed to assess the impact of the treatments on the biomechanical properties (maximum load-to-rupture and stiffness). RESULTS: There was a significant increase in cell proliferation with the 10.2 and 102 µg rhPDGF-BB dose groups (p=0.049 and 0.015 respectively) compared to vehicle control after seven days. There was also a significant increase in tendon thickness at the midsubstance of the tendon with 10.2 µg of rhPDGF-BB (p=0.005) compared to controls. By day 21, cell proliferation and tendon thickness in rhPDGF-BB-treated tendons returned to control levels. The maximum load-to-rupture in the 1.02 and 102 µg rhPDGF-BB groups were not significantly different than the control group. The maximum load-to-rupture was significantly increased, relative to control, in the 10.2 µg rhPDGF-BB group at seven days (p=0.003) and persisted over 21 days (p=0.019). DISCUSSION AND CONCLUSION: Intra-tendon injections of rhPDGF-BB significantly increased the maximum load-to-failure of treated tendons in a dose-dependent manner in a rat Achilles tendinopathy model.

POSTERS

POSTER NO. P406

A Systematic Review of Complications Reporting in Clinical Trials in Sports Medicine

Damian Kosempa, MD, Pittsburgh, PA
Albert Lin, MD, Pittsburgh, PA
James J. Irrgang, PhD, Pittsburgh, PA
Christopher D. Harner, MD, Pittsburgh, PA

INTRODUCTION: The purpose of this study was to determine the consistency of reporting complications in high quality sports medicine clinical trials. METHODS: A systematic review of five highly respected orthopedic journals was performed by a single reviewer. The journals included
INTRODUCTION: The bony architecture of the hip depends upon functional adaptation to mechanical use via dynamic interactions between the acetabulum and femoral head. Variation in the orientation of the acetabulum, proximal femur, or a combination of both is believed to directly damage the hip. Acetabular retroversion is thought to contribute to pincer-type femoroacetabular impingement. However, studies of pathologic hip joints suggest proximal femoral anatomy compensates for acetabular retroversion. This study tested for correlations among proximal femoral and acetabular angles, age and gender associated with normal hips. METHODS: Computed tomography (CT) scans fully depicting the pelvis and lower extremities of 143 anonymized subjects were obtained from a previously established database of vascular CT angiography scans investigating either peripheral artery disease or lower extremity aneurysm between November 2007 and March 2010. Twenty-eight scans were excluded because of radiographic evidence of osteoarthritis, defined as either narrowing of the joint space, subchondral sclerosis, bony cysts, marginal osteophytes, bony erosions or loose bodies. A chart review was performed to assure the remaining 115 subjects did not have hip symptoms (e.g., difficulty walking, joint pain, joint redness, joint stiffness, joint swelling) during any prior orthopaedic or rheumatology visits or during a primary care visit in which a musculoskeletal review of systems and physical examination were performed. Images were reconstructed at 1 mm increments and loaded into an in-house, proprietary software package. Three-dimensional volumetric images were generated, allowing the pelvis and lower extremities to be rotated and viewed from any angle and analyzed as a free body, independent of patient orientation within the gantry. The femoral neck version, femoral neck shaft angle, acetabular version, acetabular inclination and acetabular center edge angle were measured in 230 normal hip joints from 115 adults using three-dimensional reconstruction software. Correlations between the angles, age and gender were examined using stepwise regression and backward elimination. RESULTS: Positive correlations were found between femoral version and acetabular version (p=0.0014), femoral neck shaft angle and acetabular version (p=0.0134), acetabular version and gender (p=0.018), and center edge angle and gender (p=0.018) (Table 1). Negative correlations were observed between femoral neck shaft angle and age (p=0.0003), and femoral version and acetabular inclination (p=0.0026), although this latter relationship was only observed unilaterally (i.e., left hip) (Table 1). DISCUSSION AND CONCLUSION: The correlation between multiple proximal femoral and acetabular angles demonstrated in this study supports the hypothesis that a complementary developmental relationship occurs between the femoral head and acetabulum. Future investigation into the relationship between these angles in patients with the signs and symptoms of pincer-type femoroacetabular impingement may alter a surgeon’s approach to treating this patient population.

Table 1

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POSTER NO. P408

Surgical Hip Dislocation for Failed Arthroscopic Management of Femoroacetabular Impingement

Michael R. Pagnotto, MD, Wexford, PA
Justin A. Walker, MD, Rochester, MN
Robert T. Trousdale, MD, Rochester, MN
Rafael J. Sierra, MD, Rochester, MN

INTRODUCTION: Hip arthroscopy is the preferred option by some in treating patients with femoroacetabular impingement (FAI). Not all deformities associated with FAI can be treated arthroscopically. We report on a select group of patients that underwent surgical hip dislocation (SHD) for treatment of persistent FAI after hip arthroscopy with emphasis on reporting the reasons for failure of the hip arthroscopy and surgical outcomes after SHD. METHODS: Twenty-three patients (25 hips) who had undergone hip arthroscopy prior to SHD were identified from 155 patients (178 hips) treated with SHD between 8/2002 and 2/2011. Of the 25 hips, 18 were in women and seven in men with an average age of 28.4 years (18-50). The average follow up was 18 months (2-54). The average time between hip arthroscopy and SHD was 1.5 years (0.5-4). Clinical notes, radiographs and operative notes were reviewed to determine the primary reason for failure of arthroscopic treatment and to determine clinical results, complications, and the need for additional procedures. RESULTS: The primary mode of failure of arthroscopic surgery was identified as a persistent offset abnormality in 12 hips, persistent acetabular overcoverage in 10 hips (six anterior/superior and four global), significant femoral head articular cartilage damage in two hips, and one hip had a shortened lateral neck which accounted for persistent symptoms. Figure 1 demonstrates a persistent offset abnormality after failed arthroscopy. Note the difference between the arthroscopic and the open osteochondroplasty. At last follow up, 18 of 25 hips had pain relief while seven continued to have significant symptoms. Two hips underwent subsequent total hip arthroplasty and two underwent hip arthroscopy for recurrence of labral tears. Eight hips underwent hardware removal. At the time of arthroscopy, three hips had no labral work, 15 had labral debridement, six had labral resection, and one had the labrum taken down and then re-fixed. At the time of SHD one hip had no labral work, five had the labrum taken down and re-fixed, seven had labral reconstruction with either
Assessment of the Validity of an Industry Produced Deep Venous Thrombosis Risk Assessment Tool

Trevor Owen, MD, Boston, MA
Tyler R. Clark, BA, New Orleans, LA
Kellen G. Hayes, MS, BS, New Orleans, LA
George F. Chimento, MD, Metairie, LA

INTRODUCTION: Deep venous thrombosis (DVT) is a known complication of knee arthroscopy, however routine prophylaxis is not without risk. The purpose of this study was to validate an industry produced DVT risk assessment tool in patients undergoing simple knee arthroscopy. If valid, this tool could be used to stratify DVT risk in patient's undergoing knee arthroscopy and guide prophylactic treatment.

METHODS: A total of 1,655 outpatient knee arthroscopies, without ligament reconstruction, were retrospectively reviewed and assigned a risk score based on the presence or absence of risk factors according to the risk assessment tool. The risk scores of patients with and without DVT were compared and the individual risk factors were assessed for their correlation with DVT rate. Multiple cutoffs of risk score were evaluated to determine their ability to predict actual DVT risk.

RESULTS: A total of 62% of all patients were classified as high risk. Symptomatic DVT occurred in six patients (0.36%) in the study population. There was no significant difference between the average risk score of patients with DVT, 3.33, and without, 3.14 (p=0.74). No significant difference was noted between the incidences of DVT in the different risk categories, 0.37% high risk, 0.45% moderate risk, 0% low risk (p=>0.4 for all comparisons). No cutoff of the risk score was identified which provided useful sensitivity and specificity of predicting DVT occurrence. The only variable that showed significance with DVT rate was history of recent major infection (p=0.002).

DISCUSSION AND CONCLUSION: This DVT risk assessment tool overestimates the DVT risk and does not effectively stratify risk of DVT in patients undergoing simple knee arthroscopy. Therefore, this tool should not be used to guide prophylactic treatment.
ACL reconstruction with or without remnant preservation. METHODS: A total of 134 knees that underwent ACL reconstruction were evaluated with minimum follow up of two years. Patients were divided into two groups, depending on the ACL reconstruction method: patients with non-remnant group (n=83) and remnant group (n=51). Clinical assessments were carried out to compare Lachman and pivot-shift test, range of motion, Tegner activity scales, and Lysholm knee scores between two groups. The intraoperative stability after reconstruction with navigation system and stability based on stress radiographs at the final follow up were compared between two groups. RESULTS: Mean Lysholm knee and Tegner activity scales did not show any difference at the final follow up between two groups. Mean range of motion was 139.8 and 135.4 in each group (120-150) without any significant flexion contracture. According to Lachman test results, 71 cases (85%) were converted to negative and 12 (15%) to mild instability in non-remnant group and 46 cases (90%) were converted to negative and five (10%) to mild instability in remnant preservation group, which showed no significant difference between two groups (p>0.05). On the pivot-shift, remnant preservation group showed better results than non-remnant group (12% vs. 20% of Gr I instability, p=0.04). Mean side to side differences measured also showed better stability at the final follow up in remnant preservation group than non-remnant group (1.2 vs. 2.4mm, p=0.03). While the intraoperative anterior displacement of remnant preservation group was significantly less than non-remnant group at 30° and 60°, it showed no significant differences than those found at other degrees of flexion (p>0.05). The intraoperative rotational stability also showed better results in remnant groups (p<0.05) at 0° and 60°. DISCUSSION AND CONCLUSION: ACL reconstruction with remnant preservation shows better pivot-shift outcomes and instrumented stability compared to ACL reconstruction without remnant preservation.

POSTER NO. P412

Cost Effectiveness Analysis of Early Reconstruction vs. Rehabilitation and Delayed Reconstruction for ACL Tears

Richard C. Mather, III, MD, Traverse City, MI
Carolyn Hettrich, MD, MPH, Iowa City, IA
Warren Dunn, MD, MPH, Nashville, TN
Brian J. Cole, MD, Chicago, IL
Bernard R. Bach, Jr, MD, River Forest, IL
Kurt P. Spindler, MD, Nashville, TN

INTRODUCTION: An initial anterior cruciate ligament (ACL) tear can be treated with focused rehabilitation or surgical reconstruction. The KANON randomized control trial compared early ACL reconstruction to rehabilitation and optional delayed reconstruction and found no difference in outcome by intention to treat analysis of KOOS scores. The purpose of this study was to compare the cost-effectiveness of early ACL reconstruction to rehabilitation and delayed reconstruction. METHODS: A Markov decision model was constructed for a cost-utility analysis of early reconstruction (ER) versus rehabilitation and optional delayed reconstruction (DR). Outcome probabilities and effectiveness were derived from two sources: The Knee Anterior Cruciate Ligament, Nonsurgical versus Surgical Treatment (KANON) Study and the Multicenter Orthopaedic Outcome Network (MOON) database of a prospective longitudinal cohort of anterior cruciate ligament reconstructions. Utilities were measured by the SF-6D. Costs were estimated from the societal perspective with use of the national average Medicare reimbursement for the procedures in 2011 U.S. dollars. Costs and utilities were discounted in accord with the United States Panel on Cost-Effectiveness in Health and Medicine. Effectiveness was expressed in quality-adjusted life years gained (QALYs). QALYs measure the quantity and quality of life and are a unit of utility. Principal outcome measures were average incremental costs, incremental effectiveness, incremental quality-adjusted life years (QALYs), and net health benefits. Willingness-to-pay was set at $50,000, the currently accepted standard in the U.S. RESULTS: In the base case, early ACL reconstruction resulted in an incremental gain of 0.28 QALYs over rehabilitation and delayed reconstruction. However, early reconstruction cost, on average, $1,690 more than rehabilitation and delayed reconstruction. The incremental cost effectiveness ratio was $5,967/QALY. This number was well below the $50,000/QALY willingness-to-pay threshold. Sensitivity analysis revealed that if the cost of ACL reconstruction falls below $1,404 or 58% of the remaining 32% of patients with residual clinical instability at two years after rehabilitation eventually choose ACL reconstruction, the early reconstruction treatment strategy becomes less costly. At these thresholds, early reconstruction was both more effective and less costly, and therefore, a dominant treatment strategy. DISCUSSION AND CONCLUSION: Early ACL reconstruction produced effectiveness gains below the willingness-to-pay threshold and is therefore, the preferred treatment compared to rehabilitation and delayed ACL reconstruction with cost effectiveness as the primary outcome. In other words, early ACL reconstruction provides a greater average benefit to the patient at a cost highly acceptable to society. Reasonable scenarios exist where early reconstruction would cost less than rehabilitation and delayed reconstruction. These findings suggest that when considering optimal societal healthcare delivery, early ACL reconstruction is a viable treatment option.

POSTER NO. P413

Dynamic In Vivo Knee Kinematics After Anatomic Double Bundle ACL Reconstruction

Sebastian Kopf, MD, Berlin, Germany
Gele Moloney, MD, Pittsburgh, PA
Kristina Freismuth, BS, Pittsburgh, PA
Freddie H. Fu, MD, Pittsburgh, PA
Scott Tashman, PhD, Pittsburgh, PA

INTRODUCTION: The anterior cruciate ligament (ACL) has two distinct bundles, the anteromedial (AM) and posterolateral (PL) bundle, which work in concert throughout the range of motion of the knee to provide anteroposterior and rotational stability. There is a known association between ACL injury and future development of osteoarthritis. Anatomic ACL reconstruction is designed to restore the native function of the ACL and can include one or both bundles. Previous dynamic studies have shown that knees which have undergone single bundle ACL reconstruction are in more varus and more externally rotated than ACL intact knees during downhill running. There is some evidence that double bundle ACL reconstruction more accurately restores rotation when compared to single bundle reconstruction. The purpose of this study is to compare knee kinematics after anatomic double bundle ACL reconstruction with intact native ACL. METHODS: Ten patients four to 23 months following anatomic double bundle ACL reconstruction were recruited for this IRB-approved study. High resolution CT scans of both knees were obtained and used to create 3D models of the femur and tibia. Biplane radiographic images were acquired at 150
frames per second during decline running and 100 frames per second during level walking. Images were collected for three trials per limb per activity. Using custom software, digitally reconstructed radiographs of 3D bone models were correlated with the biplane radiographic images to create 3D models of and track tibiofemoral motion with precision of ±0.2mm or better. Tibiofemoral kinematic data points including medial/lateral and anterior/posterior translation, ab/adduction, and internal rotation were extracted every 20ms. Statistical analysis of the 100ms following heel strike, the period of highest joint loading, was performed using within-subject repeated measures ANOVA (SPSS GLM) with α=0.05 to evaluate differences between limbs.

RESULTS: Comparing the intact ACL to anatomic double bundle ACL reconstruction, no significant differences were found between limbs during decline running (affected limb mean ± std error, control limb mean ± std error, p value) in mean AP translation (10.4±1.3mm, 9.4±1.4mm, p=0.135), ML translation (1.2±0.7mm, 1.1±0.6mm, p=0.9), ab/adduction (-0.2±0.8°, -1.0±0.0°, p=0.06), internal/external rotation (2.7±2.2°, 2.6±1.0°, p=0.9). Additionally, no significant differences were found between limbs during level walking in mean AP translation (8.3±1.1mm, 7.7±1.2mm, p=0.4), ML translation (1.4±0.6mm, 1.3±0.3mm, p=0.95), ab/adduction (0.0±0.9°, 0.1±0.9°, p=0.71), internal/external rotation (-1.3±1.5°, -1.0±1.2°, p=0.85).

DISCUSSION AND CONCLUSION: In this limited sample, anatomic double bundle ACL reconstruction restores the knee kinematics of the ACL intact native knee during level walking and decline running. The persistent varus and external rotation found previously following single bundle reconstruction was not seen following anatomic double reconstruction. It is possible that the addition of a distinct PL bundle, which is tightest in extension, helps to restore normal joint kinematics at the lower knee flexion angles seen following heel strike. Because the differences in ab/adduction between limbs during decline running approached significance (p=0.06) a larger sample size is needed to confirm the restoration of normal joint kinematics in anatomic double bundle ACL reconstruction. In addition, long term follow up is needed to assess for the effect of restoring kinematics on future development of osteoarthritis.

POSTER NO. P414
Effects of Suture Choice on Biomechanics and Physeal Status after Bio-enhanced ACL Repair - A Large Animal Study
Patrick Vavken, MD, Boston, MA
Braden C. Fleming, PhD, Providence, RI
Jason T. Machan, PhD, Providence, RI
Martha M. Murray, MD, Boston, MA

INTRODUCTION: The objective of this study was to assess the effect of absorbable and non-absorbable sutures on suture tunnel and growth plate healing and biomechanical outcomes at 15 weeks after bio-enhanced ACL repair in an skeletally immature pig model.

