



**Abstract Number:**

Paper 100

**Abstract Title:**

Biomechanical Comparison of Acute Hill-Sachs Reduction and Remplissage to Treat Complex Anterior Instability: The Potential Benefits of Anatomic Reconstruction

**Author Block:**

**Joshua S. Dines, MD<sup>1</sup>**, Grant Garcia, MD<sup>2</sup>, Michelle H. McGarry, MS<sup>3</sup>, Thay Q. Lee, PhD<sup>4</sup>, Ryan Degen, MD<sup>5</sup>.

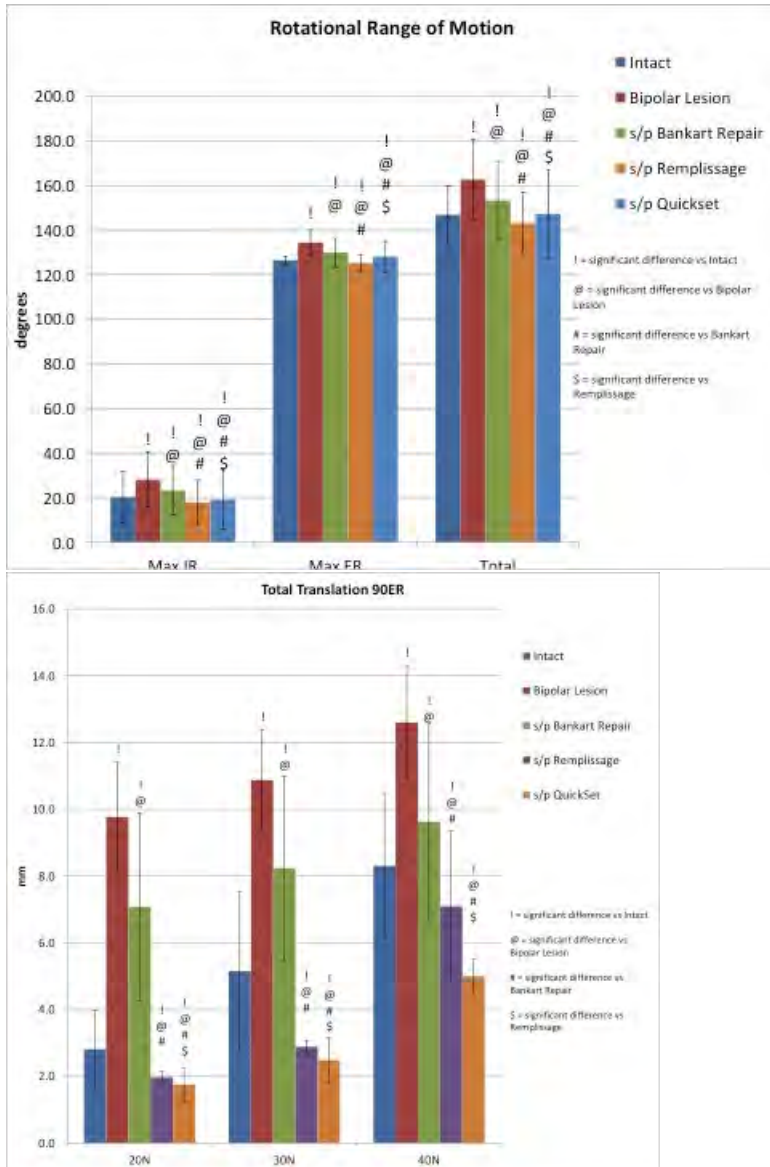
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**Abstract:**

**Objectives:** Acute Hill-Sachs (HS) reduction represents a potential alternative method to remplissage for the treatment of an engaging HS lesion. The purpose of this study is to biomechanically compare the stabilizing effects of an acute HS reduction technique and remplissage in a complex instability model.

**Methods:** This was a comparative cadaveric study of 6 shoulders. For the acute HS lesion, a unique model was used to create a 30% defect, compressing the subchondral bone while preserving the articular surface in a more anatomic fashion. In addition, a 15% glenoid defect was made in all specimens. The HS lesion was reduced through a lateral cortical window with a bone tamp, and the subchondral void was filled with Quickset (Arthrex) bone cement to prevent plastic deformation. Five scenarios were tested; intact specimen, bipolar lesion, Bankart repair, remplissage with Bankart repair and HS reduction technique with Bankart repair. Translation, kinematics and dislocation events were recorded.

**Results:** For all 6 specimens no dislocations occurred after either remplissage or the reduction technique. At 90 degrees of abduction and external rotation (ABER), anterior-inferior translation was 11.1 mm (SD 0.9) for the bipolar lesion. This was significantly reduced following both remplissage (5.1±0.7mm; p<0.001) and HS reduction (4.4 ±0.3mm; p<0.001). For anterior-inferior translation there was no significant difference in translation between the reduction technique and remplissage (p=0.91). At 90 degrees of ABER, the intact specimens average joint stiffness was 7.0 ±1.0N/mm, which was not significantly different from the remplissage (7.8±0.9 N/mm; p=0.9) and reduction technique (9.1±0.6 N/mm; p=0.50). Compared with an isolated Bankart repair, the average external rotation loss after also performing a remplissage procedure was 4.3 ±3.5 deg (p=0.65), while average ER loss following HS reduction was 1.1 ±3.3 deg (p=0.99). There was no significant difference in external rotation between remplissage and the reduction technique (p=0.83).



**Conclusion:** Similar joint stability was conferred following both procedures, though remplissage had 3.2-degree loss of ER in comparison. While not statistically significant, even slight ER loss may be clinically detrimental in overhead athletes. Overall, the acute reduction technique is a more anatomic alternative to the remplissage procedure with similar ability to prevent dislocation in a biomechanical model, making it a viable treatment option for engaging Hill-Sachs lesions.



**Abstract Number:**

Paper 101

**Abstract Title:**

Outcomes of The Remplissage Procedure and Its Effects on Return to Sports: Average Five-Year Follow Up

**Author Block:**

**Joseph N. Liu, MD<sup>1</sup>**, Grant Garcia, MD<sup>2</sup>, Hao-Hua Wu, BA<sup>3</sup>, G. Russell Huffman, MD, MPH<sup>4</sup>, John D. Kelly, MD<sup>5</sup>.

<sup>1</sup>Hospital For Special Surgery, New York City, NY, USA, <sup>2</sup>Hospital for Special Surgery, New York City, NY, USA, <sup>3</sup>University of Pennsylvania School of Medicine, Philadelphia, PA, USA, <sup>4</sup>Penn Sports Medicine Center, Philadelphia, PA, USA, <sup>5</sup>University of Pennsylvania, Philadelphia, PA, USA.

**Abstract:**

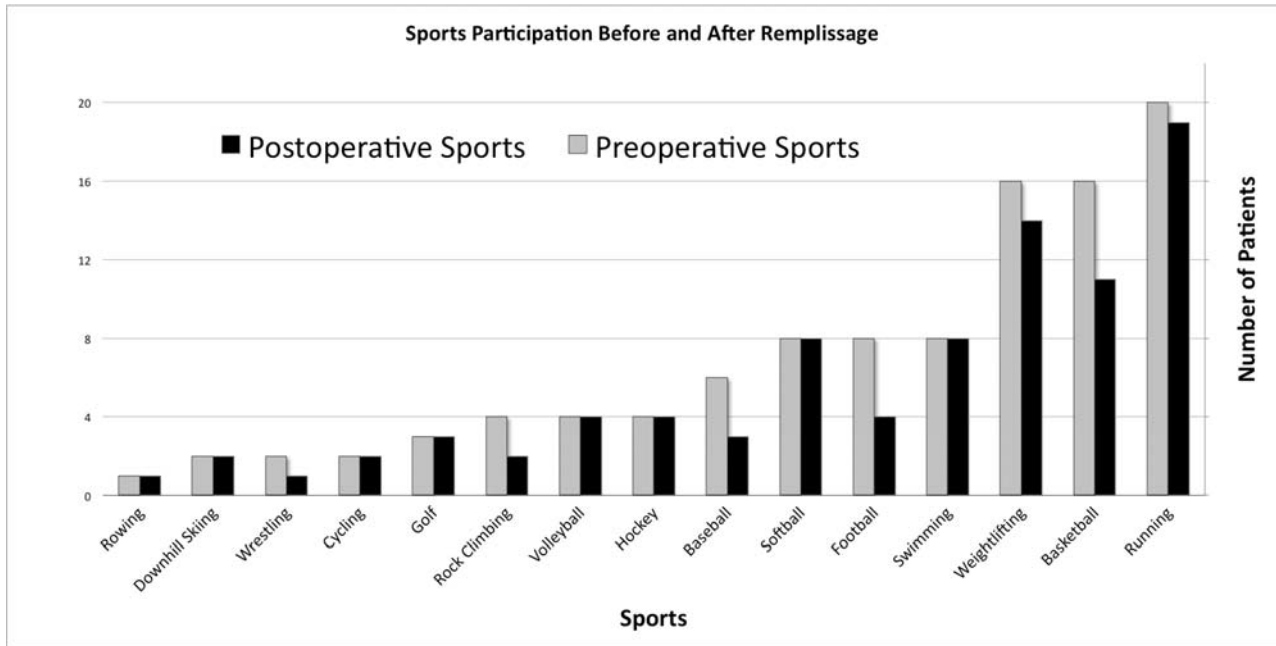
**Objectives:** Short-term outcomes for remplissage patients with large engaging Hill-Sachs lesions have demonstrated good results. However, limited data is available for longer-term outcomes. The purpose of this study was to evaluate long-term outcomes of the remplissage and determine the long-term rate of return to specific sports postoperatively.

**Methods:** This was a retrospective review of patients treated with the remplissage procedure from 2007-2013. All had preoperative MRIs demonstrating large Hill-Sachs lesions by Rowe criteria and glenoid bone loss less than 20%. All Hill-Sachs lesions were “off track” by arthroscopic examination and preoperative imaging. At final follow up, patients had a ROM evaluation and were administered a detailed outcomes survey, which included WOSI and ASES as well as questions regarding sports, employment, physical activities and dislocation events.

**Results:** Fifty-one shoulders (50 patients) were included. Average age at surgery was 29.8 years (15.0-72.4 years) and average follow up was 60.7 months (25.5-97.6 months). 20% of patients had previous surgery on their shoulder. Average postoperative WOSI scores were 79.5% and average ASES scores were 89.3.

Six shoulders had dislocation events (11.7%) postoperatively: three were traumatic, and three atraumatic. Increasing number of preoperative dislocations increased the risk of a postoperative dislocation ( $p < 0.001$ ). There was also a trend towards higher postoperative dislocation rates in revision patients ( $p = 0.062$ ). Average loss of external rotation was 5.2 degrees ( $p = 0.13$ ).

95.5% of patients returned to one or more sports postoperatively at an average of 7.0 months. 81.0% returned to their previous intensity and level of sport. 65.5% (19) of patients who played a throwing sport stated they had problems throwing. 58.6% (17) felt they could not normally wind up throwing a ball. Direct rates of return for overhead sports were volleyball 100%, basketball 69%, baseball 50% and football 50%.



**Conclusion:** Remplissage’s re-dislocation rate was 11.7% at an average of five years, with 96% of patients returning to full sports at an average of 7 months. For throwing sports, 65.5% complain of decreased range of motion during throwing. The results should be considered preoperatively in remplissage candidates who are engaged in throwing sports.



**Abstract Number:**

Paper 102

**Abstract Title:**

A Simple Population-Based Finite Element Model Eliminates the Need for Patient-Specific Models to Predict Instability of the Shoulder

**Author Block:**

**Anthony Miniaci, MD<sup>1</sup>**, Piyush Walia, D.Eng<sup>2</sup>, Stephen D. Fening, PhD<sup>3</sup>, Morgan H. Jones, MD<sup>2</sup>.

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**Abstract:**

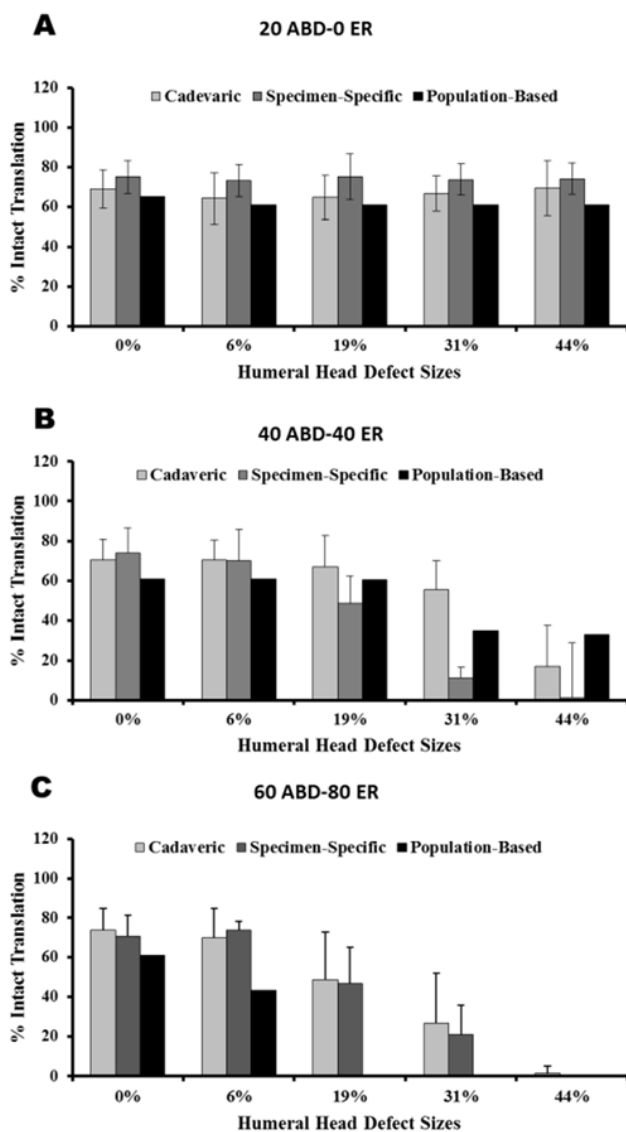
**Objectives:** Recurrent shoulder instability can significantly increase in the presence of bony Bankart and Hill-Sachs lesions. Therefore, it is important to understand the changes in shoulder biomechanics due to bony defects. Limitations of using cadaveric model to investigate the effects of combined bony defects on shoulder instability is inability to test all combination in a single specimen. Utilizing the flexibility of computational methodology like finite element (FE) model provides the advantage of testing all combinations at multiple arm positions. The aim of this study was to develop a simple FE model of combined bony lesions and its effect on anterior shoulder instability. In addition, we wanted to determine the need for patient (specimen) specific modeling. We hypothesized that the shoulder instability would be similar for all three models (population-based model, specimen-specific model, and cadaveric model).

**Methods:** Three specimens were randomly selected from specimens tested in our previous study and Computed Tomography (CT) arthrogram images were taken before and after experimentation to develop FE models. We also developed a simple population-based model representing a spherical humeral head, which was developed using the radii values for cartilage and bone from literature. The sizes of humeral head lesions chosen were: 6%, 19%, 31%, and 44% of humeral head diameter and glenoid defect sizes were 10%, 20% and 30% of the glenoid width. All simulations were performed at glenohumeral abduction angles (ABD) of 20°, 40°, and 60° and external rotation of 0°, 40°, and 80°. Each simulation comprised of translating the humeral head leading to an anterior dislocation under a constant 50N medial load. This compressive load simulated the static load of soft tissue. The percent intact translation (%IT) was computed by normalizing the distance to dislocation value for each defect condition w.r.t intact condition of each specimen. Stability Ratio (SR) was computed as a ratio of horizontal reaction force to the compressive load.

**Results:** The individual specimen-specific model results comparison to the experimental data for %IT had a good agreement as the values were similar for defect created. However, results for SR were over predicted by the FE model, but they had similar linear decreasing trends for both specimen-specific and cadaveric model. In addition, the humeral head defect size of 44% reduced the %IT from 100% to nearly 0% for all three models. The results for the comparison of all three models with increasing size of humeral defect with a 20% glenoid defect are shown in Figure 1 at three arm position.



**Conclusion:** This study proposed a simple population-based model that can be used to estimate the loss in stability due to combined defects to determine a threshold for defect augmentation in clinical practice. It was demonstrated that a smaller glenoid defect size of 10% combined with a 19% humeral head defect can cause significant instability. Similar to past studies, it was also shown that a glenoid defect would lead to loss of translation and a humeral head defect would lead to instability at a functional arm position of increased abduction and external rotation [5-6]. All three models predicted similar results during validation, which shows that the population based model can be utilized to estimate the stability, instead of needing patient-specific FE models. The limitation of the study is the absence of soft tissue restraints.



**Figure 1.** Percent intact translation values for increasing size of humeral head defect combined with a 20% glenoid at 3 different arm positions.



**Abstract Number:**

Paper 103

**Abstract Title:**

Outcomes After Arthroscopic Bankart Repair: First Time vs. Recurrent Dislocators

**Author Block:**

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**Abstract:**

**Objectives:** The shoulder is the most common joint dislocation effecting roughly 2% of the general population. Males are effected to a higher degree that females at a ratio of 3:1.1-2 The young, athletic population make up the largest portion of shoulder instability, and treated nonoperatively have a recurrent dislocation rate approaching 50%.3-5 Owens et. al recently published a cohort looking at 45 college athletes with an in season shoulder instability event. 73% of athletes returned to play in season. Only 36% of athletes completed the season without re-injury and 64% of athletes had a recurrent instability event.6 It is unknown how the outcomes of those who go on to have a recurrent dislocation in season are effected versus those who have a stabilization procedure after a first time dislocation. The objective of the current study is to report the postoperative outcomes of first time dislocators versus patients with recurrent dislocations prior to surgery.

**Methods:** CPT codes were used to identify patients who had arthroscopic Bankart repair between 2003-2013. 439 patients aged 16-30 years were identified across 8 fellowship trained surgical practices. The first phase of the study was a retrospective chart review to obtain patient demographics, number of reported preoperative dislocations, review imaging, and number of anchors placed. Patients were identified as first time dislocators or as recurrent dislocators when they had more than one dislocation prior to surgical intervention. The second phase consisted of a survey to obtain a simple shoulder test score, whether they returned to sport, postoperative instability events and further surgery on the shoulder. Postoperative instability was defined as a subluxation or dislocation reported by the patient survey in the postoperative period. Of the 439 patients identified, 296 were excluded for revision surgery, open repair, posterior instability, multidirectional instability, HAGL lesion, labral tears involving the biceps anchor and refusal to participate. This left 144 patients eligible for the study.

**Results:** 121 patients participated for a follow up rate of 85% at an average of 51 months post surgery. There were 53 patients in the recurrent dislocation group and 68 in the first time dislocation group. The average age in both groups was 19yrs. The postoperative instability rate in the first time dislocator group was 9%. The postoperative instability rate in the recurrent dislocator group was 47%. This was statistically significant with  $p < 0.0001$ . The first time dislocator group reported a 7% rate of repeat operation to address instability. The recurrent dislocator group reported a 32% rate of repeat operation to address instability. This was statistically significant with a  $p = 0.0007$ . The Simple Shoulder Test (SST)



score in the first time dislocator group was 11.4. The SST score in the recurrent dislocator group was 11. The difference was significant with  $p=0.037$ .

**Conclusion:** First time dislocators had lower postoperative instability rates and reoperation rates when compared to patients with recurrent dislocations prior to surgical intervention. The SST scores were significantly different between groups. Young, athletic patients with shoulder instability should be offered early surgical intervention to lower the risk of postoperative instability and reoperation.





**Abstract Number:**

Paper 104

**Abstract Title:**

Factors Affecting Return to Baseline Function at 6 months Following Anterior Shoulder Instability Surgery: A Multi-Center Orthopaedic Outcomes Network (MOON) Shoulder Group Cohort Study

**Author Block:**

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<sup>1</sup>University of Iowa, Iowa City, IA, USA, <sup>2</sup>UI Sports Medicine, Iowa City, IA, USA, <sup>3</sup>University of Iowa Orthopaedic Surgery, Sports Medicine, and Rehab, Iowa City, IA, USA, <sup>4</sup>Vanderbilt University, Nashville, TN, USA.

**Abstract:**

**Objectives:** Pre-operative and surgical factors related to early return to baseline function after anterior shoulder instability surgery are not clear. This study was designed to determine the pre-operative and operative factors affecting return to baseline function at 6 months following anterior shoulder instability surgery. Identifying these factors will help surgeons establish expectations for functional return post-operatively.

**Methods:** The Multicenter Orthopaedic Outcomes Network (MOON) shoulder group enrolled patients undergoing surgery for shoulder instability from 16 sites throughout the United States. Initial demographic data and validated, patient-oriented outcomes questionnaires were collected along with the physicians documented initial physical exam, treatment, surgical findings and surgical techniques used at the time of surgery. At the 6-month follow up visit, range of motion (ROM) and strength measurement of the operative shoulder were collected and compared to pre-operative measurement. Return to baseline was defined as return to within -10° ROM and full strength at the 6 month physical exam. Continuous and categorical data were analyzed using student t-tests and chi-square tests, respectively. The Kruskal-Wallis/Wilcoxin tests were used to compare groups that were not normally distributed. Factors reaching significance in a univariate analysis were then applied in a multivariable model. Significance was set a  $p < 0.05$ .

**Results:** A total of 338 patients with history of surgical intervention for anterior instability of the shoulder were identified. 278 patients had complete pre- and post-surgical range of motion and strength measurements. 138 (50%) patients (139 shoulders) returned to baseline and 133 (50%) patients did not return to baseline. Univariate analysis identified age ( $p=0.0013$ ), Beighton score ( $p=0.0004$ ), SF-36 general health ( $p=0.0017$ ), WOSI ( $p=0.0250$ ), and duration of symptoms ( $p=0.0046$ ) as significant factors. When these factors were placed into a multivariate model, significant differences were identified in age ( $p=0.0316$ ), SF-36 General health ( $p=0.0118$ ), and Beighton score ( $p=0.0016$ ).

**Conclusion:** Older age, perception of general health and generalized joint laxity are associated with failure to return to baseline function at 6 months after anterior shoulder instability surgery. Duration of symptoms and number of dislocation events did not reach significance in the multivariate model, but



trended toward likelihood of failure to return to baseline findings. Moreover, open vs. arthroscopic surgery and number of suture anchors were not significant, suggesting that pre-operative condition and not surgical factors predict return to baseline in the short-term.



**Abstract Number:**

Paper 105

**Abstract Title:**

Anisometry of Medial Patellofemoral Ligament Reconstruction in the Setting of Patella Alta and Increased Tibial Tubercle-Trochlear Groove (TT-TG) Distance

**Author Block:**

**Lauren H. Redler, MD<sup>1</sup>**, Kathleen N. Meyers, MS<sup>1</sup>, Jacqueline Munch, MD<sup>2</sup>, Elizabeth R. Dennis, MD<sup>3</sup>, Joseph Nguyen, MPH<sup>1</sup>, Beth E. Shubin Stein, MD<sup>1</sup>.

<sup>1</sup>Hospital for Special Surgery, New York, NY, USA, <sup>2</sup>Oregon Health & Science University, Portland, OR, USA, <sup>3</sup>Columbia University Medical Center, New York, NY, USA.

**Abstract:**

**Objectives:** Medial patellofemoral ligament (MPFL) reconstruction is a common procedure to treat recurrent patellofemoral instability. However, the effects of an elevated tibial tubercle-trochlear groove (TT-TG) distance and patella alta, as measured by the Caton-Deschamps (C/D) ratio, on MPFL isometry remain unclear. We hypothesized that increased lateralization and proximalization of the tibial tubercle (TT) will have increasingly adverse effects on the isometry of the MPFL.

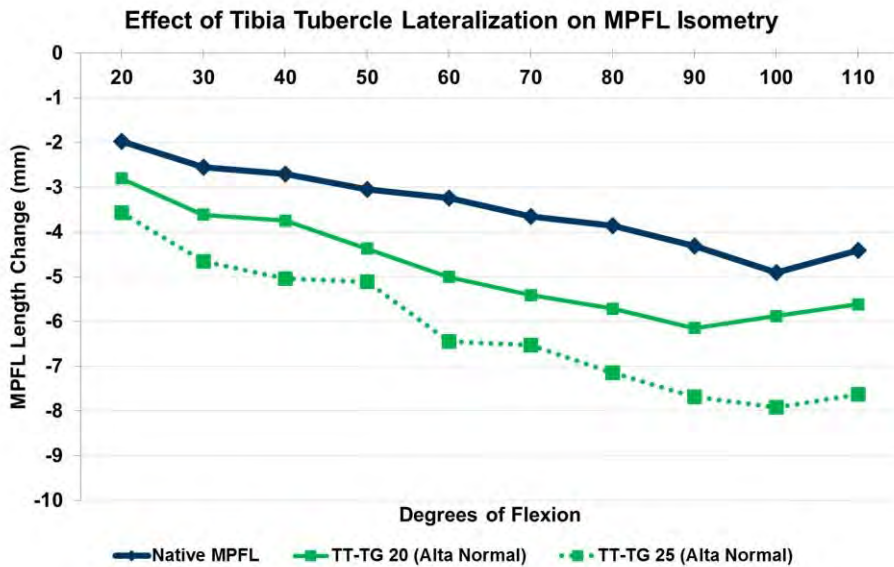
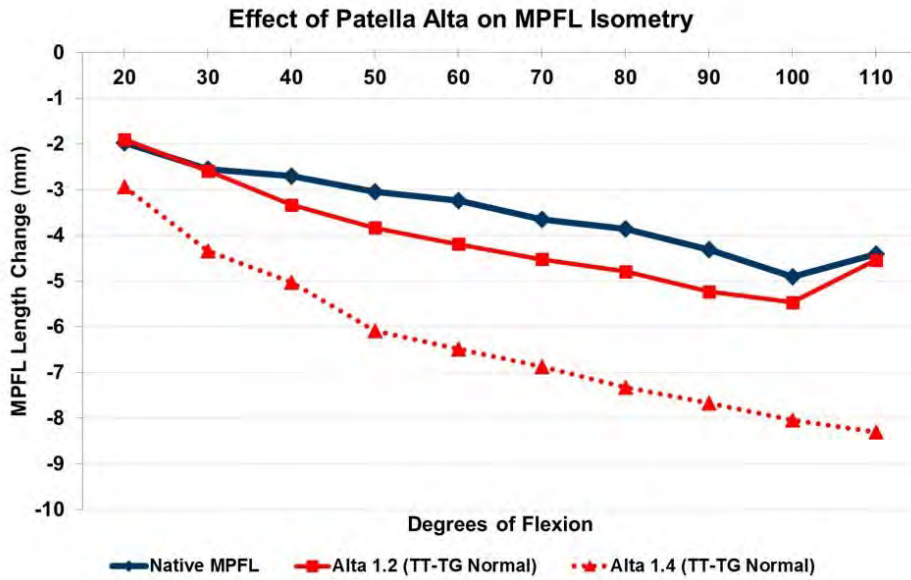
**Methods:** Ten fresh-frozen cadaveric knees were placed on a custom testing fixture, with a fixed femur and tibia mobile through 120 degrees of flexion. The quadriceps tendon was loaded with 10.8N in an anatomic direction using a weighted pulley system. A 0.2N patellar lateral displacement load was used to simulate an intact lateral retinaculum to avoid over-medializing the patella. A tunnel was drilled under fluoroscopic guidance from Schottle's point on the medial distal femur through the lateral cortex. A suture anchor was placed at the upper 66% of the medial border of the patella and the sutures were shuttled through to the lateral side and attached to a pulley with a 1N weight. Retroreflective markers were attached to the femur, tibia, patella, and suture. MPFL length change, as measured by suture marker motion, was assessed using a 3D motion capture system through a range of motion between 0deg and 110deg with the native TT anatomy. Recordings were repeated after a flat TT osteotomy and transfer to a TT-TG of 20mm and 25mm and a C/D ratio of 1.2 and 1.4, including all combinations. Generalized estimating equation (GEE) modeling technique was used to analyze and control for the clustered nature of the data. SAS version 9.3 (SAS Inc., Cary, NC) was used for all data analyses.

