Effectiveness of the Women's Lacrosse Protective Eyewear Mandate in the Reduction of Eye Injuries

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Objectives:
The objective was to evaluate the effect of the women's lacrosse protective eyewear mandate on eye injury rates at the high school level. In addition, we assessed changes in head and facial injury rates, as well as concussion and overall injury rates to address potential unintended consequences associated with the rule change.

Methods:
The high school women's lacrosse population was represented by the 25 public high schools in Fairfax County, VA, during the 2004-08 spring seasons. Injury rates were compared with those from the same data source during the 1999-2003 seasons. Pre-post mandate injury rates were evaluated adjusting for athletic-exposures, or total opportunities for injury to occur throughout the season.

Results:
The rate of eye injuries was reduced from 0.06 injuries per 1000 athletic-exposures during the period preceding the use of protective eyewear to 0.02 injuries per 1000 AE for the years 2004-07 (Incident Rate Ratio (IRR): 0.32, 95% CI: 0.11-0.96). Similarly, rates of other head/face injuries decreased with an IRR = 0.73, 95% CI: 0.42-1.20. However, IRRs of concussion (2.2, 95% CI: 1.5-3.2) and all injuries combined (1.5, 95% CI: 1.3-1.7) increased in the more recent time period.

Conclusions:
Women's lacrosse rules were changed in 2003 to mandate the use of eye protection. Although women's lacrosse is an incidental contact sport, there have been higher rates of head and facial injuries among women than men reported in both the collegiate and high school level. This study identified a reduction in both eye and other head/face injuries following the rule change. This is one of a limited number of studies that have documented the effectiveness of a rule change or protective equipment in the prevention of sports injuries. Increases were identified for rates of concussions and all injuries post-mandate.

Whether these increases are
Whether these increases are related to the introduction of protective equipment, improved recognition of concussion by clinical and team personnel, a perceived increase in the level of aggressive play over time, or some other cause remains to be determined.

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Nothing to disclose
Anterior Cruciate Ligament and Intercondylar Notch Growth Plateaus Prior to Longitudinal Growth: An MRI Observational Study

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Objectives:
With the increased incidence of anterior cruciate ligament (ACL) injuries in the skeletally immature patient population, ACL reconstructions are increasingly being performed. We aim to characterize anatomical data on the growth patterns of the ACL, intercondylar notch and tibial height in younger children.

Methods:
A knee MRI database of 137 studies performed at our institution of patients 13 years of age or younger excluded patients with ACL rupture, previous surgery, congenital structural anomalies or syndromes. ACL and intercondylar notch volumes (expressed in mm3) were estimated by measurement of cross sectional areas on sequential images of known slice thickness. Tibial epiphyseal height was measured on sagittal proton density sequences at the ACL tibial insertion. Statistical analyses were performed with patients aged 3 to 6 evaluated as one age group, followed by yearly grouping of patients through age 12.

Results:
137 MRIs performed in 135 patients aged 3 to 13 years were reviewed. A high linear correlation between patient age and ACL volume was demonstrated (Pearson correlation = 0.75). There was a mean increase of 148 ± 11 mm3 per age group (p<0.0001) (Fig 1). Sex was not a significant predictor of ACL volume in a multiple linear regression (p=0.57). Notch volume exhibited a mean increase of 835 ± 58 mm3 per age group (p<0.0001). Female patients had notch volumes on average 892 ± 259 mm3 smaller than male patients of the same age (p<0.0006). Notch and ACL volume reached a plateau at 10 years of age. There was a moderate linear correlation between patient age and height (Pearson correlation = 0.6).

Conclusions:
ACL and notch volume reach adult size by age 10 in the majority of patients. This plateau comes 4 and 6 years prior to the halt in longitudinal growth in females and males, respectively. This growth pattern is relevant when selecting graft size for ligament reconstruction. Females had smaller notch volumes as compared to males. This finding in addition to no significant differences found in ACL volumes between genders, suggests notch volume as an etiologic factor for the prominence of ACL injuries in women's sports. Statistically significant differences in ACL and notch dimensions also highlights the need for pediatric specific knee MRI protocols, with adequate through plane resolution, to allow for appropriate visualization of ligaments in young children.
Anterior Cruciate Ligament and Intercondylar Notch Growth Plateaus Prior to Longitudinal Growth: 
An MRI Observational Study

Relevant disclosure declaration for all authors: 
Nothing to disclosure
A Speed Distance-Based Classification System for Injury Prevention and Research in International and Domestic Youth Baseball Players

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Objectives:
An objective classification system for studying youth baseball players in the US based on a mathematical model, developed and validated on a sample of 967 boys was published in 1996. If the classification system is applicable to international samples, true epidemiologic comparisons can be made. Injury risk, biomechanics and pitching maturation studies can define their populations. The purpose of this study therefore was to determine if the classification system is generalizable to an international sample of youth players from countries that regularly contribute players to the Little LeagueTM World Series and MLB.

Methods:
721 international baseball players, ages 8-14, threw 5 full-speed pitches recorded with a calibrated radar gun and 4 maximum distance throws on a marked field. Demographics included age, height, weight and years pitched. Collection sites included local baseball clubs (Dominican Republic, Venezuela, Puerto Rico, Japan and the Philippines), a national tournament (Mexico), and a multinational tournament (Brazil, Peru and Colombia). The 1996 US model was used to generate predicted distances for this sample for comparison with actual distances. In addition to the overall analysis, adequate sample sizes were available for comparing predicted and actual distances by country for four of the countries (Dominican Republic, Japan, Puerto Rico and Venezuela).

Results:
The Pearson correlation between predicted and actual distance was .90 (p<0.001; Figure 1). For the four countries for which we had sufficient sample size across age groups to perform individual analyses (Dominican Republic, Japan, Puerto Rico and Venezuela) the r2 values ranged from .85 to .92 (p<0.001). The mean of the international players was 1-2 standard deviations above the USA mean for speed and one standard deviation above the mean for distance. There was no systematic over or under prediction indicating that both relative and absolute fit for the model was excellent.

Figure 1. Graph of predicted distance from the original model versus actual maximum throwing distance for the entire sample.
A Speed Distance-Based Classification System for Injury Prevention and Research in International and Domestic Youth Baseball Players

Conclusions:
The strong correlation between actual and predicted distance demonstrates that the model is robust and generalizes to the entire international sample. These data suggest that the classification is valid and can be used prospectively and retrospectively to categorize pitchers to allow for studies of youth baseball injury epidemiologically and to allow for classification for biomechanical or interventional studies in youth baseball internationally.

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Gender Helps Determine Peak ACL Strain

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Objectives:
Large ligament strain increases the risk of ligament rupture. The female anterior cruciate ligament (ACL) cross-sectional area is approximately 20% smaller than in males [1]. It is not known whether this gender difference leads to larger peak ACL strain in females under dynamic loading. We tested the primary null hypothesis that there is no difference in peak ACL strain between female and male knees from donors of similar height and weight. A secondary hypothesis was that ACL cross-sectional area would explain a significant portion of the variance in peak ACL strain.

Methods:
Twenty cadaveric knees from height- and weight-matched male and female cadavers were subjected to impulsive 3D test loads (two-times body weight in compression, flexion and internal tibial torque) using a modified Withrow testing apparatus to simulate a unipedal pivot landing [2]. The realistic 3D forces and moments applied to the knee, and pre-tensioned quadriceps, hamstring and gastrocnemius muscle forces were measured. The quadriceps muscle stretch behavior was simulated using a gender-specific, non-linear spring. Peak relative strain in the anteromedial bundle of the ACL (‘AM-ACL’) was measured using a DVRT, while ACL cross-sectional area was measured at 30% of ligament length from the tibial insertion using magnetic resonance imaging. Pre- and post-baseline trials of compression and flexion were examined to ensure ACL integrity. A repeated measures Mann-Whitney signed-rank test was used to test the primary hypothesis, while linear regression was used for the secondary hypothesis.

Results:
Female knees exhibited 95% greater mean [SD] peak AM-ACL relative strain than male knees (6.37% [2.53%] vs. 3.26% [1.89%], p = 0.004, Fig. 1a). ACL cross-sectional area (A) was a significant predictor of the peak AM-ACL relative strain (s) (s = -20.98*A + 11.18, R = -0.665, p = 0.003, Fig. 1b).

Conclusions:
The female ACL undergoes systematically greater peak strain than the male ACL for similarly-sized individuals during a pivot landing. This gender difference can be explained primarily by the smaller cross-sectional area of the female ACL. The higher strain levels in the female ACL will lead to rupture under fewer loading cycles than males due to the known fatigue behavior of ligament. Training and injury prevention programs should take this fact into consideration.
Gender Helps Determine Peak ACL Strain

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References:

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Risk Factors for Shoulder and Elbow Injuries in High School Baseball Pitchers: The Role of Preseason Strength and Range of Motion

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Objectives:
The extent to which strength and range of motion (ROM) adaptations are predictive of injury in high school baseball pitchers is not known. It was hypothesized that ROM asymmetries and weakness would be predictive of injury.