METHODS: Sixteen pigs underwent unilateral anterior cruciate ligament (ACL) transection and bio-enhanced ACL repair with either absorbable or non-absorbable sutures. At 15 weeks, suture tunnel and growth plate healing were assessed by microCT and structural properties and anteroposterior laxity of knees were measured.

RESULTS: Yield load (p = 0.0138) and failure load (p = 0.0024) were higher in the non-absorbable group, but there were statistically significant differences for displacement (p=0.4297). The non-absorbable group showed significantly larger bone tunnels (p<0.001) and physeal defects (p<0.001) and a lower bone mineral density (p<0.001).

DISCUSSION AND CONCLUSION: Non-absorbable improved the structural properties of the healing ligament, but may also jeopardize the growth plate. We suggest the use of non-absorbable sutures with an intraphyseal placement, similar to recommendations for suture fixation of tibial eminence avulsions.

Representative micro-CT images. Note the wider bone tunnel (with arrows) in the non-absorbable sample. Also, the affected growth plate area is significantly larger in the non-absorbable suture groups, and bony bars can be seen in the magnification (white squares).
The Utility of Plain Radiographs in the Initial Evaluation of Knee Pain in Sports Medicine Patients

Eric Strauss, MD, New York, NY
Michael J. Alaia, MD, New York, NY
Omar N. Khatib, MD, New York, NY
Mehul R. Shah, MD, New York, NY
Joseph A. Bosco, III, MD, New York, NY
Laith M. Jazrawi, MD, New York, NY

INTRODUCTION: Routine plain radiographs as part of the initial evaluation of knee pain in a sports medicine practice are commonly ordered, very rarely impact clinical decision making and are a waste of valuable healthcare dollars. A routine series of knee radiographs, including anteroposterior (AP) weight bearing, lateral and sunrise views is commonly ordered in the initial evaluation of a patient with knee pain presenting to a sports medicine practice. The purpose of the current investigation is to evaluate the utility of these plain radiographs in the evaluation and management of sports medicine patients presenting to the office with knee pain. We hypothesized that for the younger patient population, routine radiographs have little impact on clinical decision making.

METHODS: In an IRB-approved retrospective study, findings from 188 consecutive new patients presenting to the sports medicine office with a chief complaint of knee pain were reviewed. The attending sports medicine specialist completed a questionnaire documenting patient age, duration of symptoms, location of knee pain, associated mechanical symptoms, history of recent trauma, positive findings on plain radiographs, whether or not the plain radiographs changed management and whether or not an MRI was ordered. Collected data was then analyzed with a Student’s t-test, Chi Square test and a logistic regression analysis.

RESULTS: The patient population was 52% male and 48% female with an overall mean age of 40.8 years (range 13-76 years). Overall, plain radiographs changed management in 27.1% of evaluated patients. The mean age of patients in whom radiographs impacted their care was 55.8 years compared to 35.2 years in those evaluated patients. The mean age of patients in whom radiographs were obtained or ordered at their initial office evaluation in 60% of cases.

DISCUSSION AND CONCLUSION: The routine use of radiographs in the initial evaluation of knee pain in a sports medicine practice is of little clinical value and should not be ordered in patients younger than 40 years of age. For patients older than 40, screening radiographs are of value in those with symptoms localizing to the medial or anteromedial aspect of their knee and in those whose symptoms are present for more than six months duration.

POSTER NO. P416
Early Versus Delayed Revision Anterior Cruciate Ligament Reconstruction: Structural and Functional Outcomes

Moataz El-Husseiny, Stanmore, United Kingdom
Shelain Patel, MRCS, London, United Kingdom
Mohamed Sukeik, MD, London, United Kingdom
Fares S. Haddad, FRCS, London, United Kingdom

INTRODUCTION: Revision anterior cruciate ligament (ACL) is associated with worse outcomes than the primary. METHODS: We compared 98 patients who underwent revision ACL reconstruction surgery at two years post-operative. Patients were divided into two groups which were case matched: early revision surgery within six months of failure or delayed after six months of failure. The incidence of meniscal tears and cartilage damage were noted intra-operatively. Knee stability using KT-1000 arthrometer, proprioception using star excursion balance test and one leg hop test, quadriceps strength using weight lifts and range of motion were recorded at six months, one year and two years post-operatively. In addition, functional outcome scores including Lysonm, Tegner, IKDC were significantly higher in the early group (p<0.05). There was no significance revealed between the groups in the one leg hop test, range of motion, KT-1000 arthrometer laxity measurements and Lachman test (p=0.87).

DISCUSSION AND CONCLUSION: We conclude that there are both structural and functional advantages gained in early revision ACL reconstructions within six months of failure.
of the AC joint. Retrospective study; Level of evidence, 3.

METHODS: The outcomes of 21 consecutive patients who underwent anatomical reduction and ST grafting for AC joint separation were reviewed retrospectively. Patients were divided into two groups: single-tunnel group (11) and two-tunnel group (10). All patients were examined clinically and radiographically using a modified UCLA rating scale.

RESULTS: The majority of separations (18 of 21) were Rockwood type V, with one each in type III, IV and VI categories. The overall mean follow-up time was 16 months, and at the time of the latest follow up, the overall mean UCLA rating score was 14.1 (range 8-20). The percentage of good-to-excellent outcomes was significantly higher for patients with the two-tunnel technique than for those with the one-tunnel technique (70% vs. 18%, respectively, p=0.03). Within the single-tunnel group, there was no statistically significant difference in percentage of good-to-excellent outcomes between patients with vs. without tightrope augmentation (17% vs. 20%, p>0.99). Similarly, within the two-tunnel group, there was no significant difference in the percentage of good-to-excellent outcomes between the graft only and augment groups (67% vs. 75%, p=0.99).

DISCUSSION AND CONCLUSION: Anatomical reduction of the AC joint and reconstruction CC ligaments are crucial for optimal joint stability and function. Two-tunnel CC reconstruction with an allogenic ST graft provides statistically significantly better radiographic and clinical results compared to the single-tunnel reconstruction technique. Additionally, tightrope augmentation does not appear to provide improved clinical or radiographic outcomes.

POSTER NO. P418
Evaluation of Rotational Kinematics of Pediatric Anterior Cruciate Ligament Reconstruction Techniques
Ryan Dellamaggiora, MD, Los Angeles, CA
Mark Sena, BS, Berkeley, CA
Dezba Coughlin, PhD, San Francisco, CA
Jeffrey C. Lotz, PhD, San Francisco, CA
Brian T. Feeley, MD, San Francisco, CA

INTRODUCTION: Anterior cruciate ligament (ACL) injuries are becoming more common in the pediatric population. Reconstructions of these injuries are important to provide stability to allow for return to play as well as aiding in avoiding further injuries to the knee. Multiple reconstruction options have been described to provide stability in the skeletally immature patient. This present study uses a novel mechanical pivot shift model to evaluate the dynamic stability in cadaveric knees.

METHODS: Six cadaveric knees were subjected to a dynamic mechanical pivot shift device (MPSD) in the intact and deficient states as well as in the all-epiphyseal (AE), trans-tibial over the top (TT) and the iliotibial band, physeal-sparing (ITB) reconstruction states. The anterior-posterior (AP) displacement and rotation of the tibia (IR) relative to the femur were measured as were rotational pivot velocities. Statistical comparisons were performed between groups with an ANOVA. Significance was defined as a p<0.05.

RESULTS: All reconstructions provided more AP and rotational stability than the deficient state with MPSD. The intact state was used as a control and demonstrated 4.2 mm ± 1.3 of AP displacement and 16.6 ± 1.6 deg of internal rotation with the MPSD. The deficient state demonstrated an average of 10.1 ± 3.9 deg of internal rotation. The ITB reconstruction showed an average of 1.4 ± 2.6 mm of AP displacement and 9.8 ± 5.7 deg of internal rotation. The AP and IR values were significantly less (p<0.05, ANOVA) when compared to the deficient state.

DISCUSSION AND CONCLUSION: The findings demonstrate that all three reconstructions provide significant AP and rotational control over the deficient state through a dynamic range of motion with a simulated pivot shift. There were no significant differences in the three reconstructions’ ability to control AP translation and rotational displacement, however there was a trend to higher constraint than the intact state with the ITB reconstruction. Thus, physeal-sparing reconstructions restore AP displacement and internal rotation when tested with a mechanical pivot shift device.

Figure 1. Example pivot shift plots of AP and Internal Rotation as the knee is subjected to a mechanical pivot shift test.

POSTER NO. P419
Influence of Anthropometric Features on Graft Diameter in ACL Reconstruction
Suresh Thomas, MRCS, Newcastle Upon Tyne, United Kingdom
Raj Bhattacharya, MBBS, MSc, FRCS (Ortho), London, United Kingdom
Josette Saltikov, PhD, PT, Middlesbrough, United Kingdom
Derek J. Kramer, MD, Morpeth, United Kingdom

INTRODUCTION: There is a paucity of literature on the influence of anthropometric features on the hamstring graft obtained in anterior cruciate ligament (ACL) reconstruction, although there are studies on the sex based differences affecting the hamstring graft. This study was undertaken to assess the influence of anthropometric measurements on the graft diameter obtained at ACL reconstruction surgery within the European population.

METHODS: Data from 121 consecutive patients who had undergone ACL reconstruction by the same surgeon using the graft only and reconstruct CC ligaments are crucial for optimal joint stability and function. Two-tunnel CC reconstruction with an allogenic ST graft provides statistically significantly better radiographic and clinical results compared to the single-tunnel reconstruction technique. Additionally, tightrope augmentation does not appear to provide improved clinical or radiographic outcomes.

For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
RESULTS: Of the 121 patients there were 108 males and 13 females. Average age of the cohort was 32 years (14 - 55). There was a statistically significant positive correlation individually between the height and graft diameter \( r = 0.38, p < 0.01 \) as well as between the body weight and graft diameter \( r = 0.29, p < 0.01 \). However, when the body mass index was calculated, the correlation was not statistically significant \( r = 0.08, p > 0.1 \). Regression analysis confirmed that BMI was not statistically significant as a predictor of hamstring graft diameter whereas height was statistically the most important predictor \( F = 20.1; p < 0.01 \). This yielded the predictive equation, graft diameter = 4.5 + 0.02 x Ht (in cms) suggesting that people with height less than 125 centimetres \((4'1')\) are at greatest risk of a quadrupled graft diameter of less than seven millimeter. DISCUSSION AND CONCLUSION: Our findings suggest that although body mass index did not significantly correlate, individual anthropometric variables do influence the size of graft diameter in ACL reconstruction and give pre-operative information. This may allow surgeons to plan for alternative graft options, if they could predict the possibility of inadequate graft size prior to ACL reconstruction surgery.

POSTER NO. P420

**Single-row versus Double-row Rotator Cuff Repair: Charge-Analysis and Outcomes Assessment**

Michael A. Cohn, MD, New York, NY
Samir Nayyar, MD, Amherst, NY
Stanislav Sidash, MD, New York, NY
Saqib Hasan, BS, New York, NY
Laith M. Jazrawi, MD, New York, NY
Andrew S. Rokito, MD, New York, NY

INTRODUCTION: Despite biomechanical studies supporting double-row arthroscopic rotator cuff repairs, there is little clinical data showing improved outcomes over single-row repairs. At the same time, double-row repairs are presumably more costly and time-consuming. The objectives of this study were to determine the differences in hospital charges, operative time, functional outcomes, and rotator cuff healing rates between patients with small-to-medium tears treated with single-row and double-row arthroscopic rotator cuff repairs.

METHODS: We prospectively enrolled 68 consecutive adult patients with small-to-medium supraspinatus tears from July 2008 to October 2010. All included patients underwent arthroscopic acromioplasty and either single-row or double-row arthroscopic rotator cuff repair by one of the two senior authors (L.J. and A.R.) who are sports medicine fellowship-trained orthopaedic surgeons. We reviewed the operative reports and hospital billing records for the charge analysis. At a mean follow-up of 21.7 months, shoulder function was assessed in 60 patients using a modified American Shoulder and Elbow Surgeons (ASES) questionnaire. Ultrasound examination to assess rotator cuff healing was performed in 51 patients. The two groups were compared using the student’s t-test for continuous variables and the chi square test for categorical variables.

RESULTS: Patient demographics were normally distributed with no significant differences between the two groups (age, gender, race, BMI, employment status, and worker’s compensation status). Double-row repairs resulted in significantly higher overall surgical charges \($23,969 vs. 20,185; p=0.043\) and implant charges \($6,891 vs. 2,374; p<0.000\) and operative supply charges \($5,151 vs. 3,907; p=0.002\) compared to single-row repairs. Double-row repairs also required significantly longer mean operative times \(93 vs. 68 \text{ minutes}; p=0.000\). Comparing the single-row versus double-row repair groups, there were no significant differences in mean ASES scores \(86.31 +/-20.37\) vs. \(90.71 +/-20.37\); \(p=0.037\), VAS components \((1.63 +/-2.13\) vs. \(1.25 +/-1.18; p=0.453\)), or ADL components \((44.44 +/-10.73\) vs. \(46.96 +/-5.83; p=0.315\). There was no significant difference in ultrasound-assessed healing rates in the single-row versus double-row groups \(89% vs. 92%; p=0.532\).

DISCUSSION AND CONCLUSION: For small-to-medium rotator cuff tears, arthroscopic double-row repairs are more costly and time-consuming without improvements in functional outcomes or ultrasound-assessed healing rates.
**A Simple Radiographic Sign Vertical Femoral Tunnel Placement During Anterior Cruciate Ligament Reconstruction**

Lutul D. Farrow, MD, Garfield Heights, OH
Kellen L. Huston, MD, Saint Louis, MO
Parisa Morris, MD, Tucson, AZ
E. Tyler Hall, MD, Tucson, AZ
Scott G. Kaar, MD, Saint Louis, MO

**INTRODUCTION:** Malposition of the anterior cruciate ligament (ACL) femoral tunnel is a leading cause of graft failure following ACL reconstruction. The purpose of this study is to describe a novel radiographic sign indicative of vertical femoral tunnel placement following anterior cruciate ligament reconstruction. Our first hypothesis is that vertical ACL femoral tunnel placement is manifested by a disruption in the continuity of Blumensaat’s line on a lateral plain x-ray. Our second hypothesis is that by using well-described intraoperative landmarks (AK) for ACL femoral tunnel placement, we can always avoid vertical tunnel placement. Our third hypothesis is that this disruption of Blumensaat’s line when seen during the evaluation of a failed ACL reconstruction can be a positive indicator that a new, anatomic tunnel can be drilled while completely avoiding the previous, mal-positioned femoral tunnel. It is our hope that this method may decrease the need for computed tomography for the evaluation of mal-positioned femoral tunnels following ACL reconstruction.

**METHODS:** We reviewed 190 consecutive anatomic single-bundle anterior cruciate ligament reconstructions over a two-year period. Operative records, patient charts, arthroscopic images, and pre-operative orthogonal (anteroposterior and lateral) plain radiographic knee images were reviewed on each patient. We made note of the femoral tunnel drilling technique, transtibial or anteromedial portal. Note was also made of the graft type utilized. We reviewed postoperative lateral radiographs on each patient. Femoral tunnel position was identified and noted whether the posterior (proximal) aspect of Blumensaat’s line was violated or intact.

**RESULTS:** We reviewed a total of 190 consecutive anterior cruciate ligament reconstructions. Seventeen knees did not have postoperative lateral x-rays available and Blumensaat’s line was obscured in an additional 28 knees, precluding adequate evaluation. These knees were excluded from the study, leaving 145 knees for inclusion. We found that none of the anatomically placed femoral tunnels violated Blumensaat’s line. In all revision cases exhibiting violation of Blumensaat’s line, a new, anatomical femoral tunnel could be drilled, completely avoiding the previously placed, non-anatomic ACL femoral tunnel.

**DISCUSSION AND CONCLUSION:** Following anterior cruciate ligament reconstruction, violation of Blumensaat’s line on a lateral knee radiographic imaging is a reliable indicator of vertical, non-anatomic femoral tunnel placement. Using well described intraoperative landmarks during anterior cruciate ligament reconstruction reliably avoided vertical femoral tunnel placement. Furthermore, when violation of Blumensaat’s line is seen during the work-up of a failed anterior cruciate ligament reconstruction an anatomically placed femoral tunnel is expected to avoid the previously placed non-anatomic femoral tunnel. Ultimately, this may help to avoid costly CT scans which may unnecessarily expose patients to high levels of ionizing radiation.

