Paper 1

Modification of Practice Patterns after Analysis of Risk Factors Improved ACLR Outcomes

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Objectives: Retear of an ACL after an ACL reconstruction (ACLR) is devastating for all involved. Understanding risk factors and predictors of subsequent graft tear after an ACLR is vital for patient education of subsequent risk of injury and if modifiable risk factors are identified, adjustments can be made to minimize the risk of repeat ACL tear. The objective of this study was to compare retear risk between 2002-2003 and 2007-2008 MOON cohorts to determine if after an analysis of risk factors in the 2002-2003 cohort, a shift in clinical practice changed the risk profile of ACL graft tear in the 2007-2008 cohort. The 2002-2003 and 2007-2008 cohorts are subsets of a larger MOON cohort.

Methods: The prospectively collected data of the 2002-2003 and 2007-2008 primary ACLRs with >80% two year follow-up was analyzed. Graft type (autograft bone patellar bone (BTB), autograft hamstring, allograft), age, Marx score at time of index surgery, and sex were evaluated to determine their relative contributions to ipsilateral retear in the 2002-2003 cohort and 2007-2008 cohort separately. An ANOVA with *post-hoc* analysis was performed to detect significant differences in age and Marx score at time of index surgery by graft type between the 2002-2003 and 2007-2008 cohorts.

Results: A total of 1758 subjects met all inclusion/exclusion criteria. The mean age of subjects that received allograft rose by 8 years ($p<0.01$) from the 2002-2003 cohort to the 2007-2008 cohort, whereas the mean age of subjects that received BTB and hamstring remained constant over time [Fig 1]. The mean Marx score of subjects receiving allograft dropped by 2.7 points ($p<0.01$) from the 2002-2003 cohort to the 2007-2008, whereas the mean Marx score of cohort subjects that received BTB and hamstring remained constant over time [Fig 2]. Thus in 2002-2003, there were 38/815 (4.7%) retears compared to 34/943 (3.6%) in 2007-2008. The odds of retear for allograft subjects was 9.27 times higher compared to BTB autograft in the 2002-2003 cohort ($p<0.01$), which decreased to 5.63 times higher in the 2007-2008 cohort ($p=0.01$) [Table 1].

Conclusion: Age, activity, and graft type have been identified as predictors of increased risk of ipsilateral graft failure after ACLR. Allograft use in young active patients was shown to be a risk factor for graft tear in the 2002-2003 cohort. Subsequent to this determination, graft choice changed to use allografts in older and less active patients, which resulted in an associated decrease in graft tear risk in the 2007-2008 cohort. The risk of ACL graft retear was lower for all graft types in the 2007-2008 cohort compared to 2002-2003 cohort.