Methods:
Preseason strength and ROM measurements were made on 92 pitchers from 4 different high schools. Eight pitchers were tested prior to 3 consecutive seasons and 30 prior to 2 seasons (total 140 pitcher-seasons; 25 Freshman, 38 Junior Varsity, 77 Varsity). Internal rotation (IR), external rotation (ER) and posterior shoulder (PS) ROM were measured bilaterally. Strength in IR, ER, supraspinatus (empty can test), and scapular retraction was measured bilaterally (hand-held dynamometer). Injury incidence (injuries per 1000 pitches) was computed for players categorized as above normal (≥1 SD above mean), normal (within 1 SD of mean), and below normal (≤1 SD below mean) for each potential risk factor. Injury was defined as a missed game or practice due to shoulder or elbow problem. Pitchers throwing less than 90 pitches during the season were excluded from risk analyses. It was estimated that with normally distributed data there was 80% power to detect a relative risk of 4.0 between above- and below-normal groups at P<0.05.

Results:
The dominant versus nondominant arm had on average 9±11º less IR ROM, 7±11º more ER ROM, 8±15º less PS ROM (all P<0.001), and minimal difference in total ROM (2±12º, P=0.05). IR strength was 7.5% greater (P<0.001) on the dominant arm with no side-to-side differences in other tests. 24 pitchers sustained a shoulder (18) or elbow (6) injury (0.59 injuries/1000 pitches). Injury incidence was 0.14 (95%CI 0.04-0.79) for pitchers with above-normal loss of IR ROM (≥20º), 0.52 (0.32-0.87) for pitchers with normal IR ROM loss (19º-0º loss), and 1.31 (0.58-3.05) for pitchers with below-normal IR ROM loss(<0º loss) (linear trend P=0.016). Other ROM and strength measures were unrelated to injury risk. Age did not affect injury risk (P=0.75), however, no Freshman pitchers had above normal IR ROM loss compared with 8% of Junior Varsity and 17% of Varsity pitchers (P=0.03).

Conclusions:
Excessive loss of IR ROM in adult pitchers is thought to be a risk factor for injury. By contrast, in this study pitchers with no loss of IR ROM had increased risk of injury versus players with marked IR loss. The absence of IR ROM loss in high school pitchers may indicate inadequate prior exposure to pitching resulting in increased injury risk.

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No Disclosure
The Effect of High Pitch Volume on Musculoskeletal Adaptations in Adolescent Baseball Pitchers

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Objectives:
The objective of this study was to examine the effect of pitch volume on in-season, and year-to-year changes in shoulder range of motion (ROM) and strength in adolescent baseball pitchers. It was hypothesized that high pitch volume would magnify range of motion asymmetries.

Methods:
Shoulder strength and ROM measurements were made prior to and following the spring baseball season in 88 high school pitchers, with 53 pitchers tested on consecutive seasons. Internal rotation (IR), external rotation (ER) and posterior shoulder (PS) ROM were measured bilaterally. Strength in IR, ER, supraspinatus (empty can test), and scapular retraction was measured bilaterally with a hand-held dynamometer. Pitchers were categorized by pitch count for the season (high >400 n=28, moderate 150-400 n=30, low <150 n=30). ROM and strength changes on the dominant versus nondominant arm were assessed by Time (pre-to-post or year-to-year) by Pitch Volume (high, moderate, low) by Side (dominant, nondominant) ANOVA. The estimated effect sizes (P<0.05, 80% power) with 88 pitchers (in-season effects) were 3-5º for change in IR, ER and PST, and 5-7% for strength. Effect sizes for 53 pitchers (year-to-year effects) were 5-8º for ROM and 7-10% for strength.

Results:
Supraspinatus strength decreased on the dominant arm during the season (Time x Side P=0.02) with 15% loss in high volume pitchers (P<0.001) and insignificant losses in moderate and low volume pitchers (4%, P=0.54; 7%, P=0.09). Strength in other tests was unaffected. Consistent with physical development, strength increased bilaterally from one year to the next (16-33%, P<0.001). However, supraspinatus strength on the dominant arm was affected by pitch volume in the prior season (Side x Time x Pitch Volume P=0.04): 33% increase in low volume pitchers (P<0.001), 9% increase in moderate and high volume pitchers (P=0.32). Shoulder ROM asymmetries did not change from pre to post season or from one year to the next (P=0.53-0.64), with no effect of pitch volume (P=0.21-0.88).

Conclusions:
A high pitch volume was associated with supraspinatus strength loss during the season and diminished strength gains from year to year. ROM asymmetries did not progress during the season, or from year to year, and were unaffected by pitch volume. In conclusion, in high school pitchers a high pitch volume had a catabolic effect on supraspinatus strength.

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No Disclosure
Bony Adaption of the Proximal Humerus and Glenoid Correlate within the Throwing Shoulder of Professional Baseball Pitchers

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Objectives:
Elite throwing athletes have increased proximal humerus retrotorsion and glenoid retroversion in their throwing shoulder compared to their nonthrowing shoulder. These adaptive morphologic changes are thought to be independently protective against shoulder injury, but we do not understand how they are related to each other. In this study, we hypothesized there is a positive association between proximal humerus retrotorsion and glenoid retroversion within the same shoulders of professional pitchers.

Methods:
Proximal humerus retrotorsion (HRT) glenoid retroversion (GRV) and measurements were determined by validated techniques in asymptomatic bilateral shoulders of 32 professional pitchers (mean age= 23). Three measurements for each variable were averaged, analyzed and reliability of the techniques was verified. Pearson correlation coefficients were used to assess the relationship between HRT and GRV within same shoulders. Paired t tests were used to compare HRT and GRV between the throwing (T) and non-throwing shoulder (NT). Simple ratios were calculated between HRT and GRV.

Results:
HRT and GRV were both significantly greater on the throwing side compared with the nonthrowing side (HRT: T=9.0° ±11.4° and NT=22.1° ±10.7°, p<0.001 and GRV: T=8.6° ±6.0° and NT=4.9° ±4.8°p=0.001). Within same shoulders, there was a significant positive association between HRT and GRV only on the Throwing side (r=0.43, p=.016) and not the NT side (r=-0.13, p=.50) indicating that HRT increased concurrent with GRV on the Throwing side, not the nonthrowing side. The HRT:GRV Ratio calculated for throwing shoulders was 2.3:1 while in nonthrowing shoulders was 7:1.

Positive Correlation between Humeral Retrotorsion and Glenoid Retroversion
Conclusions:
We found there is a significant positive correlation of adaptive morphologic changes between the proximal humerus and glenoid only within same throwing shoulders and not within nonthrowing shoulders of professional baseball pitchers. The concurrent increases in proximal humerus retrotorsion and glenoid retroversion were observed in a relatively concise 2:1 “throwers’ ratio”, suggesting there is a coupled relationship between the bony adaption which occurs on both sides of the throwing shoulder during the athletes’ developing years. Future studies will aim to clarify if the magnitude and consistency of the throwers’ ratio is associated with shoulder injury.

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Humeral Retrotorsion is Associated with Decreased Shoulder Internal and Horizontal Adduction Range of Motion in the Professional Pitchers But Not Elite Quarterbacks

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Objectives:
Humeral torsion (HT) is thought to contribute to the alterations in shoulder external (ER), internal (IR), and horizontal adduction (HA) range of motion (ROM) in the throwing (T) shoulder. It is unknown the influence on osseous adaptations or shoulder ROM between pitching and football. Therefore, the purpose of this study was to compare HT and shoulder ROM between a group of professional pitchers and quarterbacks (QB) participating at the 2010 NFL Combine.

Methods:
Fifty professional pitchers (age=23) and 17 elite QBs (age=22) were currently asymptomatic and participating without restriction in spring training or the NFL Combine respectively. Supine ER, IR, HA ROM was measured with the scapula stabilized at 90° of abduction and HT was assessed via indirect ultrasonographic technique1,2. 2 trials were averaged for analysis. A mixed-model ANOVA (sideXsport) was used to compare the T and NT shoulder for HT, ER, IR, HA between sports. Pearson correlation coefficients and a stepwise linear regression were then evaluated to assess to what degree ER, IR, and HA was influenced by HT for each sport (α = 0.05). Only effects involving sport were interpreted.

Results:
Pitchers displayed greater ER ROM (130°±9.5°) compared to QBs (117.3±11°). There were no significant interactions effects indicating that sport did not influence side to side differences in HT, IR, or HA (p>.05). The T shoulder of pitchers displayed significant correlations between HT and IR (r=-.67; p<0.01), HA (r=-.50; p<0.01), and ER (r=-.27; p=0.01). There were no significant correlations between HT and IR (r=-0.33; p=0.11), HA (r=-.34; p=0.09), or ER (r=-.24; p=0.17) in QBs. Regression analyses revealed that both IR (R2=.45, P<.05) and HA (R2=.25, P<.05) were significant predictors of HT. The final regression model indicated IR and HA together predicted HT (R2=.52, P<.05) independent of gains in ER (R2=.12, P=.14) for pitchers.