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**POSTER NO. P422**

**Effect of Tibial Slope on the Stability of the Anterior Cruciate Ligament Deficient Knee**

James Voos, MD, Leawood, KS
Eduardo M. Suero, MD, New York, NY
Frank Petrigliano, MD, Santa Monica, CA
Thomas L. Wickiewicz, MD, New York, NY
Andrew D. Pearle, MD, Rye, NY

**INTRODUCTION:** Recent studies have demonstrated a positive correlation between increased posterior tibial slope and the incidence of anterior cruciate ligament (ACL) injury. Increasing the magnitude of posterior slope causes an anterior shift of the tibia in relation to the femur and a change in contact pressures distribution within the joint. The effect of posterior tibial slope on knee rotational stability and the pivot shift maneuver has not been quantified to the same extent. We aimed to quantify the effect of changes in tibial slope on the magnitude of anterior tibial translation (ATT) in the ACL deficient knee during the Lachman and pivot shift tests.

**METHODOLOGY:** Lachman and Pivot shift tests were performed on hip-to-toe cadaveric specimens and ATT of the lateral and medial compartments measured using navigation. Analysis was performed using one-way ANOVA. RESULTS: ATT of the lateral compartment during the Lachman test in the ACL intact knee was 4.7 mm (SD=2.4 mm). After sectioning the ACL, translation increased to 8.4 mm (SD=1.9 mm) (P=0.0064). Mean ATT after 5º increase in slope was 8.1 mm (SD=3.0 mm) (P=0.05). The 5º scaling level reduced lateral compartment translation to 7.2 mm (SD=3.3 mm) (P=0.05). In the medial compartment, anterior tibial translation in the ACL intact knee was 3.9 mm (SD=1.5 mm). Translation increased to 6.5 mm (SD=2.3 mm) after sectioning the ACL (P=0.0353). Mean anterior tibial translation after increasing the slope by 5º was 5.7 mm (SD=3.2 mm) (P=0.05). After the leveling osteotomy, mean translation was 5.7 mm (SD=2.9 mm) (P=0.05). Anterior tibial translation of the lateral compartment during the mechanized pivot shift in the ACL intact knee was 0.7 mm (SD=1.8 mm). After sectioning the ACL, translation increased to 7.5 mm (SD=4 mm) (P=0.05). Increasing the posterior slope of the tibial plateau by 5º further increased anterior tibial translation to 9.7 mm (SD=5.9 mm). This was significantly different from intact (P=0.0006) but not significantly different from the ACL deficient knee (P=0.05). Leveling the slope of the tibial plateau by 5º compared to the native slope reduced lateral compartment translation to 3 mm (SD=6.7 mm) (P=0.05). The difference between the increased slope condition and the leveled slope condition was statistically significant (P=0.0141). The medial compartment had 4.7 mm (SD=4.1 mm) of ATT in the intact knee. Sectioning the ACL caused an increase in translation to 8.2 mm (SD=4.5 mm) (P=0.05). ATT increased to 10.6 mm (SD=7.4 mm) after increasing the posterior slope by 5º (P=0.0424). Translation after leveling the slope was 3.9 mm (SD=6.9 mm) (P=0.05). This was significantly different from intact (P=0.0006) but not significantly different from the ACL deficient knee (P=0.05). Leveling the slope of the tibial plateau by 5º compared to the native slope reduced lateral compartment translation to 3 mm (SD=6.7 mm) (P=0.05). The difference between the increased slope condition and the leveled slope condition was statistically significant (P=0.0141). The medial compartment had 4.7 mm (SD=4.1 mm) of ATT in the intact knee. Sectioning the ACL caused an increase in translation to 8.2 mm (SD=4.5 mm) (P=0.05). ATT increased to 10.6 mm (SD=7.4 mm) after increasing the posterior slope by 5º (P=0.0424). Translation after leveling the slope was 3.9 mm (SD=6.9 mm) (P=0.05). This was significantly
different than ATT in the increased slope condition (P=0.0115).

DISCUSSION AND CONCLUSION: Tibial slope changes did not affect the magnitude of translation during a Lachman test. However, large changes in tibial slope variation affected the magnitude of the pivot shift. In the setting of failed ACL reconstruction or ACL deficiency with a high grade pivot shift, ACL reconstruction in conjunction with proximal tibial osteotomy may be considered.

POSTER NO. P424
ALTERNATE PAPER: SPORTS MEDICINE/ARTHROSCOPY VI

Return to Play after Epidural Steroid Injection for Lumbar Disc Herniation in Professional Football Athletes

Aaron J. Krych, MD, Rochester, MN
Daniel Richman, MD
Mark Drakos, MD, Uniondale, NY
Patrick Birmingham, MD, Watwatosa, WI
Leigh Weiss, East Rutherford, NJ
Ronnie P. Barnes, East Rutherford, NJ
Frank P. Cammisa, Jr, MD, New York, NY
Russell F. Warren, MD, New York, NY

INTRODUCTION: To our knowledge, there is currently no published information on the efficacy of epidural steroid injections for the treatment of lumbar disc herniation in an athletic population. As professional athletes have a high level of baseline functionality, they provide an ideal population to assess the usefulness of this modality. The purpose of the present study is to evaluate the efficacy of epidural corticosteroid injection for treatment of lumbar disc herniation in a group of professional American football players, and also to identify risk factors for success or failure of this treatment approach.

METHODS: We retrospectively reviewed the records of all professional American football players that underwent an epidural steroid injection at our institution for incapacitating pain secondary to an acute lumbar disc herniation (confirmed on magnetic resonance imaging) from 2003 to 2010. Detailed injury information, physical examination, radiographic and magnetic resonance imaging, and time to return to play was reviewed for all players in the study. The primary outcome was success of the injection, defined as return to play. The secondary outcome of the study was to evaluate risk factors for failure of this treatment approach. To assess potential risk factors, P values were calculated using a logistic regression model, with values <0.05 considered statistically significant.

RESULTS: Thirty-seven injections were performed for 27 distinct lumbar disc herniation episodes from 2003 to 2009. The success rate of returning an athlete to play for a given episode of disc herniation was 89% (24 of 27 episodes) with an average loss of 2.8 practices (range, 0-12) and 0.6 games (range 0-2) after the injection. Following successful return to play, athletes played an average of 2.8 seasons (range, 1-6) at their previous activity level, with 10 players still active in their career. Four players required a repeat injection for the same episode. Three of these four players ultimately failed conservative management and required surgical intervention. Risk factors for failing injection therapy included sequestration of the disk herniation on magnetic resonance imaging (p=0.01) and weakness on physical examination (p=0.02). There were no complications reported.

DISCUSSION AND CONCLUSION: In professional athletes with high functional demands, our results suggest epidural steroid injections are safe and effective in treating symptomatic lumbar disc herniations. When measuring success by return to play, this study shows an 89% success rate. This compares favorably to previously reported success rates of return to play following conservative treatment (79% at an average of 4.7 months) or lumbar discectomy (74-90%). However, we recommend prudence when applying this treatment approach to athletes that present with weakness or with sequestration of the disc on magnetic resonance imaging, as they demonstrate a higher rate of treatment failure in this series. In conclusion, epidural injections for acute lumbar disc herniations in professional football athletes appear to be safe and effective in returning players to competition.

POSTER NO. P425

Soft Tissue Healing in an In Vivo Anterior Cruciate Ligament (ACL) Allograft Model

Sanjeev Bhatia, MD, Chicago, IL
Rebecca Bell, BS, Chicago, IL
Rachel M. Frank, MD, Chicago, IL
Scott A. Rodeo, MD, New York, NY
Bernard R. Bach, Jr, MD, River Forest, IL
Brian J. Cole, MD, Chicago, IL
Susanna G. Chubinskaya, PhD, Chicago, IL
Vincent Wang, Chicago, IL
Nikhil N. Verma, MD, Chicago, IL

INTRODUCTION: The effect of low-dose gamma irradiation on healing of soft tissue allografts remains largely unknown. The purpose of this study was to compare soft tissue healing in a bone tunnel using three types of anterior cruciate ligament (ACL) grafts: non-irradiated allografts, low-level (1.2 MRad) gamma irradiated allografts, and autograft controls. We hypothesized that soft tissue allograft healing to bone would be delayed compared to that of autograft tissue and that low-dose (1.2 MRad) gamma irradiation would not affect the healing response of allograft tissue after ACL reconstruction.

METHODS: Surgery: 48 New Zealand white rabbits underwent bilateral ACL reconstructions with semitendinosus tendon graft. Sixteen rabbits were reconstructed with autografts, the remainder with allografts. The 32 allograft rabbits each received one irradiated allograft (1.2 Mrad), with the contralateral leg receiving a non-irradiated allograft. Animals were euthanized at two weeks or eight weeks post-operatively. Biomechanics: Tensile stiffness, maximum load, and displacement at maximum load were measured using an electro-mechanical materials testing system. Histology: Tibial and femoral segments were sectioned perpendicular to the tunnel axis (at the mid-portion of the tunnel length) allowing for histologic and histomorphometric analyses at the tendon-bone interface.

RESULTS: There were no significant differences between the maximum load or stiffness values among all groups at eight weeks. At two weeks, autograft exhibited significantly (p<0.01) lower maximum load compared to the non-irradiated grafts. There was no statistical difference between autograft and irradiated allografts, or between irradiated allografts and non-irradiated allografts at two weeks. Regarding histology, at both two and eight week time points, autograft tendon displayed more advanced degenerative and remodeling processes in comparison with irradiated allograft and non-irradiated allograft. Histomorphometric analyses demonstrated no differences between the grafts at any time point.

DISCUSSION AND CONCLUSION: The maximum load and stiffness of a healing tendon graft in ACL reconstruction appears to be independent of low-dose (1.2 Mrad) irradiation. At eight weeks, there was no difference with regard to biomechanical analysis of bone-tendon healing in allografts versus autograft controls. Histologic analyses did demonstrate a faster remodeling response in autograft specimens in comparison with allografts at all time.
INTRODUCTION: The anterior cruciate ligament (ACL) is composed of two distinct bundles, the anteromedial (AM) and posterolateral (PL) bundles, which work together to provide anteroposterior and rotational stability to the knee. There is a well-described relationship between ACL injury and development of osteoarthritis. Though the mechanism for this relationship is not well understood, exposing articular chondrocytes to shear stress has been linked to chondrocyte death and increased shear across loaded articular cartilage has been proposed as a mechanism driving the progression of osteoarthritis. ACL reconstruction, either single or double bundle, is designed to restore the native function of the ACL and tibiofemoral arthrokinematics. The purpose of this study is to compare tibiofemoral joint contact path length as an indicator of cartilage shear after single and double bundle ACL reconstruction.

METHODS: Seventeen patients four to 23 months following single (n=7) or double (n=10) bundle ACL reconstruction were recruited for this IRB-approved study. High resolution CT scans of both knees were obtained and used to create 3D models of the femur and tibia. Biplane radiographic images were acquired at 150 frames per second during decline running. Images were collected for three trials per limb. Using custom software, digitally reconstructed radiographs of 3D bone models were correlated with the biplane radiographic images to create 3D models of and track tibiofemoral motion with precision of ±0.2mm or better. Tibiofemoral joint contact path (Figure 1), as defined by the closest point between theibia and the femur in the medial and lateral compartment at a given time, was extracted every 20ms. The points along the tibial surface were used to determine path length over the first 100ms following heelstrike. This increased path length over a fixed period of time is reflective of the shear stress experienced by the cartilage. Increased shear stress in single bundle reconstructed limbs may contribute to future development of osteoarthritis. Following double bundle reconstruction there is no difference between reconstructed and control limbs suggesting that double bundle reconstruction may better restore tibiofemoral motion. Further study is needed to assess for the effect of joint contact path length on development of osteoarthritis.

**POSTER NO. P426**

**Joint Contact Path Length During Downhill Running After Single and Double Bundle ACL Reconstruction**

Gele Moloney, MD, Pittsburgh, PA
Sebastian Kopf, MD, Berlin, Germany
Kristina Freismuth, BS, Pittsburgh, PA
Freddie H. Fu, MD, Pittsburgh, PA
Scott Tashman, PhD, Pittsburgh, PA

RESULTS: Following single bundle ACL reconstruction, joint contact path length in both the medial and lateral compartments of the reconstructed limbs compared to the unaffected contralateral limbs during the first 100ms following heelstrike. This increased path length over a fixed period of time is reflective of the shear stress experienced by the cartilage. Increased shear stress in single bundle reconstructed limbs may contribute to future development of osteoarthritis. Following double bundle reconstruction there is no difference between reconstructed and control limbs suggesting that double bundle reconstruction may better restore tibiofemoral motion. Further study is needed to assess for the effect of joint contact path length on development of osteoarthritis.

**POSTER NO. P427**

**A Novel Approach to Assess Dynamic Function in the Non-Arthritic Hip**

Travis G. Maak, MD, New York, NY
Anil S. Ranawat, MD, New York, NY
Andrew Kraszewski, MS, New York, NY
Sherry I. Backus, PT, New York, NY
Howard Hillstrom, PhD, New York, NY
Bryan T. Kelly, MD, New York, NY

INTRODUCTION: There has been a recent interest in the nonarthritic hip and its associated complex pathologies. Passive range-of-motion and static specialty tests are the corner stone of diagnosis and assessment of treatment. There has been little information on the use of dynamic functional measurements to assess non-arthritic hip function. The primary aim of this study was to measure and identify objective and reliable functional parameters as a novel approach to assess dynamic hip function.

METHODS: A cross-sectional study was conducted on eight healthy non-arthritic male subjects. Functional kinematic and kinetic data were acquired with dynamic 3D motion analysis during stair ascent and descent, as well as a sit-to-stand maneuver. Surface electromyographic (EMG) activity was measured for hip and trunk musculature. The adjusted coefficient of multiple correlation (CMC) was calculated for angle, moment and EMG measures per subject, and then averaged across subjects. RESULTS: Mean sit-to-stand angle, moment, and EMG CMCs were 0.82, 0.83, and 0.63 respectively. Mean stair ascent angle, moment, and EMG CMCs were 0.83, 0.89, and 0.74, respectively. Mean stair descent angle and EMG CMCs were 0.79, 0.83, and 0.70 respectively. Hip-specific angle and moment CMCs for sit-to-stand, stair ascent, and descent were: 0.91 and 0.90; 0.91 and 0.91; 0.83 and 0.81. DISCUSSION AND CONCLUSION: Overall the kinematic, kinetic and EMG repeatability was very good; these measures...
are sufficiently reliable to objectively assess dynamic function in healthy subjects. Given the importance of these activities of daily living and their requisite stresses, neuromuscular compensation strategies may be involved that are not present with static measures. This novel protocol has been shown to be a reliable way to assess dynamic hip function in the non-arthritic hip. The resultant data may lead to improved diagnostic and therapeutic regimens and also serve as a baseline data set to assess complex pathologies.

POSTER NO. P428

Variances in Gene Expression of Human Meniscal Tears by Patient Age, Sex and ACL Status

Robert H. Brophy, MD, Chesterfield, MO
Mohammed Rai, PhD, Saint Louis, MO
Zhiqi Zhang, Jr., MD, PhD, Guangzhou, China
Adelina Torgomyan, Yerevan, Armenia
Linda J. Sandell, PhD, St Louis, MO

INTRODUCTION: The meniscus plays a critical protective role for the knee joint by contributing to load transmission, shock absorption and joint stability. Little is known about gene expression in meniscal tears, particularly as it relates to injury pattern and patient age and sex. The purpose of this study was to test the hypothesis that gene expression in meniscal tears varies depending on patient age and sex and whether the anterior cruciate ligament (ACL) is also torn.

METHODS: Meniscal tissue explants (n=28) were removed at the time of clinically indicated partial meniscectomy in patients with MMT and with MMT+ACL tear. The mRNA expression was examined by quantitative real-time PCR for several molecular markers of osteoarthritis (OA) including pro-inflammatory cytokines (IL-1α, IL-1β, IL-6, TNFα), chemokines (IL-8, CCL3, CCL3L1, CXCL1, CXCL3, CXCL6, CCL20), aggrecanases (ADAMTS-4, -5), metalloproteinases (MMP-1, -3, -9, -13), transcription factors (NFκB1, NFκB2, IkBα) and matrix components (BMP-2, COL1A1, COL2A1, aggrecan).