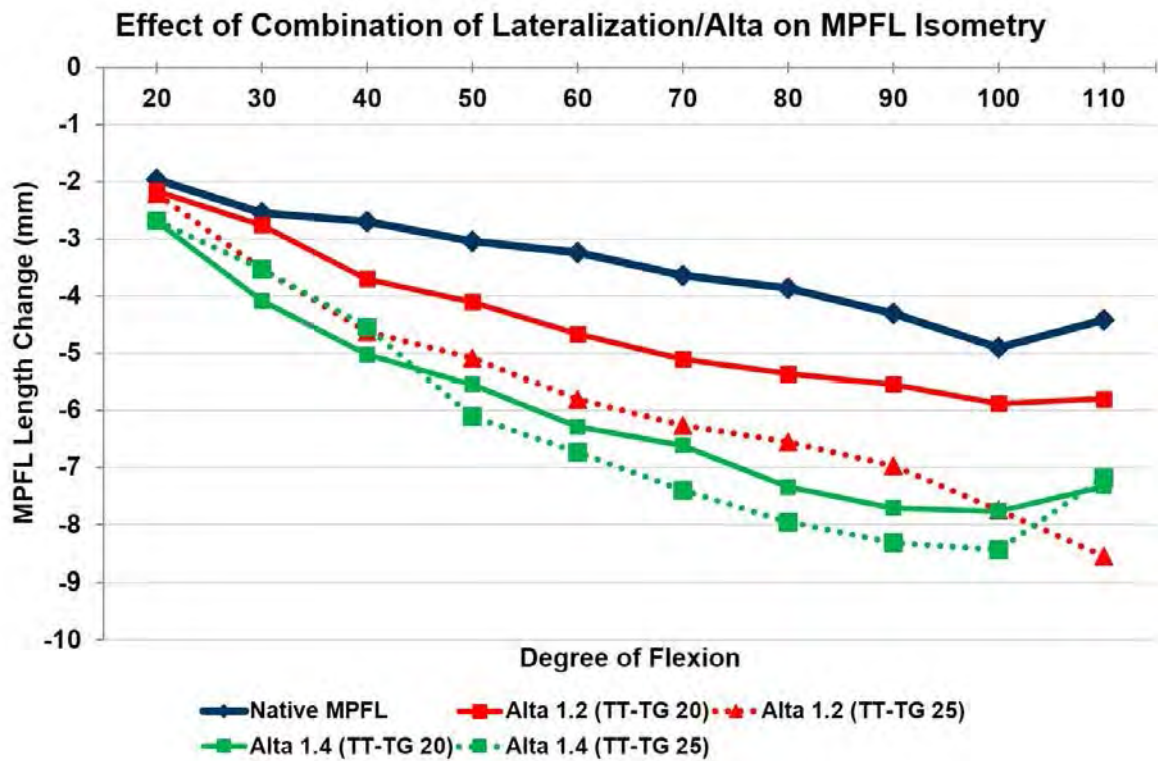
**Results:** Analysis was performed on 9 specimens secondary to significant deviations in the baseline normative data. Intact knees showed MPFL isometry through 20-70 degrees range of motion. Tibial tubercle lateralization significantly altered MPFL isometry with a threshold TT-TG of 25mm ( $p=0.045$ ) (Figure 1). Patella alta significantly altered MPFL isometry with a threshold C/D of 1.4 ( $p=0.025$ ) (Figure 2). The effect of TT lateralization combined with patella alta compounded the anisometry, lowering the threshold for patella alta to a C/D of 1.2 when combined with a TT-TG of 25mm ( $P<0.001$ ) (Figure 3).

**Conclusion:** Increased TT lateralization and proximalization significantly alter MPFL isometry. Tibial tubercle transfer should be considered when performing an MPFL reconstruction for recurrent patellofemoral instability in the setting of significant patella alta, elevated TT-TG and especially when



both are present as an isolated MPFL reconstruction may be prone to failure given the anisometry demonstrated.







**Abstract Number:**

Paper 106

**Abstract Title:**

A Novel Injective Approach For Osgood-schlatter Disease: A Prospective Randomized Double-blind Study

**Author Block:**

**Junsuke Nakase, MD, PhD**, Hitoaki Numata, MD, Takeshi Oshima, Yasushi Takata, MD, Hiroyuki Tsuchiya, MD, PhD.

Department of orthopaedic Surgery, Kanazawa University Hospital, Kanazawa, Japan.

**Abstract:**

**Objectives:** Despite first being reported more than 100 years ago, Osgood-Schlatter disease(OSD) currently has no effective treatment. The recent use of ultrasonography in the orthopedic surgery and sports medicine fields revealed that patellar tendinopathy and deep infrapatellar bursitis contributes to the pain experienced by patients with OSD. Considering the reported effectiveness and safety of hyperosmolar dextrose injection for patellar tendinopathy, here we investigated the efficacy and safety of hyperosmolar dextrose injection as a novel treatment for OSD. Our hypothesis was that hyperosmolar dextrose injection would be safe and well tolerated by patients with OSD.

**Methods:** We performed this prospective randomized double-blind clinical trial between April 2012 and June 2015. A total of 44 knees in 36 boys (average age,  $12.3 \pm 1.1$  years) for whom conventional conservative therapy for >1 month was ineffective were randomly assigned to the double-blind injection of 1% lidocaine (1 mL) with saline (1 mL) (Saline group) or 1% lidocaine (1 mL) with 20% dextrose (1 mL) (Dextrose group). Half of the solution was injected into the distal attachment of the patellar tendon, while the remaining half was injected into the deep infrapatellar bursa or infrapatellar fat pad under ultrasound guidance. Injections were administered monthly for 3 months by a single investigator. The Victorian Institute of Sport Assessment (VISA) score was used to evaluate pain.

**Results:** A total of 40 knees in 33 boys were included in this clinical trial. The mean pre-injection VISA scores of the Dextrose and Saline groups were  $59.6 \pm 19.1$  and  $62.5 \pm 16.6$ , while those at the final follow-up were  $83.6 \pm 19.3$  and  $84.1 \pm 19.1$ , respectively. There were no significant differences in the two group pre-injection versus at the final follow-up ( $P = 0.61$  and  $0.93$ , respectively). In contrast, the mean VISA score significantly increased in both group between pre-injection and final follow-up ( $P < 0.01$ ). There were no adverse effects of the injection.

**Conclusion:** We were not able to prove the efficacy of the Dextrose injection compared with control; however, our results suggest superior symptom reduction efficacy of injection therapy for both treatments compared to usual care in the treatment of OSD. Thus, injection over the distal attachment of the patella tendon and into the deep infrapatellar bursa or infrapatellar fat pad under ultrasound guidance may become a new treatment method for OSD.



**Abstract Number:**

Paper 107

**Abstract Title:**

Tibial Tubercle Osteotomy for Anterior Knee Pain: Mid-term Result and Analysis of Prognostic Factors.

**Author Block:**

**Federica Rosso, MD<sup>1</sup>**, Umberto Cottino, MD<sup>2</sup>, Giorgio Governale, MD<sup>1</sup>, Valeria Cherubini, MD<sup>2</sup>, Federico Dettoni, MD<sup>1</sup>, Matteo Bruzzone, MD<sup>1</sup>, Roberto Rossi, MD<sup>1</sup>, Davide Bonasia<sup>1</sup>.

<sup>1</sup>AO Mauriziano Umberto I, Torino, Italy, <sup>2</sup>University of Study of Torino, Torino, Italy.

**Abstract:**

**Objectives:** The aim of this study was to evaluate the mid-term radiological and clinical outcomes of tibial tubercle osteotomy in patients affected by anterior knee pain. In addition, prognostic factors correlated with the outcomes were evaluated.

**Methods:** The patients treated with tibial tubercle osteotomy (anteromedialization) for anterior knee pain between 2002 and 2014 were included. Exclusion criteria: 1) previous knee surgeries; 2) different procedures to treat anterior knee pain; 3) history of patellar dislocation, 4) Rheumatic conditions. Different variables were collected, as shown in. The patients were prospectively evaluated using the WOMAC short form and Kujala scores. An objective evaluation was performed looking for different potential risk factors and using part of the International Knee Documentation Committee (IKDC) score. Radiological evaluation was performed, including the congruence angle, the grade of osteoarthritis (Kellgren-Lawrence) and the patellar tilt angle. Three main outcomes were identified. The multiple logistic regression was used to analyze the correlation between the variables and a worse outcome.

**Results:** 72 cases were included in the study (9 bilateral). 72.2% of the cases were female, and the average age was 42,2 years (SD15,9). The average BMI was 24.4 kg/m<sup>2</sup> (SD5,2). In 70.8% of patients a lateral release was associated to the tibial tubercle osteotomy. 77.8% of patients were evaluated clinically, the remaining, who were unable to come for the visits, were interviewed and the subjective scores were administered by phone. The average follow-up was 68.4 months (SD35.5). In 62.5% of cases a valgus lower limb alignment was detected, with 25% and 39.3% of patients having respectively an increased femoral antiversión and foot pronation. Post-operatively there was a statistical significant improvement in all the scores. No differences in the pre-operative and post-operative congruence angle or patellar tilt were detected ( $p > 0.05$ ). All the osteotomies were healed at the last follow-up. No major complications were detected. In 19 cases a further surgery was necessary, with 17 cases of hardware removal and one case of arthrofibrosis. In one case a major subsequent surgery was necessary (Total Knee Arthroplasty): the cumulative survivorship resulted equal to 92.3% (SD7.4%) at the final follow-up. At the multiple regression analysis, a lower WOMAC score was associated with increased age ( $> 45$  years, OR=141.69), increased femoral antiversión (OR=69.94), poor post-operative muscular trophism (OR=127.61) and persistent post-operative pathologic Q angle (OR=18.84). Similarly, a lower Kujala score was associated with increased age (OR=8.36) and increased foot pronation (OR=5.10). Patients' poor satisfaction was associated only to post-operative factors, such as presence of a positive Rabot test (OR=4.42) and poor muscular trophism (OR=5.14). Fig.1 shows the results of regression analysis



**Conclusion:** In this study good clinical and radiological outcomes were obtained at mid-term follow-up using tibial tubercle osteotomy to treat anterior knee pain, with a cumulative survivorship of 92.3%. The procedure did not affect radiological angles such as the congruence one or the patellar tilt. Older age, increased femoral antversion, poor post-operative muscular trophism, increased foot pronation and persistent pathologic Q angle were significantly correlated with worse subjective outcomes.

Preoperative factors	WOMAC - 7				KJUALA - 80				SATISFACTION - 7			
	Single test	Logistic regression			Single test	Logistic regression			Single test	Logistic regression		
		P-value	OR	CI		P-value	OR	CI		P-value	OR	CI
Gender (Male)	0.628		N/A		0.324		N/A		0.142		N/A	
Pre-operative BMI (obese)	0.602		N/A		0.468		N/A		0.719		N/A	
Age (mid-off > 45y)	<b>0.010</b>	<b>1.0149</b>	<b>6.32-378.74</b>	<b>0.0031</b>	<b>-0.001</b>	<b>1.36</b>	<b>2.11-33.18</b>	<b>0.0026</b>	0.283		N/A	
Bilateral procedure	0.927		N/A		0.325		N/A		0.925		N/A	
Leaky (yes)	0.935		N/A		0.730		N/A		0.384		N/A	
Alignment (valgus)	0.819		N/A		0.273		N/A		0.826		N/A	
Femoral antversion (yes)	<b>0.023</b>	<b>64.94</b>	<b>3.19-1318.42</b>	<b>0.0066</b>	0.220		N/A		0.240		N/A	
Foot pronation (yes)	0.389		N/A		<b>0.014</b>	<b>5.10</b>	<b>1.33-20.63</b>	<b>0.0176</b>	0.693		N/A	
Post-operative cystitis (yes)	<b>0.054</b>	12.19	0.91-162.70	0.0286	0.106		N/A		0.103		N/A	
Post-operative positive Kibot test	0.100		N/A		0.153		N/A		<b>0.017</b>	<b>4.42</b>	<b>1.22-16.82</b>	<b>0.0235</b>
Post-operative muscle trophism	<b>0.006</b>	<b>127.61</b>	<b>4.94-3256.27</b>	<b>0.0035</b>	0.164		N/A		<b>0.017</b>	<b>5.14</b>	<b>1.21-21.81</b>	<b>0.0265</b>
Post-operative pathologic Q angle	<b>0.004</b>	<b>18.84</b>	<b>1.38-257.06</b>	<b>0.0277</b>	0.929		N/A		0.241		N/A	
Pre-operative K.L. classification (2 or 4)	0.794		N/A		0.183		N/A		0.589		N/A	
Post-operative Congruence angle (> 10°)	0.605		N/A		0.683		N/A		0.641		N/A	
Pre-operative patella tilt (> 2°)	0.794		N/A		0.207		N/A		0.219		N/A	
Pre-operative level Subvast (patella tub)	0.556		N/A		0.744		N/A		0.429		N/A	
Pre-operative subh > 3m	0.625		N/A		0.223		N/A		0.620		N/A	
Post-operative subh > 3m	0.303		N/A		0.107		N/A		0.894		N/A	
Associated procedure	0.705		N/A		0.184		N/A		0.873		N/A	
Associated Lateral Release	0.705		N/A		0.184		N/A		0.873		N/A	
Pre-operative foot pronation (yes)	0.596		N/A		0.262		N/A		0.163		N/A	





**Abstract Number:**

Paper 108

**Abstract Title:**

Clinical Outcomes of Medial Meniscus Posterior Root Tears: High Rates of Subsequent Surgery and Worsening Arthritis at 5 Year Follow-Up

**Author Block:**

**Aaron John Krych, MD<sup>1</sup>**, Patrick J. Reardon, BS<sup>1</sup>, Ayoosh Pareek, BS<sup>1</sup>, Logan Peter<sup>1</sup>, Diane L. Dahm, MD<sup>1</sup>, Bruce A. Levy, MD<sup>2</sup>, Michael J. Stuart, MD<sup>1</sup>.

<sup>1</sup>Mayo Clinic, Rochester, MN, USA, <sup>2</sup>Mayo Clinic of Rochester Minnesota, Rochester, MN, USA.

**Abstract:**

**Objectives:** Medial meniscus posterior root tears (MMPRTs) present a unique challenge for both patients and surgeons as these tears have shown to be biomechanically equivalent to complete meniscectomy. However, little is known about the natural history of these lesions. Therefore, the purpose of this study is to describe the clinical course of MMPRTs with respect to subsequent operative and non-operative treatments, and associated comorbidities.

**Methods:** Over 2600 MRIs were identified by searching radiologist reads for the terms “root” or “root tear” from 2005-2013. Presence or absence of MMPRTs and other associated bony, meniscal, or ligamentous injuries were identified and recorded. Of these MRIs, 102 MRIs from 102 patients who had unrepaired MMPRTs with minimum 2-year follow-up and no prior ligamentous surgery were followed. These MRIs were evaluated to confirm the presence of a meniscal root tear and the presence or absence of associated meniscal or ligamentous injuries, as well as meniscal extrusion, subchondral edema, or insufficiency fractures. Chart review was performed to obtain the treatment summary after diagnosis. Radiographs from before and after the diagnosis of MMPRT were reviewed and Kellgren-Lawrence scores were determined. Finally, the association between concomitant bony, ligamentous, or meniscal injuries, patient factors, and rate of arthroplasty, as well as final Kellgren-Lawrence scores were evaluated. Chi-square analysis was used for categorical variables, and Wilcoxon Rank-Sums was used for continuous variables. Kaplan-Meier analysis was used to evaluate the effect of meniscal extrusion on the time-dependant rate of arthroplasty.

**Results:** 104 patients (43M:61F) were diagnosed with MMPRTs at a mean age of 54±13. These patients were followed for a mean of 66±26 months. 75 (74%) patients had associated meniscal extrusion, 64 (62%) had associated subchondral edema, and 14 (13%) had associated insufficiency fractures at the time of diagnosis. After initial diagnosis, 59 (58%) underwent subsequent surgical treatment. This included 52 (51%) patients undergoing arthroscopic partial meniscectomy, and 29 (28%) patients undergoing total knee arthroplasty at a mean 38±32 (range 3-107) months after MRI. Kellgren-Lawrence grades worsened from 1.3±0.7 before diagnosis to 2.2±1.0 after (p<0.001), with a mean 44±32 months between radiographs. There was a higher rate of radiographic arthritis (K-L grade 2+) after diagnosis (73%) than before diagnosis (36%) (p<0.001). The presence of meniscal extrusion on MRI was associated with the presence of arthritis on post-diagnosis radiographs (p=0.03). Meniscal extrusion, subchondral edema, and insufficiency fractures were not associated with increased rates of surgical treatment, or



time to arthroplasty.

**Conclusion:** Little information is available to guide patients and physicians on the clinical outcomes for MMPRTs. These injuries are associated with a relatively high rate of arthroplasty and worsening arthritis, especially with concomitant meniscal extrusion. More information is needed to determine the efficacy of meniscal root repair in preventing these unfavorable outcomes.



**Abstract Number:**

Paper 109

**Abstract Title:**

Arthroscopic Repair of Posterior Meniscal Root Tears: Comparing Outcomes of Medial and Lateral Root Repairs

**Author Block:**

**Lauren Matheny, MPH<sup>1</sup>**, Samuel G. Moulton, BA<sup>2</sup>, Chase S. Dean, MD<sup>2</sup>, Robert F. LaPrade, MD, PhD<sup>3</sup>.

<sup>1</sup>Steadman Philippon Research Institute, Vail, CO, USA, <sup>2</sup>Steadman Philippon Research Institute, Vail, CO, USA, <sup>3</sup>The Steadman Clinic, Vail, CO, USA.

**Abstract:**

**Objectives:** The purpose of this study was to compare subjective clinical outcomes in patients requiring arthroscopic transtibial pullout repair for posterior meniscus root tears of the medial and lateral menisci. We hypothesized that improvement in function and activity level would be similar among patients undergoing lateral and medial meniscal root repairs.

**Methods:** This study was IRB approved. All patients who underwent posterior meniscal root repair by a single orthopaedic surgeon were included in this study. Detailed operative data were documented at surgery. Patients completed a subjective questionnaire, including Lysholm score, Tegner activity scale, WOMAC, SF-12 and patient satisfaction with outcome, which were collected preoperatively and at a minimum of two years postoperatively. Failure was defined as any patient who underwent revision meniscal root repair or partial meniscectomy following the index surgery.

**Results:** There were 50 patients (16 females, 34 males) with a mean age of 37.8 years (range, 16.6-65.7) and a mean BMI of 27.3 (range, 20.5-49.2) included in this study. Fifteen patients underwent lateral meniscus root repair and 35 patients underwent medial meniscus root repair. Three patients who underwent lateral meniscus root repair required revision meniscus root repair surgery, while no patients who underwent medial meniscus root repair required revision surgery ( $p=0.26$ ).

There was a significant difference in preoperative and postoperative Lysholm score (53 vs. 78) ( $p<0.001$ ), Tegner activity scale (2.0 vs. 4.0) ( $p=0.03$ ), SF-12 physical component subscale (38 vs. 50) ( $p=0.001$ ) and WOMAC (36 vs. 8) ( $p<0.001$ ) for the total population. Median patient satisfaction with outcome was 9 (range, 1-10).

There was no significant difference in mean age between lateral and medial root repair groups (32 vs. 40) ( $p=0.12$ ) or gender ( $p=0.19$ ). There was no significant difference in gender between lateral and medial root repair groups ( $p=0.95$ ). There was a significant difference in concurrent ACL reconstructions between lateral versus medial root repair groups (67% vs. 17%) ( $p<0.001$ ).

There was no significant difference in average postoperative Lysholm score (75 vs. 80) ( $p=0.31$ ), IKDC (72 vs. 71) ( $p=0.23$ ), SF-12 physical component subscale (48.4 vs. 51.0) ( $p=0.85$ ) or WOMAC score (2.7 vs. 1.7) ( $p=0.80$ ) for lateral versus medial meniscus root repairs. There was no significant difference in median postoperative Tegner activity scale for lateral versus medial meniscus root repairs (4 vs. 4) ( $p=0.88$ ) or in median patient satisfaction with outcome for lateral versus medial meniscus root repairs (9 vs. 9) ( $p=0.61$ ).



**Conclusion:** There were no differences in outcomes between patients who underwent medial versus lateral arthroscopic meniscus root repair surgery. All patients who underwent arthroscopic repair of medial or lateral meniscus root tears demonstrated a significant improvement in function and activity level at a minimum two year follow-up. Overall, patients were highly satisfied with their outcomes.



**Abstract Number:**

Paper 110

**Abstract Title:**

Do Age and Weight Bearing Films Affect Lateral Joint Space and Fibular Height Measurements in Patients with Discoid Lateral Meniscus?

**Author Block:**

**Matthew David Milewski, MD<sup>1</sup>**, Ryan Krochak, MD<sup>2</sup>, Andrew J. Duarte, BA<sup>3</sup>, Joseph Marchese, MD<sup>4</sup>, James Lee Pace, MD<sup>5</sup>, Alexander M. Broom, BA<sup>6</sup>, Matthew Solomito, PhD<sup>7</sup>.

<sup>1</sup>Elite Sports Medicine - Connecticut Children's Medical Center, Farmington, CT, USA, <sup>2</sup>Maimonides Medical Center Department of Orthopaedics, Brooklyn, NY, USA, <sup>3</sup>University of Connecticut School of Medicine, Farmington, CT, USA, <sup>4</sup>University of Connecticut Dept. of Orthopaedics, Farmington, CT, USA, <sup>5</sup>Children's Hospital Los Angeles, Los Angeles, CA, USA, <sup>6</sup>Children's Hospital of Los Angeles, Los Angeles, CA, USA, <sup>7</sup>Connecticut Children's Medical Center, Farmington, CT, USA.

**Abstract:**

**Objectives:** Several radiographic parameters have been associated with discoid lateral meniscus. We sought to determine the effect of age and weight bearing (WB) on radiographic parameters associated with lateral discoid menisci in pediatric patients.

**Methods:** Radiographs of patients with arthroscopically confirmed lateral discoid meniscus were compared to age, side, sex matched individuals with confirmed normal menisci. The radiographs were measured by a pediatric orthopaedic sports medicine attending and two orthopaedic residents for the following parameters: lateral joint space width (LJSW), fibular head height (FHH), width of the distal femur (WDF), tibial spine height (TSH), cupping of the lateral tibial plateau (CLTP), and obliquity of the lateral tibial plateau (OLTP). The results of this review focus on FHH and LJSW only.

**Results:** 68 knees with discoid lateral menisci with a mean age of  $11.6 \pm 3.3$  (15 WB films) were compared to 67 control knees with a mean age of  $11.9 \pm 3.2$  (15 WB films). Results indicated that there were significant differences between the discoid and control groups when comparing LJSW ( $8.7 \pm 2.2$  mm discoid compared to  $7.6 \pm 2.1$  mm control  $p=0.002$ ) and FHH ( $13.5 \pm 4.5$  mm discoid compared to  $18.6 \pm 3.9$  mm control  $p<0.001$ ). Inter-rater reliability was satisfactory for LJSW and FHH (ICC 0.635 and 0.759 respectively). WB films were noted to have better inter-rater reliability compared to NWB films for LJSW (ICC 0.729 vs 0.514 respectively) but reduced inter-rater reliability for FHH (ICC 0.625 vs 0.868 respectively). Subgroup analysis based on age was also done comparing patients under 10 years old, patients between 10-14 years old, and patients over 14 years old. The FHH measurement was significantly decreased (indicative of a high fibular head) in the discoid group in all age groups. However, LJSW was only noted to be significantly different in patients over the age of 14.

**Conclusion:** Increased lateral joint space width and a high fibular head were associated with discoid lateral menisci and also showed satisfactory inter-rater reliability. Weightbearing films showed better inter-rater reliability for LJSW but decreased reliability for FHH. Higher fibular height was consistently seen across age groups but increased LJSW was only significantly different in the over 14 years old



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group. Fibular height might be a better radiographic parameter for discoid lateral meniscus evaluation across all age groups while lateral joint space may be better in older adolescent patients.



**Abstract Number:**

Paper 111

**Abstract Title:**

Sex, Age, and Graft Size as Predictors of ACL Re-tear: A Multivariate Logistic Regression of a Cohort of 503 Athletes.

**Author Block:**

**Duong Nguyen, MD,FRCS, MSc,FAAOS,CIME,DipSportsMed(ABOS/CASEM).**

William Osler Health System / McMaster University, Toronto, ON, Canada.

**Abstract:**

**Objectives:** The minimum size required for a successful quadrupled hamstring autograft ACL reconstruction remains controversial. The risks of ACL re-tear in younger patients who tend to participate in a higher level of sports activity, and female athletes who have numerous predisposing factors, are poorly defined.

**Purpose**

To identify risk factors for graft re-tears within 2 years of ACL surgery. The hypotheses are that female sex, a smaller size graft, and younger patients will increase the odds of failure.

Study Design Cohort Study. Level of evidence, 3.

**Methods:** A cohort of 503 athletes undergoing primary, autograft hamstring ACL reconstruction, performed by a single surgeon using the same surgical technique and rehabilitation protocol, between September-December 2012, was followed for a total duration of 2 years. Return to play was allowed between 6 and 12 months post-surgery upon completion of functional testing.

Exclusion criteria included infections, revisions, double bundle techniques, multi-ligament injuries, non-compliance, BTB/allografts/hybrid grafts.

Primary outcome consisted of binary data (ACL graft re-tear or no tear) as measured on physical exam (Lachman and pivot shift) and MRI.

Multivariate logistic regression statistical analysis with model fitting was used to investigate the predictive value of sex, age, and graft size on ACL re-tear.

Secondary sensitivity analyses were performed on the adolescent subgroup, age and graft size as categorical variables, and testing for interactions among variables. Sample size was calculated based on the rule of 10 events per independent variable for logistic regression.

**Results:** The mean age of the 503 athletes was 27.5 (SD 10.6; range = 12-61). There were 235 females (47%) and 268 males (53%) with a 6 % rate of re-tears (28 patients; 17 females). Mean graft size was 7.9 (SD 0.6; range = 6-10).

Univariate analyses of graft size, sex, and age only in the model showed that younger age (odds ratio [OR] = 0.86; 95% confidence interval [CI] = 0.80-0.93; P = .001) and smaller graft size (OR = 0.36; 95% CI = 0.18-0.70; P = .003) were significantly predictive of re-tear. Female sex was correlated with re-tear but was not significant (OR = 1.8; 95% CI = 0.84-3.97; P = .13).

Multivariate analysis with all 3 variables in the model showed similar significant results. Graft size < 8 mm (OR = 2.95; 95% CI = 1.33-6.53; P = .008) and age < 25 (OR = 7.01; 95% CI = 2.40-20.53; P = .001)



were significantly predictive of re-tear.

Entire model was statistically significant (Omnibus test  $P = .001$ ; Hosmer-Lemeshow statistic  $P = .68$ ; Receiver Operating Curve [ROC] = 0.8).

**Conclusion:** Surgeons should counsel their patients who are female, younger than 25 and with a graft size less than 8 mm accordingly and consider modifying their surgical or rehabilitation techniques to mitigate these re-tear risks.





**Abstract Number:**

Paper 112

**Abstract Title:**

Rehabilitation Predictors of Clinical Outcome following Revision ACL Reconstruction

**Author Block:**

**Rick W. Wright, MD<sup>1</sup>**, Mars Group<sup>2</sup>.

<sup>1</sup>Washington University Dept of Orthopaedic Surgery, St. Louis, MO, USA, <sup>2</sup>Washington University St. Louis, St Louis, MO, USA.