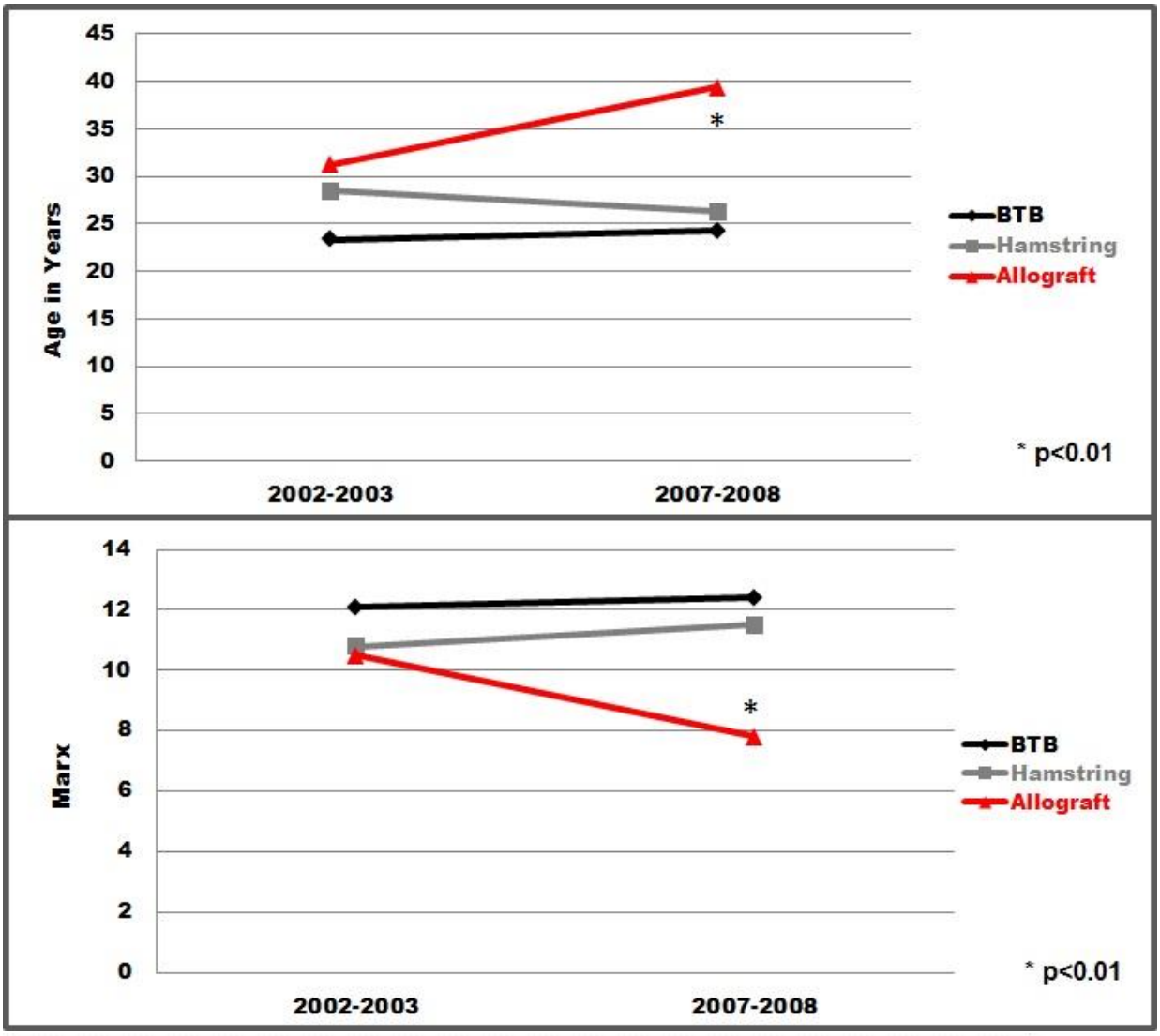

Table 1. Odds of ipsilateral graft tear

	2002-2003			2007-2008		
Ipsilateral graft tear	Odds ratio	p-value	95% CI	Odds ratio	p-value	95% CI
Age	**0.88**	**<0.01**	**0.82-0.94**	**0.89**	**<0.01**	**0.83-0.95**
Marx (t0)	1.09	0.14	0.97-1.21	1.12	0.09	0.98-1.27
BTB autograft	REF	REF	REF	REF	REF	REF
Hamstring autograft	1.85	0.18	0.75-4.58	1.46	0.32	0.69-3.09
Allograft	**9.27**	**<0.01**	**3.98-21.58**	**5.63**	**0.01**	**1.54-20.56**
Male	REF	REF	REF	REF	REF	REF
Female	0.68	0.29	0.33-1.39	0.77	0.47	0.37-1.57

Paper 2

Outcomes 2 Years After ACLR In Athletes: Function, Return To Sport Rates, And Re-Injury Rates From The Delaware-Oslo ACL Cohort Study.

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Objectives: At least 175,000 Anterior Cruciate Ligament Reconstructions (ACLR) are performed yearly in the United States, with the goal of restoring static knee stabilization for full return to previous level of function. Large data registries have reported general population outcomes after ACLR, but less is known about the athletic population. The purpose of this study is to evaluate functional outcomes, return to sport rates, and re-injury rates 2 years after ACLR from an all athlete cohort and make comparisons to outcomes reported in the literature.