RESULTS: Expression of IL-1β (p=0.02), ADAMTS-4 (p=0.03), -5 (p=0.01), MMP-1 (p=0.007), -9 (p=0.002), -13 (p=0.01) and NFκB2 (p=0.01) was significantly higher in MT patients <40. Similarly, the expression of ADAMTS-4 (p=0.002), -5 (p=0.02), and MMP-1 (p=0.02), -13 (p=0.002) was also higher in MT+ACL patients <40. In MT+ACL tear patients, the expression of IL-1β (p=0.01), TNFα (p=0.02), MMP-13 (p=0.004), CCL3 (p=0.03), and CCL3L1 (p=0.03) was significantly higher while that of aggregan (p=0.03) was lower than in isolated MT patients. The only sex-based difference in gene expression revealed significantly higher levels of CCL3L1 in MT+ACL tear females compared to MT+ACL tear males (p<0.05) and isolated MT males (p<0.01) and females (p<0.001).

DISCUSSION AND CONCLUSION: Gene expression in meniscal tears varies by patient age, sex and injury pattern. Our findings suggest that elevated expression levels of OA-specific markers indicate an increased catabolic (inflammatory) response in young patients with MMT as well as MMT+ACL tear. Furthermore, higher expression of inflammatory markers in MMT+ACL tear compared to MMT alone suggests the combined injury pattern is more likely to lead to the development of OA. These findings suggest clinically relevant differences in the response of the knee to meniscus and ACL tears based on patient age and sex. Catabolic activity may be predictive of patients at risk for progression of OA following partial meniscectomy and ACL reconstruction.

POSTER NO. P429

10-Year Arthroplasty Conversion Rates after Arthroscopic Treatment for Osteoarthritis of the Knee

J. Richard R. Steadman, MD, Vail, CO
Henry B. Ellis, Jr, MD, Dallas, TX
Karen K. Briggs, MPH, Vail, CO
Lauren M. Matheny, Vail, CO

INTRODUCTION: Arthroscopic treatment of osteoarthritis of the knee remains a controversial topic. The purpose of this study was to investigate and report long-term outcomes and total knee arthroplasty (TKA) conversion rate following arthroscopic treatment for osteoarthritis.

METHODS: This study was IRB approved. Eighty-one knees in 72 patients (49 males, 32 females), with a mean age of 58 years (range: 37-79 years) were treated with an arthroscopic regimen for osteoarthritis between August of 2000 and November 2001. Inclusion criteria were patients with severe osteoarthritis as determined by radiographic and intraoperative criteria who had failed conservative therapy. The arthroscopic regimen included a joint insufflation, lysis of adhesions, anterior interval release, contouring of cartilage defects to a stable rim, shaping of meniscus tears to a stable rim, synovectomy, removal of loose bodies, and removal of osteophytes that affect terminal extension. Each patient was required to complete a strict postoperative rehabilitation program for at least two months. A survivorship analysis was performed to determine the conversion rate to a total knee arthroplasty (TKA). In the remaining patients, outcomes measures that were collected included, Lysholm score, Tegner Activity Scale, patient satisfaction with outcome and WOMAC score.

RESULTS: Of the 81 knees, seven were decreased and two refused to participate. Thirty-one knees (43%) were converted to a TKA at an average of 4.6 years (range: 1.4-10.0 years) following index arthroscopy. Repeat arthroscopy was performed in 15 knees due to recurrent mechanical symptoms. Survivorship analysis showed a mean survival time of 6.8 years [95% CI: 5.9 to 7.6 years]. Survivorship was 50% at six years, 47% at seven years and was 40% at eight, nine and 10 years following index arthroscopy. For patients who did not undergo arthroplasty, mean Lysholm score was 74.4 (range: 38-100), median Tegner Activity Scale was 9 (range: 0-8), median patient satisfaction with outcome was 8 (range: 1-8) and mean WOMAC score was 19.2 (range: 0-65).

DISCUSSION AND CONCLUSION: An arthroscopic regimen for moderate to severe osteoarthritis of the knee is a good option for active individuals who want to delay a TKA. Even at 10 years, there seems to be a benefit of a knee arthroscopy for a select group of patients.
10 to 16 Years Follow Up of Autologous Chondrocyte Implantation and Survivorship Analysis

Arvind G. Von Keudell, MD, Chestnut Hill, MA
Tim Bryant, BSN RN, Chestnut Hill, MA
Tom Minas, MD, Chestnut Hill, MA

INTRODUCTION: Autologous chondrocyte implantation has proven to have good to excellent results in about 80% of patients under 55 years up to 10 years. There is only scarce literature in cartilage restoration after 10 years, especially for autologous chondrocyte implantation.

METHODS: A total of 210 patients (238 knees, RK=128, LK=110, ØBMI=27kg/m²) were treated with autologous chondrocyte implantation between 1994-2001 for cartilage lesions (Outerbridge grade 4) in the knee. The mean age at surgery was 36±9 and total defect size measured 8.2±5.3cm². High tibial osteotomy (HTO) was performed in 51, tibial tubercle osteotomy (TTO) in 69 (44 Fulkerson, 25 McKay), combined HTO/TTO in 16 and distal femoral varus osteotomy in two patients. ACL was repaired in 10, LCL in one, and combined ACL/LCL in another patient. Modified Cincinnati was collected pre- and postoperatively at the last follow up. Survival analysis was completed using Kaplan-Meier curve.

RESULTS: Out of the 210 patients who were treated for cartilage defects, 205 (97%) patients were available for postoperative evaluation. The defect type was classified as simple (Single unipolar grade 3/4 lesion on femur or grade 2 or less on the tibia or patella) in 18, complex (Multifocal unipolar grade 3/4 chondral lesions on femur, concurrent HTO/TTO, OCD, unipolar lesions on tibia or patella) in 113 and salvage (Bipolar focal chondral lesions, generalized chondromalacia grade 2 or greater) in 107 knees. An average of 1.7 defects/patient were treated. After a mean of 148±19 months, the modified Cincinnati increased from an average 3.7±1.4 to 5.6±1.8 (p<0.0001). At 16 years follow up 62 (26%) patients had at least one failed autologous chondrocyte graft. Failure was defined as revision cartilage repair procedure for a minimum of one lesion in 32, partial or total knee replacement in 25 patients. Four patients were lost to follow up and one declined further treatment. Kaplan-Meier survival demonstrated significantly different chances for survival between simple, complex, and salvage cases, respectively (see figure).

DISCUSSION AND CONCLUSION: Up to 16 years, autologous chondrocyte implantation provides a durable repair of cartilage in patients for the treatment cartilage defects in the knee. Our results advocate good to excellent results in clinical assays after a minimum follow up of 10 years and can substantially delay the need for prosthesis in the young.

Outcome of Meniscal Repair Prior Compared with Concurrent Anterior Cruciate Ligament Reconstruction

Joern Lange, MD, Greifswald, Germany
Matthias Frank, MD, Greifswald, Germany
Sebastian Keil, MD, Greifswald, Germany
Peter Hinz, PhD, MD, Greifswald, Germany
Axel Ekkernkamp, MD, Berlin, Germany

INTRODUCTION: The purpose of this study was to determine in a prospective, randomized clinical trial the outcome of meniscal repair with delayed anterior cruciate ligament (ACL) reconstruction and a combined repair.

METHODS: The result of 81 meniscal tears who underwent meniscal repair using one manufacturer’s device were prospectively evaluated with a follow-up rate of 100%. All cases were performed by one surgeon. We identified 40 patients who underwent isolated repair of a torn meniscus (group 1). We identified 20 patients who underwent repair of a torn meniscus before having their ACL reconstruction (group 2). As a comparison group we identified 21 patients who underwent meniscus repair at the time of ACL reconstruction (group 3). All patients included had a minimum of two years of follow up. Follow up was assessed by clinical examination, the knee disorders subjective history, IKDC-, Lysholm-, Tegner-Score, additional functional tests and radiographs.

RESULTS: At an average follow up of 3.5 years (range, 24-91 months) significant differences were found. Five (12.5%) of the patients in group 1 underwent meniscectomy. Five (25%) of the patients in group 2 and two (9.54%) of the patients in group 3 underwent meniscectomy subsequently. This gives a success rate of 87.5% (35/40) in the isolated meniscus repair patients and a success rate of 82.9% (34/41) in the ACL deficient patients. The difference in success of the meniscal repair between the groups was significant (Fisher's exact test p = 0.05).

DISCUSSION AND CONCLUSION: Meniscal repair and delayed ACL reconstruction is more likely to fail than a combined repair and ACL reconstruction.

The Evaluation of Arthroscopic Remplissage by High Resolution MRI: Are We Getting Our Fill?

Min J. Park, MD, MSc, Philadelphia, PA
Grant Garcia, Philadelphia, PA
Amit Malhotra, MD, Bethlehem, PA
Nancy M. Major, MD, Bryn Mawr, PA
Fotios P. Tjoumakaris, MD, Ocean View, NJ
John D. Kelly, IV, MD, Newtown Square, PA

INTRODUCTION: Remplissage (French for “fill-in”) is a novel procedure recently advocated for the treatment of large Hill Sachs lesions. We have shown previously that infraspinatus tenodesis reduces engagement of the posterolateral humeral head and reduces the risk of recurrent instability in high risk patients. The purpose of this study is to evaluate and characterize the post-operative appearance of the Remplissage procedure on high resolution MRI, and correlate these findings to clinical outcome (WOSI score, range of motion).

METHODS: This study was designed as a prospective, IRB-approved cohort study enrolling patients who had undergone prior arthroscopic Remplissage for recurrent glenohumeral instability with large Hill Sachs defects. Images were acquired with a 3T protocol (and reviewed by two musculoskeletal radiologists) with the shoulder in the ABER and neutral position.
Measured parameters included: signal intensity of tissue within the prior defect, signal intensity of the residual infraspinatus, degree of atrophy (Goutallier grade), presence of marrow edema, and number of anchors in the defect. Functional scores were obtained with the WOSI questionnaire and comprehensive range of motion data was recorded with a goniometer.

RESULTS: Eleven patients were recruited for this study and the average follow up of the patients was 18.0 months (range 8.8 - 27.2). The average size of the Hill Sachs deformity was 334.3 cm³ (range 93.6 to 825.1). The percentage of the deformity filled in with tendon was 75-100% and the degree of atrophy was 0-25% for all patients studied. No defects were left unfilled. Two patients had granulation tissue filling the deformity, and three patients had fibrous tissue, rest of the patients with mixed granulation tissue and fibrous tissue, with transition from granulation to fibrous tissue between 8.1 and 9.5 months post surgery. Four out of nine patients had tendinopathy or partial tears of the residual tendon insertion. In one case, the patient had a large resorptive cyst at the distal aspect of the anchor. One patient had mild humeral marrow edema. The average number of anchors used was 1.4 (range 1 - 3). One patient with the largest Hill-Sachs defect (825.1 cm³) dislocated once at 21 months post-operatively while playing softball, but was able to relocate without incident, and was satisfied with the procedure reporting marked improvement of symptoms compared to prior to the surgery. The average WOSI score was 74.3 (range 41.6 - 91.7) with the average external rotation loss of 5.8 degrees (range 0 - 22). None of the patients reported having noticed losing external rotation on the operative shoulder. There was no clear correlation between WOSI score, defect size, and degree of fill.

DISCUSSION AND CONCLUSION: Our data suggest that there is evidence of tendon incorporation and fill into the Hill-Sachs defect following Remplissage at eight months and beyond. Although MRI findings did not correlate with the clinical findings, patients did not have significant external rotation deficit and were satisfied with the procedure. Figures-Top Left: T2 Sagittal, Top Right: T2 ABER view, Bottom Left:L T2 Coronal, Bottom Right T1 Coronal views demonstrating “fill” of infraspinatus tendon along with posterior capsule into the Hill-Sachs defect.

**POSTER NO. P433**

**Single-row versus Double-row Rotator Cuff Repair: Charge-Analysis and Outcomes Assessment**

Michael A. Cohn, MD, New York, NY  
Samir Nayyar, MD, Amherst, NY  
Samir Nayyar, MD, Amherst, NY  
Stanislav Sidash, MD, New York, NY  
Saqib Hasan, BS, New York, NY  
Laith M. Jazrawi, MD, New York, NY  
Andrew S. Rokito, MD, New York, NY

INTRODUCTION: Despite biomechanical studies supporting double-row arthroscopic rotator cuff repairs, there is little clinical data showing improved outcomes over single-row repairs. At the same time, double-row repairs are presumably more costly and time-consuming. The objectives of this study were to determine the differences in hospital charges, operative time, functional outcomes, and rotator cuff healing rates between patients with small-to-medium tears treated with single-row and double-row arthroscopic rotator cuff repairs.

METHODS: We prospectively enrolled 68 consecutive adult patients with small-to-medium supraspinatus tears from July 2008 to October 2010. All included patients underwent arthroscopic acromioplasty and either single-row or double-row arthroscopic rotator cuff repair by one of the two senior authors (L.J. and A.R.) who are sports medicine fellowship-trained orthopaedic surgeons. We reviewed the operative reports and hospital billing records for the charge analysis. At a mean follow-up of 21.7 months, shoulder function was assessed in 60 patients using a modified American Shoulder and Elbow Surgeons (ASES) questionnaire. Ultrasound examination to assess rotator cuff healing was performed in 31 patients at least one year after surgery.

Two groups were compared using the student’s t test for continuous variables and the chi square test for categorical variables. RESULTS: Patient demographics were normally distributed with no significant differences between the two groups (age, gender, race, BMI, employment status, and worker’s compensation status). Double-row repairs resulted in significantly higher overall surgical charges ($23,969 vs. $17,294; p=0.000), operative supply charges ($5,151 vs. $3,907; p=0.002), and mean number of anchors (3.76 vs. 1.32; p=0.000) compared to single-row repairs. Double-row repairs also required significantly longer mean operative times (93 vs. 68 minutes; p=0.000). Comparing the single-row versus double-row repair groups, there were no significant differences in mean ASES scores (86.31 +/-20.37 vs. 90.71 +/- 10.41; p=0.347), VAS components (1.63 +/-2.13 vs. 1.25 +/-1.18; p=0.453), or ADL components (44.44 +/- 10.73 vs. 46.96 +/- 5.83; p=0.315), respectively. On ultrasound examination, 83.3% of single-row repairs were completely healed versus 66.7% of double-row repairs. The remainder of repairs had partial re-tears of the involved rotator cuff tendon.

DISCUSSION AND CONCLUSION: For small-to-medium rotator cuff tears, arthroscopic double-row repairs are more costly and time-consuming without improvements in functional outcomes or ultrasound-assessed healing rates.
Anterior Glenoid Bone Loss: Correlation of MR Imaging and CT Using a Cadaveric Study Model

Soterios Gyftopoulos, MD, New York, NY
Ikemefuna Onyekwelu, MD, New York, NY
Samir Nayyar, MD, Amherst, NY
Saqib Hasan, BS, New York, NY
Jason Mayo, MD, New York, NY
Jenny Bencardino, New York, NY
Laith M. Jazrawi, MD, New York, NY

INTRODUCTION: The purpose of this study was to compare the measurement of glenoid bone loss using CT, CT3D and MRI.

METHODS: Eighteen fresh-frozen cadaveric shoulders from skeletally mature individuals were utilized. An oscillating saw was used to create a straight cut along the anterior/anteroinferior margin of the glenoid at a predetermined distance from the glenoid bare spot. A post-resection sagittal digital photograph was then taken of the remnant glenoid and a ruler placed along its inferior aspect. Each specimen then underwent CT and MRI examinations, and CT 3D reconstruction of each glenoid. MRI, CT, CT3D en-face images of each glenoid were than analyzed using the best-fit circle technique and percentage bone loss was calculated for each specimen. The glenoid defects on the post-resection digital images were then measured using the same technique and software. The CT and MRI data were analyzed again four weeks after the initial measurements were obtained. All measurements were performed three times with mean used for final assessment. Statistical analysis was performed using paired sample t-tests. RESULTS: The mean glenoid bone loss as measured on the digital images was 7.04 ± 2.54 mm (range 2.5-13.5 mm). This correlated to a mean percentage bone loss of 25.28 ± 9.16%. The mean glenoid bone loss as determined using the three imaging modalities was as follows: MRI - 7.10 ± 2.10 mm (25.22 ± 8.19%); CT3D - 7.23 ± 2.32 mm (25.17 ± 7.75%); CT - 6.62 ± 2.02 mm (24.06 ± 7.97%). There were no significant differences between measurements using the digital images and those obtained using each of the imaging techniques (p > .2). Similarly, there were no significant differences comparing measurements obtained using each of the imaging techniques (p > .2).

DISCUSSION AND CONCLUSION: In this cadaveric study there were no significant differences between MRI, CT3D, and CT for the measurement of glenoid bone loss. This study suggests that technique-specific MRI scans can be utilized to assess soft tissue injury and osseous insufficiency in patients with shoulder instability thus potentially obviating the need for the use of CT. This would have both cost and health benefit to the patient by avoiding unnecessary radiation exposure.