**Abstract:**

**Objectives:** Revision ACL reconstruction has been documented to have worse outcomes compared with primary ACL reconstructions. The reasons why remain unknown. The purpose of this study was to determine whether rehabilitation-related factors prescribed at the time of ACL revision reconstruction significantly influence two year outcomes, as well as the incidence of incurring a subsequent re-operation. Our hypothesis was that immediate versus passive, active range of motion (ROM) and weightbearing will result in improved outcomes without incidence of subsequent surgery. Use of postoperative and functional return to sport braces will not improve return to sports function.

**Methods:** Revision ACL reconstruction patients were identified and prospectively enrolled between 2006 and 2011. Data collected included baseline demographics, surgical technique and pathology, prescribed post-op and rehabilitation instructions (ie. timing of weightbearing, timing of passive and active ROM, use of postoperative and return to sport braces) and a series of validated patient reported outcome instruments (IKDC, KOOS, and Marx activity rating score). Patients were followed up for 2 years, and asked to complete the identical set of outcome instruments. Because meniscal repair, meniscal transplants, HTOs, concurrent ligamentous reconstructions, and certain chondral treatments (ie. microfracture, abrasion arthroplasty, mosaicplasty, etc) are known to affect prescribed rehab treatments, patients with these pathologies were excluded from the analyses. Regression analysis was used to control for age, gender, activity level, baseline outcome scores, and the above-mentioned rehabilitation-related variables, in order to assess the risk factors for clinical outcomes 2 years after revision ACL reconstruction.

**Results:** A total of 843 patients met the inclusion criteria and were successfully enrolled. 482 (57%) were males, with a median cohort age of 27 years. Baseline characteristics of the cohort are summarized in Table 1.

At 2 years, follow-up was obtained on 82% (694/843). There were two rehabilitation-related factors which were found to be influential of 2 year outcomes. Patients who were prescribed an ACL brace for return to sport had significantly better KOOS sports/rec scores at 2 years (odds ratio=1.50; 95% CI=1.07-2.11; p=0.019). Patients who were prescribed an ACL derotation brace to be used in post-op rehab were 2.26 times more likely to have a subsequent surgery by 2 years (OR = 2.26; 95% CI=1.11-4.60; p=0.024). Lower baseline outcome scores, activity level, and female gender all significantly increased the odds of reporting poorer clinical outcomes (IKDC, all KOOS subscales, and Marx activity rating score) at 2 years. Alternatively, whether or not a physician restricted a patient's passive or active ROM post-operatively,



restricted full weight-bearing without support, or prescribed a motion control brace post-op, were all found not to be influential risk factors for 2 year outcomes in this revision cohort.

**Conclusion:** There are rehabilitation-related factors that the physician can control at the time of an ACL revision which have the ability to modify clinical outcomes at 2 years. The odds of having a higher KOOS sports/rec score increases by 50% in patients who wore a functional brace for sports (versus patients who didn't). However, patients who were prescribed a derotation brace used for post-op rehab were 2.3 times more likely to incur a subsequent surgery by 2 years.

Table 1. Baseline Cohort Characteristics	Percentage (n)	If yes, then median (25 <sup>th</sup> , 75 <sup>th</sup> quartile) time (in days)
Gender <ul style="list-style-type: none"> <li>• Male</li> <li>• Female</li> </ul>	57% (482) 43% (361)	
Passive range of motion (ROM)restriction: <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	89% (745) 11% (94)	14 (5, 28)
Active ROM restriction: <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	86% (722) 14% (115)	16 (7, 30)
Post-op full <u>weightbearing</u> (without support) restriction: <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	60% (507) 40% (332)	21 (14, 28)
Motion control brace (i.e. knee immobilizer) prescribed post-operatively: <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	45% (380) 55% (458)	24 (14, 42)
ACL <u>derotation</u> brace used in post-op rehab: <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	85% (715) 15% (124)	180 (90, 365)
ACL <u>derotation</u> brace used in return to sport: <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	69% (573) 31% (253)	365 (300, 365)



**Abstract Number:**

Paper 113

**Abstract Title:**

Anatomic Anterolateral Ligament Reconstruction of the Knee Leads to Overconstraint at any Fixation Angle

**Author Block:**

**Jason Schon, BS<sup>1</sup>**, Alex Brady, MSc<sup>1</sup>, Gilbert Moatshe, MD<sup>1</sup>, Raphael Cruz, MD<sup>1</sup>, Jorge Chahla, MD<sup>1</sup>, Grant Dornan, MSc<sup>1</sup>, Travis L. Turnbull, PhD<sup>1</sup>, Lars Engebretsen, MD, PhD<sup>2</sup>.

<sup>1</sup>Steadman Philippon Research Institute, Vail, CO, USA, <sup>2</sup>Oslo University Hospital-Ullevaal, Oslo, Norway.

**Abstract:**

**Objectives:** Anterior cruciate ligament (ACL) tears are one of the most common injuries among athletes. However, the ability to fully restore rotational stability with ACL reconstruction (ACLR) remains a challenge because up to 25% of patients may present with a residual pivot shift following surgery. Advocacy for reconstruction of the anterolateral ligament (ALL) is rapidly increasing because biomechanical studies have reported that the ALL is a significant contributor to internal rotational stability of the knee. Although several graft fixation angles for the anatomic ALL reconstruction (ALLR) have been reported in literature, none have been biomechanically validated. Therefore, the purpose of this study was to assess the effect of ALLR graft fixation angle on knee joint kinematics in the clinically relevant setting of a concomitant ACLR. The goal was to find the optimal knee flexion angle for fixation of the ALLR graft that would most accurately restore native knee kinematics without introducing overconstraint to the knee. It was hypothesized that all fixation angles would significantly reduce rotational laxity compared to the sectioned ALL state and that fixation at 30° would best reproduce native joint kinematics.

**Methods:** Eight non-paired fresh-frozen human cadaveric knees with no prior injury, surgical history, or gross anatomic abnormality were evaluated with a 6 degree-of-freedom robotic system. Each specimen underwent a full kinematic assessment in each of the following states: 1) intact, 2) anatomic single-bundle (SB) ACLR with intact ALL, 3) anatomic SB ACLR with sectioned ALL, 4) 7 anatomic SB ACLR and ALLR states utilizing ALL graft fixation knee flexion angles of 0°, 15°, 30°, 45°, 60°, 75° and 90°, and 5) sectioned ACL and ALL. Internal rotation during a 5 N-m internal rotation torque and anterior displacement during an 88 N anterior load were recorded at 15° intervals between 0° and 120° of knee flexion. Axial plane displacement and internal rotation during a simulated pivot shift (combined 5 N-m internal rotation and 10 N-m valgus torques) were recorded between 0° and 60°. Kinematic changes were measured and compared to the native state for all reconstructed and sectioned states.

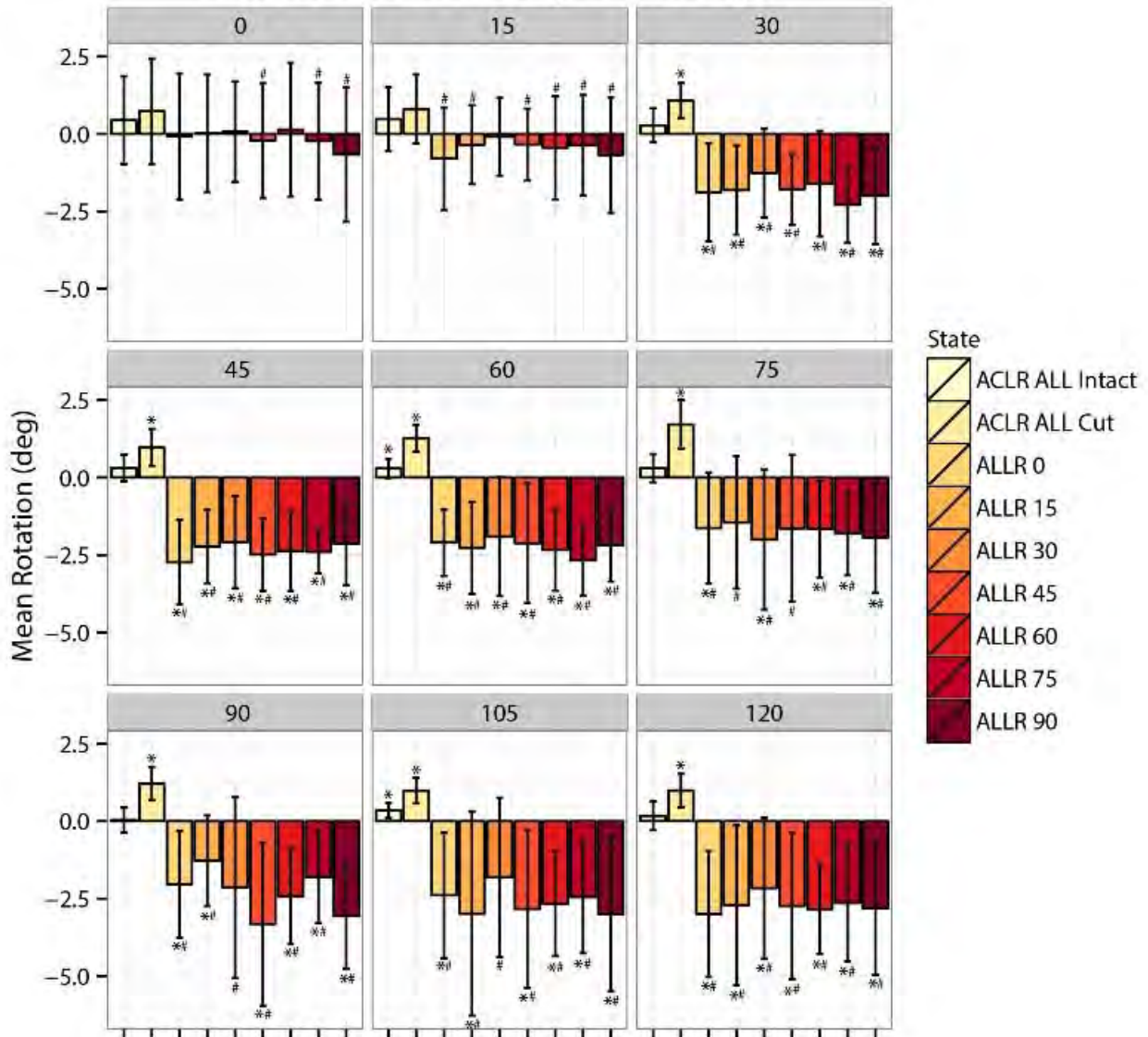
**Results:** Anterolateral ligament reconstruction at all graft fixation angles significantly reduced internal rotation of the knee with respect to the ACLR with sectioned ALL state at all knee flexion angles beyond 30° (Figure 1). However, ALLR overconstrained the knee joint at each tested ALL graft fixation angle and through all tested knee flexion angles beyond 15° during simulated internal rotation torque and pivot shift tests (Figure 1). Furthermore, no significant difference was observed between the different graft fixation angles on the kinematics of the knee with respect to anterior drawer, pivot shift and internal



rotation.

## Internal Rotation

Difference from Intact, by Flexion Angle



\* significantly different from ACLR ALL Intact

# significantly different from ACLR ALL Cut

**Conclusion:** Anatomic ALLR in conjunction with an ACLR overconstrained internal rotation of the knee joint at flexion angles beyond 15° regardless of graft fixation angle. The surgical technique and indications for this procedure should be investigated further and it is recommended that ALLR be used with caution.



**Abstract Number:**

Paper 114

**Abstract Title:**

Open versus Arthroscopic Tennis Elbow Release: Randomized Controlled Trial

**Author Block:**

**Jeff Leiter, MSc, PhD**, Tod Clark, MD, Sheila McRae, PhD, James Dubberley, MD, Peter B. MacDonald, MD, FRCS.

Pan Am Clinic, Winnipeg, MB, Canada.

**Abstract:**

**Objectives:** The primary objective of this study was to determine if quality of life and function are different following arthroscopic versus open tennis elbow release surgery. Based on retrospective studies, both approaches have been found to be beneficial, but no prospective randomized comparison has been conducted to date.

**Methods:** Following a minimum six-months of conservative treatment, seventy-one patients (>16 yrs old) were randomized intraoperatively to undergo either arthroscopic or open lateral release. Outcome measures were the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH), a 5-question VAS Pain Scale, and grip strength. Study assessments took place pre-, and 6-week, 3-, 6-, and 12-months post-surgery. Comparisons between groups and within groups over time were conducted using repeated measures ANOVA. A minimal clinically significant difference for the DASH had been previously identified as 15 points, and was used to compare groups as well at 12-months post-operative (Beaton et al. 2001).

**Results:** Fifteen women and 19 men underwent the open procedure with a mean age of 47.1 years (6.7) and 13 women and 21 men were in the arthroscopic group with a mean age of 45.0 (6.9). No pre-surgery differences were found between groups based on age, sex, DASH or VAS scores.

Both groups demonstrated a significant improvement in subjective measures and grip strength by 12-months post-surgery, and no significant differences were found between groups at any time point. The DASH, our primary outcome, decreased from a mean (SD) of 47.5 (14.5) pre-surgery to 21.9 (21.8) at 12-months post-surgery in the Open group and from 52.7 (16.0) to 22.6 (21.1) in the Arthroscopic group. VAS-pain scores (%) decreased in the Open group from 62.5 (17.2) pre-operatively to 30.0 (26.5) at 12-months. In the arthroscopic group, scores decreased from 63.7 (15.9) to 26.2 (24.6). Grip strength (kg) increased on the affected side from 23.6 (14.9) to 29.3 (16.3) and 21.4 (15.4) to 29.8 (15.4) for Open and Arthroscopic groups, respectively. The number of participants to reach the minimum clinically significant change did not differ between groups, 17 in the open group and 19 in the arthroscopic group. Ten in each group did not reach this threshold.

Based on post hoc regression analysis, no factors (age, gender, WCB status, or smoking status) were found to be significant predictors of DASH or VAS outcome at 12-months post-surgery. However, this study was not adequately powered to draw any specific conclusions in this regard.

The only significant difference between study groups was that the arthroscopic technique resulted in longer surgery time, 34.0 versus 22.5 minutes ( $p=0.005$ ).



**Conclusion:** Based on this study, there is no difference between arthroscopic and open tennis elbow release surgery in subjective outcome, specifically DASH and VAS pain scale, or in function, specifically, grip strength, at 12-months post-operative. Therefore, there may not be any benefit to the increased experience and operating room time required to perform a lateral release arthroscopically versus an open approach.



**Abstract Number:**

Paper 115

**Abstract Title:**

Vascularity Visualized by Doppler Sonography as a Predictor of Healing Potential of the OCD of the Humeral Capitellum

**Author Block:**

**Yoshikazu Kida, MD<sup>1</sup>**, Toru Morihara, MD<sup>2</sup>, Yoshihiro Kotoura, MD<sup>3</sup>, Tsuyoshi Sukenari, MD<sup>2</sup>, Ryuhei Furukawa, MD<sup>2</sup>, Yukichi Kabuto, MD<sup>2</sup>, Okihito Onishi, MD<sup>2</sup>, Masataka Minami, MD<sup>2</sup>, Takashi Tsujihara, MD<sup>2</sup>, Tatsuya Hojo, MD<sup>4</sup>, Hiroyoshi Fujiwara, MD<sup>2</sup>, Toshikazu Kubo, MD<sup>2</sup>.

<sup>1</sup>Department of Orthopaedic Surgery, Fukuchiyama City Hospital, Kyoto, Japan, <sup>2</sup>Department of Orthopaedics, Graduate School of Medical Science, Kyoto Prefectural University of Medicine, Kyoto, Japan, <sup>3</sup>Department of Orthopaedics, Nantan general hospital, Kyoto, Japan, <sup>4</sup>Faculty of Health and Sports Science, Doshisha University, Kyoto, Japan.

**Abstract:**

**Objectives:** The significance of vascularity visualized by Doppler sonography in osteochondritis dissecans (OCD) lesion of the humeral capitellum is unclear. The objectives of this study were twofold: 1) to evaluate the relationship between Doppler ultrasound (US) signals observed in OCD lesion of the humeral capitellum and X-ray stage; 2) to determine if the presence of Doppler US signals in OCD lesion of the humeral capitellum could be the predictor of healing potential.

**Methods:** Fifty patients with OCD of the humeral capitellum treated conservatively were enrolled in this study. During the conservative treatment period, Doppler sonography was performed on affected elbow to assess the presence of vascularity in the OCD lesion (Figure 1), and radiographic examination were evaluated on the same day to determine the X-ray stage (stage I: radiolucent stage, stage II: fragmentation stage, and stage III: loose body stage) of the OCD lesion (Figure 2). Radiographic examination of the elbow was examined after 6 weeks to evaluate the healing of the lesion. If the size of the lesion decreased or new bone formations were observed around the fragments, the healing of the lesion was considered to be improved. The  $\chi^2$  test was used to determine if the presence of Doppler US signals were related to X-ray stage and the improvement of the healing.  $P < 0.05$  was considered significant for all statistical analyses.

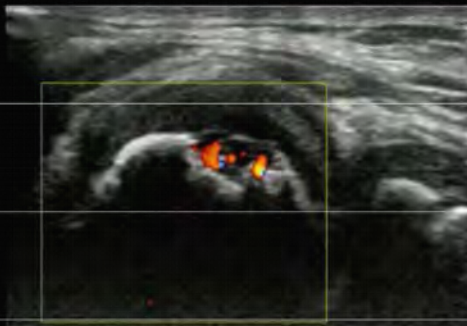
**Results:** The Doppler US signals in OCD lesions were positive in 23 patients and negative in 27 patients. Of these patients, 19 were X-ray stage I, 17 were stage II, and 9 were stage III. The healing of OCD lesions improved in 78.2% for the positive Doppler US signal group, but only 18.5% for the negative Doppler US signal group (Figure 3). The presence of the Doppler US signal was significantly related to the improvement of healing ( $P = 0.00002$ ). The Doppler US signal were positive in 78.9% for stage I, 36.4% for stage II, and 0.0% for stage III (Figure 4). The presence of Doppler US signal was significantly related to early X-ray stage ( $P = 0.0002$ ).

**Conclusion:** From this study, the presence of vascularity in the OCD lesion of the humeral capitellum is important for the improvement of healing during the conservative treatment period. The vascularity

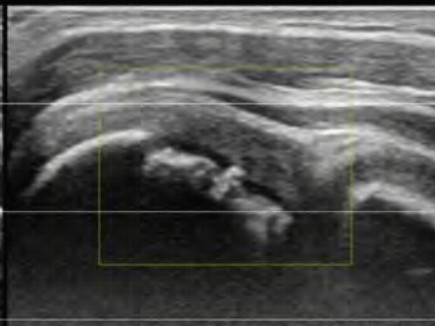


visualized by Doppler sonography could be a useful predictor for healing potential of the OCD of the humeral capitellum when treated conservatively.

Figure 1.  
Doppler US Signal of  
OCD of the Humeral Capitellum



Doppler US (+)



Doppler US (-)





Figure 2.  
X-ray stage of  
OCD of the Humeral Capitellum

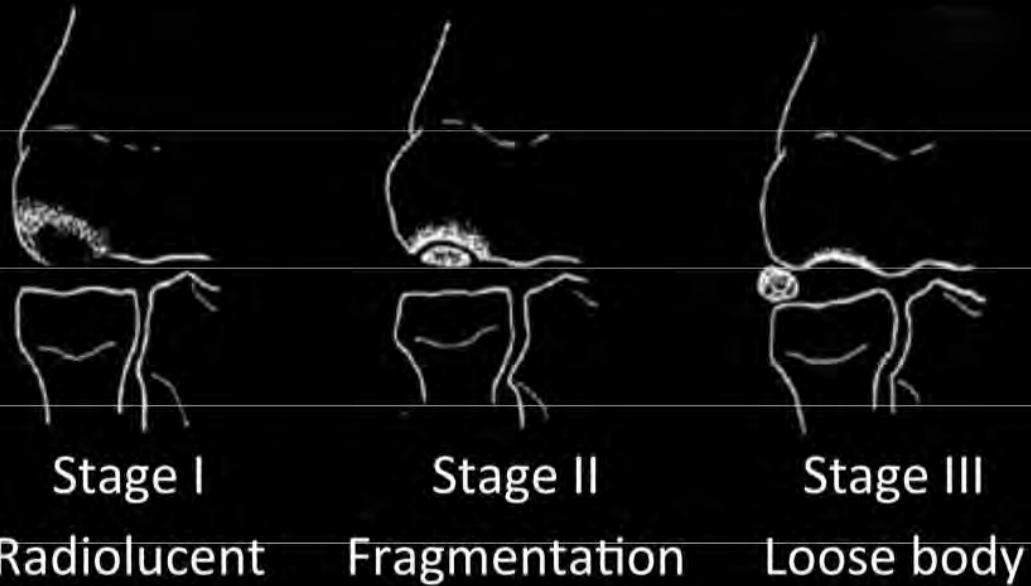
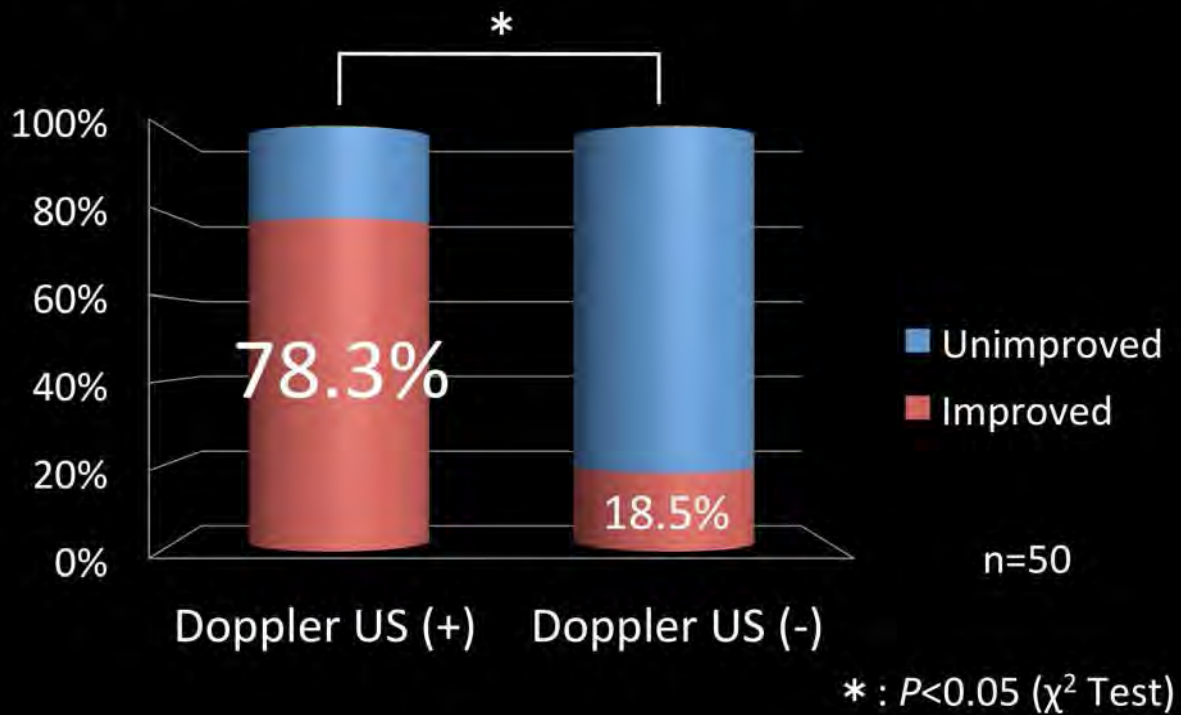
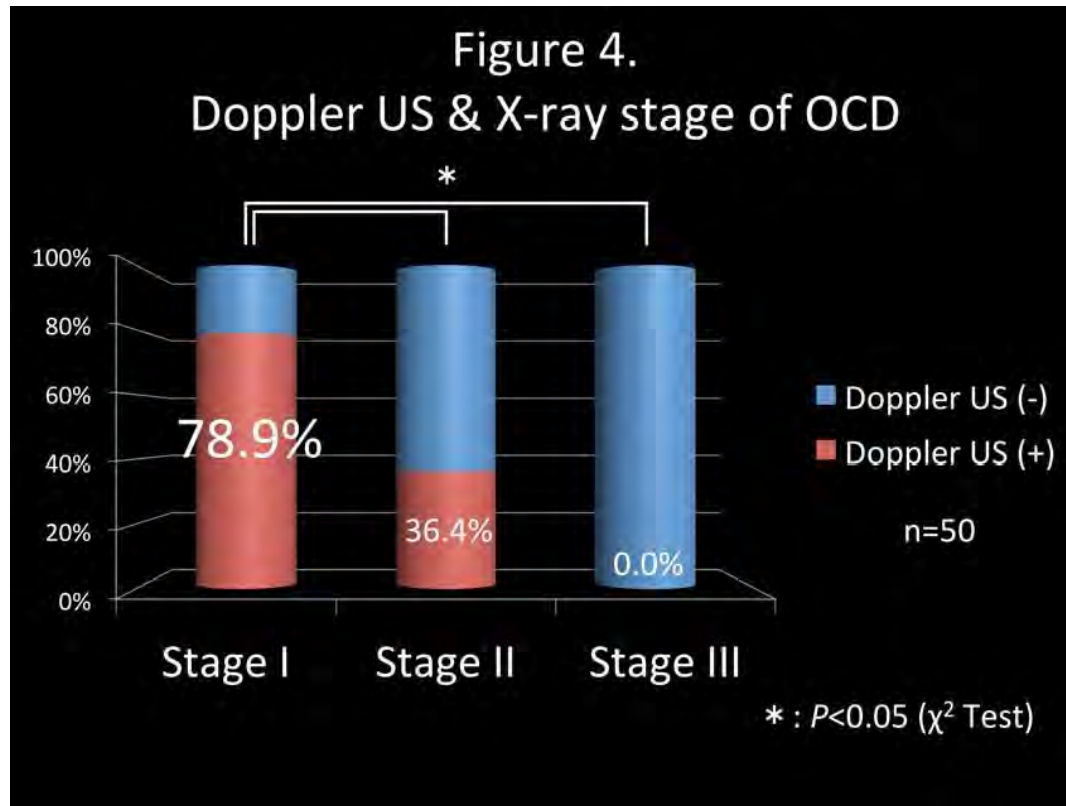




Figure 3.  
Doppler US & Healing improvement of OCD







**Abstract Number:**

Paper 116

**Abstract Title:**

MRI Predictors of Failure in Non-operative Management of Ulnar Collateral Ligament Injuries in Professional Baseball Pitchers.

**Author Block:**

**Salvatore Frangiamore, MD, MS<sup>1</sup>**, Thomas Sean Lynch, MD<sup>2</sup>, Michael Derek Vaughn, MD<sup>1</sup>, Lonnie Soloff, ATC<sup>3</sup>, Mark S. Schickendantz, MD<sup>1</sup>.

<sup>1</sup>The Cleveland Clinic Sports Health Ctr., Cleveland, OH, USA, <sup>2</sup>Columbia Orthopaedics, New York, NY, USA, <sup>3</sup>Cleveland Indians, Cleveland, OH, USA.

**Abstract:**

**Objectives:** Ulnar collateral injuries (UCL) of the elbow are prevalent among professional baseball pitchers. The decision on initial operative versus nonoperative management of these injuries remains subjective in many cases, with reported success rates with nonoperative management ranging from 42 to 93% in professional throwing athletes. No studies to date have identified objective characteristics specific to success or failure of nonoperative intervention. The purpose of this study was to identify radiologic predictors for success or failure in nonoperative management of ulnar collateral ligament injuries in professional pitchers.