Methods: Three hundred subjects were prospectively enrolled after ACL injury. All subjects sustained an isolated ACL injury and were enrolled within 7 months of injury. Subjects regularly participated in level I or II sports greater than 50 hours per year. All subjects underwent preoperative neuromuscular training. 201 of these subjects underwent ACLR. 157 patients returned for follow-up 2 years after surgery for performance-based and patient-reported testing. Quadriceps strength testing was completed either isometrically or isokinetically using an electromechanical dynamometer, and reported as quadriceps index (QI) [involved/uninvolved x 100]. Patient reported measures included The International Knee Documentation Committee 2000 Subjective Knee Form (IKDC2000), return to pre-injury activity (RTS), return to pre-injury activity competitive level (RTS-L), and re-injury. Statistics are expressed in means and standard deviations with T-tests or Chi-square for comparisons with values reported in literature.

Results: Two year follow up QI (mean±SD: 96.94±13.4%) revealed significantly higher quadriceps index compared to Hamada 2001 (89.8±16.5%) (P<.001). IKDC2000 (90.40±11.0; median: 94) scores were higher than the median score reported by the MOON group at 2 years (median: 75). Our RTS (72%) was significantly higher than Arden et al. 2014 (65%) (P=.012), whereas, our RTS-L (55%) was similar to Arden 2014 (55%) (P=.997). Our Re-injury rate was 13.9% (19 ipsilateral, 9 contralateral) which was significantly less (P=.002) than Paterno 2014 (29.5%).

Conclusion: A comprehensive pre-operative rehabilitation program including neuromuscular training, combined with a post-operative rehabilitation program resulted in higher quadriceps strength, return to sport rates, and re-injury rates in athletes 2 years after ACLR compared to recent findings in the scientific literature. These findings highlight that despite excellent clinical outcomes, ACLR does not guarantee return to sport, and re-injury rates remain high. Limitations include motivational differences in athletes compared to general populations as well as age differences compared to Paterno 2014. Further research is needed to determine how to improve return to sport competitive levels rates and reduce subsequent injury risk in athletes after ACLR.

Paper 3

O'Donoghue Award: Utilization of ACL Injury Biomechanical and Neuromuscular Risk Profile Analysis to determine the effectiveness of Neuromuscular Training: A Prospective Cohort Double Blind Randomized Controlled Trial

Authors:
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Objectives: Over 125,000 anterior cruciate ligament (ACL) injuries occur each year in the United States. External loads on the knee in the frontal plane, specifically the knee abduction moment (KAM), predict future ACL injury with high sensitivity and specificity. The purpose of this randomized controlled trial (RCT) was to determine if biomechanical and neuromuscular factors could be used to characterize athletes by distinct factor profiles, to examine if neuromuscular training (NMT) would decrease the potential risk factors, and if NMT would preferentially benefit athletes that exhibited specific risk profiles. The hypotheses tested were: 1) a priori chosen biomechanical and neuromuscular factors would characterize subjects into distinct at-risk profiles, 2) NMT would decrease biomechanical and neuromuscular factors related to increased injury risk and 3) the decrease in these biomechanical and neuromuscular factors would be greater in those athletes characterized by the overall higher risk profiles.

Methods: A total of 624 female athletes from 52 basketball, soccer and volleyball teams participated and were screened prior to their competitive season. During the pre-season testing, the athletes performed 3 different types of tasks for which biomechanical measures were taken: 1) drop vertical jump (DVJ), 2) single leg drop (SLD), and 3) single leg cross drop (SCD) landings. Using data from these tasks a latent profile analysis (LPA) was conducted to identify distinct profiles based on pre-intervention biomechanical and neuromuscular measures. As a validation, we examined whether the profile membership was significant predictor of KAM. Analysis of Co-Variance (ANCOVA) was used to examine treatment effects of NMT on biomechanical and neuromuscular measures in the 375 athletes who completed both pre- and post-intervention tasks. Differences were considered statistically significant at $p<0.05$.

Results: LPA using six pre-intervention biomechanical measures selected *a priori* resulted in three distinct profiles. Athletes in profiles II and III had significant higher KAM, compared to Profile I. The Core/Trunk-based NMT significantly increased hip external rotation moments and moment impulse and increased peak trunk flexion and decreased extension. In addition, the treatment effect of NMT varied by pre-intervention risk profile. Athletes with pre-intervention risk Profile II and III (higher risk) had a more significant treatment effect of NMT than Profile I.