POster NO. P435

Use of a Fluoroscopic Overlay to Guide Femoral Tunnel Placement During PCL Reconstruction

Paulo H. Araujo, MD, Pittsburgh, PA
Gele Moloney, MD, Pittsburgh, PA
Gustavo Rincon, MD, Bogota, Colombia
Xudong Zhang, Pittsburgh, PA
Christopher D. Harner, MD, Pittsburgh, PA

INTRODUCTION: Posterior cruciate ligament (PCL) injury occurs at a rate of 25,000 per year. Many PCL injuries can be treated nonoperatively and, even among experienced academic knee surgeons, greater than 78% are performing fewer than 10 PCL reconstructions per year. Control of posterior laxity of the knee after PCL reconstruction is dependent on the position of the femoral tunnel. To assist with intraoperative placement of the femoral tunnel an image overlay was designed to identify the point on a lateral X-ray of the femur where the center of the anatomic footprint of the PCL is located. The purpose of this study was to define the femoral insertion site of the PCL and to evaluate the efficacy of using an overlay system based on fluoroscopic landmAK to guide surgeons to more anatomic femoral tunnel placement for PCL reconstructions.

METHODS: The femoral PCL insertion site was identified arthroscopically in 20 cadaveric knees. Using an optical measurement system, 20 to 25 points surrounding the footprint were recorded and mapped onto 3D bone models generated from high resolution CT scans using a co-registration process. Digitally reconstructed radiographs were then created to simulate a lateral radiograph of the knee and the insertion sites were quantitatively defined in the coordinate system previously described by Bernard et al for the anterior cruciate ligament (ACL). Twenty experienced orthopaedic surgeons were recruited. Each participant identified and marked the locations on the femur where they would place the PCL tunnel in a single bundle reconstruction. A lateral fluoroscopic image of the knee was obtained and the image overlay applied. Surgeons then adjusted their initial location to match the location given by the overlay, a point based on literature data (figure 1a,b). The distance between the literature point and the surgeon’s position was measured. The distance between the surgeons’ position and the natural insertion site specific to the knee they were operating on was also measured.

RESULTS: Surgeons made a statistically significant improvement (p < 0.05) from the point given by the femoral overlay. After adjustments based on fluoroscopy, only one out of 20 surgeons continued to be > 5 mm from the overlay point. Comparing surgeon’s position...
Delay in Anterior Cruciate Ligament Surgery is Related to Meniscal and Chondral Lesions which Correlated with Pain

August Fok, FRCS, Hong Kong, Hong Kong

INTRODUCTION: Previous studies had shown increased surgical delay was associated with higher incidence of meniscal and cartilage lesions, but most of them were retrospective. Though it is widely believed that meniscal and chondral lesions in anterior cruciate ligament (ACL) deficient patient will cause functional disturbance especially pain, but such association has never been established or studied so far in the literature. The goal of our prospective study was to investigate the associations between surgical delay, pain and meniscus, articular cartilage lesions seen at the time of surgery. We hypothesized that delay in ACL reconstruction will cause meniscal and cartilage lesions.

METHODS: A total of 162 consecutive patients who had received ACL reconstruction in the author’s institution between January 2008 and August 2010 were recruited prospectively. The pre-operative International Knee Documentation Committee questionnaires, and August Fok

POSTER NO. P436

Presence of meniscal tear increased risk of cartilage lesions (p = 0.038, OR = 2.14). Patients with cartilage lesions complain of higher frequency of pain (mean 6.9/7.7, p = 0.048). Moderate correlation was found between the size of cartilage lesion and the frequency of pain (p = 0.013, Pearson correlation = 0.53).

RESULTS AND CONCLUSION: Increased surgical delay was associated with increased incidence of meniscus and articular cartilage injuries in patients suffering from ACL tear, also the meniscus was less likely to be repaired. Presence of cartilage lesions would lead to higher frequency of pain. Size of meniscal and cartilage lesions was significantly associated with pain.

POSTER NO. P437

Bone Bruise Volume and the Presence of Meniscal Tears in Acute ACL Ruptures on Magnetic Resonance Imaging

Kenneth Illingworth, MD, Pittsburgh, PA
Daniel Hensler, MD, Pittsburgh, PA
Bethany U. Casagrande, DO, Pittsburgh, PA
Camilo G. Borrero, MD, Pittsburgh, PA
Carola F. Van Eck, MD, Pittsburgh, PA
Freddie H. Fu, MD, Pittsburgh, PA

INTRODUCTION: Anterior cruciate ligament (ACL) ruptures are often associated with concomitant injuries, such as cartilage damage, collateral ligament injuries and meniscal tears. The mechanism of ACL injury results in a tibiofemoral bone bruise pattern that can be visualized on magnetic resonance imaging (MRI). The purpose of this study was to determine if there was a relationship between the size of the bone bruise volume in the tibiofemoral joint after an acute ACL rupture on MRI and the presence of meniscal tears in the medial and lateral compartment. Our hypothesis is that a larger bone bruise volume will be associated with an increased presence of meniscal tears.

METHODS: Fifty consecutive patients with an acute ACL rupture and MRI imaging within 30 days of injury were identified. Two fellowship-trained musculoskeletal radiologists evaluated the lateral and medial menisci with consensus. Three specific meniscal groups were defined: no meniscal tear, tear of one meniscus (uni-compartmental) and tear of both menisci (bi-compartmental).

RESULTS: The number of meniscal tears was as follows: no tear 16/50 (32%), lateral meniscus tear 7/50 (14%), medial meniscus tear 13/50 (30%), bi-compartmental 14/50 (28%). Forty-three of 50 (86%) patients had a tibiofemoral bone bruise on MRI. There was a statistically significant relationship in femoral bone bruise volume when comparing no tear to bi-compartmental tears as well as uni-compartmental tears compared to bi-compartmental tears. The intra and intertester reliability for femoral bone bruise volume measurements were ICC = 0.970, 95% CI (0.887 - 0.992) and ICC = 0.967, 95% CI (0.879 - 0.992), respectively. The intra and intertester reliability for tibial bone bruise volume measurements were ICC = 0.912, 95% CI (0.682 - 0.977) and ICC = 0.806, 95% CI (0.387 - 0.948), respectively.

DISCUSSION AND CONCLUSION: There is a statistically significant relationship between femoral bone bruise volume...
and the presence of meniscal tears, especially in the setting of bi-compartmental pathology. MRI evaluation of menisci can be difficult and the use of secondary signs, such as femoral bone bruise volume, can increase confidence in diagnosis of meniscal tears in the setting of acute ACL injury.

Figure 1 - Measurement of bone bruise volume for both A) femoral bone bruise and B) tibial bone bruise.

![Figure 1](image1.png)

Figure 2 - Percent of femoral bone bruise compared to each defined meniscal group. *Significant relationship between no tear and bi-compartmental tear, as well as uni-compartmental tear and bi-compartmental tear.

![Figure 2](image2.png)

POSTER NO. P438

Diagnostic Accuracy of an iPhone DICOM Viewer for the Interpretation of Magnetic Resonance Imaging of the Knee

John Theodoropoulos, MD, North York, ON, Canada
Lawrence White, MD, Toronto, ON, Canada
Robert Bleakney, Toronto, ON, Canada
Peter N. De Maio, MBBS, BS, Toronto, ON, Canada

INTRODUCTION: Multiple medical imaging applications have been developed for the Apple iPhone. The ability to view medical images on a handheld mobile device offers promising benefits for both the orthopedic surgeon and radiologist. With the recent approval of an iPhone radiology application by the U.S. FDA, mobile device based teleradiology solutions will soon be a reality. To appropriately integrate this technology into medical practice, we must have an understanding of diagnostic limitations. There are few studies evaluating the diagnostic accuracy of a handheld mobile device. The purpose of this study is to evaluate the accuracy of viewing medical images on a handheld mobile device compared to conventional workstation for the diagnosis of intra-articular knee pathology. METHODS: Retrospective study comparing the diagnostic accuracy of two methods for viewing MR imaging of the knee: the OsiriX DICOM viewer on an Apple iPhone 3G and the eFilm DICOM viewer on a conventional workstation. Fifty-two consecutive patients less than 50 years of age who had knee arthroscopy and a pre-operative MR between January 1 and December 31, 2009 were included. Two musculoskeletal radiologists blinded to patient information randomly reviewed each MR study on both a conventional PACS workstation and an Apple iPhone using a standardized reporting template. A single orthopedic surgeon performed arthroscopy on all patients and prospectively recorded surgical findings using the same template as MR evaluation. Five knee components: medial meniscus, lateral meniscus, anterior cruciate ligament, posterior cruciate ligament and cartilage, were assessed. An independent reviewer compared the diagnostic interpretations of knee MR images using knee arthroscopy results as a gold standard. Sensitivity and specificity of the iPhone DICOM viewer with respect to knee arthroscopy and intra-rater agreement between the conventional PACS workstation and iPhone interpretation was determined. RESULTS: iPhone versus arthroscopy demonstrated high sensitivity and specificity for medial meniscus and cruciate ligaments injuries with lower sensitivity for lateral meniscus tears and lower specificity for cartilage injuries (Table 1). iPhone versus PACS workstation demonstrated excellent agreement for medial meniscus and cruciate ligament injuries and good agreement for cartilage injuries (Table 2). DISCUSSION AND CONCLUSION: The use of a mobile device for the interpretation of knee MRI is promising. This may increase access to sub-specialty trained musculoskeletal radiologists making interpretation of musculoskeletal MRI available in remote areas without the need for fixed workstations.

Table 1. Sensitivity and Specificity of MR interpretation using either an iPhone or PACS Workstation

<table>
<thead>
<tr>
<th></th>
<th>iPhone vs. Arthroscopy</th>
<th>iPhone vs. Workstation</th>
<th>Workstation vs. Arthroscopy</th>
<th>Workstation vs. Arthroscopy</th>
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<tbody>
<tr>
<td></td>
<td>Specificity</td>
<td>Specificity</td>
<td>Specificity</td>
<td>Specificity</td>
</tr>
<tr>
<td>Medial Meniscus</td>
<td>83% (19/23)</td>
<td>93% (27/29)</td>
<td>87% (29/34)</td>
<td>93% (27/29)</td>
</tr>
<tr>
<td>Lateral Meniscus</td>
<td>88% (30/34)</td>
<td>67% (12/18)</td>
<td>85% (29/34)</td>
<td>72% (13/18)</td>
</tr>
<tr>
<td>ACL</td>
<td>87% (32/37)</td>
<td>93% (14/15)</td>
<td>92% (14/15)</td>
<td>93% (14/15)</td>
</tr>
<tr>
<td>PCL</td>
<td>100% (52/52)</td>
<td>100% (52/52)</td>
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</tr>
<tr>
<td>Cartilage</td>
<td>57% (8/14)</td>
<td>92% (35/38)</td>
<td>71% (10/14)</td>
<td>84% (32/38)</td>
</tr>
</tbody>
</table>

Table 2. Agreement between iPhone and PACS Workstation in interpretation of knee MRI

<table>
<thead>
<tr>
<th></th>
<th>iPhone vs. Workstation</th>
<th>iPhone vs. Workstation</th>
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<tbody>
<tr>
<td></td>
<td>Concordance</td>
<td>Kappa</td>
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<tr>
<td>Medial Meniscus</td>
<td>98% (51/52)</td>
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<tr>
<td>Lateral Meniscus</td>
<td>96% (50/52)</td>
<td>0.913</td>
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<tr>
<td>ACL</td>
<td>96% (50/52)</td>
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<tr>
<td>PCL</td>
<td>100% (52/52)</td>
<td>NO PCL INJURIES</td>
</tr>
<tr>
<td>Cartilage</td>
<td>87% (45/52)</td>
<td>0.654</td>
</tr>
</tbody>
</table>

* 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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
3.0-Tesla MRI and Diagnostic Arthroscopy in Assessing Knee Articular Cartilage Lesions

INTRODUCTION: Early identification of articular cartilage pathology may allow patients to take advantage of the growing number of operative and non-operative treatments for osteoarthritis. The purpose of this study was to determine the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of a 3.0-Tesla MRI for evaluation of knee articular cartilage lesions. The hypothesis was that the 3.0-T knee MRI was equal to arthroscopic evaluation for identifying and grading articular cartilage lesions, and that there will be no difference whether the images are read by the orthopaedic surgeon or by a musculoskeletal radiologist.

METHODS: Sixteen patients who received a 3.0-T knee MRI and a knee arthroscopy for partial meniscectomy by a single orthopaedic surgeon were reviewed. Three fellowship-trained sports medicine orthopaedic surgeons reviewed and graded all 16 digital video recordings of the knee arthroscopy using both the Outerbridge and International Cartilage Repair Society (ICRS) grading systems. Corresponding MRIs were reviewed and scored by these orthopaedic surgeons and by a fellowship-trained musculoskeletal radiologist. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the MRI to detect cartilage lesions present on arthroscopy were determined in the patella, trochlea, medial femoral condyle, lateral femoral condyle, medial tibial plateau, and lateral tibial plateau.

RESULTS: Of the 96 articular surfaces graded, 53 surfaces (55%) were classified as disease-negative (grade 0-1), and the remaining 43 surfaces (45%) were classified as disease-positive (grade 2-4). Of the disease-positive surfaces, there was no damage predilection for a particular anatomic region. Using the Outerbridge classification as a reference standard, the overall sensitivity of 3.0-T MRI as read by the orthopaedic surgeons was 55%, overall specificity was 73%, overall positive predictive value was 56%, overall negative predictive value was 73%, and overall accuracy was 66%. Using the ICRS grading system, average overall sensitivity for the orthopaedic surgeons was 52%, overall specificity was 70%, overall PPV was 45%, overall NPV was 82%, and overall accuracy was 67%. Review of the images by the musculoskeletal radiologist using the Outerbridge scale increased sensitivity to 57%, specificity to 92%, and accuracy to 77%.

DISCUSSION AND CONCLUSION: While 3.0-T MRI, using a standard pulsing sequence, can provide a non-invasive method of identifying the presence of articular cartilage defects, 3.0-T MRI imaging was clearly inferior to direct arthroscopic evaluation for grading of knee articular cartilage lesions. Further study of 3.0-T MRI imaging of articular cartilage is warranted to provide the most accurate and reliable non-invasive evaluation of the articular cartilage status.
**Familial Predisposition toward Anterior Cruciate Ligament Tears in Males**

**Randy Rust, MD, Ocoee, FL**  
**Gregory D. Myer, PhD, Cincinnati, OH**  
**Samuel A. Finck, DO, Zanesville, OH**  
**Chad A. Waits, MD, Avon, IN**  
**Robert S. Heidt, Jr, MD, Cincinnati, OH**  
**Tim E. Hewett, PhD, Columbus, OH**

**INTRODUCTION:** Rupture of the anterior cruciate ligament (ACL) is a common, yet significant injury. While many advances have been made toward improving surgical techniques and patient outcomes, methods focusing on injury prevention have gained less support. In an effort to identify patients at risk for ACL injury, many potential risk factors have been proposed, including familial predisposition. Although this concept has been proposed previously, there is a paucity of literature that critically evaluates this relationship. Additionally, no study has evaluated familial predisposition for male or female predominance. The purpose of our study was to determine if there is a genetic predisposition to ACL rupture, as well as to evaluate potential sex effects.

**METHODS:** Patients aged 18-40 who underwent ACL reconstruction were identified through a database. Patients who underwent arthroscopic meniscectomy without ACL reconstruction, who served as an age and gender matched control group, were also identified through the database. All patients were contacted via telephone interview and completed a questionnaire developed for this study. Fisher's exact test were used to test the one sided hypothesis that ACL injury would be more prevalent in relatives of patients with ACL injury. 

**RESULTS:** From the 227 recruited subjects, 14% of those who visited the clinic with a meniscus injury reported a first degree relative with an ACL injury, while those patients who were treated for an ACL injury reported a familial prevalence of an ACL injury in 20% of their relatives. The increased prevalence of familial ACL injury in those treated for the similar injury (ACL) was not statistically significant (p=0.16). Female patients with either a meniscus or ACL injury were more likely to have a relative with an ACL injury (F- 23% vs. M -14%) compared to males (p=0.05). When the data were split by sex and evaluated by patient type (ACL vs. meniscus injured), in male patients there was an increased prevalence of family history for ACL patients (p=0.03). Family history of ACL injury occurred in 19% of ACL patients with reduced prevalence of familial ACL injury in the patients with meniscus injury (7%). Conversely, female patients with an ACL injury reported nine out of 42 (21%) first relatives with the similar ACL injury while 10 out 40 (25%) relatives with ACL injury were reported for patients with meniscus injury. Familial history of ACL prevalence was not different between female ACL vs. meniscus patients (p=0.45).