Conclusions:
Our results show pitchers display greater overall ER ROM but similar alterations in T shoulder IR and HA to QBs. HT influences clinical measures of shoulder IR and HA ROM in pitchers independent of gains in ER. However, HT did not influence T shoulder ROM in elite QBs. These results suggest the pitching shoulder IR and HA ROM is largely influenced by osseous adaptations while the T shoulders of QBs are likely explained by soft tissue adaptations. Clinicians should carefully interpret pitcher’s and quarterback’s shoulder ROM. Future studies should examine a larger sample of quarterbacks as this may influence the results.

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References:

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Evaluation of rhPDGF-BB in Combination with a Bi-phasic Collagen Implant for Osteochondral Defect Repair in a Caprine Model

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Objectives:
Platelet-derived growth factor-BB (PDGF-BB) is a well characterized wound healing protein known to be chemotactic and mitogenic for cells of mesenchymal origin, including osteoblasts and chondrocytes [1,2]. Biocompatible scaffolds, combined with growth factors such as PDGF-BB, have potential to stimulate regeneration and repair of osseous and cartilaginous tissues. The purpose of this study was to determine the efficacy and safety of recombinant human PDGF-BB (rhPDGF-BB) combined with a collagen implant to augment healing of osteochondral defects.

Methods:
A single osteochondral defect (8mm x 8mm) was created in the medial femoral condyle of 32 adult goats. Collagen implants (8.5mm x 8mm) hydrated with four doses of rhPDGF-BB(0µg, 15µg, 75µg, 500µg) were press-fit into the defect. Defects in four animals were left untreated. All goats were sacrificed 12 weeks postoperatively. Macroscopic evaluation and quantitative micro-computed tomography (µCT) analyses were performed. Histologic sections were stained with Safranin O/Fast Green and assessed with a modified O’Driscoll scoring scale for cartilage and bone repair [3]. Significance was determined by One-Way ANOVA or nonparametric Kruskal-Wallis(p≤0.05).

Results:
Macroscopic evaluation indicated significant improvement of the gross cartilage repair score for the rhPDGF-BB treatment groups compared to the 0µg rhPDGF-BB control (500µg; 0µg) and empty defect groups (500,75,15µg; Empty). µCT analysis (Figure 1) indicated a significant increase in trabecular number for the 500µg group compared to 0µg control, 75µg, and Empty groups(p=0.004). Average bone volume reconstitution for the 500µg group was increased (58.8%) compared to the 0µg control. The total cartilage repair score was significantly improved (p=0.048) in the 500µg group (14.3±0.3) compared to the 0µg control (12.1±0.4). All rhPDGF-BB treatment groups exhibited increased Safranin-O staining of the matrix compared to the 0µg control group, and a significantly decreased incidence (p=0.01) of subchondral cyst formation compared to the empty defect group.

Conclusions:
Macroscopic, radiographic, and histologic assessment indicate enhanced reconstitution of the subchondral bone and overlying repair tissue for rhPDGF-BB treatment groups compared to control. Combined with a significant decrease in cyst formation in all rhPDGF-BB treatment groups, these results suggest that rhPDGF-BB, combined with a collagen implant, may have promise as a therapeutic agent for osteochondral defect repair.
Evaluation of rhPDGF-BB in Combination with a Bi-phasic Collagen Implant for Osteochondral Defect Repair in a Caprine Model

References:

Relevant disclosure declaration for all authors:
No disclosure.
The Chondrotoxicity of Single-Dose Local Anesthetic Injections

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Objectives:
Despite generally positive patient outcomes, the chondrotoxicity of local anesthetics has become increasingly evident. Investigation of the administration of these medications via pain pumps or multiple injections has revealed chondrotoxic patterns. The purpose of this study was to evaluate whether single-dose injections of three commonly used local anesthetics also result in decreased chondrocyte viability.

Methods:
Human chondrocytes were seeded at a density of 0.5 X 10^6 cells/well in 6 well plates and cultured for one week in media. A bioreactor was used to simulate normal joint fluid metabolism. The clinically relevant dose of 10 cc was adjusted to account for decreased cartilage surface area of experimental conditions versus human knee. Three anesthetics were tested: 1% Lidocaine, 0.25% Bupivacaine and 0.5% Ropivacaine. Each medication was delivered to the chondrocytes over the average duration of action of each drug. A Live/Dead Viability/Cytotoxicity Assay was used for staining and evaluation of the cultures. The ratio of dead: live cells were then calculated. ANOVA tests using post-hoc Bonferroni's multiple comparison method were used to determine the p-value for each anesthetic in comparison to media control at each time point. Results were considered significant at p <0.05.

Results:
Chondrocytes treated for three hours with 1% Lidocaine demonstrated a significant decrease in viability (7.60% cell death ± 1.88%) when compared with those in the control medium (2.83± 1.88%, p=0.000). No significant decrease in cell viability was observed in chondrocytes treated for six hours with 0.25% Bupivacaine compared to those in control medium (2.69± 1.39% vs. 2.57± 1.97%, p=1.00). Similarly, cells treated for 12 hours in 0.5% Ropivacaine did not show a significant difference in viability when compared with the control cohort (3.02±2.48% vs. 2.38±1.08, p=1.00).

Conclusions:
The results of our in vitro model indicate that single-doses of 1% Lidocaine result in a significant decrease in chondrocyte viability when compared with control medium cultures. Single-dose administrations of 0.25% Bupivacaine and 0.50% Ropivacaine did not show signs of chondrotoxicity.

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No Disclosure.
Changes in Serum Biomarkers of Cartilage Turnover Following ACL Reconstruction

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Objectives:
The purpose of the study was to define the levels of serum biomarkers for cartilage turnover (C1,2C and C2C, markers of cartilage degradation, and CPII and CS 846, markers of cartilage formation) both before ACL injury and after ACL reconstruction in a cohort of cadets at the US Military Academy (USMA) at West Point and compare them to matched, uninjured control cadets.

Methods:
Cadets undergoing ACL reconstruction were matched with uninjured controls of similar age, sex, and BMI. Serum drawn upon entry to USMA and prior to graduation from both groups were tested. ELISA kits (IBEX, Inc, Montreal, CA) for the four biomarkers were performed in triplicate. Mean serum concentrations of each marker were calculated with t-tests performed followed by 2-way mixed model ANOVA. Significance was set at p<0.05.

Results:
Pre-injury and post-injury serum sample levels of C1,2C of the ACL injured cohort were 5490 ng/ml and 4970 ng/ml, and 5190 ng/ml and 4750 ng/ml for the controls. C2C levels pre- and post- ACL injury were 5.1 ng/ml and 4.47 ng/ml for the ACL injured cohort, and 4.54 ng/ml and 4.25 ng/ml for the controls. CPII concentrations for the pre- and post-injury ACL injured sera were 5.54 ng/ml and 5.24 ng/ml, and were 4.88 ng/ml and 4.51 ng/ml for the controls. CS846 levels pre- and post-injury for the ACL injured group were 6.11 ng/ml and 6.19 ng/ml; and 6.27 ng/ml and 6.05 ng/ml for the controls. There were significant differences (p<0.05) in the C2C and CPII levels between groups pre-injury, but not the C1,2C and CS846 levels. There were significant differences (p<0.05) in the C1,2C, C2C, and CPII levels between groups in the post-reconstruction state, but not for CS846. Comparing within group changes, all biomarkers were significantly different over time (p<0.05) in both groups except for the control C1,2C and ACL injured CS846. Significant group by time interactions were observed (p<0.05) for C2C and CS846.

Conclusions:
This study is the first to describe the pre-injury and post-injury levels of four accepted biomarkers of cartilage turnover in patients who subsequently sustained an ACL injury and compare them to a matched-control group. The difference in CPII and C2C levels in the pre-injury state suggests that there may be differences in cartilage metabolism of individuals at risk for ACL tear. Significant changes over time were observed in 3 of the 4 markers in the ACL-injured group and further study is warranted into the prognostic capabilities of these biomarkers.

Biomarkers of cartilage turnover plotted over time for ACL-injured and control groups
(CONT.)

Changes in Serum Biomarkers of Cartilage Turnover Following ACL Reconstruction

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No Disclosure.
A Biomechanical Comparison of Fixation Techniques for Unstable Distal Clavicle Fractures

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Objectives:
Unstable fractures of the distal clavicle (type IIB fractures) are often encountered in high-demand, young contact athletes. Due to the high rate of nonunion, many have advocated surgery for treatment of this injury. However, the operative results are often less than optimal. Numerous operative techniques have been described, but, the gold standard has yet to be defined, as many of these techniques have a substantial complication rate. The distal clavicle fragment is often small, comminuted and technically difficult to address. Many new locking plates exist to accommodate this fragment, but, may give a false sense of security. While suture fixation alone may not appear as strong as plate fixation, if it fails, the complication is not nearly as catastrophic as plate failure. Our purpose was to evaluate the biomechanical performance and mode of failure of distal clavicle locking plates versus suture fixation of the unstable type II distal clavicle fracture.