Conclusion: This is the first study to use LPA analysis of biomechanical landing data to create KAM and potentially ACL injury risk profiles. The LPA of multiple biomechanical and neuromuscular measures identified three distinct risk groups; associated with differences in peak KAM Analysis of the RCT showed that NMT significantly increased hip external rotation moments and moment impulse and increased peak trunk flexion and decreased extension, and that alterations in risk factors are different across risk profile group, with higher risk groups showing an overall significant improvement in KAM. These findings show the existence of discernable groups of athletes that are more appropriate for NMT intervention; further study is needed in even larger cohorts to investigate ACL injury as our primary outcome variable.

Paper 4

Knee Kinematics Are Related to Patient-Reported Outcomes 6 Months After Anatomic ACL Reconstruction

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Objectives: Anterior cruciate ligament (ACL) reconstruction is among the most common procedures performed in orthopaedics. Patient reported outcomes (PRO) are widely utilized to evaluate symptoms, activity, and participation in sport after ACL reconstruction. Although altered in vivo knee kinematics after ACL reconstruction have been reported, the association with PRO has not been established. The purpose of this study was to determine the relationship between PRO and dynamic knee kinematics as tracked by a Dynamic Stereo X-ray system (DSX system).

Methods: Fifty subjects (33 males, age: 24.2 years ± 7.6, BMI: 24.7 ± 2.97) participating in a randomized clinical trial to compare anatomic single- and double-bundle ACL reconstruction underwent surgery using quadriceps tendon bone block autograft. Six months post-operatively, patients performed downhill treadmill running (3.0 meters/second, 10° slope) within a DSX system (150 hertz). Knee kinematics, determined using a validated process of matching DSX images and subject-specific tibiofemoral bone models derived from computed tomography scans, were expressed as a function of the gait cycle. Involved limb and differences in side-to-side kinematics were analyzed from foot-strike to mid-stance phase (0-15% gait cycle corresponding to the loading phase). Subjects also completed the International Knee Documentation Committee Subjective Knee Form (IKDC-SKF) and Knee Injury and Osteoarthritis Outcome Score (KOOS). Correlation coefficients were calculated to determine the associations between PRO and knee kinematics.

Results: Greater post-operative knee flexion and more symmetric restoration of knee flexion and axial rotation in comparison to the contralateral knee had the highest correlations with the IKDC-SKF and KOOS Sports and Recreation and Knee-Related Quality of Life subscales ($p < 0.05$). Symmetry of anterior tibial translation and varus-valgus rotation of the surgical knee were less strongly associated with PRO.

Conclusion: Knee kinematics when running 6 months after ACL reconstruction were associated with patient-reported symptoms, activity, and participation levels. Therefore, clinicians should strive for anatomic precision during ACL reconstruction to optimally restore knee kinematics so as to achieve optimal PRO.

Correlations between IKDC-SKF and KOOS with kinematics running data (N=50)

Patient Reported Outcome Scale	Anterior Tibial Translation Range (Side-to-Side Difference)	Flexion Range (Operative Knee)	Flexion Range (Side-to-Side Difference)	Axial Rotation Range (Side-to-Side Difference)	Average Varus (Operative Knee)	Maximum Varus (Operative Knee)
IKDC-SKF	.10	.36*	0.31*	0.36**	0.22	0.22
KOOS Symptoms	.23	.25	.20	.19	.13	.13
KOOS Pain	.02	.32*	.19	.23	.20	.19
KOOS Activities of Daily Living	.01	.30*	.23	.29*	.29*	.28*
KOOS Sport	.09	.26	.28*	.49**	.29*	.27
KOOS Quality of LIfe	.47**	.40**	.38**	.28*	.23	.24
* p<.01 IKDC & KOOS: higher score indicates better patient symptoms, function, and quality of life	(Note: column represents difference in ranges between operative and control extremities)		(Note: column represents difference in ranges between operative and control extremities)	(Note: positive value indicates internal rotation, negative value indicates external rotation) (Note: column represents difference in ranges between operative and control extremities)		