**DISCUSSION AND CONCLUSION:** The results of this study indicate that male athletes with a family history (first degree relative) significant for an ACL tear are at higher risk of an ACL tear than the average population. This could be explained as males may have a genetic predisposition to increased familial ACL injury risk while females may be susceptible to other risk factors (i.e. neuromuscular control deficits). Understanding the multiple patient risk factors for ACL injuries could help guide future prospective studies, as well as intervention programs aimed at preventative treatment strategies. The results of this study show that male patients with ACL tears are more likely to have a relative with an ACL tear compared to control male subjects.

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**Table 1 - Postive Cultures and Organisms**

<table>
<thead>
<tr>
<th>Specific Conditions</th>
<th>Positive Cultures</th>
<th>Bacteria Types</th>
<th>Negative Cultures</th>
<th>Percentage Positive Culture</th>
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<td>Staph. Aureus (3)</td>
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<td>23%</td>
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<td>Staph. Non Aureus (1)</td>
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<td></td>
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<td>Strept. Viridians (3)</td>
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<td>Corynebacterium (2)</td>
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<td></td>
<td></td>
<td>E. Coli (1)</td>
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<tr>
<td>Dropped on Floor</td>
<td>10</td>
<td>Staph. Aureus (7)</td>
<td>20</td>
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<td>(5s)</td>
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*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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
INTRODUCTION: Few options exist to effectively treat articular cartilage defects, in part because of the challenges of creating a mechanically functioning and well-integrated tissue. We have developed a macroporous, nondegradable polyvinyl alcohol (PVA) scaffold, the mechanical properties of which can be controlled, while the morphology allows for chondrocytes to lay down matrix within the scaffold in vitro. Our objective was to assess the ability of the scaffold to act as a functional implant for articular cartilage defects by assessing its ability to protect adjacent cartilage from damage and remain well fixed in vivo. We hypothesized that the ability of chondrocytes to migrate into the scaffold and therein generate matrix would be enhanced with partial digestion of the edges of articular cartilage.

METHODS: Gelatin sponges were soaked in 20% wt/vol PVA, subjected to four freeze-thaw cycles, digested in 500U/mL of collagenase for 14h, and cored to 5mm diameter. Bilateral 3.5mm diameter x 4mm deep osteochondral defects were created in the trochlea of 14 New Zealand White rabbits and randomized to 15 min treatment with collagenase type II or saline. PVA implants were press-fit into the defects, flush to the cartilage surface. Based on an a priori power analysis, six and then five additional rabbits were sacrificed at one month PVA scaffold implantation was subjected to creep-indentation testing.

RESULTS: There were no significant differences between the groups with regards to highest level of activity without knee pain, severity of pain, stiffness, swelling, stability and locking of knee. In addition, no statistical difference was shown when comparing function of knee involving sports.

DISCUSSION AND CONCLUSION: Our hypothesis was rejected: the ability of cells to migrate into the scaffold and therein generate matrix was not enhanced with collagenase treatment. This result is contrary to what was found in vitro; likely caused by the fact that an osteochondral defect was used in vivo while a chondral defect was used in vitro. Nonetheless, the porous PVA scaffold integrated with articular cartilage in vivo, chondrocyte-like cells producing cartilage-specific matrix components (collagen II and aggrecan) were present in the scaffold as early as one month postoperatively, and the site of scaffold implantation had mechanical properties similar to that of native cartilage. The progressive fibrous encapsulation of the scaffold suggests the need to block such formation in future designs.
no significant subjective difference between STG and ST ACL reconstruction. Using an additional tendon may be an unnecessary step.

POSTER NO. P444

3D-CT Measurement of Tunnel Widening in ACL Reconstruction using Allograft versus Autografts

Steven A. Claes, MD, Pellenberg, Belgium
Cedric C. Robbrecht, Gent, Belgium
Michiel Cromheecke, Maldegem, Belgium
Peter Mahieu, MD, Ledeberg, Belgium
Kyriakos Kakavelakis, MD, Heraklion, Crete, Greece
Johan Bellemans, MD, Langdorp, Belgium
Peter Verdonk, MD, PhD, Gent, Belgium

INTRODUCTION: Tunnel widening has been described after anterior cruciate ligament (ACL) reconstruction and is explained by mechanical and biological phenomena. Both plain radiographs and MRI are unable to adequately assess tunnel diameters after ACL reconstruction. The aim of this study was to examine the feasibility of 3D-computed tomography (CT) reconstructions to study tunnel widening after ACL surgery. Secondly, the goal was to examine differences in tunnel widening between allo- vs. autografts.

METHODS: Forty subjects underwent either allo- or autologous ACL reconstruction: a deep-frozen tibialis posterior tendon allograft was used in 10 patients, while in 25 patients both autologous semitendinosus and gracilis tendons were implanted. The patients were evaluated at one year post-operatively using a CT-based 3D reconstruction with at least 60 axial CT-slices. Subsequently, the images were imported into the image processing software. The tunnel contours were defined semi-automatically on every four slices in the coronal and the sagittal planes. Tunnel contours in the axial plane were then drawn automatically by the software. Based on that information, the software calculated a 3D-model, on which a best-fit cylinder could be calculated using a least-square method. Intra- and inter-observer reliability measures were performed.

RESULTS: High inter- and intra-observer reliabilities were found concerning the use of the semi-automated 3D-CT based imaging processing software to assess tunnel diameters. On the femoral side, tunnels were enlarged by 53% in the allograft group versus 35% for the autograft group. On the tibial side, tunnels were enlarged 48% in the allograft group versus 38% in the autograft group. These differences were significant.

DISCUSSION AND CONCLUSION: Semi-automated 3D-CT imaging based processing software proved a reliable method to assess tunnel diameters. Tunnel widening after ACL reconstruction is significantly increased with the use of allografts compared to autografts. The biology of intra-tunnel phenomena during graft healing is influenced by graft origin.

POSTER NO. P445

Allograft Reconstruction for Failed or Neglected Extensor Mechanism Injuries

Seth Sherman, MD, Columbia, MO
Vasili Karas, BS, Chicago, IL
Champ Baker, III, MD, Columbus, GA
Bernard R. Bach, Jr, MD, River Forest, IL
Brian J. Cole, MD, Chicago, IL
Charles A. Bush-Joseph, MD, Chicago, IL

INTRODUCTION: Chronic extensor mechanism deficiency in a native knee joint is a rare and complex problem that is secondary to either chronic neglect of an extensor injury or failure of primary repair. There is a paucity of literature on the surgical management of these patients in the non-arthroplasty population. We hypothesize that extensor mechanism allograft restores extensor power and returns patients to activities of daily living.

METHODS: Between 2000 and 2007, 17 patients (18 knees) underwent extensor mechanism reconstruction with either nonirradiated Achilles or whole bone-patellar tendon-bone allograft. Patients presented with failure of primary extensor repair, or chronic neglect of initial injury. Two patients were lost to follow up and one underwent a total knee arthroplasty and was considered a failure. The remaining 14 patients (15 knees) returned for clinical and radiographic evaluation at a minimum 24 months post-operatively. Patients completed questionnaires using the IKDC, Tegner, Lysholm, KOOS, Noyes sports activity, and SF-12 scoring systems.

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 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
RESULTS: Fourteen patients with a median age of 46.5 years (range, 18-70) returned for evaluation at a median follow up of 4.0 years (range, 2.5-8.2 years). Patients with prior surgery had a median of two procedures before reconstruction (range, 1-7). Post-operatively, the median IKDC score was 74 (range 28-90), Tegner 8 (range 0.5-10), Lysholm 62 (range 28-100), KOOS pain 92 (range 36-100), KOOS symptom 64 (range 21-100), KOOS ADL 82 (range 51-100), KOOS sport 50 (range 5-95), KOOS QOL 44 (range 12.5-100), Noyes sport activity 39 (range 5-100), SF-12 physical 43 (range 29-47), and SF-12 mental 49 (range 28-64). All patients were able to perform a straight leg raise post-operatively but five patients had an extensor lag at final evaluation averaging 6.5 degrees (range, 3-18). There were no post-operative infections or re-ruptures. DISCUSSION AND CONCLUSION: Extensor allograft reconstruction is a safe and effective salvage procedure for patients with chronic extensor mechanism deficiency in a native joint. At a minimum of two years, the majority of patients demonstrate reduced pain and improved activities of daily living. Return to higher level function is guarded, and patients should be counseled appropriately in this regard.

POSTER NO. P446
Can Different Fixation Devices Affect Bone Tunnel Widening in Anterior Cruciate Ligament Reconstruction? A CT Study
Raffaele Iorio, MD, Rome, Italy
Antonio Vadala, MD, Rome, Italy
Jacopo Conteduca, MD, Rome, Italy
Giuseppe Argento, MD, Rome, Italy
Fabio Conteduca, MD, Rome, Italy
Barbara Maestri, MD, Rome, Italy
Andrea Ferretti, Rome, Italy

INTRODUCTION: Femoral and tibial tunnel widening following anterior cruciate ligament (ACL) reconstruction using hamstring autograft has been described in literature. The mechanism for tunnel widening has not been definitively elucidated and is largely debated. Mechanical and biological factors have been defined that as both leading to a multifactorial widening process. The aim of this prospective study is to evaluate femoral and tibial tunnel enlargement in two groups using different surgical techniques and fixation devices with different mechanical properties. METHODS: For this study we selected 44 patients (33 males and 11 females) affected by unilateral chronic ACL instability. All surgical procedures were performed by the same author with double gracilis and semitendinosus tendons (DGST). In all cases 9.00mm holes were performed. Patients were randomly divided to enter group A (22 patients) or group B (22 patients). In group A the reconstruction was performed with a standard single incision and an In-Out technique, while in group B a two incisions technique was done, with an Out-In technique. In group A, bioabsorbable screws on the tibial side and a suspension device on the femoral side were used to fix the graft. In group B interference screw with the coil and a cortical fixation device were used for the tibial and femoral fixation respectively. Previous studies have shown higher stiffness values of the fixation devices used in group B. The two groups were homogeneous for sex, age and activity level. After surgery and at a mean follow up of 10 months, all patients underwent CT scan exam to evaluate diameters of both femoral and tibial tunnels. RESULTS: The mean femoral tunnel diameter increased significantly from 9.05±0.3 mm (post op) to 10.01±2.3 mm (follow-up) in group A and from 9.04±0.8 mm to 9.3±1.2 mm in group B. The mean increase in femoral tunnel diameters observed in group A was significantly higher than that observed in group B (p<0.05). The mean tibial tunnel diameter increased significantly from 9.03±0.04 mm to 10.68±2.5 mm in group A and from 9.04±0.03 mm to 10.7±0.78 mm in group B. The mean increase in tibial tunnel diameters observed in group A was significantly higher than that observed in group B (p<0.05). DISCUSSION AND CONCLUSION: The causes of enlargement of bone tunnels are still little known. We believe, like other authors, that the most plausible hypothesis is the concomitant involvement of several factors, mechanical and biological, which interact with each other. In this study the only difference between the two groups was the fixation devices with different mechanical properties just evaluated in previous works. The results of this prospective study suggest that different hardware devices may affect tunnel enlargement after hamstrings reconstruction. The reason can be reached from the different stiffness of the devices and their backlashes on the tunnels walls.

POSTER NO. P447
Risk Factors for ACL Injury: Assessment of Tibial Plateau Anatomic Variables
Eun K. Song, MD, Hwasungun, Republic of Korea
Kyung-Do Kang, Hwasun, Republic of Korea
Jong-Keun Seon, MD, Hwasun, Republic of Korea
Chan-Hee Park, Jeonnam, Republic of Korea

INTRODUCTION: Tibial plateau slopes, medial plateau (MTPS) and lateral plateau (LTPS), independently are important determinants of knee biomechanics. Many reports note increased tibial anterior translation in the knee with greater TPS. The purpose of this study was to assess, in anterior cruciate ligament (ACL)-injured and -uninjured population, tibial plateau anatomic variables [medial and lateral tibial plateau slopes (MTPS and LTPS) and medial tibial plateau depth (MTPD)] on conventional magnetic resonance imaging (MRI) using a novel combined method and to determine whether these variables are risk factors for ACL injury. METHODS: There were 73 ACL-injury patients (20 women and 53 men), with mean age 30.5 (range,14-54) years. In the control group, patients whose knee was screened due to minor trauma or bruises or due to other medical reasons were included. Patients with patellofemoral pain were excluded. There were 51 patients in this group (19 women and 32 men), with mean age 28.4 (range 16 to 49) years. Patients with meniscal injury were excluded from both groups. No patient had osteoarthritis. On the MRI image, MTPS, LTPS, and MTPD were compared between the two groups. RESULTS: The injured group, comprising both men and women, had increased LTPS compared with the control group (p=0.0001). There was no significant difference in MTPS and MTPD. Men with ACL injury had steeper LTPS (p=0.0001) compared with men in the control group. Women with ACL injury had significantly shallower MTPS, LTPS, and MTPD than women in the control group and men with ACL injury (both p<0.05). Uninjured women had steeper MTPS and LTPS and shallower MTPD than uninjured men (p<0.05 in all three measurements). Women in the control group had steeper injured and control group (men and women combined) comparison revealed that LTPS had the highest predictive value with OR of 3.031 [95% confidence interval (CI): 1.406-6.533, p=0.005] for ACL injury. MTPS had increased LTPS compared with the control group (p=0.0001). Post-operatively, all patients underwent CT study to evaluate diameters of both femoral and tibial tunnels.

DISCUSSION AND CONCLUSION: The causes of enlargement of bone tunnels are still little known. We believe, like other authors, that the most plausible hypothesis is the concomitant involvement of several factors, mechanical and biological, which interact with each other. In this study the only difference between the two groups was the fixation devices with different mechanical properties just evaluated in previous works. The results of this prospective study suggest that different hardware devices may affect tunnel enlargement after hamstrings reconstruction. The reason can be reached from the different stiffness of the devices and their backlashes on the tunnels walls.
with steeper LTPS are at higher risk of sustaining ACL injury. Overall, steeper LTPS is a significant risk factor for sustaining ACL injury.

POSTER NO. P448

Does Operative Fixation of Chondral Loose Bodies Lead to Healing and Maintenance of Knee Function?

Robert A. Magnussen, MD, Columbus, OH
Christian N. Anderson, MD, Nashville, TN
Kurt P. Spindler, MD, Nashville, TN

INTRODUCTION: Osteochondritis dissecans (OCD) or traumatic injuries can result in cartilage injury and the formation of loose bodies. When a loose body is purely chondral, it is generally excised and the cartilage defect is managed conservatively or addressed with a cartilage restoration procedure. There are no published reports of replacement and fixation of purely chondral loose bodies in the literature. We hypothesized that open reduction and internal fixation (ORIF) of purely cartilaginous loose bodies back into full thickness defects will result in healing at second look arthroscopy, restored cartilage appearance on MRI, and near “normal” knee function as determined by patient-oriented outcome scores.

METHODS: Five patients were identified who underwent ORIF of a purely cartilaginous loose body back into the full thickness cartilage defect that was its source. The defects ranged in size from 1.5 to 3.75 cm² (mean: 2.5 cm²). Two were located on the lateral trochlea and three on the medial femoral condyle. ORIF was performed through a mini-arthroscopy with compression screws and all patients were non-weight-bearing for 12 weeks postoperatively. After 12 weeks, arthroscopy was performed for screw removal and the stability of the repaired OCD evaluated by probing. Four of five patients underwent MRI and the status of the articular cartilage was recorded. The findings of any subsequent surgery on the index knee were recorded. Patients were contacted and asked to complete the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire.

RESULTS: Second look arthroscopy 12 weeks post-operative revealed healed lesions in all five patients. Four patients underwent an MRI at an average of 3.3 years post-operatively. Complete incorporation was noted in three patients and partial incorporation was noted in one patient. An irregular cartilage surface was noted in two of the four patients. These two patients underwent repeat arthroscopy at a mean of 2.4 years post-operative. In both cases the loose body was noted to be stable to probing. No patients required subsequent surgery for a loose body. Four patients completed to KOOS questionnaire at an average of 4.6 years follow up (range 2 - 8 years) KOOS subscale scores for knee pain (mean 91, range 78 to 97), knee symptoms, (mean 83, range 75 to 93), and function in activities of daily living (mean 92, range 76-100) were not clinically different from published age-matched controls.(1) However the KOOS subscale for sports and recreation function (mean 70, range 55-95) and knee related quality of life (mean 67, range 56-81) and least 10 points lower than published age-matched controls.(1)

DISCUSSION AND CONCLUSION: Operative fixation of purely chondral loose bodies results in stable fixation as assessed with MRI and second look arthroscopy. Recurrent loose body formation was not noted. At an average 4.6 years after surgery, patients did not have significant pain and had normal function in activities of daily life. However, patients reported significantly lower knee related quality of life and sport and recreation function. References: 1. Paradowski PT, Bergman S, Sundelin-Lundius A, et al. Knee complaints vary with age and gender in the adult population. Population-based reference data for the Knee injury and Osteoarthritis Outcome Score (KOOS). BMC Musculoskelet Disord. 2006;7(38).