**Methods:** A retrospective review of pitchers sustaining UCL injuries between 2006 and 2015 from one professional baseball organization (one major league team and all minor league teams included) was performed. UCL injuries were identified in 38 players based on clinical and radiographic findings. Six players underwent initial surgical intervention without attempted nonoperative intervention and were excluded from analysis. This left 32 (84%) professional pitchers who underwent an initial trial of nonoperative treatment for partial UCL tears. Success was defined as return to same level of play (RTSP) or higher for >1 year. Failure was defined as recurrent pain or weakness requiring surgical intervention after a minimum of 3 months' rest when attempting a return to throw rehabilitation program. MRI findings were classified as high or low grade sprains, proximal or distal location of injury, and with or without the presence of concomitant chronic findings.

**Results:** Of the 32 patients who underwent nonoperative management, 10 (36%) failed and required subsequent ligament reconstruction. Between the success and failure groups, there was no significant difference seen in total shoulder arc of motion ( $P=.7776$ ), shoulder internal rotation deficit ( $P=.3846$ ) or loss in elbow extension ( $P=.0644$ ) at the time of injury. When comparing MRI findings between the groups, distal tears were found in 90% (9/10) of those who failed nonoperative management compared to 18.2% (4/22) who were successful nonoperatively ( $P<.0001$ ). No significant difference was seen with high grade tears ( $P=.0817$ ) between the groups. When adjusting for age, location and evidence of chronic changes on MRI, the likelihood of failing nonoperative management was 22.7 times greater ( $P=.001$ ) with distal tears. No other variable reached significance, and no combination of variables showed a greater likelihood than distal location alone.



**Conclusion:** In professional pitchers, distal ulnar collateral ligament tears described on MRI show significantly higher rates of failure with nonoperative management compared to proximal tears. This information provides an objective measure for evaluating operative versus nonoperative management of ulnar collateral ligament injuries in throwing athletes.



**Abstract Number:**

Paper 117

**Abstract Title:**

The Prevalence and Clinical Characteristics of Medial Epicondyle Apophysitis in Juvenile Baseball Player - Ultrasonographic Assessment of 2,926 Cases

**Author Block:**

**Kenichi Otoshi, MD, PhD.**

Department of Sports Medicine, Fukushima Medical University School of Medicine, Fukushima, Japan.

**Abstract:**

**Objectives:** Apophysitis of humeral medial epicondyle, often referred to as “Little Leaguer’s Elbow, is one of the major throwing injuries in juvenile baseball players as common as osteochondritis dissecans of humeral capitellum. Repetitive valgus stress to the skeletally immature elbow can result in fragmentation, hypertrophy, or separation of the medial epicondyle apophysis, and these injuries may induce elbow pain and adversely influence on elbow function and throwing performance. Although several reports have described various morphological variations of the medial epicondyle apophysis, little is known about the natural course and clinical significance of these variations. The purpose of this study was to investigate the prevalence of these variations in each age group and clarify the association with elbow pain using the large epidemiologic data from medical check-ups of juvenile baseball players.

**Methods:** Of 3,626 juvenile baseball players aged 6 to 17 years, 2,926 players were enrolled in this study. Experience of elbow pain was rated by self-completed questionnaires. Ultrasonographic assessment was used to assess the morphological variations of the antero-inferior medial epicondyle (MEC) and humeral capitellum. Regarding MEC lesion, enthesi of medial ulnar collateral ligament (MUCL) was classified into four types: normal, irregular (IR), fragmentation (FG), and hypertrophy (HT). Osteochondral lesion (OCL) of humeral capitellum was judged by the irregularity or fragmentation of subchondral bone. The prevalence of these lesions was investigated in each age group and evaluated the influence on elbow pain using multivariable logistic regression analysis.

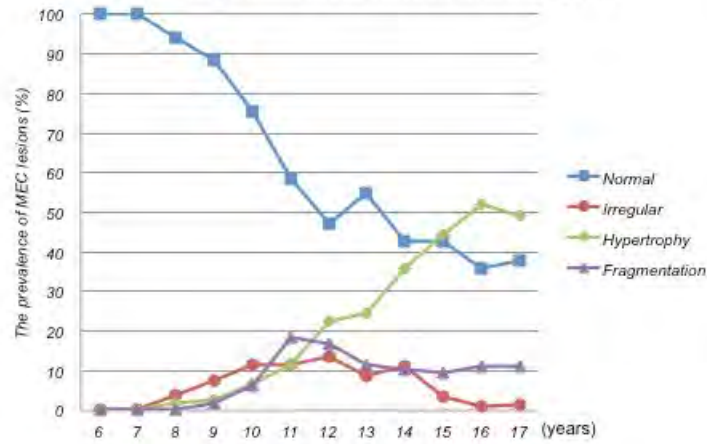
**Results:** The overall prevalence of MEC lesions and capitellum OCL was 49.9% (IR:6.7%, FG:11.7%, HT:31.5%) and 2.1%, respectively. The prevalence of IR and FG gradually increased until reaching its highest at 11-12 years of age. At 12-17 years of age, the prevalence of IR was decreased with age, whereas that of FG persisted at approximately 10% after a temporally decrease. Conversely, the prevalence of HT increased while those of IR and FG simultaneously decreased (Figure 1). Age- and position adjusted multivariable analysis revealed that the presence of MEC lesions were high risk of elbow pain, and significantly higher risk for FG (odds ratio [OR]: 4.25, 95% confidence interval [CI]: 3.23-5.62) compared to IR (OR:3.17, 95%CI:2.31-4.39) and HT (OR:2.12, 95%CI:1.76-2.55). Capitellum OCL of was also significantly high risk of elbow pain (OR:2.69, 95%CI:1.42-5.45) (Table 1).

**Conclusion:** Our study demonstrated that morphology of MEC apophysis in juvenile baseball player varied with age. As the presence of FG was a significantly high- risk factor for elbow pain as compared to HT, appropriate management of “Little Leaguer’s Elbow” in the preadolescent period might be quite



important to accelerate the bony healing of medial epicondyle apophysitis and decrease preventable

Figure 1: The prevalence of MEC lesions in each age group



adulthood elbow pain.

Multivariable analysis adjusted by age and position				
		odds ratio	95% confidence interval	p-value
MEC lesion	normal	1		
	irregular	3.17	2.31-4.39	
	fragmentation	4.25	3.23-5.62	
	hypertrophy	2.12	1.76-2.55	p<0.001
capitellum OCL	normal	1		
	irregular	2.69	1.42-5.45	P=0.0014



**Abstract Number:**

Paper 118

**Abstract Title:**

Practice Patterns in the Care of Acute Achilles Tendon Ruptures: Is There an Association with Level I Evidence?

**Author Block:**

**Ujash Sheth, MD<sup>1</sup>**, David Wasserstein, MD<sup>2</sup>, Rahim Moineddin, PhD<sup>1</sup>, Richard Jenkinson, MD, MSc, FRCSC<sup>1</sup>, Hans Kreder, MD, MSc, FRCSC<sup>3</sup>, Susan Jaglal, PhD<sup>1</sup>.

<sup>1</sup>University of Toronto, Toronto, ON, Canada, <sup>2</sup>Sunnybrook Health Sciences Centre, North York, ON, Canada, <sup>3</sup>Sunnybrook Health Sciences Centre, Toronto, ON, Canada.

**Abstract:**

**Objectives:** Over the last decade, there has been a growing body of level I evidence supporting non-operative management (focused on early range of motion and weight bearing) of acute Achilles tendon ruptures. Despite this emerging evidence, there have been very few studies evaluating its uptake. Our primary objective was to determine whether the findings from a landmark trial assessing the optimal management strategy for acute Achilles tendon ruptures influenced the practice patterns of orthopaedic surgeons in Ontario, Canada over a 12-year time period. As a second objective we examined whether patient and provider predictors of surgical repair utilization differed before and after dissemination of the landmark trial results.

**Methods:** Using provincial health administrative databases, we identified Ontario residents  $\geq 18$  years of age with an acute Achilles tendon rupture from April 2002 to March 2014. The proportion of surgically repaired ruptures was calculated for each calendar quarter and year. A time series analysis using an interventional autoregressive integrated moving average (ARIMA) model was used to determine whether changes in the proportion of surgically repaired ruptures were chronologically related to the dissemination of results from a landmark trial by Willits et al. (first quarter, 2009). Spline regression was then used to independently identify critical time-points of change in the surgical repair rate to confirm our findings. A multivariate logistic regression model was used to assess for differences in patient (baseline demographics) and provider (hospital type) predictors of surgical repair utilization before and after the landmark trial.

**Results:** In 2002, ~19% of acute Achilles tendon ruptures in Ontario were surgically repaired, however, by 2014 only 6.5% were treated operatively. A statistically significant decrease in the rate of surgical repair ( $p < 0.001$ ) was observed after the results from a landmark trial were presented at a major North American conference (February 2009). Prior to the dissemination of trial results, the odds of undergoing surgical repair at a teaching hospital were found to be significantly higher than if treated at a non-teaching hospital (odds ratio (OR), 1.52; 95% confidence interval (CI), 1.04-2.22;  $p = 0.03$ ). However, after the landmark trial there was no significant difference in the odds of undergoing surgical repair between teaching and non-teaching hospitals ( $p = 0.46$ ). All other predictors of surgical repair utilization remained unchanged in the before-and-after analysis.





**Conclusion:** The current study demonstrates that large, well-designed randomized trials, such as the one conducted by Willits et al. can significantly change the practice patterns of orthopaedic surgeons. Moreover, the significant decline in surgical repair rate at both teaching and non-teaching hospitals after the landmark trial suggests both academic and non-academic surgeons readily incorporate high quality evidence in to their practice.



**Abstract Number:**

Paper 119

**Abstract Title:**

Treatment of Low Energy Lisfranc Joint Injuries in a Young Athletic Population: Primary Arthrodesis Compared with Open Reduction and Internal Fixation

**Author Block:**

**Grant Cochran, MD<sup>1</sup>**, Christopher Renninger<sup>1</sup>, Trevor Tompane<sup>2</sup>, Joseph Bellamy<sup>1</sup>, Kevin Kuhn<sup>1</sup>.

<sup>1</sup>Naval Medical Center San Diego, San Diego, CA, USA, <sup>2</sup>Emory University, Atlanta, GA, USA.

**Abstract:**

**Objectives:** Acute Lisfranc joint injuries have historically been associated with high-energy trauma, and high quality data exists describing injury patterns and recommended treatment protocols. There is a lack of comparable data investigating injuries associated with low energy mechanisms. The objective of this study is to report low energy injury patterns and to retrospectively compare primary arthrodesis with open reduction and internal fixation in a young athletic population.

**Methods:** All surgically managed low-energy (sustained during athletic activity, ground level twisting, or fall from less than three feet) Lisfranc injuries were identified at a single military tertiary referral center from July 2010 to June 2015. The injury pattern, time to diagnosis, and method of treatment (open reduction internal fixation (ORIF) or primary arthrodesis) were reviewed. Complication rates, secondary procedures, VAS pain score, and return to full military activity (defined as the ability to perform their primary job functions and participate in mandatory athletic activity) were reviewed.

**Results:** Of the thirty-three injuries identified, twenty (60.6%) were primarily ligamentous. Only one patient had evidence of lateral column instability. Average patient age was twenty-eight. Eleven injuries (33%) were initially missed, delaying diagnosis an average of thirty-four days. Primary arthrodesis was performed in fifteen patients; most were secondary to subacute or chronic presentation. ORIF was performed on the remaining eighteen patients. All fixation constructs included solid screws, dorsal plates, or a combination of both. Minor complications occurred in twelve patients and included sensory changes, superficial infection treated with antibiotics, and symptomatic hardware. Complications requiring surgery other than hardware removal were seen in two patients including one ORIF patient who underwent secondary arthrodesis. VAS pain at final evaluation averaged 1.6. Thirty-one of thirty-three (93.9%) were able to return to full military activity. There were no significant differences in demographic data, injury patterns, complication rates, VAS pain score, and return to full activity. Hardware removal was performed in thirteen ORIF and two arthrodesis patients ( $p < 0.005$ ). The arthrodesis group returned to full activity at an average of 4.7 months while the ORIF returned at an average of 6.7 months ( $P < 0.05$ ).

**Conclusion:** Low energy Lisfranc injuries are most commonly ligamentous, almost always spare the lateral column, and are commonly missed on initial presentation. Arthrodesis and ORIF consistently result in the ability to resume work and athletic activity with low rates of serious complication.



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Predictably, hardware removal is more common with ORIF. In this study, primary arthrodesis led to earlier return to work and athletic activity by an average of two months.



**Abstract Number:**

Paper 121

**Abstract Title:**

Repair of the Ankle Syndesmosis: A Biomechanical Analysis of Three Current Repair Techniques

**Author Block:**

**Scott R. Whitlow, MD<sup>1</sup>**, Brady T. Williams, BS<sup>2</sup>, Travis Lee Turnbull, PhD<sup>2</sup>, Adriana Saroki, BS<sup>2</sup>, Robert F. LaPrade, MD, PhD<sup>1</sup>, Thomas O. Clanton, MD<sup>1</sup>.

<sup>1</sup>The Steadman Clinic, Vail, CO, USA, <sup>2</sup>Steadman Philippon Research Institute, Vail, CO, USA.

**Abstract:**

**Objectives:** Historically, biomechanical data has been reported regarding individual tibiofibular ligament properties and contributions to joint stability including resistance to syndesmotic diastasis and external rotation of the fibula with respect to the tibia, and the effects of injury on tibiotalar joint contact pressures and mechanics. However, these results have not been validated based on more recent anatomic descriptions or using current biomechanical testing devices and techniques. Therefore, the purpose of the current investigation was to quantify the individual contributions of the syndesmotic ligaments, as redefined in recent anatomic literature, to rotational stability using a modern and reproducible testing method.

**Methods:** Eight matched-pair, lower leg specimens were tested. Dissections were performed to identify and isolate the syndesmotic structures of the ankle. The proximal tibiofibular joint and the medial and lateral ankle ligaments were identified and left intact. Two pins were inserted through anterior-posterior directed tunnels in the proximal tibia to facilitate mounting to the dynamic tensile testing machine. For testing, specimens were oriented in neutral plantar/dorsiflexion and neutral internal/external rotation with the respect to the vertical tibia.

After fixation, specimens were axially loaded under 750 N and preconditioned for 10 cycles to a maximum applied torque of  $\pm 7.5$  N-m. Specimens were biomechanically tested following sequential cutting of the syndesmosis ligaments to assess the individual ligamentous contributions to syndesmotic stability. Matched pair specimens were split and randomly assigned to one of two cutting sequences corresponding to anterior and posterior cutting orders: (1) Intact, AITFL, ITFL, Deep PITFL, Superficial PITFL, Complete Interosseous Membrane; (2) Intact, Superficial PITFL, Deep PITFL, ITFL, AITFL, Complete Interosseous Membrane. While under a 750 N axial load, the foot was externally rotated 15° and internally rotated to 10° for each sectioned state. Torque (N-m) and rotational position (degrees) were recorded continuously throughout testing.

**Results:** Biomechanical data describing each sectioned state can be found in Table 1. With sequential sectioning of the syndesmotic ligaments, reduced resistance to both internal and external rotation was observed. Furthermore, isolated anterior injuries to the AITFL were found to reduce resistance to external rotation by an average of 24%. However, resistance to internal rotation was not substantially diminished until the majority (2/3) of the syndesmotic ligaments had been sectioned.



**Conclusion:** The ligaments of the syndesmosis provide significant contributions to the rotary stability of the ankle mortise within the physiologic range of motion. The degree of instability was increased with each additional injured structure; however, isolated injuries to the AITFL alone may lead to significant external rotary instability.



**Abstract Number:**

Paper 122

**Abstract Title:**

Recreational Athletes Return to Sport at a Comparable Rate to Elite Athletes Following Hip Arthroscopy for Femoroacetabular Impingement

**Author Block:**

**Alexander E. Weber, MD<sup>1</sup>**, Benjamin Kuhns, M.S.<sup>2</sup>, Gregory Cvetanovich, MD<sup>3</sup>, David Levy, MD<sup>4</sup>, Shane Jay Nho, MD, MS<sup>5</sup>.

<sup>1</sup>Rush University Medical Center Program, Chicago, IL, USA, <sup>2</sup>Rush University Medical Center, Chicago, IL, USA, <sup>3</sup>Rush Univ, Chicago, IL, USA, <sup>4</sup>Rush University, Chicago, IL, USA, <sup>5</sup>Midwest Orthopaedics at Rush, Chicago, IL, USA.

**Abstract:**

**Objectives:** The objective of the current study was to evaluate patient reported outcomes and return to sport in a cohort of distinctly recreational and amateur level athletes following hip arthroscopy for femoroacetabular impingement (FAI).

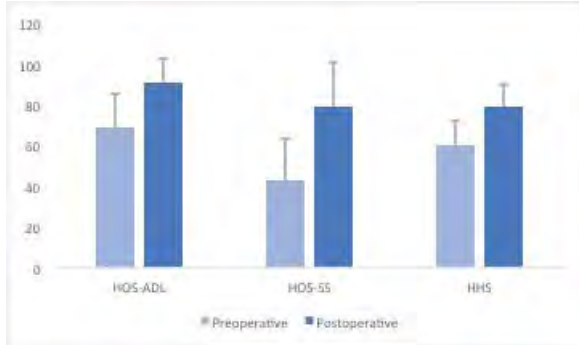
**Methods:** Following IRB approval, clinical data was retrospectively retrieved for 66 consecutive FAI patients (26 men, 40 women) who had undergone hip arthroscopy and identified themselves as recreational or amateur athletes on intake forms. Two-year patient-reported outcomes (PRO) included a sport-specific questionnaire, modified Harris Hip Score (mHHS), and Hip Outcome Scores with Activities of Daily Living (HOS-ADL) and Sports-Specific (HOS-SS) subscales were analyzed.

**Results:** The mean age and BMI of all subjects was  $26.8 \pm 7.6$  years and  $23.9 \pm 3.2$  kg/m<sup>2</sup>, respectively. Athletes had withdrawn from sport for an average of  $9.5 \pm 6.7$  months prior to surgery and on average required  $9.7 \pm 5.1$  months to return to sport. After two years, all mean PRO scores had improved significantly (Figure 1), and 57 patients (92%) had returned to play and continued participation. Patients who had withdrawn from sport for greater than 8 months before surgery returned to sport significantly more slowly than those who had withdrawn for less than 8 months ( $p=0.01$ ). Greater withdrawal from sport prior to surgery also correlated with lower postoperative improvements in HOS-ADL and HOS-SS scores. Bivariate analysis revealed that increasing body-mass index (BMI) was associated with lower improvements in PROs.

**Conclusion:** Recreational athletes, following hip arthroscopy for FAI, return to play at a high rate. Increasing BMI and preoperative withdrawal from sport both significantly prolong return to play and diminish two-year PROs. Most return-to-play studies following hip arthroscopy for FAI have focused on professional athletes, with limited generalizability to the average sports medicine surgeon practice. This is the first study of its kind to focus on the recreational athlete and demonstrates comparable return-to-



play rates while increasing the generalizability to the average sports medicine practice.





**Abstract Number:**

Paper 123

**Abstract Title:**

Predictors of Length of Career Following Hip Arthroscopy for Femoroacetabular Impingement in Professional Hockey Players

**Author Block:**

**Travis Menge, Md**, Karen K. Briggs, MPH, MBA, Marc J. Philippon, MD.  
Steadman Philippon Research Institute, Vail, CO, USA.

**Abstract:**

**Objectives:** Previous studies have shown that professional hockey players return to sport at a high rate following hip arthroscopy. The average length of a National Hockey League (NHL) career has been reported to be 5.5 years, and it is unknown how long players continue to play after hip arthroscopy. The purpose of this study was 1) to determine predictors of length of career in players following hip arthroscopy for treatment of symptomatic femoroacetabular impingement (FAI), and 2) investigate the rate of those who continue to play professional hockey a minimum of 5 years after hip arthroscopy.

**Methods:** Seventy professional hockey players underwent hip arthroscopy for FAI between 2005 and 2010 by a single surgeon. Data was retrieved from NHL.com regarding the duration of each player's professional career. In addition, position played, draft position, age at time of surgery, and surgical details were also used in data analysis.

**Results:** Our cohort included thirteen players that were centers, 15 defensemen, 20 goalies, and 22 wings. The average overall draft number was 57 (range 1 to 228), and average age at surgery was 27 years (range 17 to 38). Forty of the 70 athletes (57%) continued to play professionally a minimum of 5 years after hip arthroscopy. As of the most recent 2015 season, the average NHL length of career was 13 years (range 8 to 23 years), with an average of 6.9 years played following hip arthroscopy. There was no difference in length of career and years played when goalies were compared to other players ( $p=0.760$ ). Length of career and years played after arthroscopy correlated with age at surgery ( $r=0.799$  and  $r=-0.408$ ). Players who played 5 or more years after arthroscopy were significantly younger than those who did not (25 vs. 30 years,  $p=0.001$ ). Sixty-five players (93%) had labral repair and 5 (7%) had labral reconstruction. There were no differences in length of career or years played after arthroscopy based on type of labral treatment ( $p=0.278$ ). Ten patients (14%) additionally underwent microfracture of the acetabulum for chondral damage, and no players required microfracture of the femoral head. Players who had microfracture were older (31 vs 26 years,  $p=0.007$ ) and had longer careers (17 vs. 13 years,  $p=0.036$ ). There was no difference in years played after surgery between the microfracture group and those who did not have microfracture (5 vs 4.9 years,  $p=0.854$ ). Multiple regression analysis showed the only independent predictor of years played after arthroscopy was age ( $r^2=0.232$ ,  $p=0.001$ ).

**Conclusion:** Professional NHL players who underwent hip arthroscopy for FAI were able to continue playing at an elite level for an average of 6.9 years following surgery, with 57% playing a minimum of 5 years postoperatively. Younger age at time of surgery correlated with greater length of career and years





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played after hip arthroscopy. Type of labral treatment (repair vs. reconstruction) and presence of acetabular chondral damage requiring microfracture did not significantly impact length of career or years played postoperatively. Our data supports early arthroscopic treatment of professional hockey players with symptomatic FAI.



**Abstract Number:**

Paper 124

**Abstract Title:**

The Fate of the Contralateral Hip in Femoroacetabular  
Impingement: Rates and Predictors of Short-term  
Symptom Development

**Author Block:**

**Jeffrey J. Nepple, MD**, Craig Louer, MD, John C. Clohisy, MD.  
Washington University School of Medicine, St Louis, MO, USA.

**Abstract:**

**Objectives:** The pathophysiology of femoroacetabular impingement (FAI) remains to be better understood. Only a fraction of all individuals with bony FAI morphology will ever develop hip symptoms or osteoarthritis. The purpose of the current study was to determine (1) rates of initial and subsequent symptom development in the contralateral hip of patients with symptomatic ipsilateral FAI and (2) to identify predictors of symptomatic contralateral FAI.

**Methods:** The study cohort included 179 consecutive patients presenting for surgical treatment of FAI. Patients were excluded if they had previously underwent contralateral surgery. At baseline and postoperative follow-up time points, patients recorded standardized outcome questionnaires, including the presence of symptoms in the contralateral hip. Significant symptoms were defined as the presence of at least mild pain, while none or slight pain was not included. All patients underwent AP pelvis and bilateral 45 degree Dunn lateral radiographs at baseline. Patients developing symptoms in the contralateral hip were subclassified as having symptoms at presentation (initial symptoms) or developing symptoms during the follow-up period (symptom development). Patients were followed over a minimum of one year time period postoperatively. Multivariate logistic regression was performed to identify independent predictors of symptoms development.

**Results:** The study cohort had a mean age of 30.2 years and included 60.3% females. FAI was classified as isolated cam in 63.1% (n=113), isolated pincer 1.1% (n=2), and combined type in 35.8% (n=64). Forty-two (23.5%) of patients had initial symptoms in the contralateral hip. Twenty-two additional hips developed symptoms during the follow-up period (16.1% of initially asymptomatic hips). For multivariate logistic regression of any symptoms development (initial or subsequent), competitive athletes ( $p=0.041$ ) and contralateral HNO ratio on AP pelvis ( $p=0.009$ ). However, the overall model poorly predicted symptoms development.

**Conclusion:** Approximately one in four patients with FAI presents with symptoms in the contralateral hip. Additionally, 16% of initially asymptomatic contralateral hips will develop symptoms during the next several years. A variety of clinical, radiographic, and physical examination factors poorly predict the development of symptoms. Competitive athletes may be less likely to have contralateral symptoms, while significant contralateral cam deformity on the AP pelvis radiograph may make a patient more likely to have contralateral symptoms.



**Abstract Number:**

Paper 125

**Abstract Title:**

Clinical Outcomes Following Arthroscopic Micro Fracture of the Hip

**Author Block:**

**John P. Begly, MD<sup>1</sup>**, Michael K. Ryan, MD<sup>1</sup>, Brian Capogna, MD<sup>1</sup>, Thomas Youm, MD<sup>2</sup>.

<sup>1</sup>NYU Langone Hospital for Joint Diseases, New York, NY, USA, <sup>2</sup>RVC Orthopaedics PC, New York, NY, USA.

**Abstract:**

**Objectives:** Objective and clinical results of microfracture for treatment of chondral defects of the knee is well documented, yet outcomes for microfracture of the hip have not been extensively studied. Recently, several studies demonstrated clinical improvements in patients treated with microfracture of the hip. The purpose of this study is to examine clinical outcomes and survivorship in patients who underwent microfracture during arthroscopic hip surgery.

**Methods:** A retrospective analysis of a prospectively collected database was performed. Thirty-eight patients with a mean age of 41 (range, 17-64) who underwent microfracture during arthroscopic hip surgery by a single surgeon (senior author) were identified. Demographic data, diagnosis, and details regarding operative procedures were collected. All patients were indicated for hip arthroscopy based on standard pre-operative examination as well as routine and advanced imaging. Baseline pre-operative modified Harris Hip Scores (mHHS) and Non-Arthritic Hip Scores (NAHS) were compared to mHHS and NAHS at two-year follow-up. Additionally, survivorship data was assessed to determine failure, defined as any subsequent revision arthroscopic surgery and/or hip arthroplasty of the same hip.

**Results:** Thirty-four of the 38 (89.5%) patients were available for two-year clinical follow-up. Baseline mean mHHS and NAHS for all patients improved from 50.6 (+/- 12.7) and 46.9 (+/-12.8) to 84.7 (+/- 12.5) and 85.6 (+/- 11.2) respectively. Both improvements were statistically significant ( $p < 0.05$ ). Eight patients (23.5%) met failure criteria and underwent additional surgery at an average of 23.9 months. Two patients (5.8%) underwent revision arthroscopic surgery, and six patients (17.7%) underwent hip arthroplasty.

**Conclusion:** Significant improvements in clinical outcomes are seen at two-year follow-up after microfracture treatment of chondral lesions of the hip. Despite overall success, failure rates are relatively high. As with microfracture of the knee, results favor short-term clinical improvements, but results may decline at two years. Larger studies are needed to fully assess the efficacy of microfracture in arthroscopic hip surgery.



**Abstract Number:**

Paper 126

**Abstract Title:**

Survivorship of Primary Hip Arthroscopy in New York State - A Population-Based Study

**Author Block:**

**Ryan Degen, MD<sup>1</sup>**, Ting Pan, MPH<sup>2</sup>, Danyal H. Nawabi, MD<sup>2</sup>, Anil S. Ranawat, MD<sup>2</sup>, Bryan T. Kelly, MD<sup>2</sup>, Stephen Lyman, PhD<sup>2</sup>.

<sup>1</sup>Hospital for Special Surgery/Cornell Medical Center Program, New York, NY, USA, <sup>2</sup>Hospital for Special Surgery, New York, NY, USA.