Paper 5

Effects of Anterolateral Capsular Injury and Extra-Articular Tenodesis on Knee Kinematics During Physical Examination

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Objectives: Recently, the interest in the anterolateral knee anatomy and tears of the anterolateral structures following anterior cruciate ligament (ACL) injury has brought back interest in extra articular procedures in an attempt to aid reestablishing normal rotational laxity to the ACL deficient knee. However, the contribution of an extra articular tenodesis combined to the ACL reconstruction, as well as the role of the lateral capsule of the knee in the knee stability, are poorly understood. The objective of this study was to determine the effect of anterolateral capsule injury and extra-articular tenodesis on the intact, ACL-deficient, and ACL-reconstructed knees. Our hypothesis was that the extra articular tenodesis associated with ACL-reconstruction would be necessary to reestablish intact knee kinematics exclusively when an anterolateral capsule injury is associated with an ACL tear.

Methods: Seven knees from whole lower extremity fresh-frozen human cadavers (mean age: 60 years) were utilized in the study. Three Orthopedic surgeons performed the pivot shift test and one surgeon applied maximal anterior load at 30° of knee flexion and maximal rotatory torques (internal and external rotations) at 30° and 90° of knee flexion. Three trials of each examination were recorded in seven knee states (Table 1). Injury to the anterolateral capsule was created by making a 2 cm incision at the level of the joint line starting 5 mm anterior to lateral collateral ligament. Extra articular tenodesis was performed by a modified Lemaire procedure.

An electromagnetic tracking system (Nest of Birds, Ascension Technology) was used to measure the kinematics of the knee (accuracy: 0.5 mm and 0.5°). Tibial and femoral coordinate systems were determined in the Grood-Suntay joint coordinate system and anterior tibial translation and rotations were determined with respect to the femur.

The Kruskal-Wallis test was used since the data was non-Normally distributed.

Testing Protocol. ACL-R: ACL reconstruction, EAT: extra articular tenodesis

Protocol		Data Acquired
Structure Injured	Procedure Performed	
None	None	Intact knee kinematics
ACL	None	ACL-Deficient knee kinematics
ACL	ACL-R	ACL-R knee kinematics
ACL	ACL-R + EAT	ACL-R + EAT knee kinematics
ACL + Lateral Capsule	None	ACL-Deficient + Lateral capsule deficient knee kinematics
ACL + Lateral Capsule	ACL-R	Capsule deficient + ACL-R knee Kinematics
ACL + Lateral Capsule	ACL-R + EAT	Capsule deficient + ACL-R + EAT knee Kinematics

Results: Anterior tibial translation (ATT) during the pivot shift test (Figure 1) significantly increased from 8.0 ± 5.2 mm to 12.7 ± 6.2 mm ($p = .006$), and internal rotation (IR) significantly increased from 12.6 ± 6.1° to 16.4 ± 6.9° ($p = .04$) after injuring the lateral capsule in an ACL deficient knee. There was no difference in knee kinematics when an extra articular tenodesis was performed in a knee with intact lateral capsule. Significant difference was found in ATT (decreased from 7.0 ± 3.4 mm to 4.4 ± 2.7 mm, $p = .014$) and IR (decreased from 13.4 ± 6.8° to 8.4 ± 4.3°, $p = .01$) when the extra articular procedure was performed after the ACL reconstruction in a lateral capsule injured knee. When evaluating the maximum manual loads, the effects of injuring the capsule and adding the extra articular tenodesis were less relevant then when evaluating a dynamic test like the pivot shift.