Methods:
A type IIB unstable distal clavicle fracture was created in 10 fresh-frozen human cadaveric shoulders. 5 of the fractures were reduced and plated with a distal clavicle locking plate that accommodates a 1.5 cm cluster of distal locking screws. 5 fractures were reduced with suture: a No. 5 Fiberwire cerclaged in figure of eight fashion around the fracture as well as a No. 5 Fiberwire placed under the coracoid and up through 2 drill holes in the clavicle. A cyclic pre-load and a load-to-failure protocol was performed.

Results:
Locking plate fixation load to failure against superior forces was 514 +/- 257 N. Suture fixation alone was 502 +/- 288 N. However, the cerclage suture slipped at an average of 125 N +/- 90N, but ultimate failure of the construct was at 502 N. No significant difference in load to failure was found between the techniques. The plate constructs all failed by either clavicle fracture or distal plate pullout whereas the suture constructs failed either with the suture itself, or the suture stretching out and the fracture displacing.

Conclusions:
No significant difference in ultimate load to failure was found between locking plate fixation versus suture fixation in treatment of the unstable Type IIB distal clavicle fracture. However, the mechanism of failure was more catastrophic for plate fixation and would necessitate a return trip to the operating room. Therefore, suture fixation may ultimately be the safest technique for management of these troublesome fractures.

Relevant disclosure declaration for all authors:
No disclosure.
Accuracy of Acromioclavicular Joint Injections

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Objectives:
To evaluate the accuracy of in vivo acromioclavicular (AC) joint injections.

Methods:
Thirty patients with pain localized to the AC joint were injected with 1 mL of 1% lidocaine and 0.5 mL of radiographic contrast material. Radiographs of the AC joint were taken immediately after injection. Each radiograph was reviewed by a musculoskeletal radiologist and the injections were graded as either intra-articular, extra-articular or partially intra-articular.

Results:
Of the 30 injections performed, 13 (43.3%) were intra-articular, 7 (23.3%) were partial articular and 10 (33.3%) were extra-articular. When the intra-articular and the partial articular groups were combined, 20 patients (66.7%) had some contrast dye in the AC joint.

Conclusions:
This study demonstrates that despite the relatively superficial location of the AC joint, the clinical accuracy of AC joint injections remains relatively low. Patients should be counseled appropriately prior to receiving an injection.

References:

Relevant disclosure declaration for all authors:
No disclosure.
Arthroscopic Repair for Posterior Shoulder Instability in the Young Athlete

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Objectives:
Posterior instability in athletes is less common than anterior instability. Operative treatment has been less predictable than with anterior instability. We report a consecutive series of young athletes with posterior recurrent shoulder instability treated with consistent arthroscopic repair technique.

Methods:
34 consecutive shoulders with symptomatic recurrent posterior instability treated with arthroscopic repair were evaluated at an average follow-up of 36 months (12-67). The average age was 22 (15-35 yrs). There were 27 males (79%) and 7 females (21%) with 59% dominant shoulders affected. 26 (77%) had suffered a known traumatic injury but only 2(6%) a documented dislocation. Our arthroscopic repair technique is in the lateral decubitus position utilizing an anterosuperior 12 o’clock portal for the arthroscope, providing excellent visualization for evaluation and anchor placement. 25 had posterior bankart lesions, 5 osseous bankart lesions, and 4 with capsular redundancy. Suture anchor repairs were in 30 and plication to the intact labrum in 4. Aftercare was in a sling and de-rotation wedge for 4 weeks, then progressive active ROM. Patients were allowed to weight lift at 3 months and contact sports at 6 months.

Results:
Significant improvement (p<.05) from pre-op to post-op was seen for ASES scores: 66 to 93; and for Simple Shoulder Test (SST): 9.0 to 11.6. All patients return to their previous level of athletic activity. There were no post-operative complications. There was one recurrent subluxation that eventually required revision surgery (3%).

Conclusions:
Posterior shoulder instability has been thought to have less predictable outcomes with surgery than anterior instability. Patients in this series presented with loss of performance, subluxations, and pain, not recurrent dislocations. Only 2 had a documented posterior dislocation initially. This arthroscopic technique for posterior instability repair in a young, athletic population provided consistent outcomes, and return to sport in all. Only one (3%) had a recurrent subluxation requiring additional surgery.

Relevant disclosure declaration for all authors:
No disclosure.
Ulnohumeral Chondral and Ligamentous Overload (UCLO): Clinical Outcomes for Posteromedial Chondromalacia During Ulnar Collateral Ligament Reconstruction in Baseball Players

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Objectives:
Biomechanical studies support ulno-humeral chondral and ligamentous overload (UCLO) to describe the development of posteromedial chondromalacia in the setting of UCL insufficiency in baseball players. Although UCL reconstruction has afforded baseball players with 90% return to same level of play, no previous studies have analyzed clinical outcomes in patients with concomitant posteromedial chondromalacia.

Methods:
We identified baseball players treated for combined posteromedial chondromalacia and UCL injuries and performed a 2:1 case-control study utilizing isolated UCL injuries matched on level of play and position. UCL reconstruction was accomplished utilizing the docking technique, and PMC was addressed arthroscopically with nothing or debridement if Grade 2 or 3 and with debridement or microfracture if Grade 4. Chi-square tests were used to compare variables, including modified Conway classification.

Results:
29 baseball players (18%) were treated for the PMC/UCL injury comprising mostly college athletes (76%) and pitchers (93%). Patients had a statistically significant increase in chronic symptomatology, loss of terminal extension, posteromedial impingement signs, and posteromedial osteophytes within the PMC/UCL group (p<0.001). There was no statistically significant difference in excellent outcomes (p = 0.125) between the PMC/UCL (76%) and UCL (86%) groups or re-operations (p = 0.999) between groups.

Conclusions:
After UCL reconstruction, baseball players with PMC/UCL injuries secondary to UCLO obtain similar outcomes for short-term return to play; however, intra-operative attention is necessary to assure proper recognition and treatment as there may be implications for long-term return to play. Pre-operative PMC predictors include chronic symptomatology, loss of terminal extension, and posteromedial impingement signs.

Relevant disclosure declaration for all authors:
No disclosure.
Contributions of the Iliofemoral Ligament and the Acetabular Labrum in Limiting Hip External Rotation

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Objectives:
The purpose of this study was to determine the relative contributions of the acetabular labrum and iliofemoral (IF) ligaments in limiting external rotation of the femur relative to the acetabulum. It was hypothesized that each structure would significantly limit external rotation of the hip joint, with the most important limitation provided by the IF ligament.

Methods:
A pilot study determined that 15 fresh-frozen cadaveric hips with no evidence of prior injury, arthritis, or other abnormalities were required for this study. Each specimen was selectively skeletonized down to the capsule. Four tantalum beads (1.0 mm) were embedded into each femur and pelvis and were used to accurately measure external hip rotation using biplane fluoroscopy while a standardized 5 Nm external rotation torque was applied. The hips were tested in 4 hip flexion angles (10° extension, neutral, and 10° and 40° of flexion) in the intact state and by sectioning and later repairing the acetabular labrum and IF ligament in a randomized order.

Results:
External rotation (ER) significantly increased from the intact condition (41.5 ± 7.40) to the cut IF ligament condition (54.4 ± 6.60) and both cut condition (61.5 ± 5.70; p < 0.01), but there was no significant increase in ER in the cut labrum condition (45.6 ± 5.90). This relationship was mirrored in the repair conditions. There was no significant reduction in ER in the repaired labrum condition compared to the fully sectioned condition, while the repaired IF ligament condition (42.5 ± 6.10) resulted in an average of 19.0° less ER compared to the fully sectioned condition (p<0.01). Additionally, the intact and fully repaired conditions were not significantly different. ER significantly decreased when the hip flexion angle decreased from 40° of flexion to 10° of extension (p < 0.01) regardless of condition (Figure 1).

Figure 1: Hip external rotation angle versus hip flexion angle for the seven sectioned conditions.
Conclusions:
The iliofemoral ligament had a significant role in limiting external rotation of the hip while the role of the acetabular labrum was limited. Therefore, we recommend careful repair of an arthroscopic capsulotomy to avoid increased external hip rotation post-arthroscopy. In addition, the results demonstrate that once torn, both the acetabular labrum and IF ligaments should be surgically repaired to restore the native rotational stability observed in the hip; particularly in high level athletes that require full and stable rotational range of motion.

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No disclosure.
Factors Associated with Failure of Arthroscopic Treatment of Labral tears in Pincer Type Femoroacetabular Impingement (FAI)

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Objectives:
This study evaluated outcomes of hip arthroscopy for labral tears due to pincer FAI.