**Abstract:**

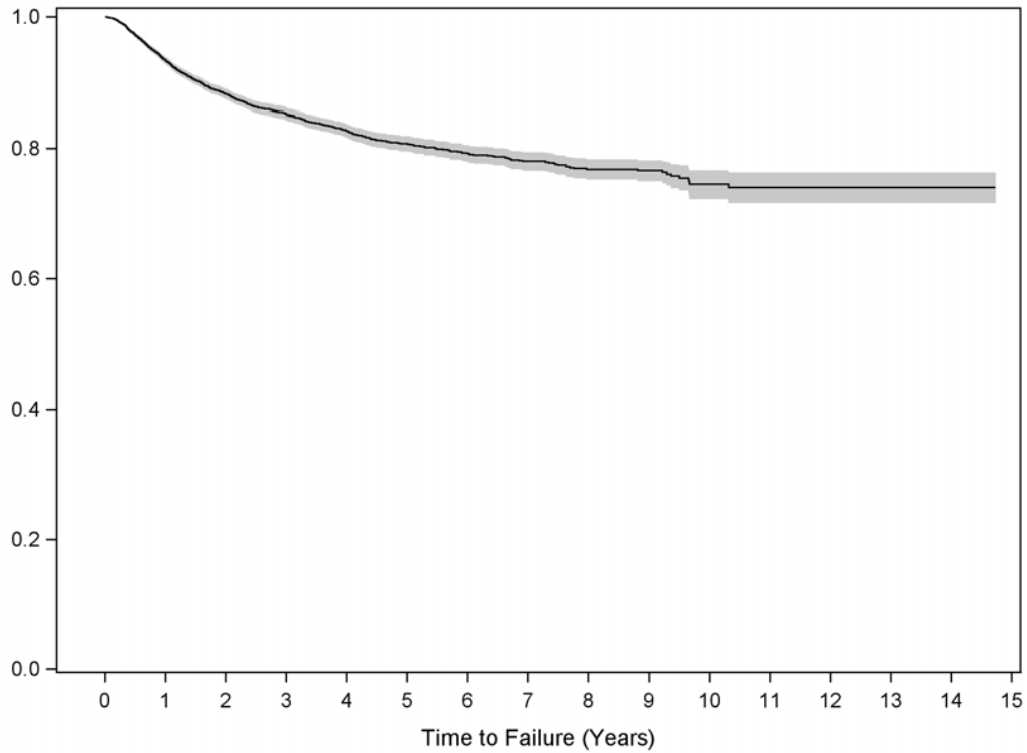
**Objectives:** Hip arthroscopy utilization has significantly increased over the past decade, with annual rates increasing as much as 300-600% in that time period. While large sample data demonstrates significant improvement in clinical outcomes out to two years post-operatively, with low rates of associated post-operative complications, there is little information on the long-term survival of primary hip arthroscopy procedures. The purpose of this study is to report on the rates of revision hip arthroscopy and conversion to resurfacing or total hip arthroplasty (THA) following hip arthroscopy in the State of New York. We will also report on prognostic variables that may contribute to the need for repeat surgery.

**Methods:** The Statewide Planning and Research Cooperative System (SPARCS) database, a census of all hospital admissions and ambulatory surgery in New York State, was used to identify cases of outpatient primary hip arthroscopy. Demographic information was collected for these patients. After case identification, unique identifiers were utilized to identify those patients that underwent revision hip arthroscopy or subsequent ipsilateral hip resurfacing or THA. The risks of each of these outcomes were modeled with use of age, sex, socio-economic status, hospital and surgeon volume as potential risk factors. Patients were also tracked for 30-day and 90-day complications requiring re-admission.

**Results:** We identified 8,267 hip arthroscopy cases from 1998-2012 performed by 295 surgeons in 137 different surgical centers. Demographics revealed that 46.1% of patients were male, with 80.2% carrying private insurance. Annual hip arthroscopy rates increased 88-fold over the observation period, with a 750% increase over the last 10 years. Revision surgery (scope or arthroplasty) was required in 1,087 cases (13.1%) at a mean of  $622 \pm 603$  days. More specifically, revision hip arthroscopy was required in 310 cases (3.8%) at a mean of  $649 \pm 586$  days after the index procedure, while conversion to either resurfacing or THA was required in 796 (9.7%) cases at an average of  $616 \pm 616$  days. The 30-day complication rate, excluding revision surgery, was 0.2%, while the 90-day complication rate was 0.3%. Thirty-day all-cause re-admission rate was 0.7%. Regression analysis revealed that age > 50 y.o. was associated with increased risk of re-operation (Hazard Ratio[HR] 2.30; CI 2.02-2.62), while males carried a slightly lower risk of re-operation (HR 0.88, CI 0.78-1.0). Additionally, increased surgical volume, for both surgeon and center ( $\geq 75$ th percentile of annual cases), resulted in a lower risk of re-operation (HR 0.64; CI 0.53-0.77; HR 0.61; CI 0.51-0.73).



**Conclusion:** Hip arthroscopy represents a viable treatment option for femoroacetabular impingement, with low rates of revision surgery and conversion to hip arthroplasty. Age less than 50 and higher surgeon and center surgical volume were associated with lower risk of re-operation.





**Abstract Number:**

Paper 127

**Abstract Title:**

Comparison of Femoral Neck Stress Fractures in Pediatric versus Young Adult Athletes

**Author Block:**

**Benton E. Heyworth, MD<sup>1</sup>**, Bridget Quinn, MD<sup>2</sup>, Lauren Ehrlichman, MD<sup>2</sup>, Sarah Bixby, MD<sup>3</sup>, Kathryn Ackerman, MD, MPH<sup>3</sup>, Yi-Meng Yen, MD<sup>4</sup>, Matthew John Boyle, MD<sup>2</sup>, Young-Jo Kim, MD<sup>5</sup>, Michael B. Millis, MD<sup>2</sup>.

<sup>1</sup>Boston Children's Hospital, Division of Sports Medicine, Boston, MA, USA, <sup>2</sup>Boston Children's Hospital, Boston, MA, USA, <sup>3</sup>Boston Children's Hospital, USA, <sup>4</sup>Children's Hospital Boston, Boston, MA, USA,

<sup>5</sup>Children's Hospital, Boston, MA, USA.

**Abstract:**

**Objectives:** To compare the demographics, metabolic bone health, radiologic features, treatment approaches and recurrence rates of pediatric versus young adult athletes with femoral neck stress fractures.

**Methods:** A retrospective review was performed on all patients <45 years-old who were diagnosed with a femoral neck stress fracture at a single tertiary-care referral center from 2003-2015. Patients who had undergone previous hip surgery or had primary bone disorders/lesions were excluded. Variables analyzed included demographics, presenting symptoms, metabolic bone health (laboratory results, DEXA scores, menstrual history, eating disorder history), imaging, treatment approach and clinical course.

**Results:** Forty-nine patients (mean age 21.4 years, range 5-44, 78% females) met study inclusion criteria, including 28 pediatric patients (mean age 14.4 years, range 5-19 years, 71% females) and 21 young adults (mean age 30.8 years, range 20-44 years, 86% females). A higher percentage of females was seen with each increasing decade of age, with 50% of pediatric patients under 11 years-old being male. Mean BMI was lower ( $p=0.04$ ) in the pediatric group (20.6 kg/m<sup>2</sup> +/-3.42) than the adult group (21.8 kg/m<sup>2</sup> +/-2.04). Pain was the presenting complaint in all patients, with pain localized to the groin in 80% of cases. Participation in running sports was higher for the young adult cohort (86%) than the pediatric cohort (50%), while multiple sports were played more by pediatric patients (29%) than young adults (5%). History of previous acute fractures (2%) and previous stress fractures (14%) was identical between groups. Delayed menarche was recorded in 6% of pediatric patients, and menstrual irregularity was reported in 29% and 33% of pediatric and adult females, respectively. The base of the femoral neck was most common location for fracture in both pediatric (67%) and adult (81%) groups, while transcervical fractures were more likely to occur in pediatric (29%) than adult patients (6%). More significant treatment interventions were pursued in the pediatric group (spica casting:  $n=2$ , operative screw fixation,  $n=4$ ) than the adult group, all of whom demonstrated healing with activity modification, with varying degrees of weight bearing protection and medical optimization of metabolic bone health. There was no difference in the meantime to healing (13.3 weeks), or in the meantime to return to sports (Peds: 16wks, Adults: 13wks) between groups. There was a significant correlation between time to RTS and the extent of the femoral neck edema ( $p=0.048$ ).



**Conclusion:** Pediatric caregivers should be aware of femoral neck stress fractures in young athletes, an entity historically described almost exclusively in adults. Stress fractures in pediatric and adolescent patients are more likely to occur higher on the neck than adult patients, and both sexes in children may be affected to a greater degree than in adult counterparts, in whom females are affected much more commonly. Groin pain and participation in running sports are common in both groups, while multi-sport pediatric athlete patients may be more likely to be affected than in the adult population. More significant treatment interventions may be warranted in children. To avoid the catastrophic sequella of a displaced femoral neck fracture, proactive diagnostic workup and consideration of interventions such as spica casting or surgical screw fixation should be exercised given concerns related to non-compliance in this population.



**Abstract Number:**

Paper 128

**Abstract Title:**

Return to Play after Shoulder Instability Surgery in NCAA Division I Intercollegiate Football Athletes

**Author Block:**

**Richard J. Robins, MD<sup>1</sup>**, Jimmy Hoshang Daruwalla, MD<sup>2</sup>, John W. Xerogeanes, MD<sup>3</sup>, Patrick E. Greis, MD<sup>4</sup>.

<sup>1</sup>Dept. of Orthopaedics and Sports Medicine, U.S. Air Force Academy, CO, USA, <sup>2</sup>Emory University Department of Orthopaedics, Atlanta, GA, USA, <sup>3</sup>Emory Orthopaedic Center, Atlanta, GA, USA,

<sup>4</sup>University of Utah Orthopaedic Center, Salt Lake City, UT, USA.

**Abstract:**

**Objectives:** The purpose of this study was to evaluate return to play (RTP) rates and variables influencing RTP in division I intercollegiate football athletes following shoulder instability surgery.

**Methods:** Requests for participation in the study were sent to select sports medicine programs caring for athletes participating in football from the PAC-12, SEC, and ACC athletic conferences. After gaining IRB approval, 7 programs were able to participate in the study. Inclusion criteria were restricted to athletes active during the 2004-2013 seasons that required surgical treatment for shoulder instability. Direction of instability, type of surgery, time to resume participation, quality and level of play data both before and after surgery was collected for each athlete. Data was analyzed to determine overall RTP and the influence that scholarship and depth chart position prior to surgery had on RTP. To determine the effect that surgery had on players' ability to RTP, the percent of games played before and after surgery was determined.

**Results:** 177 shoulder injuries in 153 athletes were identified and met inclusion criteria. Overall, 85.4% of players who underwent arthroscopic surgery without concomitant procedures returned to play. 82.4% of players who underwent anterior labral repair, 88.7% of those that underwent posterior labral repair, and 84.8% who underwent combined anterior-posterior repair returned to sport. Categorized by depth chart position, 93.3% of starters, 95.4% of utilized players, and 75.7% of rarely used players returned to play. The percentage of games played in by athletes prior to injury was 49.9%, and rose to 71.5% following surgery. Athletes who played in a higher percentage of games prior to injury (49.4 +/- 43.4%) were more likely to return to play than athletes who played in a fewer percentage of games (19.6 +/- 39.4%). Of the 42 athletes identified as starters prior to injury that returned to play, 98% continued as starters; 2% became utilized players. Of the 41 players that prior to injury were utilized, 49% became starters, 49% remained utilized, and 2% rarely played following surgery. For the 56 players identified as rarely playing pre-injury that returned to play, 36% became starters, 23% were utilized athletes, and 41% maintained their rarely playing status. Having a scholarship significantly correlated with RTP after surgery.

**Conclusion:** RTP rates in high-level intercollegiate football players undergoing shoulder stabilization surgery was 85%. Posterior labral repair, anterior labral repair, and combined labral repair





demonstrated no statistical difference in RTP rates. The majority of surgical interventions were isolated arthroscopic stabilization procedures, and demonstrated no statistically significant difference in RTP rates when concomitant arthroscopic procedures or open stabilization procedures were performed. Finally, athletes who return to play often did so in a higher percentage of games following surgery than they did prior to injury, and many players were utilized at the same or a higher level by their teams following surgery. These findings suggest that the majority of football players at the division 1 level who undergo shoulder stabilization surgery are able to participate fully in their programs, and progress and develop as players following their return to sport.



**Abstract Number:**

Paper 129

**Abstract Title:**

Pectoralis Major Tendon Repair: Clinical Outcomes, Return to Sport and Incidence of Second Surgery.

**Author Block:**

**Frank A. Cordasco, MD, MS<sup>1</sup>**, Ryan Degen, MD<sup>2</sup>, Gregory Thomas Mahony, BA<sup>3</sup>, Nicholas Tsouris<sup>1</sup>.

<sup>1</sup>Hospital for Special Surgery, New York, NY, USA, <sup>2</sup>Hospital for Special Surgery/Cornell Medical Center Program, New York, NY, USA, <sup>3</sup>Hospital for Special Surgery; Sports Medicine and Shoulder Group, New York City, NY, USA.

**Abstract:**

**Objectives:** Systematic reviews of the literature have identified 365 reported cases of Pectoralis Major Tendon (PMT) injuries. While surgical treatment has demonstrated improved outcomes compared to non-operative treatment, there is still relatively limited data on the functional outcome, return to sport and need for 2nd surgery in athletes following PMT repair. This study comprises the largest series of athletes following PMT repair reported to date.

The Objective is to report on the functional outcomes, return to sport and need for 2nd surgery in a consecutive series of PMT tears.

**Methods:** From 2009, 81 patients with PMT tears were enrolled in this prospective series. Baseline evaluation included patient demographics, mechanism of injury, physical examination and PMT specific MRI for confirmation of the diagnosis and analysis of the extent of injury. Each patient underwent surgical repair by the senior author utilizing a previously published surgical technique. Patients were then followed at 2 weeks, 6 weeks, 3 months and 6 months and further follow-up was conducted annually thereafter with functional outcome scores and adduction strength testing. The return to sport and incidence of 2nd surgery data were recorded. This study includes the first 40 athletes to reach the 2-year post-operative period.

**Results:** All athletes were male, with an average age of 34.4 years (range 23-59). The patient cohort consisted of 4 professional NFL players and 36 recreational athletes. Average follow-up duration was 2.5 years (range 2 - 6.0 years). The most common mechanisms of injury occurred during the bench press (n=26) and contact sport participation (n=14). Sixteen injuries were complete avulsions involving both the clavicular and sternocostal heads, while 24 were isolated sternocostal head avulsions. Average pre-injury bench press of 396 lbs (range 170-500 lbs) was restored to 241 lbs post-operatively (range 140-550 lbs). Single Assessment Numeric Evaluation (SANE) scores averaged 93.6 (range 62-100) with an average overall patient satisfaction rated at 9.6 out of 10 (range 6-10). All athletes returned to their pre-injury level of activity at average 5.5 months post-op (range 4.5-6.5 months). Isokinetic evaluation assessing adduction strength revealed an average decrease of <11% (avg. 9.9%, range -18 - 41%) compared with the contralateral extremity. Application of the Bak criteria revealed 50% of athletes scored as excellent, 35% as good and 15% as fair. One athlete developed a pulmonary embolus 10 days post-op. Two athletes required a 2nd surgery (5%), both were re-injured within 3 weeks of surgery.



**Conclusion:** As demonstrated in this consecutive series, which represents the largest cohort of PMT repairs reported to date, surgical repair resulted in 96% patient satisfaction, with 85% good to excellent restoration of function and adduction strength. The athletes returned to sport on average at 5.5 months post-operatively and the incidence of 2nd surgery was 5%.



**Abstract Number:**

Paper 130

**Abstract Title:**

Hamstring Injuries in Major and Minor League Baseball: Are They Preventable?

**Author Block:**

**Holly J. Silvers, MPT<sup>1</sup>**, James Zachazewski, DPT, MS<sup>2</sup>, Bernard Li, PT<sup>3</sup>, Lynn Snyder-Mackler, PhD<sup>4</sup>,  
Stephanie Insler, BA<sup>5</sup>, Christopher S. Ahmad, MD<sup>6</sup>, Bert R. Mandelbaum, MD<sup>7</sup>.

<sup>1</sup>University of Delaware, Los Angeles, CA, USA, <sup>2</sup>Massachusetts General Hospital, Boston, MA, USA, <sup>3</sup>Los Angeles Angels of Anaheim, Anaheim, CA, USA, <sup>4</sup>University of Delaware Physical Therapy Dept., Newark, DE, USA, <sup>5</sup>Santa Monica Sports Medicine Foundation, Santa Monica, CA, USA, <sup>6</sup>Columbia University, New York, NY, USA, <sup>7</sup>Santa Monica Orthopaedic and Sports Medicine, Santa Monica, CA, USA.

**Abstract:**

**Objectives:** The purpose of this study is to test the efficacy of a hamstring injury prevention program designed to address the high incidence of acute and chronic hamstring injuries and re-injuries that occur in the sport of professional baseball.

**Methods:** This was a prospective cluster cohort study assessing the efficacy of an injury prevention intervention designed to address hamstring injury in rookie and professional baseball players participating in Minor and Major League Baseball (N = 213). Each athlete was asked to participate and consented (Johns Hopkins Internal Review Board, Baltimore, Maryland). Those athletes who agreed to participate completed a questionnaire detailing their hamstring injury history. The hamstring injury prevention program was disseminated to each medical staff (team physician, certified athletic trainer and strength and conditioning coach) and they were instructed on how to implement the program. Weekly individual compliance with the program and injury data was collected. At the end of the season, the data were analyzed for program compliance and hamstring (HS) injury rates (both acute and reoccurrence) compared to the control data in the MLB HITS database. All data were stripped of individual and team identifiers prior to analysis.

**Results:** For the major and minor league intervention study, one Major and Minor League organization served as the intervention (INT) team, which encompassed Rookie League, Fall Ball, Class A, AA, AAA and major league rosters (6 total teams). A total of 213 athletes consented to participate: Minor League: N = 173 players and Major League: N = 40. Weekly compliance, injury incidence and time loss due to injury was compared to the HITS database (age, skill matched control group). The average weighted utilization of the injury prevention program was 25.30 utilizations for the uninjured group compared to 13.53 in the injured group (p=0.09). In the majors, there were 2 HS injuries in the INT vs. 79 in the CON (IR: .025 INT vs .068 CON, p < 0.05); constituting a 25% reduction in HS injury. In the minors, there were 7 HS injuries in the INT vs. 297 in the CON (IR: .039 INT vs. .065 CON, p < 0.05), constituting a 40% reduction in the minor league HS injuries. There was a significant reduction in time loss due to injury for both the major and minor league INT players compared to the CON. For the Major League INT, there were 9 vs. 25.9 days lost in the CON group, resulting in a 65.3% reduction in time loss (p<0.05). The Minor League INT reported a similar finding: 11.63 vs. 21.3 days lost to injury in the CON group, resulting in a 45.3%



reduction in time loss ( $p < 0.05$ ).

**Conclusion:** The reduction in hamstring injury in the major and minor league intervention teams is consistent with what researchers have reported with respect to the efficacy and value of utilizing a this intervention program in other sports. The intervention is a time and cost efficient means to reduce hamstring injury incidence and time loss in professional baseball players. This study is continuing in a prospective manner for an additional competitive season.



**Abstract Number:**

Paper 131

**Abstract Title:**

Does Choosing Autograft Hamstring vs. Patellar Tendon by Gender, Sport, Level of Competition or Laxity in High School and College Aged Athletes Improve KOOS, IKDC or Marx?

**Author Block:**

**Laura J. Huston, MS<sup>1</sup>**, Emily Reinke, PhD<sup>2</sup>, Michael W. Kattan, PhD<sup>3</sup>, Kevin Chagin, M.S.<sup>4</sup>, Kurt P. Spindler, MD<sup>5</sup>.

<sup>1</sup>Vanderbilt Orthopaedic Institute, Nashville, TN, USA, <sup>2</sup>Vanderbilt University, Nashville, TN, USA,

<sup>3</sup>Cleveland Clinic, Cleveland, OH, USA, <sup>4</sup>Cleveland Clinic Foundation, Cleveland, OH, USA, <sup>5</sup>Cleveland Clinic Sports Health Center, Garfield Hts, OH, USA.

**Abstract:**

**Objectives:** Physicians' and patients' decision-making process between autograft hamstring (HG) vs. patellar tendon (BTB) for ACL reconstruction (ACLR) may be influenced by patient gender, laxity level, sport played, and/or competition level in the young, active athlete. ACLR specific to high school and college-aged athletes with these aforementioned factors in mind has not been evaluated. Therefore, our objectives were twofold: first, to develop a simple web-based risk calculator as a decision-making aid to provide the best estimate of expected 2-year KOOS, IKDC, and Marx outcomes by gender, sport, level of competition, and knee laxity. Second, to identify whether autograft HG or BTB is the optimal graft choice given any combination of the aforementioned variables.

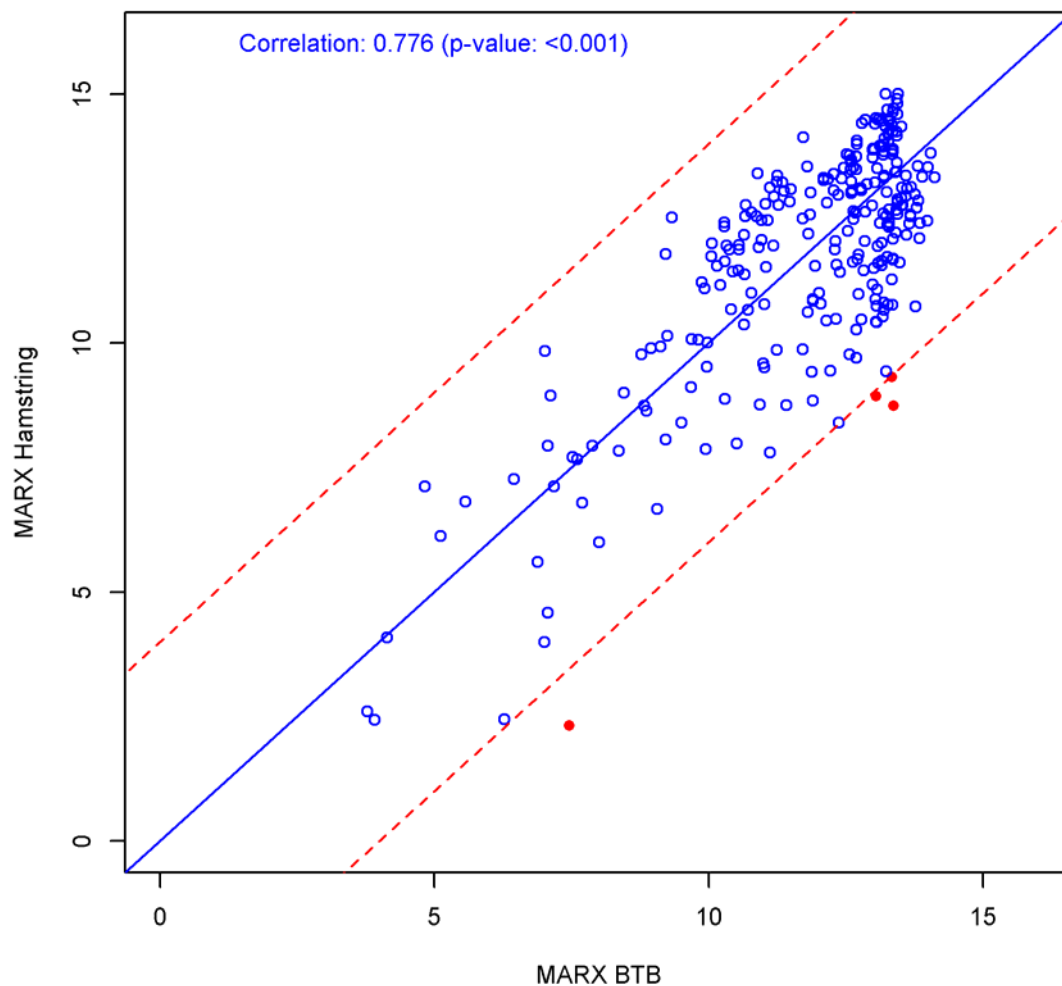
**Methods:** Our inclusion criteria in the MOON cohort were patients aged 11-22 who were injured in sport (football, soccer, basketball, other), who were due to have a unilateral primary ACLR with either an autograft HG or BTB, and who had a contralateral normal knee. Excluded were revisions, allografts, those with a contralateral ACLR and concomitant MCL/LCL/PCL surgery. Laxity was graded as increased (Lachman > 10 mm or a pivot lock) or normal based on the EUA. Our modeling controlled for BMI, ethnicity, and baseline measures of patient-reported outcomes. Our two year outcomes were the KOOS knee related quality of life subscale, KOOS sports and recreation subscale, IKDC, and Marx activity level. Our multivariable modeling for risk online calculator and nomograms was generated in two ways. The performances for our models were measured using R squared, calibration curves, and bootstrapping.

**Results:** 937 patients were eligible, 809 (86%) had 2 year follow-up data. The average age was 17, with 50% females, and the distribution of HG to BTB was 301/508 respectively. First, in evaluating our models for ACLR autograft choice, neither KOOS subscale models performed better than chance. The IKDC and Marx models predicted significantly better than chance. For the IKDC outcome the combined modeling strategy was preferred, and in the Marx model the separate model strategy predicted better. Second, the model results by autograft type for the two KOOS subscales, IKDC, and Marx are as follows. For KOOS quality of life the predictions for HG vs. BTB were significantly and highly correlated (0.77  $P < 0.001$ ). In a scatter plot only 23 observations (9%) had a change in KOOS by 10 points. For KOOS sports/recreation the two autograft models were also significantly and highly correlated (0.62,  $p < 0.001$ ). In a scatter plot only 20 (7%) had a change in KOOS by 10 points. For the IKDC adjusted R<sup>2</sup> in the



combined model is 0.075 95% CI (0.026, 0.109). For the Marx ( see figure scatter plot) the two autografts were significantly and highly correlated (0.78,  $p < 0.001$ ).

**Conclusion:** There were no significant or clinically relevant predicted differences between autograft hamstring vs. patellar tendon in the two KOOS subscales, IKDC and Marx activity level in 11-22 year old athletes .The choice between HG and BTB should be made on an outcome besides these endpoints, and there is little need for a calculator to predict these outcomes because patients will all be the same (HG vs BTB)





**Abstract Number:**

Paper 132

**Abstract Title:**

Incidence, Mechanisms, and Severity of Game-Related High School Football Injuries Across Artificial Turf Systems of Various Infill Weight

**Author Block:**

**Michael Clinton Meyers, PhD.**

Idaho State University, Pocatello, ID, USA.

**Abstract:**

**Objectives:** Today's new generations of artificial turf are increasingly being installed to duplicate or exceed playing characteristics of natural grass. Rather than playing on the polyethylene turf fibers, shoe: surface interaction actually occurs between the cleat and the various proprietary sand/rubber infill composites of varying weight. At this time, the influence of surface infill weight on football trauma is unknown. Therefore, this study was conducted to quantify incidence, mechanisms, and severity of game-related high school football trauma across artificial turf systems of various infill weight.

**Methods:** Artificial turf systems were divided into four sand/rubber infill weight groups based on lbs per square foot: (A) > 9.0, (B) 6.0 - 8.9, (C) 3.1 - 5.9 and, (D) 0.0 - 3.0. A total of 52 high schools participating across four states over 5 competitive seasons were evaluated for injury incidence, injury category, time of injury, injury time loss, player position, injury mechanism and situation, primary type of injury, injury grade and anatomical location, field location at time of injury, injury severity, head, shoulder, and lower extremity trauma, elective imaging and surgical procedures, cleat design, turf age, and environmental factors.