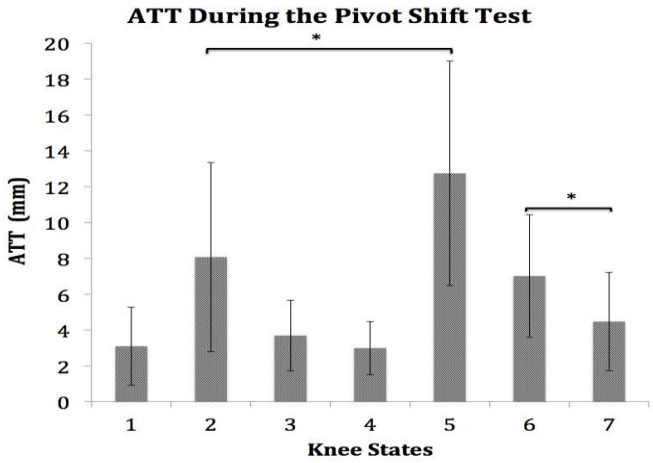

Figure 1. Average ATT during the pivot shift test
* Significant different ($p < 0.05$)
Knee states: 1) intact, 2) ACL deficient, 3) ACL reconstructed, 4) ACL reconstructed + extra articular tenodesis, 5) ACL deficient + lateral capsule injured, 6) ACL reconstructed + lateral capsule injured, 7) ACL reconstructed + extra articular tenodesis/ lateral capsule injured

Conclusion: An extra articular tenodesis was beneficial in reestablishing the normal knee kinematics only when a lateral capsule lesion was present. Moreover, This study may aid in developing guidelines regarding the proper indication of an extra articular tenodesis following an ACL reconstruction.

Paper 6

Long-term In-vivo Evaluation Of A Resorbable PLLA Scaffold For Regeneration Of The ACL

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Objectives: A synthetic device for ACL reconstruction has long been sought to eliminate co-morbidities of autograft harvest, and variability, potential for disease and allogeneic reaction with allograft. We hypothesized that a PLLA graft and hamstring autograft would regenerate similarly in an ovine model of ACL rupture.

Methods: 125 ACL reconstructions were performed with PLLA grafts in 79 sheep and autograft tendons in 46 sheep. 3 combinations of fixation were used: (1) titanium screws outside-in on tibia, inside-out on femur, (2) screws outside-in on tibia & femur, (3) screw outside-in on the femur, suspension fixation on femur. The PLLA graft was made of 3-D braided fibers with loose braid intra articularly and tight braid for fixation. ACL reconstructions were evaluated 6 weeks through 4 years for clinical function, synovitis, serology, gross reaction, scoring of cartilage and menisci, histology, radiography, micro-CT, MRI, and pathology of organs. Strength of the BLB complex was measured at 6 weeks, and 6 and 12 months.

Results: Sheep with PLLA grafts were fully functional post-op; autograft sheep exhibited early morbidity. There was no evidence of synovitis, serology and gross findings were normal. Micro CT, radiographs, MRI, and histology indicated resorption of PLLA grafts and regeneration of the ACL at 12 months. Intra articular histology of PLLA- and auto- grafts showed neo-ligamentization at 3 months, increased collagenous deposition and cellularity with time, a reconstituted ACL at 1 year, and continued maturation. Intra-articularly, PLLA grafts were intact at 6 weeks, and 3 & 6 months, and nearly fully resorbed at 1 year. Histology in the tibial bone tunnel (6 - 48 months) showed the PLLA graft between the screw and aperture filled with new collagenous tissue and tendon-bone healing. At 18, 24, and 48 months, PLLA grafts were intact and encapsulated by bone. Pathology of lymph nodes and organs indicated occasional presence of PLLA particulate. Histology and pathology yielded no adverse findings locally, systemically, or functionally. Biomechanical testing of BLB complexes with inside-out screw fixation on the femur (1) was found to impede healing and function of the PLLA graft. Testing of sheep with suspension fixation (3) showed PLLA grafts to bear a load of 423N (n=6, SD 119N) at 6 weeks, 491N (n=5, SD 116N) at 6 months, and 386N (n=6, SD 220N) at 12 months. In comparison, autograft at 6 weeks, 6 months, and 12 months failed at 111N (n=5, SD 40N), 526N (n=3, SD 185N), and 525N (n=5, SD 171N), respectively. Outside-in fixation for the tibia and femur (2) showed the PLLA graft to bear loads at 6 and 12 months of 320N (n=6, SD 142N) and 601N (n=6, SD 186N). Autograft failed at loads of 358N (n=1) and 422N (n=3, SD 164N).