Methods:
After IRB approval, we reviewed 106 consecutive patients (mean age = 39 yrs) who underwent hip arthroscopy for labral tears in pincer FAI with minimum 1 year followup. Patients with femoral osteochondroplasty, prior hip surgery, or severe dysplasia were excluded. Radiographs were analyzed for center-edge angle, acetabular version, and Tonnis grade. Functional outcome was evaluated by modified Harris hip score and HOOS score. Failure was identified by reintervention or progression to Tonnis grade 3.

Results:
38 of 50 patients had acetabular retroversion combined with borderline dysplasia. At a mean FU of 33 months, 23 patients had reintervention (13 THA). In dysplastic-debridement group, 11 of 25 patients had reintervention (8 THA). In dysplastic-repair group, 4 of 25 patients had reintervention (1 THA). In nondysplastic-debridement group, 7 of 39 patients had reintervention (3 THA). In nondysplastic-repair group, 1 of 17 patients had reintervention (THA). Multivariate regression showed that independent factors associated with failure are dysplasia (p=0.04) and labral debridement (p=0.02). Increasing age (p=0.01) and labral debridement (p=0.01) are independent predictors of THA. The dysplastic debridement group had 44% early failures. Modified HHS improved from mean of 62 to 85 without any significant intergroup difference (p=0.23). Kaplan Meir survival curves with failure as endpoint (upper graph) and THA as endpoint (lower graph).

Conclusions:
Hip arthroscopy for pincer FAI results in improved outcomes in some cases, but dysplasia and increasing age predict poorer results. Rate of reintervention is less in labral repair than debridement especially in dysplastic hips.
(Cont.)
Factors Associated with Failure of Arthroscopic Treatment of Labral tears in Pincer Type Femoroacetabular Impingement (FAI)

References:
Ganz FAI cause for OA hip CORR03.Li Morphologic feature acetabular dysplasia CORR03.Byrd Hip arthroscopy in dysplasia Arthroscopy03.Parvizi Arthroscopy for labral tears in DDH JArthroplasty09

Relevant disclosure declaration for all authors:
No disclosure
Clinical Examination with MRI Validation to Assess High Hip Alpha Angle: A Prospective Study Among Asymptomatic Elite Youth and Pre-Collegiate Ice Hockey Players

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Objectives:
Currently diagnosed via MRI or radiographs, high hip alpha angles \((\alpha) > 50^\circ\) and femoroacetabular impingement (FAI) are recognized as an epidemic among college-aged ice hockey players. Little is known about the developmental stage of FAI etiological and pathological emergence. We hypothesized that a younger adolescent cohort would have lower \(\alpha\) than an older adolescent cohort, and that a positive clinical exam would be able to predict abnormally high \(\alpha\).

Methods:
This prospective study was IRB approved. Seventeen asymptomatic Peewee (11.3 years \([ \pm 0.6]\)) ice hockey players and 18 asymptomatic Midget Majors (MM) (pre-collegiate) (17.1 years \([ \pm 0.6]\)) were evaluated. Players had hip range of motion, strength, and a clinical exam with impingement testing, and a FABER distance test, before an MRI to determine hip \(\alpha\), femoral version, and evaluate for acetabular labral pathology.

Results:
Seven of 17 Peewees and 15 of 18 MM were diagnosed with acetabular labral tears. Five of 17 Peewees and 12 of 18 MM had positive clinical exams with a positive impingement test, FABER distance test, or decreased internal rotation. Peewees had a significantly lower average \(\alpha\) (58.5 vs 65.8, \(p<0.001\)). MM with a positive clinical exam were 15 times [95%CI: 1.5 to 134.3] more likely to have an \(\alpha>64^\circ\). A positive clinical exam had a sensitivity of 0.9 [95% CI 0.7 to 0.98] and a specificity of 0.625 [0.38 to 0.73] for \(\alpha=64^\circ\). The clinical exam had a positive predictive value for \(\alpha>64^\circ\) of 0.750 [0.588 to 0.817] and a negative predictive value for \(\alpha\leq 64^\circ\) of 0.833 [0.51 to 0.97]. A significant correlation existed between femoral anteversion and increased \(\alpha\) in MM (\(r^2=0.35, p=0.009\)). Neither cohort had a correlation of total hip motion or strength ratios with the \(\alpha\).

Conclusions:
High hip \(\alpha\) and FAI pathology are problems among hockey players beginning at previously unidentified young ages. Using our screening protocol for Midget Majors, we identified severe \(\alpha\) (>64°), reportedly at risk to develop FAI symptoms, we also observed lower \(\alpha\) in the Peewee cohort. Utilization of the described clinical exams for future athletic screenings could aid in the identification of asymptomatic athletic participants at increased risk of suffering hip injury due to abnormal bone structure at the femoral neck, indicated by a high \(\alpha\). This identification could allow for precautionary measures to be taken in an effort to prevent athletes’ pathologies from becoming symptomatic and causing injury to the hip during their athletic activities.

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We would like to thank Sean Garvey ATC, Mark Ryan PT, MC, Mike Wahoff PT, SCS, John McDonald MD, Cliff Willimon MD and Linda Chase, without whom this study possible would not have been possible.
Clinical Examination with MRI Validation to Assess High Hip Alpha Angle: A Prospective Study Among Asymptomatic Elite Youth and Pre-collegiate Ice Hockey Players

References:

Relevant disclosure declaration for all authors:
No disclosure
Hip Range of Motion is correlated to Radiographic Measurements of Femoroacetabular Impingement in Collegiate Football Players
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Objectives:
Physical exams are commonly used to evaluate patients with femoroacetabular impingement (FAI) [1,2]. It is unknown if physical exams, particularly the assessment of range of motion, can detect radiographic findings of FAI in asymptomatic individuals. The objective of this study was to determine if physical exams could be used to screen for underlying FAI abnormalities in athletes.

Methods:
Prospective, IRB approved study of 65 male collegiate football players. Both hips (n=130) were evaluated by two orthopaedic surgeons for radiographic signs of FAI. The alpha angle (AA) and head neck offset (HNO) were measured on frog-lateral films. Lateral center edge angle, acetabular index, cross-over ratio, and anteroposterior alpha angle were measured on anteroposterior films. Measures were averaged for both observers.

Maximum hip range of motion in flexion (supine) and internal/external rotation (supine, sitting, and prone) were measured using a goniometer. 49 players went to one of two stations, staffed by two clinicians (one examined, one measured). 16 players went to both stations to assess repeatability.

The relationship between each range of motion and radiographic measure was determined by a random-effects linear regression model. Correlation coefficients (r-values) were calculated following a method by Bland and Altman [3]. Data from the two physical exam stations were assessed separately. Only those regressions significant (p<0.05) for both stations were considered clinically significant. Regression/correlation coefficients were averaged for both stations. Inter-observer repeatability of radiographic and physical exam data was assessed with the interclass correlation coefficient (ICC).

Results:
Average regression and correlation coefficients for those relationships that were statistically significant are summarized in Table 1. AA (ICC=.71) and HNO (ICC=.74) were significantly correlated to prone (ICC=.74), supine (ICC=.73), and sitting internal rotation (ICC=.55) for both stations.

<table>
<thead>
<tr>
<th>X-ray Measure</th>
<th>Internal Rotation</th>
<th>Regression Coefficient</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Angle</td>
<td>Supine</td>
<td>-0.43</td>
<td>-0.43</td>
</tr>
<tr>
<td></td>
<td>Sitting</td>
<td>-0.55</td>
<td>-0.47</td>
</tr>
<tr>
<td></td>
<td>Prone</td>
<td>-0.42</td>
<td>-0.42</td>
</tr>
<tr>
<td>Head-neck Offset</td>
<td>Supine</td>
<td>0.12</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>Sitting</td>
<td>0.15</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>Prone</td>
<td>0.14</td>
<td>0.45</td>
</tr>
</tbody>
</table>
Conclusions:
Supine, prone, and sitting internal rotation can predict radiographic findings of cam FAI in athletic males. Radiographic and supine/prone internal rotation measurements were reproducible as quantified by the ICC. Screening athletes with supine and prone internal rotation exams may identify hips at risk for the development of osteoarthrosis due to FAI.

Acknowledgements:
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References:

Relevant disclosure declaration for all authors:
No disclosure.
**The Use of Fibrin Clot Enhancement in Double Bundle ACL Reconstruction in a Caprine Model**

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**Objectives:**
The purpose of this study was to assess the healing potential of an autologous fibrin clot in a double bundle ACL reconstruction in a caprine model. It was hypothesized that the fibrin clot addition to ACL reconstruction will result in advanced graft remodeling and healing when compared to a control group at 12 weeks as observed by histology, immunohistochemistry and magnetic resonance imaging (MRI).