POSTER NO. P449

Regeneration of the Anterior Cruciate Ligament (ACL) in an Ovine Model Using a Resorbable Polymer Scaffold

William R. Walsh, PhD, Randwick, Australia
Nicky Bertollo, PhD, Randwick, Australia
Cato T. Laurencin, MD, PhD, Farmington, CT
Robert A. Arciero, MD, Farmington, CT
Robert A. Poggie, PhD, Lake Hopatcong, NJ

INTRODUCTION: The purpose of this research was to characterize in an ovine model for anterior cruciate ligament (ACL) reconstruction the clinical, biological, and biomechanical performance of a Poly-L-Lactic Acid (PLLA) scaffold designed for regeneration of the anterior cruciate ligament (ACL). METHODS: ACL reconstructions were performed with PLLA implants in 24 sheep and autograft extensor tendons in 22 sheep. Reconstructions were evaluated at 12, 24, and 52 weeks for clinical function, synovitis, serology, gross reaction, histology, imaging via radiographs, micro-computed tomography (CT), and magnetic resonance imaging (MRI), and strength of the bone-ligament-bone (BLB) complex. RESULTS: Micro CT, radiographs, MRI, histology, and pathology showed regeneration of the ACL at 52 weeks. Sheep with PLLA devices were functional post-op and at all time points. Histology of the intra articular space for sheep with PLLA implants and autograft showed neo ligamentization at 12 weeks, increased collagenous deposition and cellularity with time, and a reconstituted ACL at 52 weeks. Testing of BLB complexes with PLLA scaffolds showed the strength at 52 weeks to be lower than expected; tibial fixation was robust and similar to autograft. DISCUSSION AND CONCLUSION: Histology of the intra articular space at 52 weeks in sheep with PLLA scaffolds showed a reconstituted ACL that resembled autograft, with complete resorption of the PLLA. The difference in biodegradation between the bone tunnels and intra articularly is ascribed to the more vascular, biologically dynamic environment and loose braid in the intra articular space. Sheep with PLLA implants were functional without lameness immediately post-op, thereby confirming one of the advantages of this synthetic graft as compared to autograft. This is the first study to demonstrate complete regeneration of ACL tissue and resorption of the implant intra-articularly at one year using a degradable synthetic polymeric scaffold.
and biological benefits. Although enhanced knee joint proprioception in ACL augmented patients has been previously reported, there are no studies that have assessed the biological healing advantages of the graft after the ACL augmentation procedure. The purpose of this study was to evaluate biological markers and mechanical properties of the augmented graft for the partial ACL tear model and compared to the reconstructed graft for a complete ACL tear model. We hypothesized that selected ACL augmentation for partial tears can enhance the healing process which will consequently lead to higher mechanical strength compared to whole ACL reconstruction for a complete tear.

METHODS: Two different ACL injury models were established in normal rats: 1) ACL augmentation of a partial tear and 2) an ACL reconstruction of a complete tear. To biologically assess the models, cell infiltration and angiogenesis in the grafted tendons were analyzed using hematoxylin/eosin staining and immunostaining using isoelectin B4 respectively. Additionally, rat-specific type III collagen and alpha-smooth muscle actin were evaluated by immunohistochemical staining to determine the extent of healing, while anti-rat neurofilament antigen was assessed to examine proprioceptive recovery. Biological assessments of the augmented and reconstructed grafts were conducted postoperatively at week 2 and biomechanical testing was performed at week 8.

RESULTS: The cell numbers in the grafted tendon were confirmed by H&E staining using tissue samples collected two weeks after surgery, which resulted in a significantly greater number of infiltrating cells in the augmented graft compared to the reconstructed graft. We also observed an increase in angiogenesis as shown by isoelectin B4 staining. Moreover, there was an increased amount of rat-specific type III collagen, alpha-smooth muscle actin, and anti-rat neurofilament antigen expressed in the augmented graft compared to the reconstructed graft, which indicated that graft maturation and a proprioceptive recovery were significantly promoted in the augmented graft. Functional recovery after ACL reconstructive surgery was biomechanically evaluated by failure to load (tensile test) at week 8. Biomechanical testing showed that failure load was significantly higher in the augmentation group compared with the reconstruction group.

DISCUSSION AND CONCLUSION: Our results indicate that the augmented graft demonstrated healing advantages of the graft after the ACL augmentation procedure.

POSTER NO. P451

Anteromedial versus Central Single Bundle ACL Graft Position: Which Anatomic Graft Position to Choose?

Michael B. Cross, MD, New York, NY
Volker Musahl, MD, Pittsburgh, PA
Asheesh Bedi, MD, Ann Arbor, MI
Padhraig F. O'Loughlin, MD, Dublin, Ireland
Sommer Hammoud, MD, Chelsea, MA
Eduardo M. Suero, MD, New York, NY
Claus C. Egidy, MD, Linz, Austria
Andrew D. Pearle, MD, Rye, NY

INTRODUCTION: Despite anatomic socket position, single bundle anterior cruciate ligament (ACL) reconstructions cannot restore the entire surface area of the native footprint. The aim of this controlled laboratory study was to compare the time zero stability of an anatomic anteromedial (AM) single bundle ACL reconstruction to an anatomic central (CTR) single bundle ACL reconstruction. We hypothesized that no significant difference exists in time-zero stability between anatomic AM and CTR single bundle ACL reconstructions using a Lachman and mechanized pivot shift test.

METHODS: Following IRB approval, 12 (six paired) hip to knee cadaveric specimens were studied. Using custom ACL computer navigation software, a Lachman test and a previously validated, navigated mechanized pivot shift test was performed on four separate experimental groups in each specimen: 1. intact ACL, 2. ACL-deficient with total medial and lateral meniscectomy, 3. following anatomic AM single bundle ACL reconstruction, and 4. after anatomic CTR single bundle ACL reconstruction. Maximum anterior tibial translation in each group was measured. Repeated-measures analysis of variance with a post-hoc Tukey multiple comparison test was used to compare the translations of the Lachman exam and for each tracked point during the pivot shift exam of the AM and CTR ACL reconstructions respectively. Significance was set at p <0.05.

RESULTS: Lachman: No significant difference was observed between the AM and CTR reconstructions (p>0.05) or between either reconstruction and the intact ACL (3.4 ± 1.7 mm) (p>0.05). Pivot Shift: Both the AM and CTR ACL reconstructions significantly reduced anterior translation relative to the ACL/meniscus deficient condition (lateral compartment: 8.9 ± 3.8 mm and 6.75 ± 4.6 mm vs. 17.25 ± 3.5 mm respectively; p <0.001 and medial compartment: -3.0 ± 5.3 mm vs. -3.7 ± 5.7 mm vs. 6.2 ± 6.7 mm, p <0.05). There was also a significant difference between the AM (p<0.001) and CTR (p<0.05) ACL reconstructions and the intact ACL (2.8 ± 4.4 mm) for lateral compartment translation. Further, no difference was found between lateral or medial compartment translations in the AM vs. CTR reconstructions (p>0.05).

DISCUSSION AND CONCLUSION: We have shown that there was no difference in the time-zero biomechanical stability between an anatomic anteromedial and anatomic central single bundle ACL reconstruction.

POSTER NO. P452

Treatment of Degenerative Horizontal Tear of the Medial Meniscus: Arthroscopic versus Conservative

Eun-Kyoo K. Song, MD, Hwasungun, Republic of Korea
Jong-Keun Seon, MD, Hwasungun, Republic of Korea
Kyung-Do Kang, Hwasun, Republic of Korea
Chan-Hee Park, Jeonnam, Republic of Korea

INTRODUCTION: Recently, frequent occurrences of degenerative horizontal tear in the medial meniscus and their various treatment methods have been reported. However, no comparative studies...
on treatment methods have been performed. The purpose of this study was to compare the clinical results of treating a degenerative horizontal tear of the medial meniscus between the arthroscopic meniscectomy and conservative treatment.

METHODS: From January 2003 to July 2008, 102 patients with a degenerative horizontal tear of the medial meniscus were reviewed and followed them for at least two years. There were 81 female and 21 male patients whose average age was 56.8 years old (range, 43~82). The average follow-up period was 37.3 months (range: 24~82.2). And there were 50 patients with arthroscopic meniscectomy followed by supervised exercise (Meniscectomy group) and 52 patients with supervised exercise alone (Conservative group). We compared the functional outcomes using a Visual Analogue Scale, Lysholm Knee score, Tegner activity scale, and the subjective satisfaction. Radiologic evaluation was done according to the Kellgren and Lawrence’s classification. RESULTS: According to the functional outcomes, meniscectomy group did not lead to greater improvement than conservative group. At final follow up, average Visual Analogue Scale were 1.8 (range, 1~5) and 1.7 (range, 1~4) in the conservative group, which was not significantly different (p=0.698). Average Lysholm Knee score were 82.2 (range, 32~100) in the meniscectomy group and 84.3 (range, 42~100) in the conservative group, but there was no significant difference (p=0.237). Average Tegner activity scale and the subjective satisfaction also showed no significant difference between two groups (p=0.522, p=0.357, respectively). Although most patients had intense mechanical pain initially, both groups reported decreased knee pain, improved knee function and a high satisfaction after the treatment (p<0.05 for all values). Two patients in meniscectomy group and three patients in conservative group with Kellgren-Lawrence grade 2 progressed to grade 3 at the median follow up of three years. DISCUSSION AND CONCLUSION: We found that arthroscopic meniscectomy followed by supervised exercise had no advantage over supervised exercise alone in terms of reduced knee pain, improved knee function and improved quality of life.

POSTER NO. P453
Long-term Outcomes Following Allograft Anterior Cruciate Ligament Reconstruction
Eric A. Lenehan, MD, Tucson, AZ
Brad Askam, Tucson, AZ
William A. Grana, MD, MPH, Tucson, AZ
Lutul D. Farrow, MD, Garfield Heights, OH

INTRODUCTION: Generally, good-excellent long-term results following anterior cruciate ligament (ACL) reconstruction exceed 90%. Recently some authors have reported higher rates of both reoperation and graft failure following allograft reconstruction of the ACL. We hypothesize that the rates of reoperation and revision surgery following allograft ACL reconstruction are not as high as that reported in the literature. The purpose of this study is to evaluate the long term results of a cohort of patients undergoing allograft ACL reconstruction at a single institution.

METHODS: We retrospectively reviewed all patients undergoing allograft ACL reconstruction performed by two senior surgeons over an eight-year period (2000 - 2008). We recorded preoperative patient demographics and concomitant knee pathology. We also recorded the incidence of postoperative complications following ACL reconstruction (i.e. infection, repeat surgical procedures, graft rupture, etc.). Clinical evaluation was performed utilizing the International Knee Documentation Committee (IKDC) assessment and the Tegner Lysholm Knee scoring scale as well as the Tegner Lysholm activity scale.

RESULTS: A total of 99 patients with allograft and 24 patients with autograft ACL reconstruction were available for follow up with an average length of follow up of 50 months. Seventeen percent (17/99) of patients required additional surgery following allograft ACL reconstruction (revision ACL reconstruction - 10/17, meniscus repair - 4/17, partial meniscectomy - 6/17, infection - 3/17, and hardware removal - 2/17). The rate of revision surgery was much higher (30%) for patients under the age of 25 (revision ACL reconstruction - 8/12, meniscus repair - 3/12, partial meniscectomy - 5/12, infection - 1/12, and hardware removal - 1/12). Patients who did not have additional surgeries reported higher Tegner Lysholm (Avg 83) and IKDC (Avg 79) scores compared to those undergoing additional surgical procedures with Tegner and IKDC scores of 59 and 54, respectively. Fifty-five percent of participants (55/99) were “happy” they had surgery. Only 51 percent of patients (51/99) reported that they would have the surgery again. Comparatively, the rate of revision anterior cruciate ligament reconstruction following autograft ACL reconstruction was 4%. No patient under the age of 25 years required revision ACL reconstruction following autograft ACL reconstruction.

DISCUSSION AND CONCLUSION: The principal findings of this study demonstrate that the overall reoperation rate following allograft ACL reconstruction was much higher than that generally quoted following autograft ACL reconstruction. The rate of reoperation and revision ACL reconstruction for patients less than age 25 was 30 and 20%, respectively. Patients who required additional surgery had a lower subjective IKDC and Tegner Lysholm scores. While the overall rate of reoperation is acceptable in this patient population, the rate of reoperation in patients younger than 25 years of age is concerning and should be taken into account when considering allograft ACL reconstruction in patients younger than 25 years of age.

POSTER NO. P454
Knee Preservation with Combined High Tibial Osteotomy and Matrix Induced Autologous Chondrocyte Implantation
Stefan H. Bauer, Perth, WA, Australia
Riaz J Khan, FRCS, Cottesloe, WA, Australia
Jay R. Ebert, PhD, Perth, WA, Australia
William Brett B. Robertson, PhD, Perth, WA, Australia
William Breidahl, MBBS, Subiaco, WA, Australia
Tim R Ackland, Crawley, WA, Australia
David Wood, Nedlands, WA, Australia

INTRODUCTION: There is no ideal treatment for younger patients with medial knee osteoarthritis (OA) and varus malalignment. We have investigated the first case series of combined neutralizing high tibial osteotomy (HTO) and Matrix-induced Autologous Chondrocyte Implantation (MACI) with MRI. Treatment goals were clinical improvement and delay of arthroplasty. METHODS: Between 2002 and 2005, 18 patients (mean age 47 years) underwent surgery. Exclusion criteria were lateral compartment and advanced patellofemoral OA. The Knee Injury and Osteoarthritis Outcome Score (KOOS), six minute walk test (6MWT) and a validated MRI score were outcome measures. RESULTS: There were significant improvements (p<0.05) in all five KOOS domains. Four were significantly maintained to five years. The domain “symptoms” and results in the 6MWT dropped off at five years. MRI results were first significantly improved (24/12) but declined at 60 months. Good quality infill was found in 33% patients at the study endpoint (n=5/15). Histological investigation of one knee demonstrated full-thickness hyaline-like cartilage (20/12). After two early failures and one graft...
INTRODUCTION: Repair of complete radial meniscal tears is a key to restoring the mechanical integrity necessary to maintain hoop tension in the meniscus. The primary stability of the meniscal repair is one of the most important factors for meniscal healing, but the biomechanical structural properties of different repair techniques for the complete radial meniscal tears remain unknown. Hypothesis: Our novel cross-suture technique with suturing oblique to the collagen fibrils of the meniscus, will yield better fixation than the standard double horizontal suture technique with suturing parallel to the collagen fibrils in the meniscus. Study design: Biomechanical testing study.

METHODS: Biomechanical investigations were performed on 40 fresh human menisci (two groups of 20 menisci each) from patients who underwent total knee arthroplasty. In the cross-suture technique group (Group A), the sutures were crossed over 5 mm from the tear, 5 mm and 10 mm from the rim. In the double horizontal suture technique group (Group B), the sutures were parallel and had the same attachment points as Group A. The specimens were cyclically loaded 500 times between 5 and 30 N and then loaded to failure after completion of the cyclic load testing.

RESULTS: Compared with the double horizontal suture group, the cross-suture group had a significantly higher ultimate failure load (78.96 ± 19.27 N vs. 68.16 ± 12.92 N; p < .05), significantly greater stiffness (8.01 ± 1.54 N/mm vs. 6.46 ± 1.12 N/mm; p < .05), and significantly lower displacement (5.74 ± 1.84 mm vs. 8.56 ± 2.39 mm; p < .05) after a 500-cycle loading protocol.

DISCUSSION AND CONCLUSION: Our cross-suture technique significantly improved the structural properties of the repaired complete radial meniscal tears.