**Results:** Of the 1,467 high school games documented, 494 games (33.7%) were played on infill (A), 404 (27.5%) on infill (B), 379 (25.8%) on infill (C), and 190 (13.0%) on infill (D). A total of 3,741 injuries were documented, with significantly lower total injury incidence rates (IIR), [18.4 (95% CI, 18.0-18.7) vs 27.5 (26.8-27.9) vs 33.5 (32.7-34.0) and 23.7 (22.7-24.4)], substantial IIRs [3.4 (95% CI, 3.0-3.8) vs 6.6 (6.2-7.1), 8.5 (8.2-8.9) and 6.5 (5.8-7.1)], trauma from shoe:surface interaction during contact [4.6 (95% CI, 4.1-5.0) vs 7.5 (7.0-7.9), 6.4 (5.9-6.9) and 6.9 (6.2-7.5)], playing surface impact trauma [2.4 (95% CI, 2.1-2.8) vs 4.9 (4.4-5.4), 6.1 (5.6-6.6) and 4.4 (3.7-5.1)], and less total elective imaging and surgical procedures [4.6 (95% CI, 4.1-5.0) vs 7.5 (7.0-7.9), 6.4 (5.9-6.9) and 6.9 (6.2-7.5)], while competing on infill weighing >9.0 (A) versus 6.0 -8.9 (B), 3.0 - 5.9 (C), and 0.0-3.0 (D), respectively. Significantly lower trauma ( $P<.05$ ) was also observed across player-to-player collisions, muscle-tendon overload, injury time loss, injury grade, skill positions, injury mechanism and situation, various cleat styles, adverse weather conditions, and turf age while competing on infill (A) when compared to infill (C).

**Conclusion:** As the artificial infill surface weight decreased, the incidence of game-related high school football trauma significantly increased across numerous playing conditions. This is the first study to investigate the influence of artificial infill surface weight on the incidence of game-related high school football trauma. Since this study is in the early stages, initial findings warrant further investigation.





**Abstract Number:**

Paper 133

**Abstract Title:**

A Wearable Neuromuscular Device Reduces ACL Injury Risk in Female Soccer Athletes

**Author Block:**

**Michael John Decker, PhD<sup>1</sup>**, Matthew Shaw<sup>2</sup>, Casey Maddan<sup>3</sup>, Julie Campbell<sup>3</sup>, Bradley Davidson<sup>4</sup>.

<sup>1</sup>Human Dynamics Laboratory, Mechanical and Materials Engineering Department, University of Denver, Denver, CO, USA, <sup>2</sup>Strength and Conditioning Department, University of Denver, Denver, CO, USA,

<sup>3</sup>Sports Medicine Department, University of Denver, Denver, CO, USA, <sup>4</sup>Human Dynamics Laboratory, Mechanical and Materials Engineering Department, University of Denver, Denver, CO, USA.

**Abstract:**

**Objectives:** Female soccer athletes have a three-fold greater risk of sustaining an ACL injury compared with their male counterparts yet only 1 in 5 teams engage in ACL risk reduction programs due to several participation barriers. The purpose of this study was to determine the effects of a wearable neuromuscular (WNM) device on postural control, performance and ACL injury risk in female soccer athletes.

**Methods:** Seventy-nine elite youth and collegiate female soccer athletes (age range: 12-25 y) trained with a WNM device that applied bi-lateral, topical pressure to the medial quadriceps and hamstrings muscles (Topical Gear, Austin, TX). The athletes performed 7-9 weeks of pre-season training with the WNM device consisting of strength and conditioning exercises and on-field team practices (46-64 total hours of exposure). Postural control was measured in 15 athletes with and without the WNM device before and after the training program; and performance was measured in 25 athletes without the WNM device before and after the training program. Postural control was determined from a single-leg landing on a force plate from a horizontal distance normalized to leg length. The athletes were instructed to gain their balance as fast as possible upon landing and remain balanced for 5 seconds. The peak ground reaction forces (GRF) and the medial-lateral, anterior-posterior and net center of pressure (COP) velocities and displacement ranges were calculated during 2 seconds of single-leg stance. Performance measures including speed, power and endurance were measured from the 40 yard dash, vertical jump for height and the Beep test, respectively. A two-way repeated measures ANOVA and post-hoc comparisons were used to compare the postural variables; and t-tests were used to compare the performance tests ( $p=.05$ ). ACL injury rates, the absolute risk reduction (ARR) and the number needed to treat (NNT) to prevent one ACL injury were calculated between the WNM intervention group and 11 control groups identified from 10 studies in the literature that followed female soccer athletes for an entire soccer season. The treatment effect of the WNM device was determined to be statistically significant at the .05 level if the 95% confidence interval for the ARR of an ACL injury did not include zero.

**Results:** Training with the WNM device demonstrated 18% lower peak medial GRFs ( $p=.005$ ), 12% lower medial-lateral COP velocities ( $p=.032$ ) and 18% longer landing phase durations ( $p=.001$ ). Landing and balance performance with, compared to without, the WNM device demonstrated 2% lower peak vertical



GRF ( $p=.047$ ), 6% lower net COP velocities ( $p=.044$ ) and 10% lower medial-lateral COP displacements ( $p=.018$ ). Speed, power and endurance significantly improved 7, 22 and 14% after training with the WNM device (all  $p<.05$ ). No athletes in the current study sustained an ACL injury during training or over the course of the season. The ARR was on average lowered 1.5% and statistically improved in 9 of the 11 control group comparisons ( $p<.05$ ) and corresponded to a RRR of 100%. From the NNT analysis, it was determined that 92 female soccer athletes would need to be trained with the WNM device to prevent one ACL injury over the course of one competitive season.

**Conclusion:** Training with a WNM device improved postural control without limiting performance and reduced ACL injury risk in female soccer athletes. Wearable neuromuscular products may provide a solution to the current participation barriers of ACL injury risk reduction programs.



**Abstract Number:**

Paper 134

**Abstract Title:**

Expected Time to Return to Athletic Participation Following Stress Fracture in Division I Collegiate Athletes

**Author Block:**

**Marissa Jamieson, MD<sup>1</sup>**, Sonsecharae Everson, ATC<sup>2</sup>, Courtney Siegel, ATC<sup>2</sup>, Timothy Lee Miller, MD<sup>3</sup>.

<sup>1</sup>The Ohio State University Wexner Medical Center, Columbus, OH, USA, <sup>2</sup>Ohio State University Athletics, Columbus, OH, USA, <sup>3</sup>The Ohio State Univ Sports Medicine Ctr, Columbus, OH, USA.

**Abstract:**

**Objectives:** The objective of this study was to evaluate and determine the expected time to return to athletic participation in Division I Collegiate Track and Field athletes.

**Methods:** All stress fractures diagnosed in athletes on a single Division I collegiate men's and women's track and field/ cross-country team were recorded over a 4-year period. Site and severity of the injury were recorded and graded based on the Kaeding-Miller Classification System for stress fractures. Time to return to full unrestricted athletic participation was recorded for each athlete and correlated with the site and severity grade of the injury. Time to return to athletic participation was also analyzed for gender differences.

**Results:** Fifty-seven stress fractures were diagnosed in 38 athletes over a 4-year period. Thirty-seven of these injuries occurred in women; twenty in men. Mean time to return to participation in women was 13.9 weeks and 11.2 weeks in men. There were 10 athletes who sustained recurrent or multiple stress fractures. Thirty-three stress fractures occurred in the tibia, and 10 occurred in the 2<sup>nd</sup> through 4<sup>th</sup> metatarsals. Three occurred in the 5<sup>th</sup> metatarsal, 6 in the tarsal bones (2 navicular), and 5 in the pelvis. Mean times to return to athletic activity based on site of injury and with extreme outliers removed were as follows: tibia- 13.3 weeks, 2<sup>nd</sup> through 4<sup>th</sup> metatarsals- 11.7 weeks, 5<sup>th</sup> metatarsal- 11.7 weeks, tarsals- 12.1 weeks, and pelvis- 13.0 weeks. There were 31 grade 2 stress fractures, 11 grade 3 stress fractures, and two grade 5 stress fractures that occurred bilaterally in the same patient. Mean times to return to athletic participation again with extreme outliers excluded were as follows: Grade 2- 12.3 weeks, Grade 3- 14.1 weeks, and Grade 5- 17 weeks. There were no Grade 4 (displaced) stress fractures diagnosed in this cohort of patients.

**Conclusion:** Stress injuries to bone occur frequently in track and field athletes. Based on data collected from review of all recorded stress fractures diagnosed in members of a single Division I collegiate men's and women's track and field team over a period of four seasons, the expected time to return to full unrestricted athletic participation following diagnosis of a stress fracture is 12 to 13 weeks for all injury sites. Greater severity of injury correlated with increased time to return to participation with small numbers in the Grade 5 (nonunion) category making determining expected time to return to activity difficult.



**Abstract Number:**

Paper 135

**Abstract Title:**

Knee Hyperextension as a Predictor of Failure in Revision ACL Reconstruction: A Prospective Cohort Study

**Author Block:**

**Daniel E. Cooper, MD<sup>1</sup>**, Warren R. Dunn, MD, MPH<sup>2</sup>, Rick W. Wright, MD<sup>3</sup>, Amanda Haas, MA<sup>4</sup>, Laura J. Huston, MS<sup>5</sup>.

<sup>1</sup>The Carrell Clinic, Dallas, TX, USA, <sup>2</sup>University of Wisconsin, Madison, WI, USA, <sup>3</sup>Washington University Dept of Orthopaedic Surgery, Saint Louis, MO, USA, <sup>4</sup>Washington University School of Medicine, St. Louis, MO, USA, <sup>5</sup>Vanderbilt Orthopaedic Institute, Nashville, TN, USA.

**Abstract:**

**Objectives:** We studied the minimum 2 year follow-up outcomes in an ACL revision cohort. The hypothesis is that knees that hyperextend will have a worse outcome and greater odds of graft failure than knees that do not hyperextend. The null hypothesis is that there is no difference in outcomes or graft rupture between the two groups.

**Methods:** Revision ACL reconstruction patients were identified and prospectively enrolled between 2006 and 2011. Data collected included baseline demographics, surgical technique and pathology, and a series of validated patient reported outcome instruments (IKDC, KOOS, WOMAC, and Marx activity rating score). Patients were followed up for 2 years, and asked to complete the identical set of outcome instruments. A regression model using graft failure as the dependent variable included graft type, age, and hyperextension greater than or equal to 5 degrees yes/no (HE) in order to assess these potential surgical risk factors for clinical outcomes 2 years after revision ACL reconstruction.

**Results:** There were 1,145 subjects included in the analyses. The median age of the cohort was 26 (IQR= 20, 35), and 58% were male. The proportion that were enrolled for their first revision surgery was 88%, their second 10%, and third or greater 2%. The number of subjects categorized as HE was 375 (33%). The median age of subjects that failed was 18, compared to 26 for those with intact grafts. All three variables included in our regression model were significant predictors of graft failure: younger age, inter-quartile range odds ratio (IQROR) = 3.32 (95%CI 1.5, 7.2) p= 0.002; use of allograft OR = 3.1 (95%CI 1.4, 6.9) p= 0.01, and HE 2.1 (95%CI 1.02, 4.42) p= 0.04.

**Conclusion:** The MARS Study Group has previously reported that young age and the use of allograft as a graft source are independent predictors (over 3X odds ratio) of graft rupture after revision ACLR. This study found that knee hyperextension greater than or equal to 5 degrees is present in 1/3 of patients who undergo revision ACLR. HE is also an independent predictor of graft failure after revision ACLR. This is the first study to investigate and confirm knee physiologic hyperextension as a risk factor (over 2X odds ratio) of graft rupture in ACL surgery. Future reports on ACL reconstruction results should separately evaluate the group of knees that hyperextend 5 degrees or more as compared to those that do not.



**Abstract Number:**

Paper 136

**Abstract Title:**

Effect of Intraoperative Platelet-Rich-Plasma Treatment on Post-Operative Donor Site Knee Pain in Patellar Tendon Autograft ACL Reconstruction: A Double-Blind Randomized Controlled Trial

**Author Block:**

**Brian L. Walters, MD<sup>1</sup>**, Sarah Hobart, MD<sup>2</sup>, David Porter, MD<sup>3</sup>, Daniel E. Hogan, MS<sup>4</sup>, Malachy P. McHugh, PhD<sup>5</sup>, Benjamin B. Bedford, MD<sup>6</sup>, Stephen J. Nicholas, MD<sup>6</sup>, Devon Klein, MD, MPH<sup>7</sup>, Kendall Harousseau, PA-C<sup>6</sup>.

<sup>1</sup>American Sports Medicine Institute (St. Vincent's) Program, Birmingham, AL, USA, <sup>2</sup>Lenox Hill Hospital North Shore LIJ, New York, NY, USA, <sup>3</sup>Lenox Hill Hospital-North Shore LIJ, New York, NY, USA, <sup>4</sup>Nicholas Institute of Sports Medicine and Athletic Trauma, Lenox Hill Hospital, NY, NY, USA, <sup>5</sup>Nicholas Institute of Sports Medicine and Athletic Trauma, Lenox Hill Hospital, New York, NY, USA, <sup>6</sup>NY Orthopedics, New York, NY, USA, <sup>7</sup>North-Shore LIJ Healthcare, New York, NY, USA.

**Abstract:**

**Objectives:** Donor site morbidity in the form of anterior knee pain is a frequent complication after bone-patellar tendon-bone (BPTB) autograft ACL reconstruction. The purpose of this Level I study was to examine the effect of the intraoperative administration of platelet-rich plasma on post-operative knee pain and patellar defect healing.

**Methods:** Fifty-nine patients (29±12 y/o) undergoing BPTB ACL reconstruction and eligible to enter the study, were randomized to the treatment (PRP; n=31) or non-treatment (sham n=28) arms of the study just prior to surgery. In either case, 10 cc of venous blood was drawn prior to the induction of anesthesia and either discarded (sham) or processed (PRP) for preparation of a PRP gel to be later mixed with donor site bone chips and inserted into the patellar defect. At 12 weeks and 6 months after surgery, patients completed IKDC forms and VAS pain scores for ADLs and kneeling (0-10 scale). Healing indices at the donor site were assessed by MRI at 6 months and included the following measurements taken from axial sequences: AP tendon dimensions at the level of the superior tibial cortex, roof of the intercondylar notch and width at the largest patella graft deficit. Mixed model ANOVA was used to assess the effect of PRP on patient symptoms and MRI indices of donor site healing. The primary dependent variable was VAS kneeling pain. It was estimated that with 25 patients per group there would be 80% power to detect a 1.5-point difference in kneeling pain between treatments at P<0.05. A between group difference of 1.5-points in VAS for kneeling pain was deemed to represent a clinically relevant difference.

**Results:** VAS Kneeling Pain at 12 weeks tended to be lower in the PRP versus placebo group (4.5±3.6 vs. 6.2±2.4, P=0.051) but no difference was apparent at 6 months (3.7±3.2 vs. 4.4±2.9, P=0.41). Kneeling pain decreased from 12 weeks to 6 months (P<0.001) with a trend for a greater decrease in the placebo group (Time by Treatment P=0.097). VAS Pain with ADLs was not different between treatment groups at 12 weeks (PRP 2.0±2.3 vs. Placebo 2.8±1.8, P=0.16) or 6 months (1.5±1.9 vs. 1.7±2.1, P=0.60). Pain with ADLs decreased from 12 weeks to 6 months (P<0.05) with no difference between treatment groups



(Time by Treatment  $P=0.52$ ). IKDC scores improved from 12 weeks to 6 months ( $P<0.001$ ), with no difference between treatment groups (Time by Treatment  $P=0.73$ ). IKDC scores were not different between treatment groups at 12 weeks ( $64\pm 16$  vs.  $64\pm 12$ ,  $P=0.83$ ) or 6 months ( $75\pm 18$  vs.  $73\pm 11$ ,  $P=0.66$ ). MRI indices of donor site healing were not different between treatment groups ( $P=0.60$  to  $0.97$ ).

**Conclusion:** Whether randomized to receive PRP in their patellar defect or not, patients continued to have similar levels of kneeling pain and patellar defect sizes 6 months after BPTB ACL autograft reconstruction. The intraoperative administration of PRP into the patellar donor site following ACL reconstruction with BPTB autograft has no significant effect on the parameters of post-operative knee pain or donor site healing.



**Abstract Number:**

Paper 137

**Abstract Title:**

Multicenter Orthopaedic Outcome Network Early Anti-inflammatory Treatment in Patients with Acute ACL Tear" (MOON-AAA) Clinical Trial

**Author Block:**

**Christian Lattermann, MD<sup>1</sup>**, Mary Proffitt, PhD<sup>2</sup>, Laura J. Huston, MS<sup>3</sup>, Lee Gammon, MD<sup>4</sup>, Darren L. Johnson, MD<sup>5</sup>, Virginia B. Kraus, MD, PhD<sup>6</sup>, Kurt P. Spindler, MD<sup>7</sup>.

<sup>1</sup>Univ of Kentucky Medical Ctr, Lexington, KY, USA, <sup>2</sup>University of Kentucky, Lexington, KY, USA,

<sup>3</sup>Vanderbilt Orthopaedic Institute, Nashville, TN, USA, <sup>4</sup>University of Kentucky, Dept. Orthopaedic Surgery, Lexington, KY, USA, <sup>5</sup>Univ of Kentucky Sports Medicine, Lexington, KY, USA, <sup>6</sup>Duke University, Durham NC, NC, USA, <sup>7</sup>Cleveland Clinic Sports Health Center, Garfield Hts, OH, USA.

**Abstract:**

**Objectives:** We present the early results from the "Multicenter Orthopaedic Outcome Network Early Anti-inflammatory Treatment in Patients with Acute ACL Tear and Painful Effusions" (MOON-AAA) clinical trial (figure 1). This trial allows for a well-controlled prospective cohort of patients with isolated ACL injury at risk for OA. We compared the effect of a single versus a repeated dosage of Kenalog within the first two weeks after ACL injury and its effect on chondral degradation in the first 4 weeks prior to surgical reconstruction of the ACL.

**Methods:** 49 patients with isolated ACL tears were enrolled. Knee joints were aspirated and patients received an injection with 40mg Kenalog either within 4 days, 10 days, both time points or not at all (saline injection control). Serum, synovial fluid and urine were collected at 3 time points. Permuted block randomization, triple blinding, independent monitoring and standardized x-ray was performed to comply with GCP standards. Patient reported outcomes were collected at 6 time points up to 6 months post-ACL reconstruction (IKDC, KOOS and Marx activity level). A standardized synovial fluid biomarker panel was analyzed according to OARSJ guidelines. Statistical analysis were performed using SAS mixed models analysis.

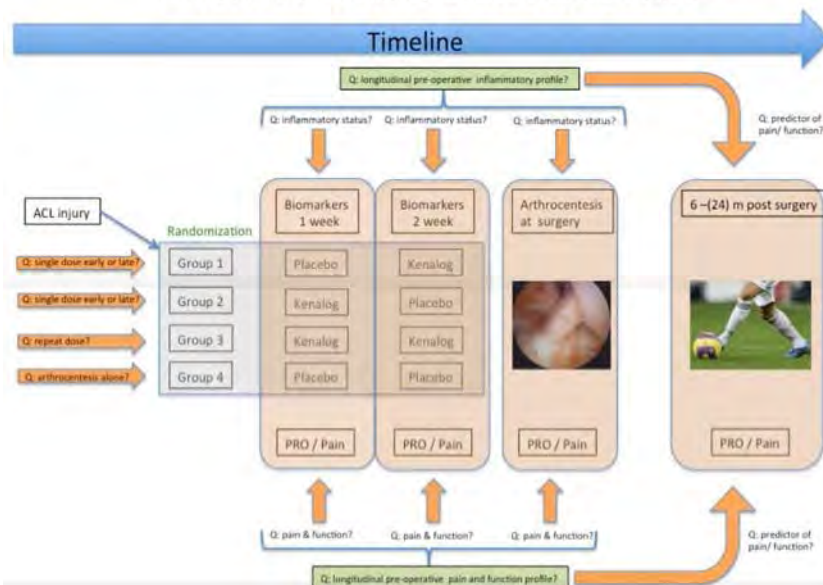
**Results:** Serum analysis shows significant change after injury. Chondrodegradatory markers such as CTX-II, MMP-1 and MMP-3 as well as COMP indicate a progressive destruction of chondral matrix and collagen breakdown. There is a dramatic (250%) increase of CTX-II in the first 4 weeks. Matrix proteins such as MMP-1 and 3 as well as COMP show an initial increase and then a steep decline (see figure 1). Inflammatory markers (IL-1 alpha, IL-1beta, IRAP) show a decline from the time of injury. IL-1 alpha, however shows a dramatic uptake after week 2. This longitudinal data confirms a dramatic onset of early osteoarthritic biomarker profiles immediately after ACL injury as measured in synovial fluid. The administration of 40 mg of Kenalog significantly changes this dynamic. CTX-II shows a dramatic reduction and stays close to baseline levels over the course of 4 weeks pre-operatively. COMP and MMP-1 show a significantly lesser decline. There is no significant difference in the effect of Kenalog if given within 4 days of injury or within 2 weeks. There is a statistical trend indicating that a repeated dose of Kenalog may be more efficient in normalizing the biomarker levels. No AE's, infections were



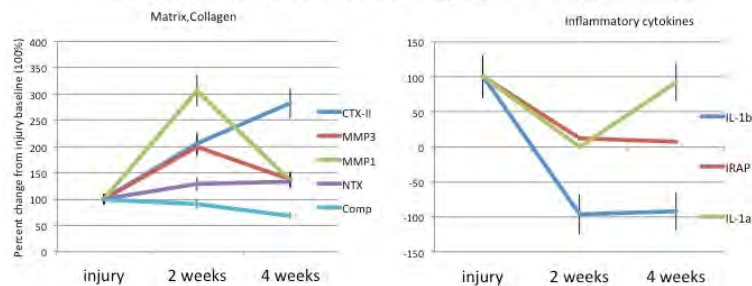
observed. Two of 49 patients suffered a re-tear at 6 months upon return to activities.

**Conclusion:** Our data show that posttraumatic osteoarthritis begins at the time of injury and results early on in dramatic matrix changes in the knee joint. An early intervention with an antiinflammatory agent, such as Kenalog, maybe be able to prevent some of these changes observed. We do not currently know if the early intervention results in meaningful clinical differences in overall outcome. Further follow-up will answer this question. However, it is encouraging that a simple early intervention is able to affect early chondral degeneration. Should the early intervention with Kenalog lead to meaningful changes in outcome at 2 or 6 years the current treatment paradigm for ACL injured patients may have to be changed.

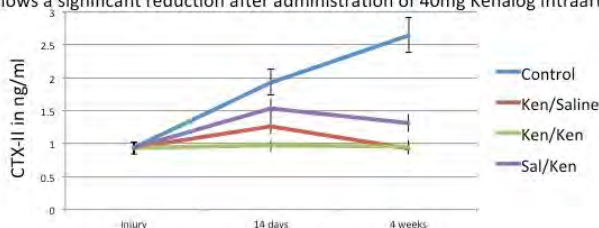
### MOON-AAA Trial: Questions to be asked



### Serum biomarkers after ACL injury at 0, 2 and 4 weeks



CTX-II shows a significant reduction after administration of 40mg Kenalog intraarticularly







**Abstract Number:**

Paper 138

**Abstract Title:**

Magnetic Resonance Imaging of Cartilage Contact and Bound Water in ACL-Deficient and ACL Reconstructed Knees

**Author Block:**

**Geoffrey Scott Baer, MD, PhD<sup>1</sup>**, Jarred Kaiser<sup>2</sup>, Michael Vignos<sup>2</sup>, Fang Liu, PhD<sup>2</sup>, Colin Robert Smith<sup>2</sup>, Richard Kijowski, M.D.<sup>2</sup>, Darryl Thelen, PhD<sup>2</sup>.

<sup>1</sup>University of Wisconsin Hospitals & Clinics, Madison, WI, USA, <sup>2</sup>University of Wisconsin - Madison, Madison, WI, USA.

**Abstract:**

**Objectives:** Osteoarthritis (OA) is common following ACL-reconstructive (ACLR) surgery (6). The cause of early OA is not understood, but theories have focused on osteochondral damage at the time of injury (2) and abnormal joint mechanics following surgical repair (7). In this study, we investigate the inter-relationship of cartilage mechanics and biomarkers of OA in both ACL-deficient (ACLD) and ACLR knees. Our approach employs a novel dynamic MR sequence to measure joint mechanics (3) and the recently developed mcDESPOT to assess regional variations in water bound to proteoglycan (PG) (5). We hypothesize that bound water will be diminished in the cartilage of ACLD knees and, after surgery, will continue to adapt in a manner that reflects altered cartilage loading. This abstract presents initial observations on a cross-section of healthy, ACLD and ACLR knees.

**Methods:** The dominant knees of 8 healthy controls, ACLD knees of 5 patients and ACLR knees of 8 patients were imaged in a 3T MRI scanner (Table). Controls had no history of pain, injury, or surgery to their knee. Patients had no additional ligament injury and no meniscal damage. ACLD subjects were imaged prior to reconstructive surgery. Femoral and tibial cartilage were segmented from MR images and cartilage thickness was calculated. The mcDESPOT sequence provided a fraction map of water bound to PG (Fpg).

Subjects flexed their knee against an inertial load at 0.5 Hz, while a SPGR-VIPR sequence continuously acquired volumetric data. Kinematics were obtained using model tracking of the dynamic images (3). Cartilage was registered to the bone segments for all frames, and contact patterns were characterized by the proximity between surfaces. Spatial representations of tibial cartilage contact, thickness and Fpg were co-registered for each subject.

**Results:** Our initial images suggest lower Fpg values in ACLD knees, primarily on the posterior-lateral tibia. This is also observed in ACLR knees, with additional evidence of diminished Fpg on the weight-bearing medial tibia. Contact patterns were altered in both groups. ACLD tended to exhibit increased contact on the posterior lateral tibia and anterior contact in the medial tibia. Contact differences in the ACLR knees were more subtle, but tended to show a posterior-lateral shift on the medial tibia when compared to control knees (Figure).

These initial observations support our hypotheses that cartilage composition may be altered in ACLD knees and continues to adapt following ACLR. While contact in ACLR knees appears to be restored close



to the healthy condition, we observed a residual shift in the medial plateau. Interestingly, this shift corresponds with a decrease in PG content not observed in ACLD knees. Loss of PG occurs early in OA, prior to any morphological changes (1, 4). Decreased PG content was also observed in ACLD and ACLR knees in the postero-lateral tibia, consistent with observations of edema and cartilage damage following an ACL injury (2).

**Conclusion:** Initial observations of our novel dynamic and quantitative MR images suggests altered cartilage composition due to both injury and abnormal mechanics following surgical repair.

References: 1) Andreisek G et al. 2009. OA Cartilage 17: 8. 2) Bolbos RI et al. 2008. Invest Radiol 43: 14. 3) Kaiser J et al. 2013. MRM 69: 7. 4) Li X et al. 2011. Radiology 258: 10. 5) Liu F. et al 2014. JMRI 39: 8. 6) Lohmander LS et al. 2007. Am J Sport Med 35: 14. 7) Tashman S et al. 2007. Clin Orthop Relat Res 454: 8.