**Methods:**
Eleven Spanish Boar goats underwent double bundle ACL reconstruction, 8 were available for analysis. Group 1 was treated with DB ACL reconstruction utilizing autologous fibrin clots (n = 4) and group 2 was treated with standard DB ACL reconstruction (n = 4). All animals were euthanized after 12 weeks. Each animal underwent 3T MRI immediately after euthanization for evaluation of graft signal intensity utilizing the signal noise quotient (SNQ) [1]. Intra-articular graft specimens were then cryosectioned followed by routine histological staining (hematoxylin and eosin [H&E]) and analyzed using the Ligament Tissue Maturity Index as described by Murray et al. [2]. For immunohistochemical analysis cryosections were stained with monoclonal antibodies against alpha–smooth muscle actin (α-SMA) to determine vascularity.

**Results:**
The mean ligament tissue maturity index score was significantly higher for the fibrin clot group (15 +/- 2.3) compared to the non-fibrin clot group (7.75 +/- 5.19) (p < 0.05). The mean vascularity (vessels/mm2) for the fibrin clot group was 7.08 +/- 1.32 and 9.29 +/- 3.09 for the non-fibrin clot group (n.s.). The mean SNQ for the AM-bundle was 1.1 +/- 0.71 for the fibrin clot group and 3.07 +/- 1.76 for the non-fibrin clot group (n.s.). The mean SNQ for the PL-bundle was significantly lower for the fibrin clot group (1.13 +/- 0.68) compared to the non-fibrin clot group (3.68 +/- 1.34) (p < 0.05).

**Conclusions:**
The use of an autologous fibrin clot in ACL reconstruction in a caprine model demonstrated improved healing with respect to histological analysis of the intra-articular ACL reconstruction segment and decreased signal intensity on MRI.

**Acknowledgements:**
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**References:**
1) Ahn et al. AJSM 2010.

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No Disclosure.
Chondrogenic Metabolic Activity of Fresh Osteochondral Allograft (OCA) Transplants in Comparison to Native Femoral Condyle Controls using Delayed Gadolinium-Enhanced MRI of Cartilage (dGEMRIC)

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Objectives:
dGEMRIC is a non-invasive technique to quantitatively evaluate the health of native and repair cartilage. To our knowledge, it has not been previously reported following therapeutic application of fresh OCA transplant in the human knee. We compared relative chondrogenic metabolic activity in adjacent native cartilage controls to distal femoral OCA transplants at one year using dGEMRIC.

Methods:
Nine patients with focal grade 4 International Cartilage Repair Society (ICRS) articular cartilage defects of the femoral condyle were treated with single cylindrical OCA grafts. They were evaluated with dGEMRIC at one year. Scans were obtained before and after administration of gadolinium and a brief period of exercise Custom image software was created to generate color-coded T1 maps from three-dimensional inversion recovery scans. T1 values were collected by drawing 3 regions of interest (ROI) within the repair cartilage (RC) on each of 3 consecutive sagittal image slices. Healthy control cartilage (NC) was sampled anterior and posterior to each graft, and from the uninvolved femoral condyle. Raw T1 values were used to calculate several established dGEMRIC indexes including relaxation rate (R1), change in relaxation rates (?R1) before and after contrast, and a relative change ratio between RC and NC for each ROI.

Results:
Six of 9 patients were male. Average age was 43.1 ± 16.4 years, and mean BMI was 25.2 ± 4.0. Mean lesion size was 377.4 ±116.1 mm2. Pre-contrast T1 values averaged 1292±237 ms for RC and 1287±184 ms for NC (p=0.872). Average post-contrast T1 values were 553±141 ms for RC and 602±76 ms for NC (p=0.182). There was no difference in average ?R1 for RC (1.241) and NC posterior to the graft (0.943, p=0.083), anterior to the graft (1.049, p=0.315), or in the adjacent femoral condyle (0.849, p=0.185). Average relative ?R1 comparing RC to all controls was 1.778. Four patients had statistically higher ?R1 values for the RC regions compared to adjacent NC, indicating lower proteoglycan content in the repair tissue in those cases. In 5 patients there was no statistical difference in ?R1 between repair and control cartilage regions (p>0.05).

Conclusions:
Non-invasive dGEMRIC allows in-vivo measurement of chondrogenic metabolic activity of the repair tissue following OCA transplant in the knee. One year after osteochondral allograft transplant, the measured proteoglycan content of repair tissue is similar to the surrounding native host cartilage in most patients.

Relevant disclosure declaration for all authors:
No disclosure.
Higher Incidence of Articular Cartilage Lesions at the Time of Revision ACL Reconstruction in Knees with a History of Previous Partial Meniscectomy

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Objectives:
Knees undergoing revision ACL reconstruction typically have more intra-articular injuries than knees undergoing primary reconstruction. The association between prior meniscal surgery and the incidence of articular cartilage lesions at the time of revision ACL reconstruction has not been well studied in the literature. The purpose of this study was to test the hypothesis that the incidence of articular cartilage lesions at the time of revision ACL reconstruction would be higher in knees with a history of previous meniscal surgery.

Methods:
Data from the MARS study group was reviewed to determine the history of prior meniscal surgery (partial meniscectomy/repair) and the presence of grade II, III and IV chondral lesions at revision ACL reconstruction. The association between previous meniscal surgery and the incidence of chondral lesions was examined for the entire knee, the same compartment, and the patellofemoral compartment.

Results:
The cohort included 725 ACL revision surgeries. Median patient age was 26 (range 12-63). 421 patients (58%) were male and 204 (42%) were female. Based on the highest grade chondral lesion in the entire knee (medial, lateral or patellofemoral compartments), knees with previous meniscal surgery were more likely to have high grade lesions (p<0.01). However, the incidence of articular cartilage injury was significantly increased in knees with a history of previous partial meniscectomy or debridement (p<0.001) but not in knees with a history of meniscal repair (p=0.7)(Figure 1). By compartment, the incidence of chondral lesions was significantly higher within the same compartment as previous partial meniscectomy (p<0.0001). Knees with previous meniscal repair did not have a significantly higher incidence of chondral lesions in the same compartment. Previous medial meniscus surgery was associated with a higher incidence of chondral lesions in the patellofemoral compartment (p<0.02) but lateral meniscus surgery was not.

Figure: Figure 1
Higher Incidence of Articular Cartilage Lesions at the Time of Revision ACL Reconstruction in Knees with a History of Previous Partial Meniscectomy

Conclusions:
The status of articular cartilage at the time of revision ACL reconstruction is related to previous meniscal surgery in this cohort. While a history of partial meniscectomy appears to be associated with a higher incidence of articular cartilage lesions, a history of meniscal repair does not. Although this association may reflect underlying differences in the knee at the time of prior surgery, it does suggest that meniscal repair is preferable when possible at the time of ACL reconstruction.

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No disclosure.
Objectives:
High tibial osteotomy (HTO) is a common treatment for medial compartment arthritis of the knee in younger, more active patients. The HTO shifts load away from the degenerative medial compartment and into the lateral compartment. This change can be accomplished with either a lateral closing or a medial opening wedge HTO. An HTO also potentially affects leg length. Mathematical models predict that the osteotomy type (opening versus closing) and the magnitude of the correction determine the change in leg length, but no in vivo studies have been published. The purpose of this study is to quantify and compare leg length change following opening and closing wedge HTO.

Methods:
Thirty-two medial opening and 32 lateral closing HTO’s were selected from patients treated at our institution between 2006 and 2009. Pre-operative and one-year post-operative full-length lower extremity radiographs were obtained along with operative reports. Pre- and post-operative coronal plane alignment and leg length were measured and surgical details were collected.

Results:
The 64 osteotomies were performed in 62 patients (43 male, 19 female) at an average age of 57 years. The mean opening wedge was 9.3 mm (range: 5 to 17 mm) and the mean closing wedge was 8.0 mm (range: 6 to 10 mm). Knee alignment changed from a mean of 174 degrees pre-operatively to a mean of 183 degrees post-operatively in both groups. In the medial opening wedge group, total leg length was found to increase from 836.3 ± 63.5 mm pre-operatively to 841.8 ± 64.1 post-operatively, a change of 5.5 ± 4.4 mm (p < 0.0001). A significant correlation was found between the amount of correction and the increase in overall leg length (r2 = 0.21, p = 0.009). In the lateral closing wedge group, total leg length was found to decrease from 840.6 ± 51.5 mm pre-operatively to 837.9 ± 52.0 post-operatively, a decrease of 2.7 ± 4.0 mm (p = 0.0008). No correlation was found between the amount of correction and the change in overall leg length. The difference in mean leg length change between opening and closing wedge osteotomies was 8.2 ± 5.9 mm (p < 0.0001).

Conclusions:
Medial opening wedge HTO can result in significant leg lengthening depending on the degree of opening. Leg length changes associated with lateral closing wedge HTO are generally smaller. Both techniques results in less leg length change than mathematical models predict. Pre-operative leg length discrepancy should be considered when choosing an osteotomy technique.