<table>
<thead>
<tr>
<th>Suture Technique</th>
<th>Ultimate Failure Load, N</th>
<th>Stiffness, N</th>
<th>Displace, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross suture</td>
<td>78.9 ± 19.2</td>
<td>8.0 ± 1.5</td>
<td>5.7 ± 1.8</td>
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<tr>
<td>Double horizontal suture</td>
<td>68.2 ± 12.9</td>
<td>6.5 ± 1.1</td>
<td>8.6 ± 2.3</td>
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</tbody>
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SCIENTIFIC EXHIBIT NO. SE70

The Approach to the Evaluation and Surgical Treatment of Mechanical Hip Pain in the Young Patient

Jack G. Skendzel, MD, Ann Arbor, MI
Alexander Weber, MD, Ann Arbor, MI
Michael Leunig, MD, Zurich, Switzerland
Bryan T. Kelly, MD, New York, NY
Asheesh Bedi, MD, Ann Arbor, MI

This scientific exhibit reviews the evaluation and surgical management of mechanical hip pain in the young patient, including an evidence-based algorithm to select the best treatment method. The cause of hip pain in a young, athletic individual is often multifactorial and reflects a complex interplay of static and dynamic mechanical factors. Dynamic factors, such as a cam lesion with loss of femoral head-neck offset and/or focal rim lesions, can lead to abnormal stress and contact between the femoral head and acetabular rim with motion. Conversely, static factors, such as acetabular undercoverage (dysplasia) or coxa valga, cause abnormally increased loads between femoral head and acetabulum in positions that do not require motion. The goal of this exhibit is to provide an accurate diagnostic algorithm to properly diagnose hip pain through focused physical examination techniques and appropriate interpretation of plain radiographs and advanced imaging studies. The use of 3-dimensional computed tomography scans to determine the location of the cam lesion and thus predict labral/chondral injury is reviewed. Video illustrations of physical examination tests and surgical management will highlight the key points. The current literature and our own experience of surgical management of mechanical hip pain are presented. An evidence-based algorithm will aid the clinician in determining the best treatment options for the patient, including consideration of hip arthroscopy, open surgical dislocation, a mini-open approach, peri-acetabular osteotomy, or a combined approach (i.e. PAO and arthroscopy). Recognition of the abnormal mechanical factors pertinent to each case allows for thoughtful preoperative planning and adequate correction of the pathoanatomy. In addition, common patterns of compensatory injury in femoroacetabular impingement, including stress fracture and tendinopathy, are reviewed. A comprehensive diagnostic approach is of paramount importance to surgical technique in order to successfully address all causes of mechanical pain in the young, pre-arthritic patient.

SCIENTIFIC EXHIBIT NO. SE71

Reconstruction of the Anterior Cruciate Ligament in the Skeletally Immature Athlete: A Review of Current Concepts

Kristofer Jones, MD, New York, NY
Peter D. Fabricant, MD, New York, NY
Demetris Delos, MD, New York, NY
Daniel W. Green, MD, New York, NY
Robert G. Marx, MD, New York, NY
Andrew D. Pearle, MD, Rye, NY
Russell F. Warren, MD, New York, NY

Introduction: Intrasubstance tears of the ACL were once considered a rare injury in skeletally immature athletes; however, they are now observed with increasing frequency. Treatment...
strategies have evolved, as recent studies have identified unique considerations specific to the skeletally immature patient. Current literature now supports the trend toward early operative treatment to restore knee stability and prevent progressive meniscal and/or chondral damage, but the optimal approach to ACL reconstruction remains controversial. **Materials and Methods:** Despite the reported clinical success with transphyseal reconstruction, iatrogenic growth disturbance secondary to physeal damage remains a genuine concern. The reluctance to drill across open physes has led to the development of numerous “physeal-sparing” reconstruction techniques that adequately restore anteroposterior and rotational knee stability in biomechanical studies but have yielded mixed results in the clinical setting. **Results:** The intent of this exhibit is to: 1) Review the unique anatomical considerations (intercondylar notch and femoral/tibial epiphysis) as they pertain to ACL reconstruction in the skeletally immature athlete 2) Discuss preoperative clinical and imaging assessment of the pediatric patient with a suspected ACL injury 3) Review transphyseal and physeal-sparing reconstruction techniques and highlight technical considerations utilizing supplemental video and diagrammatic visual aids 4) Present clinical outcomes based on patient and technique specific factors 5) Review age-specific injury prevention treatment strategies and a novel treatment algorithm based upon skeletal maturity. **Discussion:** ACL reconstruction in the skeletally immature athlete typically results in successful clinical outcomes; yet several questions still exist regarding optimal surgical technique. This exhibit will provide important data to guide the management of ACL injury through patient/parental counseling, technical considerations and an evidence-based algorithm for the selection of the appropriate graft construct and surgical technique.

**SCIENTIFIC EXHIBIT NO. SE72**

◆ **Meniscus Replacement: Current Status of Allograft Transplantation and Synthetic Materials**

Clifford Voigt, MD, New York, NY
Demetris Delos, MD, New York, NY
Florian Wanivenhaus, MD, Vienna, Austria
John M. Solic, MD, Raleigh, NC
Kirsten Stoner, M.S., New York, NY
Saif Alzoobaee, BA, New York, NY
Suzanne A. Maher, PhD, Manhattan, NY
Scott A. Rodeo, MD, New York, NY

**Introduction:** The meniscus plays an important role in preserving and maintaining normal knee function including stabilization, load distribution, shock absorption, and joint congruity. Absence of the meniscus has been shown to lead to articular cartilage degeneration. Consideration of the functional role of the meniscus makes clear the importance of meniscal preservation whenever possible. Meniscal allograft transplantation (MAT) has been used for restoration of meniscus function in knees that have undergone meniscectomy. Although MAT can predictably improve symptoms in the knee, there is currently no data to suggest that we can alter the long-term natural history of the meniscus-deficient knee. Limitations associated with meniscus allograft tissue, such as availability, sizing, and long-term survival, have led to efforts to develop synthetic materials for meniscus substitution. This exhibit will review the most current clinical data related to the status of meniscal allograft transplantation and the development of synthetic materials.

**Methods:** The question of greatest importance is whether meniscal allograft transplantation or synthetic meniscal materials can preserve cartilage in the knee. Many studies have showed that arthritis is inevitable in a meniscectomized knee. We will present these studies with their levels of evidence. We will present outcomes data on meniscus transplantation from our institution. **Results:** Currently there are several limitations to the use of meniscus allografts: tissue sizing, tissue availability, and the lack of viable cells that can repair microscopic matrix damage. These limitations have led to the search for synthetic materials (either permanent or biodegradable) or tissue-engineered approaches for meniscus regeneration. Various materials including collagen/glycosaminoglycan composites (Collagen Meniscus Implant, Regen Biologics), porous polyurethane (Actifit, Oretq, Ltd), polycarbonate-urethane, polycaprolactone, and others have been developed. This exhibit will highlight the research on these meniscal substitutes and will review current studies comparing the potential benefits of these meniscal substitutes. We plan on displaying clinical images from the operating room demonstrating surgical techniques. Video will accompany our presentation exhibiting our surgical techniques and our reasoning for particular approaches. We will discuss indications and contraindications for meniscus replacement, including their use in early arthritis, focal chondral disease, and as an adjunct to ligament reconstruction to restore knee stability. **Discussion and Conclusion:** The efficacy of meniscus allograft transplantation in sports medicine requires further investigation, with the ultimate goal being to slow the process of cartilage degeneration. This exhibit will introduce the reader to up to date science regarding meniscus replacement and potential future improvements, allowing the reader to make informed judgments about potential and appropriate usage. The authors would like to thank Maureen Doyle for her help with clinical followup.

**SCIENTIFIC EXHIBIT NO. SE73**

**Ultrasound Imaging in Sports Medicine: Current Concepts, Techniques and Perspectives for the Orthopaedic Surgeon**

Laith M. Jazrawi, MD, New York, NY
Eric Strauss, MD, New York, NY
Stanislav Sidash, MD, New York, NY
Abiola Atanda, MD, New York, NY

**Introduction:** This exhibit will review the current concepts and techniques in using ultrasound imaging as a modality in the diagnosis, management, and treatment of sports-related injuries. Ultrasound (US) is a valuable diagnostic and procedural tool that has gained popularity in the orthopaedic sports practice in the past decade. Over the past 3 decades there have been significant advances in US that have increased applicability in the orthopaedic practice. Ultrasound is currently used in evaluation of all of the major joints: shoulder, elbow, hip, knee, and ankle. In addition, it is applicable in a variety of clinical scenarios including: guided percutaneous interventions, tendon and ligament pathology, fluid collections subluxating tendons, etc. Ultrasound affords multiple advantages over other modalities including no medical counter-indications, lack of radiation, portability, low cost, short evaluation time, high acceptance by the patients as well as offering the benefits of dynamic real-time examination.

**Methods:** We will review the current implementation of US, discuss US techniques, and introduce innovative applications in sports medicine practice. The exhibit will utilize an innovative “hands on” multimedia approach to present a complete review of US techniques for most common sports medicine procedures and athletic injuries.
Posterior shoulder instability remains difficult to diagnose secondary to a variety of patient complaints, often confusing the clinical picture and challenging physical examination findings. With improved recognition of this condition, however, the incidence is increasing, especially in specific demographic groups such as weight lifters, football players, paddling athletes and climbers. Successful treatment requires a sophisticated appreciation of shoulder anatomy and biomechanics, as well as familiarity with proven surgical techniques. The purposes of this exhibit are to provide a comprehensive multimedia review of posterior shoulder instability to include anatomy, biomechanics, pathogenesis, key history and physical findings, imaging findings, treatment options, examples of surgical techniques and clinical outcomes.

Methods: This exhibit will employ the use of representative anatomic diagrams, radiographic studies and images, including clinical photographs and video, to review the spectrum of injury, pathology, exam techniques and findings associated with posterior shoulder instability. Treatment options, specifically operative techniques and pearls will be illustrated with diagrams and arthroscopic images and video. Specifically we will review patient positioning, arthroscopic portal placement, and surgical technique.

Results: A comprehensive review of clinical outcomes data will be presented along with results of our own outcomes with a specific focus on return to duty status and overall functional status in a military population. We will also review current literature to present a logical approach to the best practice management of patients with posterior shoulder instability.

Discussion and Conclusion: Results of treatment for posterior shoulder instability have not been nearly as promising as those for anterior shoulder instability. With improved understanding of the pathoanatomy associated with posterior shoulder instability, outcomes are improving. In order to obtain good results, careful patient selection must be performed and treatments should focused on correcting specific pathologic changes.
show difference between the groups in 1 year. There was no case of serious or unexpected adverse event in both groups. Conclusion: MSC-Hyaluronate composite is safe and effective to repair articular cartilage defect of the knee, with some evidence of better repair than repair with microfracture.

**SCIENTIFIC EXHIBIT NO. SE76**

**Managing Bone Loss in Anterior Instability**

Mark Schrumpf, MD, New York, NY
Joshua Dines, MD, Great Neck, NY
Asheesh Bedi, MD, Ann Arbor, MI
Travis G. Maak, MD, New York, NY
Demetris Delos, MD, New York, NY
Kristofer Jones, MD, New York, NY
Gilles Walch, MD, Lyon, France
David M. Dines, MD, Great Neck, NY

Glenohumeral instability is often multifactorial and can result from injury to static and dynamic soft tissue stabilizers as well as loss of humeral head and glenoid bone stock. Failure to recognize and treat bone loss is one of the most commonly recognized cause for technical failure and recurrence after shoulder stabilization surgery. In several recent studies, high recurrence rates after arthroscopic stabilization were directly attributable to unaddressed bone loss on the glenoid, humeral head, or both. Determining the optimal surgical technique to treat anterior shoulder instability depends on a patient's age, activity demands and pathology. Recent literature suggests that glenoid rim lesions may be seen in up to 90% of shoulders with recurrent anterior instability. The quantification of bone loss can be difficult and unreliable on plain radiographs and often requires further imaging with computed tomography (CT). Biomechanical data from cadaver studies on a bone-block as well as a soft-tissue stabilization procedure will be presented with regards to stability and post-treatment range of motion. This exhibit will provide an evidence-based algorithm to the diagnosis and surgical management of glenohumeral instability in the setting of bone loss. Methods to define the location and quantify the severity of bone loss by CT and arthroscopy will be reviewed. Evidence-based recommendations on surgical technique, including consideration of arthroscopic stabilization, open capsular shift, osteochondral allograft, remplissage, and Latarjet procedures will be reviewed. Equally important will be the review of potential complications of each procedure to help provide treating physicians with the appropriate data to make informed risk-benefit analyses. The exhibit will conclude with a post-test to review the pertinent points in managing anterior instability in the context of bone loss.

**SCIENTIFIC EXHIBIT NO. SE77**

**Characterization of Patellofemoral Instability With 3-Dimensional Kinematic Computed Tomography**

Miho J. Tanaka, MD, New York, NY
John J. Elias, PhD, Akron, OH
John A. Carrino, MD, Baltimore, MD
Emmanuel N. Menga, MD, Baltimore, MD
Gaurav K. Thawait, MD, Baltimore, MD
Andrew J. Cosgarea, MD, Lutherville, MD

Patellofemoral instability remains a disorder that is poorly understood due to its many contributing factors. We describe a new technique using dynamic kinematic computed tomography (CT) imaging to better understand the pathoanatomy of the patellofemoral joint. Our technique is based on the modification of a widely available imaging technology, currently used in cardiac imaging. Dynamic CT allows for dynamic, kinematic imaging of the patellofemoral joint with excellent bony detail. The 3-dimensional (3D) patellofemoral kinematic reconstructions can be viewed to identify patterns of maltracking that can be qualitatively described. Observation of the 3D kinematic reconstructions have allowed us to group maltracking patterns into various types, such as: (1) normal tracking, (2) lateral maltracking, (3) abrupt lateral translation in terminal extension (4) lateral translation in early extension, and (5) lateral translation in late flexion. Patterns in maltracking can also be quantified with modified radiographic measurements of bisect offset, patellar tilt, and tibial tuberosity to trochlear groove (TTTG) distance at varying flexion angles. This allows for a graphical representation of the tilt or lateralization of the patella at each flexion angle, while the changes in TTTG distance can represent the influence of bony malalignment on patellofemoral tracking. Dynamic CT imaging provides 3D visualization of patellofemoral maltracking and allows for detailed analyses of joint kinematics. Identifying and understanding the different patterns of maltracking can allow us to tailor our surgical treatments to the unique anatomy of each individual. The accessibility and applicability of 3D kinematic CT imaging to patellofemoral instability provides new information that may change the assumptions we have made based on 2D static imaging and aid in the treatment of patellofemoral instability.

**SCIENTIFIC EXHIBIT NO. SE78**

**Juvenile Unicompartmental OA: An Integrated Mechanical and Biological Approach to Avoid Metal Resurfacing**

Stefano Zaffagnini, MD, Bologna, Italy
Elizaveta Kon, MD, Italy, Italy
Giuseppe Filardo, MD, Bologna, Italy
Giulio Maria Marcheggianni Muccioni, MD, Bologna, Italy
Alessandro Di Martino, MD, Bologna, Italy
Tommaso Bonanzinga, MD, Bologna, Italy
Danilo Bruni, MD
Francesco Iacono, MD, Bologna, Italy
Maurilio Marcacci, MD, Bologna, Italy

Introduction: Degenerative articular lesions may present a complex environment, which may have a negative effect on the process of tissue regeneration. However, some evidences show that good results can be obtained also in complex cases if all comorbidities are recognized and treated. Aim of this study is to evaluate if a combined mechanical and biological approach could offer good results also in case of juvenile unicompartmental osteoarthritis (OA), thus avoiding the need of metal resurfacing. Methods: Forty-three patients affected by unicompartmental OA (Kellgren 3) were enrolled and treated. The mean age at surgery was 40.1±11.6 years (33 male and 10 females). Eleven patients were treated with osteotomy and meniscal scaffold implant, 9 with osteotomy and meniscal allograft, 15 with osteotomy and cartilage treatment with an osteochondral biomimetic scaffold implant and 8 with both cartilage and meniscal reconstruction, depending on the specific joint compartment main requirements. Outcome was documented at mean 3 years follow-up (minimum 2 years) using IKDC, EQ-VAS, VAS for pain, EQ-5D and Tegner scores. Results: A significant improvement in all the questionnaires was observed. The IKDC score improved from 51.0±17.9 to 79.2±16.4 at the f-up evaluation (p<0.05), pain measured with VAS decreased from 6.1±1.9 to 2.5±2.48 (p<0.05), and also the sport activity
level (evaluated with median Tegner score) showed a significant improvement from 2 (range 1-3) to 4 (range 3-5) (p<0.05), even if without achieving the preinjury level of 6 (range 4-8) (p<0.05). A further sub-analysis confirmed the positive outcome obtained in all the treatment subgroups. Discussion and Conclusion: This combined biological and mechanical approach allowed to obtain a marked improvement at short-medium follow-up also in patients affected by unicompartmental OA eligible for prosthetic resurfacing. Future work is needed to explore the long-term efficacy of this promising treatment approach in avoiding or at least delaying metal resurfacing in case of juvenile unicompartmental OA.