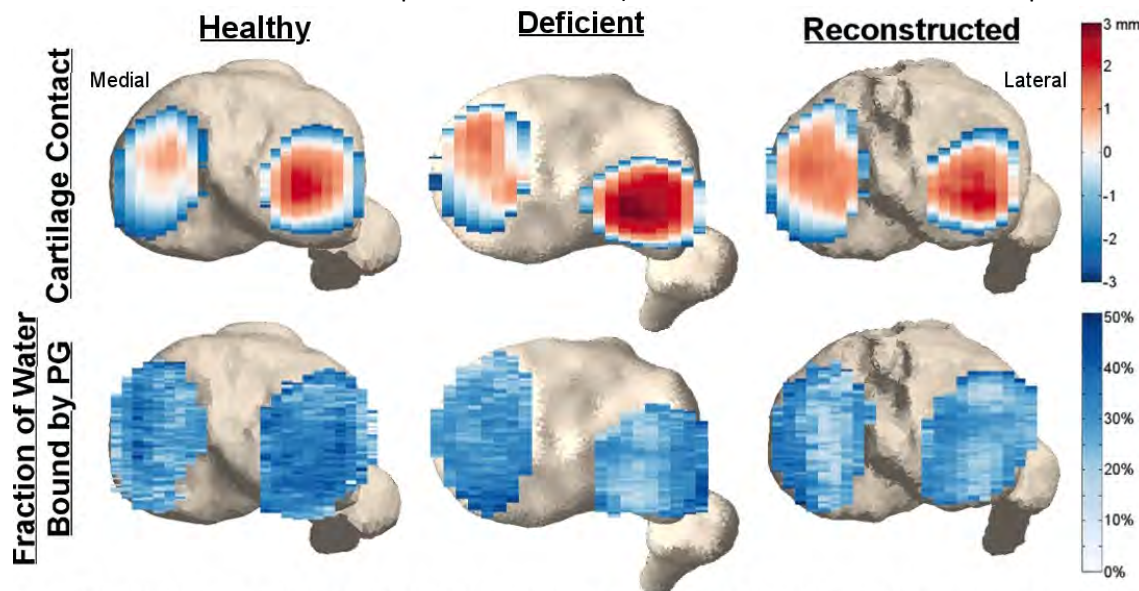


Figure 1. Maps of maximum cartilage contact (top) and fraction of water bound of PG (bottom) for representative subjects of healthy (left), ACLD (center) and ACLR (right) knees. Abnormal contact was observed in the medial compartments of ACLD knees (anterior shift) and ACLR knees (posterior-lateral shift). Decreased PG content was observed in the posterior region of the lateral compartment of the ACLD and ACLR knees, as well as the weight-bearing portion of the ACLR knees in the medial compartment.

Subject Information				
Subjects	Sex	Age (yrs)	Mass (kg)	Years post-surgery
Healthy	5M/3F	25.0 ± 4.8	76.8 ± 12.1	-
ACLD	1M/4F	24.4 ± 6.5	73.9 ± 10.2	-
ACLR	4M/4F	25.5 ± 4.5	78.6 ± 15.2	2.0 ± 0.7



**Abstract Number:**

Paper 140

**Abstract Title:**

Pre-operative Thresholds for Achieving Meaningful Clinical Improvement after Arthroscopic Treatment of Femoroacetabular Impingement

**Author Block:**

**Benedict U. Nwachukwu, MD, MBA**, Kara G. Fields, MS, Danyal H. Nawabi, MD, Bryan T. Kelly, MD, Anil S. Ranawat, MD.

Hospital for Special Surgery, New York, NY, USA.

**Abstract:**

**Objectives:** Knowledge of the thresholds and determinants for successful femoroacetabular impingement (FAI) treatment is evolving. The primary purpose of this study was to define pre-operative outcome score thresholds that can be used to predict patients most likely to achieve meaningful clinically important difference (MCID) after arthroscopic FAI treatment. Secondly determinants of achieving MCID were evaluated.

**Methods:** A prospective institutional hip arthroscopy registry was reviewed to identify patients with FAI treated with arthroscopic labral surgery, acetabular rim trimming, and femoral osteochondroplasty. The modified Harris Hip Score (mHHS), the Hip Outcome Score (HOS) and the international Hip Outcome Tool (iHOT-33) tools were administered at baseline and at one year post-operatively. MCID was calculated using a distribution-based method. A receiver operating characteristic (ROC) analysis was used to calculate cohort-based threshold values predictive of achieving MCID. Area under the curve (AUC) was used to define predictive ability (strength of association) with AUC >0.7 considered acceptably predictive. Univariate and multivariable analyses were used to analyze demographic, radiographic and intra-operative factors associated with achieving MCID.

**Results:** There were 374 patients (mean + SD age, 32.9 + 10.5) and 56.4% were female. The MCID for mHHS, HOS activities of daily living (HOS-ADL), HOS Sports, and iHOT-33 was 8.2, 8.4, 14.5, and 12.0 respectively. ROC analysis (threshold, % achieving MCID, strength of association) for these tools in our population was: mHHS (61.6, 78%, 0.68), HOS-ADL (83.8, 68%, 0.84), HOS-Sports (63.9, 64%, 0.74), and iHOT-33 (54.3, 82%, 0.65). Likelihood for achieving MCID declined above and increased below these thresholds. In univariate analysis female sex, femoral version, lower acetabular outerbridge score and increasing CT sagittal center edge angle (CEA) were predictive of achieving MCID. In multivariable analysis sagittal CEA was the only variable maintaining significance ( $p = 0.032$ ).

**Conclusion:** We used a large prospective hip arthroscopy database to identify pre-operative patient outcome score thresholds predictive of meaningful post-operative outcome improvement after arthroscopic FAI treatment. This is the largest reported hip arthroscopy cohort to define MCID and the first to do so for iHOT-33. The HOS-ADL may have the best predictive ability for achieving MCID after hip arthroscopy. Patients with relatively high pre-operative ADL, quality of life and functional status appear to have a high chance for achieving MCID up to our defined thresholds. Hip dysplasia is an important



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outcome modifier. The findings of this study may be useful for managing preoperative expectation for patients undergoing arthroscopic FAI surgery.



**Abstract Number:**

Paper 141

**Abstract Title:**

Minimally Important Differences and Change across Time in Patients Treated Surgically and Non-Surgically for Full-Thickness Rotator Cuff Tears

**Author Block:**

**Joel Joseph Gagnier, ND, PhD<sup>1</sup>**, Christopher Robbins<sup>1</sup>, Bruce S. Miller, MD, MS<sup>2</sup>.

<sup>1</sup>University of Michigan, Ann Arbor, MI, USA, <sup>2</sup>MedSport, Univ of Michigan, Ann Arbor, MI, USA.

**Abstract:**

**Objectives:** The minimally important difference (MID) is the smallest change in an outcome measure that is perceived by patients as beneficial. The MIDs for the ASES and WORC scores have not been established in a homogenous population of patients with rotator cuff tears. The objective of the present study was to establish the MIDs for patients with known cuff tears who were treated both surgically and non-surgically, and to compare the MIDs over time.

**Methods:** We included 209 subjects with known full-thickness rotator cuff tears who were followed prospectively for two years. The WORC and ASES scores were collected at baseline, 4, 8, 16, 32, and 48 weeks, 1 year and 2 years. At the final follow-up point patients filled out an end-of-study form which included questions regarding change in their condition after treatment.

**Results:** For those that indicated being minimally better, the change from baseline for the ASES score was -20.57 (-2.94 to -38.20) and for the WORC was 418.60 (70.39 to 766.81); both indicated improvement in outcomes. When converted to the percentage change score the WORC change represented 19.93%. The plots of these new MID values for the ASES and WORC indicate that not only does the operative group improve more than the non-operative group but it does so to an extent that is greater than the MID. The non-operative group also improved across time, but the magnitude did not exceed the MID for either the WORC or the ASES.

**Conclusion:** We found that the ASES and the WORC MIDs in patients with rotator cuff tears is different from that previously reported, and that the operative group change was greater than the non-operative group change. This information will directly improve our ability to: (1) Determine when patients with RCTs are changing in a meaningful manner; (2) Accurately power clinical studies using these outcome measures; (3) Make more informed choices of treatments in these patients. This is the first study to report MIDs for the ASES and WORC in a population of patients with strictly rotator cuff disease and to explore their changes relative to MIDs across time.



**Abstract Number:**

Paper 142

**Abstract Title:**

Is There an Association Between the “Critical Shoulder Angle” and Clinical Outcome after Rotator Cuff Repair?

**Author Block:**

**Jacob Matthew Kirsch, MD<sup>1</sup>**, Amit Nathani, MD<sup>1</sup>, Christopher Robbins<sup>1</sup>, Joel Joseph Gagnier, ND, PhD<sup>1</sup>, Asheesh Bedi, MD<sup>2</sup>, Bruce S. Miller, MD, MS<sup>3</sup>.

<sup>1</sup>University of Michigan, Ann Arbor, MI, USA, <sup>2</sup>Domino's Farms, Ann Arbor, MI, USA, <sup>3</sup>MedSport, Univ of Michigan, Ann Arbor, MI, USA.

**Abstract:**

**Objectives:** Variations in scapular morphology have been associated with the development of atraumatic rotator cuff tears (RCT). Current theories suggest a morphologic predisposition for altered shoulder biomechanics favoring the development of RCTs. The critical shoulder angle (CSA) is a radiographic measure that accounts for both glenoid inclination and lateral extension of the acromion, and angles >35 degrees are reported to be correlated with the development of degenerative RCTs. The impact of the CSA on outcomes following rotator cuff repair (RCR) has not previously been investigated. The purpose of this study was to investigate the relationship between the CSA and clinical outcomes after rotator cuff repair.

**Methods:** As part of a prospective observational cohort study we obtained CSA measurements for 144 patients with documented full-thickness RCTs who were followed up for a minimum of 48 weeks. Patients were then stratified based on RCT etiology and treatment. Demographic data as well as The Western Ontario Rotator Cuff Index (WORC), American Shoulder and Elbow Surgeons (ASES) score and Visual Analog Scale (VAS) for pain were collected at baseline, four, eight, 16, 32 and 48 weeks. The CSA for all of the patients was measured retrospectively, with all assessors being blinded to the data and we calculated interclass correlation coefficients (ICC) to measure agreement. The statistical analysis included longitudinal multilevel regression modeling to investigate the association of the CSA and the WORC, ASES and VAS for pain.

**Results:** Controlling for demographic and clinical characteristics, patients with CSAs less than 38 degrees reported better outcome scores over time compared to those with CSAs greater than 38 degrees (WORC: B=-106.6, p=0.025, ASES: B=4.83, p=0.0001, VAS: B=-12.99, p=0.0001). Interobserver and intraobserver reliability for CSA measurements resulted in an ICC of 0.969 and 0.982 respectively, indicating excellent agreement.

**Conclusion:** We found that a CSA less than 38 degrees was associated with better outcomes in patients following surgical repair of atraumatic full-thickness rotator cuff tears. This is the first study to examine the relationship between the CSA and outcomes following RCR. These findings suggest that individual scapular morphology may influence both disease development and surgical outcomes of rotator cuff tears. This association warrants further investigation.



**Abstract Number:**

Paper 143

**Abstract Title:**

Repair Integrity and Clinical Outcomes Following Arthroscopic Rotator Cuff Repair: A Prospective, Randomized Trial of Early and Delayed Motion Protocols

**Author Block:**

**Ariel A. Williams, MD<sup>1</sup>**, Mark P. Cote, RPT<sup>2</sup>, Jessica Megan DiVenere, BS<sup>2</sup>, Stephen Austin Klinge, MD<sup>1</sup>, Robert A. Arciero, MD<sup>2</sup>, Augustus D. Mazzocca, MD, MS<sup>1</sup>.

<sup>1</sup>University of Connecticut Health Center, Dept. of Orthopaedic Surgery, Farmington, CT, USA, <sup>2</sup>Univ of Connecticut Health Center, Dept. of Orthopaedic Surgery, Farmington, CT, USA.

**Abstract:**

**Objectives:** To prospectively evaluate the effect of early versus delayed motion on repair integrity on 6-month postoperative magnetic resonance imaging (MRI) scans following rotator cuff repair, and to correlate repair integrity with clinical and functional outcomes. We hypothesized that repair integrity would differ between the early and delayed groups and that patients with repair failures would have worse clinical and functional outcomes.

**Methods:** This was a prospective, randomized, single blinded clinical trial comparing an early motion (post-op day 2-3) to a delayed motion (post-op day 28) rehabilitation protocol following arthroscopic repair of isolated supraspinatus tears. All patients underwent MRI at 6 months post-operatively as part of the study protocol. A blinded board-certified and fellowship-trained orthopaedic surgeon (not part of the surgical team) reviewed operative photos and video to confirm the presence of a full thickness supraspinatus tear and to ensure an adequate and consistent repair. The same surgeon along with a blinded sports medicine fellowship-trained musculoskeletal radiologist independently reviewed all MRIs to determine whether the repair was intact at 6 months. Outcome measures were collected by independent evaluators who were also blinded to group assignment. These included the Western Ontario Rotator Cuff (WORC) index, Single Assessment Numeric Evaluation (SANE) ratings, pain scores, sling use, and physical exam data. Enrolled patients were followed at 6 weeks, 6 months, and 1 year.

**Results:** From October 2008 to April 2012, 73 patients met all inclusion criteria and were willing to participate. 36 patients were randomized to delayed motion and 37 were randomized to early motion. The final study group at 6 months consisted of 58 study participants. Postoperative MRIs were obtained on all of these patients at 6 months regardless of whether or not they were progressing as expected. These MRIs demonstrated an overall failure rate of 29%. This did not differ significantly based on early or late motion, with 9 (26%) tears occurring in the delayed motion group compared to 10 (32%) in the early motion group ( $p=0.70$ ). When patients with repair failures were compared to those with intact cuffs, no significant differences were detected in range of motion, strength, or WORC, SANE, or pain scores at 6 months or 1 year. Interestingly, however, at 6 weeks, both WORC and SANE scores were significantly better in patients who were later found to have repair failures on MRI ( $p<0.05$ ). When evaluated irrespective of rehabilitation protocol, non-compliance with sling use was associated with higher failures rates ( $p<0.05$ ).



**Conclusion:** Repair failure rates do not significantly differ between patients randomized to early and delayed motion protocols following arthroscopic single tendon rotator cuff repair. Repair failure on MRI does not correlate with clinical outcome at 6 months or 1 year. However, better subjective outcome scores at 6 weeks are associated with higher rates of repair failure at 6 months.





**Abstract Number:**

Paper 144

**Abstract Title:**

Prospective Randomized Study of Arthroscopic Proximal vs Open Subpectoral Biceps Tenodesis: Is One Better?

**Author Block:**

**Reuben Gobezie, MD**, Yousef Shishani, MD, Janice Flocken, MS.  
The Cleveland Shoulder Institute, Cleveland, OH, USA.

**Abstract:**

**Objectives:** The biceps tendon is recognized as a significant source of pain in the shoulder for many patients. Operative techniques for tenodesis of the biceps tendon vary widely. No studies have been conducted directly comparing arthroscopic proximal vs. open subpectoral biceps tenodesis using a prospective study. We aim to compare the functional outcomes, pain relief, and complications of proximal vs. subpectoral biceps tenodesis.

**Methods:** A prospective randomized study of 129 consecutive patients requiring biceps tenodesis for treatment of biceps tendon tears, biceps instability or superior labral tears was performed. Clinical outcome measures used to conduct the study included active range of motion, VAS pain score, ASES score and SANE scores. Complications and revisions were also documented.

**Results:** Mean follow-up was 13.2 months (12-24 months) with 50 subpectoral tenodesis and 46 proximal tenodesis patients reaching minimum follow-up of 12 months. In the subpectoral group, the VAS improved from 5.7 to 2.0 ( $p < 0.001$ ), ASES score improved from 49.8 to 77.7 ( $p < 0.001$ ), and SANE scores improved from 42.1% to 77.7% ( $p < 0.001$ ). In the arthroscopic proximal tenodesis group, the VAS pain score improved from 5.9 to 1.8 ( $p < 0.001$ ), ASES score improved from 52.0 to 82.5 ( $p < 0.001$ ), and SANE scores improved from 42.8% to 78.6% ( $p < 0.001$ ). The revision rate for the subpectoral group was 4% (2/50 patients). The revision rate for the arthroscopic proximal tenodesis group was 8.6% (4/46). Twelve patients had persistent tenderness over the bicipital groove: 7 following proximal tenodesis and 5 following subpectoral tenodesis. No significant difference was found between methods in any outcome measures evaluated.

**Conclusion:** This study found no difference in the functional outcomes or pain relief between proximal vs subpectoral biceps tenodesis. However, revision rates and occurrence of post-operative persistent bicipital groove pain for arthroscopic proximal tenodesis with internal fixation screw were slightly higher than in the subpectoral approach.



**Abstract Number:**

Paper 145

**Abstract Title:**

Patient Reported Outcomes for Rotator Cuff Disease - Which PRO Should You Use?

**Author Block:**

**Eric Chugh Makhni, MD, MBA**, Jason Taizo Hamamoto, BS, John Higgins, BS, Taylor Patterson, Anthony A. Romeo, MD, Nikhil N. Verma, MD.

Midwest Orthopaedics at Rush, Chicago, IL, USA.

**Abstract:**

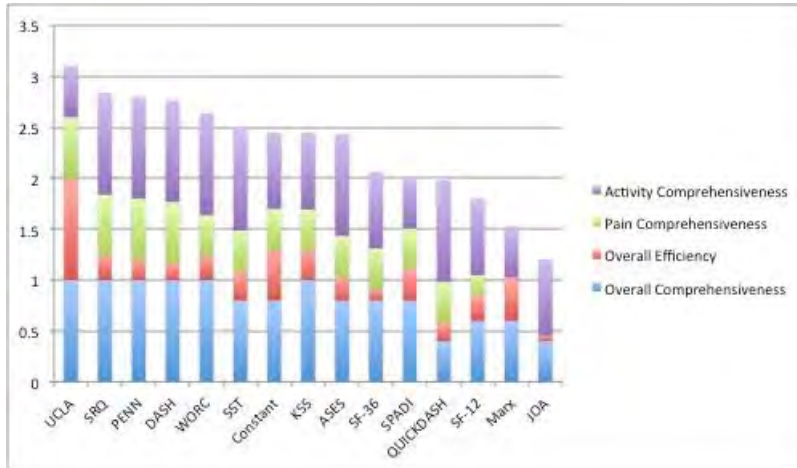
**Objectives:** Patient reported outcomes (PRO) are important clinical and research tools that are utilized by orthopedic surgeons in order to assess health outcomes following treatment. This is particularly so in the setting of rotator cuff pathology, in which several different validated patient reported outcomes exist. However, multiple recent studies have demonstrated a lack of standardization in the utilization of these scores. Moreover, many of these scores contain numerous components, thereby making them difficult to administer in a busy ambulatory setting. The goal of this study was to quantitatively assess the commonly used PRO for rotator cuff disease in order to identify the most efficient and comprehensive ones available for clinicians.

**Methods:** Fifteen different PROs commonly used for rotator cuff pathology were selected for review. These outcome tools were assessed by the study team and reviewed for comprehensiveness with regards to assessment of pain, strength, activity, motion, and quality of life. The comprehensiveness and efficiency of each tool was evaluated by inclusion of questions addressing each domain. PROs were also evaluated with a focus of pain criteria (night pain, baseline/general pain, pain during activities of daily living, pain during sport, and pain during work). Finally, all PROs were assessed with regards to comprehensiveness in assessing activity scores (motion/stiffness, activities of daily living, sport, and work). Comprehensiveness scores were calculated by dividing the number of domains or subdomains present by the total domains or subdomains possible. Efficiency was calculated by dividing the number of domains present by the number of questions contained in each PRO.

**Results:** The UCLA, Western Ontario Rotator Cuff Index (WORC), Disabilities of the Arm, Shoulder, and Hand (DASH), PENN, Shoulder Rating Questionnaire (SRQ), and Korean Shoulder Score (KSS) had an overall comprehensiveness score of 1.00 indicating all domains were present. The American Shoulder and Elbow Surgeons score (ASES), Constant score, Simple Shoulder Test (SST), 36 item Short Form Health Survey (SF-36), and Shoulder Pain and Disability Index (SPADI) had an overall comprehensiveness score of 0.80. The remaining PROs had a score of 0.60 or less. The highest scoring PROs for efficiency were UCLA, Constant, and Marx with scores of 1.00, 0.50, and 0.43 respectively. The UCLA, DASH, PENN, and SRQ had the highest pain comprehensiveness score of 0.60. The ASES, SST, WORC, DASH, Quick DASH, PENN, and SRQ had the highest activity comprehensiveness score of 1.00. The three highest averages of overall comprehensiveness, overall efficiency, pain comprehensiveness, and activity comprehensiveness were the UCLA, SRQ, and PENN PROs with averages of 0.78, 0.71, and 0.70 respectively.



**Conclusion:** This is the first study to quantitatively assess quality and efficiency of patient reported outcomes for rotator cuff tears. The UCLA shoulder score was determined to be the most comprehensive and efficient when compared to fourteen other shoulder PROs in regards to the domains of pain, strength, activity, motion, and quality of life. Clinicians should consider these metrics when incorporating these tools in everyday clinical practice and research.





**Abstract Number:**

Paper 146

**Abstract Title:**

Return To Sport and Recreational Activity Following Osteochondral Allograft Transplantation in the Knee

**Author Block:**

**William Bugbee, MD<sup>1</sup>**, Evan Scott Nielsen, MD<sup>1</sup>, Julie C. McCauley, MPHc<sup>2</sup>, Pamela Pulido, BSN<sup>2</sup>.

<sup>1</sup>Scripps Clinic, La Jolla, CA, USA, <sup>2</sup>Shiley Center for Orthopaedic Research and Education at Scripps Clinic, La Jolla, CA, USA.

**Abstract:**

**Objectives:** Osteochondral allograft (OCA) transplantation is an integral part of the cartilage repair paradigm. There is little data regarding return to sport or recreational activity after OCA. The purpose of the present study was to 1) determine if athletic patients undergoing OCA returned to sport, 2) assess reason(s) why in those who did not, 3) and ascertain patient and graft-related characteristics that differed between those who returned or did not return to sport.

**Methods:** Our institution's OCA database was used to identify 149 knees in 142 patients who participated in sport or recreational activity prior to cartilage injury (45% highly-competitive athletes and 55% well-trained and frequently sporting) and had a minimum follow-up of 1 year (Table 1). The average age was 31 years and 59% were male. The majority of patients (68%) sustained a sports-related injury to their knee and 89% had undergone previous surgery (mean 2.1). Median time from onset of symptoms to OCA transplantation was 2.7 years. Pre-injury and postoperative participation in sport or recreational activity was collected. Patients not returning to their pre-injury level of sport were mailed a questionnaire to assess why, which included knee and lifestyle-related reason(s). Standard objective and subjective outcome measures were also obtained. Further surgery on the operative knee was documented.

**Results:** At a mean follow-up of 6 years, 76% (113 of 149 knees) returned to sport or recreational activity. Among the 113, 28% returned to the same level of pre-injury sport, 48% partially returned (returned to one or more but not all of the same sports or activities), and 25% returned to a different sport or activity. Among the 24% (36 of 149 knees) who did not return to sport or activity, reasons included lifestyle events such as starting a family, changing careers, end of organized sports, knee-related issues, and worry about re-injuring the knee. Postoperatively, 79% of knees were able to participate in a high level of activity (moderate, strenuous, or very strenuous activities), and 71% reported having "very good" to "excellent" function. Thirty-eight of 149 knees (26%) had further surgery following the OCA, of which 14 knees (9% of entire cohort) were considered OCA failures. Survivorship of the OCA at 6 years was 90%. Patients who did not return to sport following OCA were more likely to be female, have injured their knee in an activity other than sports, and had a larger graft size (Table 1). Diagnosis and anatomical location also differed between groups.

**Conclusion:** OCA transplantation is a successful treatment option for athletes and highly active patients who sustain a cartilage injury to their knee. The majority of patients (76%) returned to sport or



recreational activity following the OCA and 28% of those patients returned to the same level of pre-injury sport or activity. Patients often reported that their failure to return to sport was due to lifestyle characteristics such as family or career changes rather than knee-related problems.

Table 1. Comparison of patient characteristics between those who returned to sport and those who did not.

	All patients (N=149)	Returned to sport (N=113)	Did not return to sport (N=36)	p-value*
Age	30.8 ± 11.1	30.1 ± 11.7	32.9 ± 8.9	0.142
BMI (kg/m <sup>2</sup> )	25 ± 4.4	24.9 ± 4.3	25.4 ± 4.7	0.582
Sex (%)				0.042
Male	59	64	44	
Female	41	36	56	
Pre-injury activity level (%)				0.176
Highly competitive athlete	45	49	35	
Well-trained and frequently sporting	55	51	65	
Activity/etiology of injury (%)				0.005
Sports	68	74	47	
Other	33	26	53	
Diagnosis (%)				0.001
Osteochondritis dissecans	43	51	21	
Degenerative chondral lesion	22	15	44	
Traumatic cartilage injury	21	22	18	
Other	14	12	18	
Anatomical location of graft (%)				0.004
Femoral condyle	61	68	41	
Trochlea	15	16	12	
Patella	9	5	21	
Tibial plateau	1	1	0	
Two or more locations	14	11	27	
Allograft size (cm <sup>2</sup> )	7.9 ± 4.9	7.4 ± 5	9.4 ± 4.3	0.042

Data presented as Mean ± SD or %

\*Independent samples t-test or chi-square test



**Abstract Number:**

Paper 147

**Abstract Title:**

Non-operative Treatment Outcomes of Stable Juvenile Osteochondritis Dissecans Lesions of the Knee

**Author Block:**

**Frances Tepolt, MD<sup>1</sup>**, Benton E. Heyworth, MD<sup>2</sup>, Mininder S. Kocher, MD, MPH<sup>3</sup>.

<sup>1</sup>Boston Children's Hospital, Department of Orthopaedics (CERC), Boston, MA, USA, <sup>2</sup>Boston Children's Hospital, Division of Sports Medicine, Boston, MA, USA, <sup>3</sup>Boston Children's Hospital, Boston, MA, USA.

**Abstract:**

**Objectives:** Osteochondritis dissecans (OCD) of the knee most commonly occurs in skeletally-immature pre-adolescent or adolescent patients. Stable juvenile OCD lesions are initially treated via non-operative methods, with varying rates of successful healing reported in the literature. Unloader bracing has been introduced as a relatively new method designed to reduce weight-bearing stress and promote healing for femoral condyle lesions, although the outcomes of unloader bracing compared to other forms of non-operative treatment have not been established.

**Methods:** A retrospective case series was designed to include all patients initially treated non-operatively for stable juvenile OCD of the femoral condyle at a single institution from 2002-2014. Following IRB approval, patient medical records were reviewed for demographic and clinical data, including symptom duration, prior conservative treatment, non-operative treatment modality prescribed and clinical outcome.

**Results:** 223 knees of 196 patients (146/196 (74%) male) underwent non-operative treatment for stable OCD of the medial or lateral femoral condyle. Mean age at presentation 11.5 +/- 1.7 years (range 6-16 years). 27/196 patients (14%) were diagnosed with bilateral OCD at presentation, while 169/196 (86%) presented with unilateral OCD. 180/223 knees (81%) were medial femoral condyle lesions, while 39/223 (17%) were lateral femoral condyle lesions and 4/223 (2%) bicondylar. Reported symptom duration was 10.4 +/- 8.8 months (range 0.1 - 38 months). 222/223 (99.6%) knees presented with knee pain, 68/223 (30%) with one or more mechanical symptoms (swelling, giving-way, locking, clicking). 87/223 (39%) had undergone previous non-operative treatment for an average of 2.1 months. On exam at presentation, 130/223 (58%) had tenderness to palpation noted over the associated femoral condyle or ipsilateral joint line.

Treatment was based on physician preference. 121/223 (54%) were treated with unloader bracing with activity restriction and physical therapy for a minimum of 3 months, while 102/223 (46%) were treated with other (i.e. "non-unloader") conservative therapy. In the non-unloader group, all patients were treated with activity restriction with physical therapy and 32% (33/102) had additional non-unloader bracing or immobilization. Treatment of 26/121 (21%) knees in the unloader group included weight-bearing restrictions compared with 30/102 (29%) knees in the non-unloader group. Unloader bracing was associated with healing in 57/121 (47%) knees, while non-unloader treatment led to healing in 60/102 (59%) (p=0.082). Surgical intervention was pursued for 64/121 (53%) knees in the unloader group, at mean 11.0 months after presentation (range 1.9 - 62 months), all of which included OCD



drilling and 12/121 (10%) of which included OCD fixation. Subsequent surgical intervention was pursued for 42/102 (41%) knees in the non-unloader group, at mean 6.6 months after presentation (range 0.2 - 40 months), all of which required OCD drilling and 11/102 of which included (11%) OCD fixation.