Relevant disclosure declaration for all authors:
No disclosure.
Does Chronic MCL Laxity in the Setting of ACL Reconstruction Influence Clinical Results?
A Prospective Evaluation from Surgery to Minimum 3 years Follow-up.
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Objectives:
Combined anterior cruciate ligament (ACL) and medial collateral ligament (MCL) lesions are challenging to treat. A previous study [1] with a navigation system showed that patients with combined lesions (MCL+ACL) had similar AP laxity but higher valgus laxity at 30° of knee flexion after ACL reconstruction, compared to patients with pure ACL lesions (Fig.1). This study investigated the same cohorts of patients at minimum 3 years follow-up to determine if residual valgus laxity, observed intra-operatively, affected the reconstructed ACL graft, influencing the clinical results.

Methods:
In the previous study 57 patients were included, 20 with ACL+ chronic Grade II MCL lesions (group AM) and 37 with pure ACL lesions (group A). All the patients underwent an arthroscopic double-bundle ACL reconstruction performed with hamstring tendon technique. In AM group the chronic Grade II MCL lesion was not treated. No patients had grade III MCL lesion or concomitant meniscal tears and bilateral ACL lesions. Fifty-one patients were available at follow-up: 19 for group AM and 32 for group A. AP laxity was measured using KT-2000 with Manual Maximun Test at 30°; valgus laxity was evaluated with a Telos X-Ray test with a 50 N valgus force. We evaluated clinical scores (IKDC, Lysholm, Tegner and Womac), muscle girth and time to return to activities.

Results:
We did not find any statistically significant difference (p< 0.05) concerning the clinical evaluation. A statistically significant difference was found in the medial joint opening during the valgus stress radiographs on the reconstructed knee (1.7±0.9 mm group AM and 0.9±0.7 mm group A; p=0.013). Finally there was no statistically significant difference with respect to the AP laxity considering either the AP displacement on the index side (5.8±1.9 mm group AM, 5.3±2.4 mm group A) or the side to side difference (2.4±2.5 mm group AM, 1.3±2.2 mm group A).

Conclusions:
The results demonstrated that the residual valgus laxity identified at the end of the ACL reconstruction in the AM group persisted but did not significantly affect AP laxity at a minimum follow up of 3 years. A trend was seen for AM group to have higher AP laxity value but this did not affect the final clinical results. These findings suggest that no additional surgical procedures on the MCL are needed when the surgeon is faced with a patient that has a combined ACL and chronic Grade II MCL injury.
(Cont.)
Does Chronic MCL Laxity in the Setting of ACL Reconstruction Influence Clinical Results?
A Prospective Evaluation from Surgery to Minimum 3 years Follow-up.

References:

Relevant disclosure declaration for all authors:
No disclosure.
Objectives:
Injuries to the tibiofibular syndesmosis commonly cause prolonged ankle pain and disability, particularly in athletes. Syndesmotic injuries are associated with slower healing rates and typically result in longer time away from sport compared to other ankle ligament injuries. The reason for the delayed healing of the syndesmotic ligaments relative to the other ligaments around the ankle is unclear. The purpose of this study is to evaluate the blood supply to the syndesmosis and to determine if a disruption of the blood supply at the time of injury may contribute to prolonged recovery time.

Methods:
Thirteen matched pairs of adult cadaver legs, 26 legs total, were amputated below the knee. India ink followed by Wards Blue Latex was injected into the anterior tibial, peroneal, and posterior tibial arteries under constant manual pressure. The specimens were frozen for 48 hours, thawed to room temperature, and the skin was sharply dissected away. The remaining soft tissues were chemically débrided with sodium hypochlorite, leaving the bones, interosseous ligaments, and casts of the blood vessels exposed. The vascular supply to the syndesmosis was carefully photographed and recorded for each specimen.

Results:
In 13 of the 26 specimens (50%), the anterior syndesmosis was supplied exclusively by the perforating branch of the peroneal artery. This branch passes through the interosseous membrane from posterior to anterior, 2 to 3 centimeters proximal to the ankle joint, within the potential zone of injury in a syndesmotic disruption. In the remaining 13 legs, the blood supply to the anterior syndesmosis provided by the perforating branch of the peroneal artery was augmented by small arterial branches from the anterior tibial artery circulation.

Figure: Anterior Syndesmosis
The perforating branch of the peroneal artery runs through the interosseous membrane to supply the anterior syndesmosis.
The Vascular Supply of the Tibiofibular Syndesmosis

Conclusions:
The perforating branch of the peroneal artery supplies the majority of the blood supply to the anterior syndesmosis in all ankles, and is the exclusive blood supply to the anterior syndesmosis in fifty percent of the specimens examined. Due to its location in the distal interosseous membrane, the artery is vulnerable at the time of a syndesmotic injury. Disruption of that artery would significantly decrease the blood supply to the syndesmosis and may explain the prolonged recovery time that is seen clinically.

References:

Relevant disclosure declaration for all authors:
No Disclosure
Anatomic Safe Zone for Placement of Suture Anchors in Arthroscopic Repairs for Chronic Ankle Instability

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Objectives:
The goal of this study was to examine the superficial and deep anatomy of the lateral ankle during arthroscopic repair of the lateral ligaments including the anterior talofibular (ATFL) and the calcaneofibular (CFL). Defining the proximity of structures of the lateral ankle may clarify the anatomic safe zone in which repairs may pose minimal morbidity.

Methods:
Ten lower extremity cadaveric specimens were obtained from ten cadavers (40 ± 12 yrs) and screened for gross anatomical defects and pre-existing ankle laxity. The ATFL and CFL were sectioned from the fibula using an open technique. Standard anterolateral and anteromedial portals and a third portal located 2 cm distal to the anterolateral portal were made. Electrocautery was used to mobilize the ATFL and CFL. Two anchors were placed on the fibula at the ATFL and CFL origins. A suture lasso was pierced each ligament 7-10 mm from its origin, exiting at the origin site. Sutures were tied inferior to superior, completing the reconstruction.

The distance from the suture knot to the following structures was measured by multiple observers: extensor tendons (ET), peroneus tertius (PTR), superficial peroneal nerve (SPN), peroneal tendons (PTN), sural nerve (SN), and the intermediate branch of the superficial peroneal nerve (ISPN).

Results:
Our results indicate that several anatomic structures lie in close proximity to the ATFL and CFL sutures (Figure 1). The ATFL sutures were entrapped in significantly more structures compared to sutures in the CFL, 9 of 55 structures compared to 0 of 55 structures, p = 0.003. The ATFL sutures entrapped the ET (2 specimens), PTR (5 specimens), ISPN (1 specimen), and the SPN (1 specimen). The proximity of the ISPN when present is one of the highest risks. Decreased distances between these structures and the ATFL compared to the CFL suggest a higher risk of entrapment.

Summary results reported as the distance from the tendon to the structure of interest

<table>
<thead>
<tr>
<th>Structure</th>
<th>Mean measured distance (mm)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensor tendons</td>
<td>7.4 ± 4.2</td>
<td>0.001*</td>
</tr>
<tr>
<td>Peroneus Tertius</td>
<td>5.1 ± 1.7</td>
<td>0.001*</td>
</tr>
<tr>
<td>SPN main</td>
<td>18.8 ± 6.0</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>SPN Intermediate Branch</td>
<td>22.6 ± 7.0</td>
<td>0.005</td>
</tr>
<tr>
<td>Peroneus Tendon</td>
<td>33.7 ± 4.6</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Sural Nerve</td>
<td>47.6 ± 7.6</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

* indicates statistical significant difference
Conclusions:
This study attempts to identify a “safe zone” for arthroscopic placement of suture anchors for repair of the ATFL and CFL in patients with chronic ankle instability. During placement of anchors at the ATFL and CFL origins, tissue capture is of concern due to the proximity of several anatomic structures. Awareness of these structures enables surgeons to use an arthroscopic approach, while minimizing risk of injury to important structures.

Acknowledgements:
Thanks to Sarath Koruprolu for assistance on this experiment

Relevant disclosure declaration for all authors:
No disclosure.
Sesamoidectomy for Hallux Sesamoid Fractures in Athletic Patients

David Alberto Bichara MD, Massachusetts General Hospital, Harvard Medical School, Boston, MA; Ralph Frank Henn III MD, Massachusetts General Hospital, Harvard Medical School, Boston, MA; George Theodore MD, Massachusetts General Hospital, Harvard Medical School, Boston, MA

Objectives:
Hallux sesamoid fractures are challenging to treat. Symptomatic nonunion is a common problem after nonoperative treatment. Surgical fixation of the fracture, usually with bone grafting, can result in successful union. However, it is technically challenging and can be associated with prolonged return to activities (RTA). Sesamoidectomy is an alternative surgical option that may provide more reliable outcomes and allow early RTA. The objective of this study was to evaluate a cohort of athletic patients with a symptomatic sesamoid fracture treated with sesamoidectomy.