**Conclusion:** Non-operative treatment for stable OCD of the knee in skeletally-immature patients led to healing in approximately half (52%) of cases. No significant difference was seen between outcomes of patients treated with non-operative methods that included unloader bracing versus non-unloader bracing or other modalities.



**Abstract Number:**

Paper 148

**Abstract Title:**

Risk Factors at Time of Primary ACL Reconstruction that Contribute to Significant Chondral Surface Change at Time of Revision ACL Reconstruction: A Prospective Study from the MOON and MARS Cohorts.

**Author Block:**

**Christopher C. Kaeding, MD<sup>1</sup>**, Mars Group<sup>2</sup>.

<sup>1</sup>Ohio State University Sports Medicine Center, Columbus, OH, USA, <sup>2</sup>Washington University St. Louis, St Louis, MO, USA.

**Abstract:**

**Objectives:** Articular cartilage health is an important issue following primary anterior cruciate ligament reconstruction (ACLR). It is not clear what risk factors at the time of primary reconstruction affect future articular cartilage health. The purpose of this study was to examine risk factors affecting chondral surface change in a cohort from the time of primary ACLR to revision ACLR.

**Methods:** Subjects who had both primary and revision data contained in the MOON and MARS registries were included. Data included chondral surface status (grade and size) at time of primary and revision, meniscal status (no treatment/repair,  $\leq 33\%$  excision,  $>33\%$  excision) at time of primary, time from primary to revision ACLR, and age, sex, BMI, Marx, KOOS, and IKDC at time of revision. Significant chondral surface change was defined as  $>25\%$  deterioration between time of primary and revision in the femoral condyle, tibial plateau, patella, or trochlea. Logistic regression was used to test each variable's contribution to significant chondral surface change in the medial compartment, lateral compartment, and patellofemoral compartment.

**Results:** 134 subjects met our inclusion criteria. 34/134 (25.4%) had significant lateral compartment chondral surface change, 32/134 (23.9%) had significant medial compartment chondral surface change, and 31/134 (23.1%) had significant patellofemoral chondral surface change. Median age at time of revision was 19.5 years [IQ range 17-25] and median time from primary to revision was 462.5 days [IQ range 292-1049]. KOOS and IKDC at revision were not associated with significant chondral surface change in any compartment. Patients with  $>33\%$  of their lateral meniscus excised had 13.5 times the odds of having significant lateral compartment surface change compared to subjects who either did not have lateral meniscal damage, had it repaired, or had an excision of  $\leq 33\%$  controlling for age ( $p < 0.001$ ). Patients with  $\leq 33\%$  excision of their medial meniscus had 4.5 times the odds of significant medial compartment surface change compared to subjects who either did not have medial meniscal damage, had it repaired, or had an excision  $>33\%$  controlling for age ( $p = 0.02$ ). Patients had 9% increased odds of significant patellofemoral compartment surface change for each increased point on the BMI scale controlling for age ( $p = 0.05$ ). Odds of significant chondral surface change increased by 5% for each increased year of age ( $p \leq 0.02$ ) in all compartments. Median time from primary to revision surgery, age, and Marx are summarized by chondral change and meniscal status in Table 1.





**Conclusion:** At the time of primary ACLR, excision of >33% of the lateral meniscus significantly increases the risk of worsening articular cartilage health in the lateral compartment at the time of revision ACLR. In the medial compartment, worsening articular cartilage health is significantly increased by excision of ≤33% of the medial meniscus. There appears to be an interaction between time, age, and activity in this cohort. Increased age is a risk factor for deterioration of articular cartilage in all compartments and increased BMI is a risk factor for deterioration of patellofemoral articular cartilage. Clinical Relevance: This is powerful evidence that the largest risk factor for subsequent tibial-femoral chondral degeneration after ACLR is meniscus status, especially for the lateral compartment. Maintaining or restoring meniscus integrity is integral to maintaining long term joint health after ACLR.

Table 1. Median time, age, and Marx score summarized by chondral change and meniscal status						
Medial Compartment						
	Time (days)		Age (years at revision)		Marx score (at revision)	
	No significant change	Significant change	No significant change	Significant change	No significant change	Significant change
Medial Meniscus	Median [Interquartile range]					
No Tear/Repair	427 [286-930]	522 [363-1049]	18 [17-21]	22 [17-40]	16 [12-16]	13 [7-16]
Excision ≤33%	342 [179-350]	630 [224-1630]	28 [20-29]	27 [18-37]	16 [13-16]	11 [2-16]
Excision >33%	987 [374.5-1442.5]	1083.5 [541-2408.5]	25 [19.5-33.5]	26 [21.5-31.5]	12 [5.5-14.5]	7 [3.5-13]
Lateral Compartment						
	Time (days)		Age (years at revision)		Marx score (at revision)	
	No significant change	Significant change	No significant change	Significant change	No significant change	Significant change
Lateral Meniscus	Median [Interquartile range]					
No Tear/Repair	384.5 [282.5-833]	725.5 [416-2046]	19 [17-25]	21.5 [20-31.5]	15.5 [10.5-16]	12 [6-16]
Excision ≤33%	522 [293-743]	920.5 [405-1609]	18 [17-21]	27 [17-37]	16 [14-16]	8.5 [3-16]
Excision >33%	435 [161-720]	847.5 [339.5-1085]	21 [18-22]	18 [16-20]	16 [16-16]	16 [12-16]



**Abstract Number:**

Paper 150

**Abstract Title:**

The Rise of Concussions in the Adolescent Population

**Author Block:**

**Alan L. Zhang, MD<sup>1</sup>**, David C. Sing, BS<sup>2</sup>, Caitlin Marie Rugg, MD<sup>1</sup>, Brian T. Feeley, MD<sup>3</sup>, Carlin Senter, MD<sup>1</sup>.

<sup>1</sup>University of California, San Francisco, San Francisco, CA, USA, <sup>2</sup>University of California, San Francisco, San Francisco, CA, USA, <sup>3</sup>UCSF Orthopedic Institute, San Francisco, CA, USA.

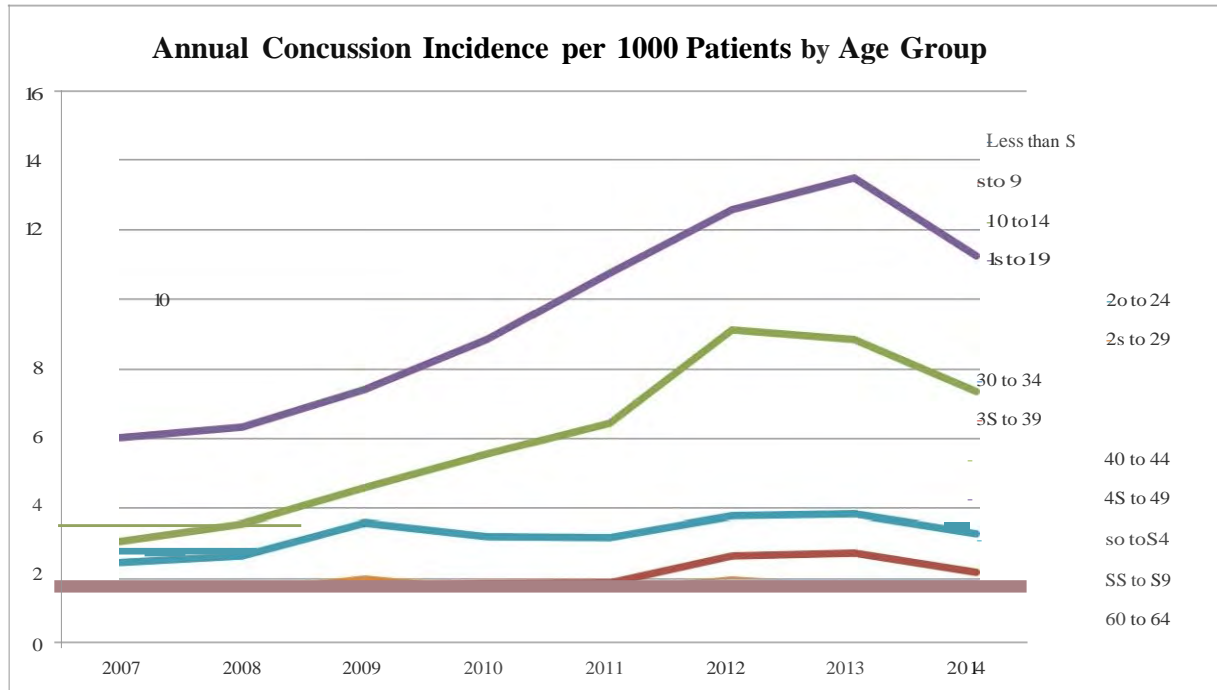
**Abstract:**

**Objectives:** Concussion injuries have been correlated with significant long-term deleterious effects on patients. While recent studies have shown increased traumatic brain injuries (TBI) diagnosed in U.S. emergency departments, no studies have evaluated trends in concussion diagnoses across the general U.S. population in various age groups. The objective of this study is to evaluate the current incidence and trends in concussions diagnosed across varying age groups and healthcare settings in a large cross-sectional population.

**Methods:** Administrative health records of 8,828,248 members of a large private payer insurance group in the United States were queried. Patients diagnosed with concussion from years 2007 through 2014 were stratified by year of diagnosis, age group, gender, classification of concussion, and healthcare setting of diagnosis (e.g. ED vs. physician's office). Chi-square testing was used to for statistical analysis.

**Results:** From a cohort of 8,828,248 patients, 43,884 patients were diagnosed with a concussion. Fifty-five percent of concussion patients were male and over 32% were in the adolescent age group (10-19 years old). The highest incidence of concussion was seen in the 15-19 age group (16.5 cases per 1000 patients) followed by the 10-14 (10.5 per 1000), 20-24 (5.2 per 1000) and 5-9 (3.5 per 1000) age groups. Overall there was a 160% increase in concussion incidence from 2007 to 2014. The largest increases were in the 10-14 (243%) and 15-19 (187%) age groups. Based on ICD-9 classification, 29% of concussions were associated with some form of loss of consciousness. Finally, 56% of concussions were diagnosed in the ED and 29% in a physician's office, with the remainder in urgent cares or inpatient settings.

**Conclusion:** The incidence of concussion diagnosed in the general population in the United States is increasing, driven largely by a substantial rise in the adolescent age group. The youth population should be prioritized for ongoing work in concussion education, diagnosis, treatment and prevention.





**Table 1- Distribution of Concussions by Year, Age Group and Gender**

	<b>Patients Diagnosed with Concussion</b>	<b>Incidence per 1000 patients</b>	<b>P-value</b>
<b>Year</b>			
2007	3529	1.4	
2008	4038	1.6	
2009	4798	2.1	
2010	4740	2.1	
2011	5149	2.2	
2012	6477	2.5	
2013	6936	2.5	
2014	8217	2.3	
			<b>&lt;0.001</b>
<b>Age Group</b>			
<5	1322	1.7	
5-9	1855	3.5	
10-14	5425	10.5	
15-19	8499	16.5	
20-24	3061	5.2	
25-29	2046	2.7	
30-34	1973	2.5	
35-39	2167	2.5	
40-44	2588	2.6	
45-49	2997	2.6	
50-54	3671	2.8	
55-59	4088	3	
60-64	4192	3.1	
			<b>&lt;0.001</b>
<b>Gender</b>			
Female	19,818	6.6	
Male	24,066	9.4	
			<b>&lt;0.001</b>



**Abstract Number:**

Paper 151

**Abstract Title:**

Recovery of Psychological Readiness May Differ Between Genders Following ACL Reconstruction in Adolescent Athletes

**Author Block:**

**Regina Kostyun, MEd<sup>1</sup>**, Julie P. Iannicelli, MS, ATC<sup>2</sup>, Kyle J. Kostyun, MS, ATC<sup>1</sup>, Matthew Solomito, BSBE<sup>3</sup>, Carl W. Nissen, MD<sup>3</sup>, Matthew David Milewski, MD<sup>4</sup>.

<sup>1</sup>Elite Sports Medicine, a Division of Connecticut Children's Medical Center, Farmington, CT, USA,

<sup>2</sup>University of Connecticut, Storrs, CT, USA, <sup>3</sup>Connecticut Children's Medical Center, Farmington, CT,

USA, <sup>4</sup>Elite Sports Medicine - Connecticut Children's Medical Center, Farmington, CT, USA.

**Abstract:**

**Objectives:** Injury to the anterior cruciate ligament (ACL) is a traumatic and emotional event for adolescent athletes. Preparation to return to play (RTP) and the potential risk of re-injury are often equally as emotional as the injury, and have been identified as possible limiting factors to a successful rehabilitation and RTP. In order to create a comprehensive rehabilitation model, further understanding of psychological readiness following surgical intervention is needed. The purpose of this study was to determine if clinical outcomes of subjective knee function and psychological readiness differ between genders following ACL reconstruction surgery in adolescent athletes, and if higher knee function and physiological readiness was associated with an earlier to RTP.

**Methods:** Athletes who underwent ACL reconstruction surgery and were successfully returned back to unrestricted sport were included in the analysis. At approximately six months post-surgery, knee function was assessed using the validated International Knee Documentation Committee (IKDC) Subjective Form, and psychological readiness was assessed using the validated ACL-Return to Sport after Injury (ACL-RSI) scale. Formal clearance to resume unrestricted sport was obtained from clinic notes. A T-test was used to determine if demographics, IKDC and ACL-RSI scores between genders. A mixed effects random intercept regression model was used to determine the association of time to RTP with IKDC and ACL-RSI scores.

**Results:** A total of 45 adolescent athletes (23 females) were included in this analysis. No significant differences were found between males and females for age (16.2±1.5 years, 16.3±2.2 years) and average time to RTP (7.3±2.0 months, 7.3±1.8 months). No significant differences in IKDC scores were found between males and females (88±10%, 87±10%). A trend was identified that males demonstrated higher ACL-RSI scores at six month post-surgery than females (81±14%, 72±17%,  $p = 0.063$ ). In females, higher IKDC scores ( $p=0.013$ ,  $B = -0.09$ ) and higher ACL-RSI scores ( $p = 0.002$ ,  $B = -0.06$ ) were associated with an earlier time to RTP. This association was not found in male athletes.

**Conclusion:** Although both genders felt their knee would function well during sport at approximately six months following ACL reconstruction, male athletes seem to demonstrate an overall stronger psychological readiness to RTP. However, better scores on the ACL-RSI and IKDC were associated with an



earlier RTP only in female athletes. The results of this study suggest a difference in the psychological readiness to RTP between male and female adolescent athletes approximately six months following ACL reconstruction. Further investigations are warranted to investigate the psychological hurdles that face each gender when trying to RTP following an ACL injury. A better understanding of these emotional limitations could help to clinically identify patients that may benefit from counseling.



**Abstract Number:**

Paper 152

**Abstract Title:**

Quality of Movement for Athletes Six Months Post ACL Reconstruction

**Author Block:**

**Polly deMille**<sup>1</sup>, Joseph Nguyen, MPH<sup>2</sup>, Allison Brown, PT, PhD<sup>3</sup>, Huong Do, MA<sup>2</sup>, Elizabeth Selvaggio<sup>2</sup>, Theresa Chiaia, PT<sup>2</sup>.

<sup>1</sup>Hospital for Special Surgery Women's Sports Medicine Center, New York, NY, USA, <sup>2</sup>Hospital for Special Surgery, New York, NY, USA, <sup>3</sup>Rutgers, The State University of New Jersey, Newark, NJ, USA.

**Abstract:**

**Objectives:** Anterior cruciate ligament (ACL) injury prevention programs evaluate quality of movement (QM) to identify and correct high-risk movement patterns. However, return to play (RTP) decisions post-ACL reconstruction (ACLR) are often based on non-sport related quantitative measures such as isokinetic tests and/or time from surgery, with six months post-ACLR being a common expectation for RTP. The purpose of this study was to evaluate whether athletes are ready to RTP 6 months post ACLR using a QM assessment (QMA).

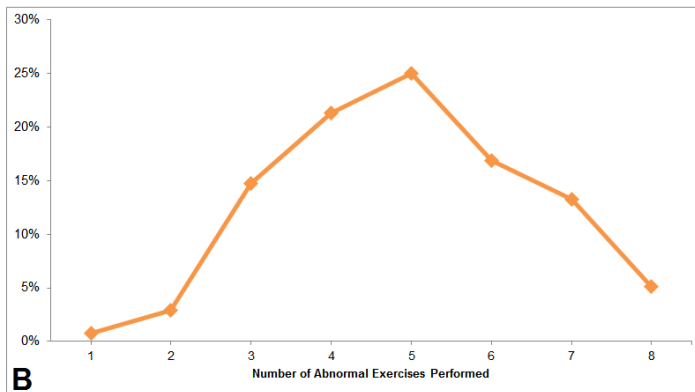
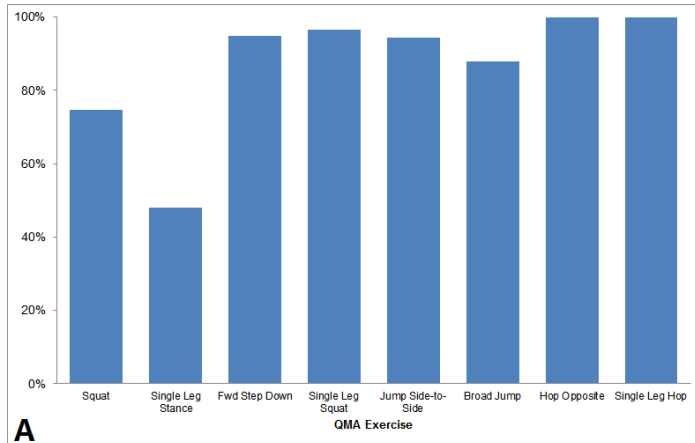
**Methods:** A QMA including nine dynamic tasks (squat, single leg [SL] stance, step down, SL squat, jump in place, side to side jump, broad jump, hop to opposite, SL hop) progressing from double- to single-limb vertical and horizontal movements was administered to 136 athletes at five to seven months post-ACLR. Tasks were viewed from the frontal and sagittal planes by a physical therapist and performance specialist. Movements were evaluated live for risk factors associated with ACL injury (strategy, depth, control, symmetry, and alignment). The proportion of patients exhibiting risky movement patterns for each task was calculated. Fisher's Exact test was used to determine if there were differences in movement patterns between males and females.

**Results:** The proportion of patients demonstrating risky movement patterns for a task ranged from 48% to 100%. All 136 patients exhibited risky movement patterns for at least one task and 60% of patients displayed risky movement patterns in five or more of the nine tasks. Rates of risky movement patterns were not different between males and females for all tasks ( $P > 0.1$  for all tasks).

**Conclusion:** Six months has been cited as a probable time for RTP post-ACLR; thus this is the expectation of the athlete. Our data show that athletes demonstrate multiple QM patterns associated with initial ACL injury, as well as 2nd injury at five to seven months post-operatively. Altered movement patterns evident in tasks as simple as a SL stance remained with the athlete through tasks of increasing difficulty. We recommend that therapists integrate QM screening into rehabilitation with a focus on movement



retraining to address mechanical risk factors prior to RTP.



**A)** Percentage of patients who did not successfully perform each QM exercise. **B)** Percentage of patients who did not successfully perform quantity of QM exercises.





**Abstract Number:**

Paper 153

**Abstract Title:**

Vertical Jump Test as a Functional Test after Anterior Cruciate Ligament Reconstruction

**Author Block:**

**Jin Goo Kim, MD, PhD<sup>1</sup>**, Sang Bum Kim, MD<sup>1</sup>, Kyu-Sung Chung, MD<sup>2</sup>, Jeong Ku Ha<sup>3</sup>.

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**Abstract:**

**Objectives:** Among the various functional tests to determine the return to sports after anterior cruciate ligament reconstruction (ACLR), the most popular one is single leg hop for distance due to its convenience to perform in clinic based offices. Although its popularity, not many clinicians can actually assess with this test because it requires a spacious room to jump across, and another investigator to check the hopped distance, manually. The purpose of this study is to compare vertical jump test which can be assessed easily with a computerized system in a smaller room, with other functional tests, which are used widely as a guide for determining return to sport, and to assess the validity of vertical jump test as a functional performance test after ACLR.

**Methods:** Seventy five ACL reconstructed patients (Mean age : 29.5±9.2 years, Mean height : 172.2±8.2cm, Mean weight : 72.3±11.0kg, Mean time since surgery : 27.5±6.1 months) completed subjective questionnaires (International Knee Documentation Committee (IKDC), Tegner and Lysholm scores) and functional performance tests ; Single leg hop for distance, vertical jump test and three other functional performance tests (Cocontraction, Shuttle run, Carioca tests). Instability was measured with KT-2000. Peak torque/body weight ratio (PT/BW ratio) of extensor and flexor muscle is used to compensate the individual differences in the absolute values of isokinetic muscle strength. Limb symmetry index (LSI, %) was calculated for single leg hop for distance and vertical jump test which were tested separately in each limb. Correlation coefficients between LSI for vertical jump test and other measurements were analyzed.

**Results:** LSI for vertical jump test was correlated to LSI for single leg hop for distance ( $r=0.354$ ,  $p=0.002$ ), cocontraction ( $r=-0.351$ ,  $p=0.002$ ), shuttle run ( $r=-0.358$ ,  $p=0.002$ ), Carioca test ( $r=-0.285$ ,  $p=0.013$ ), IKDC ( $r=0.316$ ,  $p=0.006$ ) and Tegner scores ( $r=0.237$ ,  $p=0.041$ ). There were no correlations with KT-2000 ( $p=0.626$ ) and Lysholm score ( $p=0.198$ ). In isokinetic strength tests, extensor PT/BW ratio (60 deg/sec :  $r=0.298$ ,  $p=0.009$ ; 180 deg/sec :  $r=0.247$ ,  $p=0.033$ ) and extensor strength deficit (60 deg/sec :  $r=-0.412$ ,  $p<0.001$ ; 180 deg/sec :  $r=-0.306$ ,  $p=0.007$ ) were correlated to LSI for vertical jump test, whereas flexor PT/BW ratio and flexor strength deficit were not.

**Conclusion:** As the degrees of functional performance, subjective outcome scores and recovery of extensor strength are correlated with LSI for vertical jump test which clinician can easily assess with a computerized system in clinical offices, we suggest vertical jump test as a functional test after ACLR to determine the return to sports.



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**Abstract Title:**

Influence of Combinations of Shoulder, Elbow and Trunk Orientation on Elbow Joint Loads in Youth Baseball Pitchers

**Author Block:**

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**Abstract:**

**Objectives:** Shoulder and elbow pain in youth baseball pitchers is a well-recognized phenomenon. Common problems in pitching mechanics that can lead to injury begin with stride foot contact. The purpose of this study was to address the relationships between the combinations of shoulder, elbow and trunk orientation at the instant of stride foot contact and elbow joint loads in youth baseball pitchers.

**Methods:** A total of 143 Japanese male youth baseball pitchers participated in this study after providing written informed consents approved by the hospital's institutional review board. The procedures to be performed were also explained to their parent(s) or legal guardian(s). Each participant was not currently injured or recovering from an injury at time of testing.

For data collection of baseball pitching, a set of 14-mm spherical reflective markers was placed on the skin overlying 34 anatomical landmarks determined. Subsequently, a motion capture three-dimensional automatic digitizing system was used to collect 500-Hz from 7 charge-coupled-device synchronized cameras was set up around the regulation pitching mound in an indoor laboratory. After performing a preparation routine of stretching and warm-up pitching, each player pitch to 5 fastball pitches off the pitching mound to a catcher at the regulation distance of 16 m for youth pitchers. The best pitch thrown for a strike was chosen for kinematic and kinetic analysis.

The local coordinate systems were used to calculate 3-dimensional rotation at the trunk, shoulder and elbow using the typical Eulerian sequence. Afterward, the standard inverse dynamic equation was used to estimate resultant joint forces and torques at throwing shoulder and elbow. In order to normalize data between subjects, forces and torques were expressed as percent using body weight and height. A multiple regression analysis was carried out to assess the combined effects of shoulder (external rotation, abduction and horizontal adduction), elbow (pronation and extension) and trunk (extension, contralateral tilt, rotation) orientation at SFC and the onset time of trunk rotation on elbow joint loads at SFC. The onset time of trunk rotation was defined as the event in which the magnitude of trunk rotation begins to decrease from its maximum value.

**Results:** The peak medial force of the elbow was significant correlated with the peak internal rotation torque of the shoulder and the peak varus torque of the elbow (Figure1). The medial force of the elbow at SFC was significantly correlated with the peak medial force of the elbow ( $r = .41, p < .001$ ). The



adjusted multiple R<sup>2</sup> value was 0.45, indicating that over 45% of the variance in the medial force of the elbow at SFC was explained by the regression equation. The standard error of estimate was 4.34. All 3 of the regression variables were significant and are shown in Table1.

**Conclusion:** The combinations of the greater external rotation of the shoulder, contralateral trunk tilt and elbow extension at SFC may have an indirect influence on the peak medial force on the elbow (Table1). Then the peak elbow varus torque and shoulder internal rotation torque lead to increase as a result of these. These biomechanical data provide a scientific basis for clinicians, athletes, and coaches to establish methods to prevent pitching-related injuries and improve pitching mechanics.

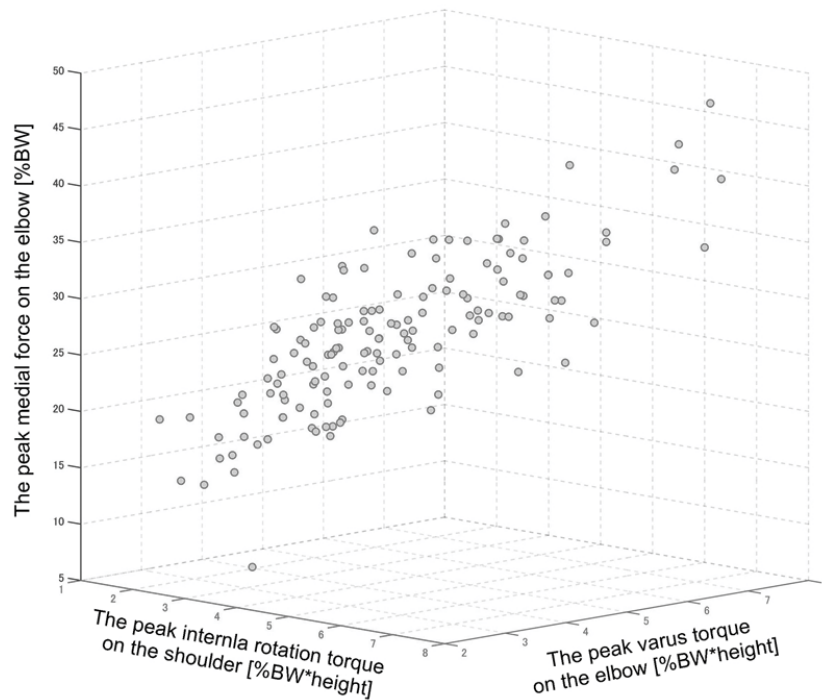


Figure1. The relationships between the peak medial force on the elbow and elbow varus torque and shoulder internal rotation torque

Table1. Significant variables in the medial force on the elbow at the instant of stride foot contact (SFC) with multiple regression analysis

Variable	Standard coefficient	P value
Shoulder external rotation at SFC	.507	< .001
Trunk contralateral tilt at SFC	.263	< .001
Elbow extension at SFC	.145	.035