Methods:
A total of 24 patients with 24 sesamoid fractures that failed to respond to nonoperative treatment were treated surgically by the senior author from 2004-2010. The patients’ age, level of activity, fractured bone, surgical approach, time required to RTA, and post-operative complications were recorded. Pre and post-operative pain was assessed with a Visual Analog Scale ranging from 0=no pain to 10=intense pain.

Results:
The 24 patients were reviewed at a mean follow-up of 35±21 months (range 8-70). Five patients were classified as elite athletes playing at an intercollegiate level and 19 were classified as active individuals, performing an athletic activity at least 3 times per week. One patient sustained a fracture at work (police officer). The mean patient age was 32.2±10.42 (range 17-54). There were 15 medial sesamoid fractures (62.5%) and 9 lateral fractures (37.3%). All 15 medial fractures were excised through a medial incision. Of the 9 lateral fractures, 8 were excised through the dorsum of the foot (88.8%) while 1 was excised through a plantar incision (11.1%). A total of 22/24 patients (91%) returned to athletic activities at a mean time of 11.6±3.87 weeks (range 8-24). Mean preoperative pain level was 6.2±1.4, and improved after treatment to a mean of 0.69±1. Pathologic evaluation of the 24 excised specimens confirmed a chronic fracture in all cases. There was 1 case with negatively birefringent crystals consistent with gout. Although no cases required revision surgery, 1 patient developed a symptomatic hallux valgus deformity after the resection of the medial sesamoid. This was 1 out of the 2 patients that didn't RTA.

Conclusions:
This case-series demonstrates good results after sesamoidectomy for sesamoid fractures in athletic individuals with reliable pain relief and RTA within 11.6 weeks. Progressive hallux valgus remains a concern after medial sesamoidectomy, with an incidence of 7% in this study.

Relevant disclosure declaration for all authors:
No disclosure.
Time To Return To Play After High Ankle Sprain In Collegiate Football Players: A Prediction Model

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Objectives:
Determining the severity of high ankle sprains in athletes and predicting the time an athlete can return to unrestricted sport activities following this injury remain significant challenges. Objectives of this study were (1) to determine if objective measurements of injury severity after high ankle sprains could predict the time to return to play in Division I collegiate football players, and (2) to determine whether physical examination or diagnostic musculoskeletal ultrasound was more predictive of return to play.

Methods:
Twenty consecutive Division I collegiate football players with a diagnosis of a Grade I high ankle sprain (syndesmosis sprain without diastasis) were studied. Two clinical measurements of injury severity were determined: (1) the height of the zone of injury on physical examination, and (2) the height of the zone of injury as defined by diagnostic musculoskeletal ultrasound examination. All athletes followed a standardized treatment program and return to play criteria. A regression model and Cox proportional hazards model were developed to determine time to return to unrestricted play as a function of injury severity and player position.

Results:
Physical examination, but not ultrasound, was significantly correlated with time to return to play after injury (r=0.68; 95% CI: 0.34, 0.86 versus r=0.35; 95% CI: -0.11, 0.67). Regression and Cox analyses revealed that injury severity on physical examination and player position were significant predictors of time to return to unrestricted play following high ankle sprain. In general, linemen returned to play sooner than other positions. The regression model is as follows:

\[
\text{Number of days to return to unrestricted play} = -1.05 + (1.29 \times \text{Height of zone of injury on physical examination in centimeters}) + (6.25 \times \text{Player position}).
\]

For “Player position” variable, Lineman = 0 and All Other Positions = 1.
(Cont.)
Time To Return To Play After High Ankle Sprain In Collegiate Football Players: A Prediction Model

Conclusions:
Injury severity on physical examination and player position are associated with the time to return to unrestricted athletic activity after high ankle sprain. A model based on our data can be applied to help predict the time to return to unrestricted play in Division I collegiate football players following high ankle sprain.

Relevant disclosure declaration for all authors:
No disclosure.
Objectives:
Ketoprofen 10% cream (TDLP-110) contains 100 mg of ketoprofen, a Non-Steroidal Anti-Inflammatory Drug (NSAID), per gram of cream in a proprietary topical formulation. A randomized, double-blind, placebo-controlled Phase 3 trial in 364 patients demonstrated that TDLP-110 was more effective than placebo in reducing pain of acute soft tissue injuries and was very well tolerated. Overall data were presented at the World Congress on Pain in 2010. We report on an interesting subgroup analysis from this trial in patients with acute strains of the upper or lower extremities.

Methods:
The primary efficacy endpoint was the change from baseline in pain intensity during daily activities over the past 24 hours as measured by a 100mm Visual Analogue Scale (VAS) on the Day 3 (+1, +2) visit. An Analysis of Covariance (ANCOVA) was performed on the primary endpoint as well as patient diary data, including treatment, baseline pain score, and body weight (BW) as covariates. In the Intent-To-Treat (ITT) population there were 95 patients with axial acute strains randomized in the TDLP-110 Phase 3 trial. Baseline observation carried forward (BOCF) imputation was applied for missing data.

Results:
TDLP-110 demonstrated a statistically significant higher reduction in pain intensity from baseline in 95 patients with acute axial sprains (p=0.0348). Prior and concomitant application of Rest, Ice, Compression, and Elevation (RICE) appeared to have resulted in a better response rate and separation between active drug and placebo. The treatment difference in these patients is 26.1 mm (p=0.0213), more than double what it was in all the axial strains (11.2 mm). It is hypothesized that patients applying RICE concomitantly may have a higher compliance to the treatment protocol. TDLP-110 was very well tolerated with no cutaneous adverse events reported in this subpopulation. The overall incidence of skin/application reactions was only 1.1% in the entire study population (n=364) vs. 2.2% in the placebo group.

Conclusions:
TDLP-110 was more effective than placebo in reducing pain of acute strains of upper and lower extremities and was very well tolerated.

Acknowledgements:
This study was sponsored by Transdel Pharmaceuticals, Inc., La Jolla, CA, USA

References:
Ekman et.al.:Efficacy & Safety of Ketoprofen 10% Cream in the Treatment of Pain Associated with Acute Soft Tissue Injuries (Phase 3 Study TDLP110-001);13th World Congress on Pain,Mtl,Canada, #420

Relevant disclosure declaration for all authors:
No disclosure
A Comparison of Medical Assistants vs. Certified Athletic Trainers on Patient Volume and Revenue Generation in a Sports Medicine Practice

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Objectives:
Medical assistants (MA’s), physician assistants (PAs) and nurses (RN’s) have classically been utilized as health care extenders in sports medicine practices. However, certified athletic trainers (AT’s) are also gaining recognition as skilled and valuable health care professionals in the orthopaedic clinic setting. The purpose of this study is to determine the impact of AT’s vs. MA’s on patient volume, generated charges, and collections in a university based primary care sports medicine practice.

Methods:
Over a twelve month period, patient encounters, billed charges, and collections were obtained for the practices of two primary care sports medicine fellowship trained physicians (Physician A and B). The practices of each physician served the same patient demographic (most commonly individuals ages 14-65 with musculoskeletal orthopaedic injuries). Physician A in general saw less patients per day than Physician B. One hundred sixty clinic days were evaluated for each physician. In eighty of these clinic days, the physician was accompanied by a MA as the physician extender, and the other 80 days an AT provided the ancillary physician support. The data was collected and analyzed with paired t-tests. Statistical significance was set a priori at 0.05.

Results:
For both physicians, there were statistically significant increases in all measured parameters when comparing AT’s to MA’s. For both physicians, patient encounters increased when using AT’s vs. MA’s (p<.001). Billed charges also improved (Physician A, p=.02; Physician B, p<.001). Finally, collections increased for both physicians when utilizing an AT compared to an MA (P<.001). (Table 1)

Table 1 comparison of AT’s to MA’s

<table>
<thead>
<tr>
<th></th>
<th>DOCTOR A</th>
<th></th>
<th>DOCTOR B</th>
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<tbody>
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<td><strong>Encounters</strong></td>
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<tr>
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<td><strong>Collections</strong></td>
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<td>MA</td>
<td>80</td>
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<td>80</td>
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<tr>
<td>ATC</td>
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<tr>
<td><strong>Bill Charges</strong></td>
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<td>MA</td>
<td>80</td>
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<tr>
<td>ATC</td>
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<td>$3,771</td>
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</tr>
</tbody>
</table>

Conclusions:
Certified Athletic Trainers are critical components in the athletic training room and during on-field coverage. However, this is the first study of it's kind to formally assess the effectiveness of AT’s in a sports medicine clinic setting. When compared to more traditional physician extenders such as medical assistants, AT’s help the sports medicine physician generate more patient encounters, more billed charges, and more collections. These findings were consistent despite the volume of patients seen by each physician. This may result from the AT’s advanced training and knowledge in musculoskeletal assessment and management. Ongoing studies will help evaluate the effectiveness of AT’s and help confirm the results of this study.

Relevant disclosure declaration for all authors:
No disclosure.