Conclusion: Histology was consistent for autograft and PLLA grafts, which is ascribed to the PLLA resembling autograft in early load bearing, gradual resorption and consequent load transfer to newly formed tissue (absence of stress shielding), and maturation of tissue. The difference in resorption in the bone tunnels versus intra articularly is ascribed to the more vascular, biologically dynamic environment of the ACL. Reliable fixation for the PLLA graft was achieved with outside-in screw fixation. Inside-out screw fixation is a contraindication. This is the first study to demonstrate regeneration of the ACL, resorption of an implant intra articularly using a bioresorbable polymer, and is the longest in-vivo evaluation of PLLA in ligament repair of which we are aware.

Paper 7

The Degree of Knee Extension Does Not Affect Postoperative Stability or Subsequent Graft Tear Rate after Anterior Cruciate Ligament Reconstruction with Patellar Tendon Autograft

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Objectives: To compare graft tear and failure rates and subjective scores between patients of varying degrees of knee extension after anterior cruciate ligament (ACL) reconstruction with patellar tendon autograft.

Methods: Of 2329 patients who underwent ACL reconstruction with patellar tendon autograft between 1998 and 2008, 625 patients met the inclusion criteria of having primary ACL surgery, no bilateral ACL injuries, no existing osteoarthritis, and having either 6^o or more of knee hyperextension before and after surgery (Group A; n=318; mean $8^o + 2^o$, range 6^o to 15^o) or 3^o or less of knee hyperextension before and after surgery (Group B; n=307; mean $0^o + 3^o$, range 3^o hyperextension to -4^o extension). As part prospective follow-up, patients were evaluated with KT-1000 arthrometer for objective stability, range of motion measurements, and subjective follow-up with International Knee Documentation Committee (IKDC), Cincinnati Knee Ratings Scale (CKRS), and Activity Rating surveys. Subsequent graft tear related to specific injury within 5 years of surgery was recorded. Graft failure was defined as a KT-1000 manual maximum difference between knees of > 5mm.

Results: Follow-up was obtained from 278 (87%) in Group A and 275 (90%) in Group B at a mean of 4.1 + 1.1 years after surgery. The KT1000 arthrometer manual/maximum difference between knees was 2.0 + 1.4 in Group A and 2.1 + 1.6 in Group B (p=.701). Within 5 years after surgery, subsequent ACL graft tear/failure occurred in 22 patients (6.9%) in Group A and 30 patients (9.8%) in Group B (p=.246.) Further sub-analysis of Group A showed that the graft tear/failure rate was 6 of 81 (7.4%) for patients with $\geq 10^o$ of hyperextension versus 16 of 237 (6.8%) for patients with 6^o to 9^o of hyperextension. The percentage of patients who participated in jumping and pivoting sports before surgery was 85% in Group A and 86% in the Group B before surgery and 87% in Group A and 90% in Group B after surgery. The mean activity rating score was 8.4 + 1.1 in both groups after surgery. There was no statistically significant difference in the IKDC giveway or CKRS stability scores between groups after surgery (p=.174 and p=.107 respectively). Similarly, there was no difference in IKDC total score or CKRS total score between groups after surgery (p=.933 and p=.155 respectively).

Conclusion: Obtaining full hyperextension that is anatomically normal for most patients does not affect postoperative objective stability, ACL graft tear/failure rates, or subjective scores after ACL reconstruction with patellar tendon autograft.

Paper 8

ACL Reconstruction: Is There A Difference In Graft Motion For Bone-tendon-bone and Hamstring Autograft At 1 Year?

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Objectives: It has often been suggested that bone-patellar tendon-bone (BTB) grafts heal more quickly to graft tunnels than soft-tissue grafts after ACL reconstruction, due to rapid bone-to-bone healing. Little is known, however, about the motion of the grafts under functional, dynamic loads, or the actual time course for graft-tunnel healing in humans. The goal of this study was to assess the motion of both hamstrings (HS) and BTB grafts during gait at two time points (6 and 52 weeks) after surgery. It was hypothesized that there would be greater graft-tunnel motion in HS than BTB grafts, and that graft motion would be less at 1 year when compared with 6 weeks.

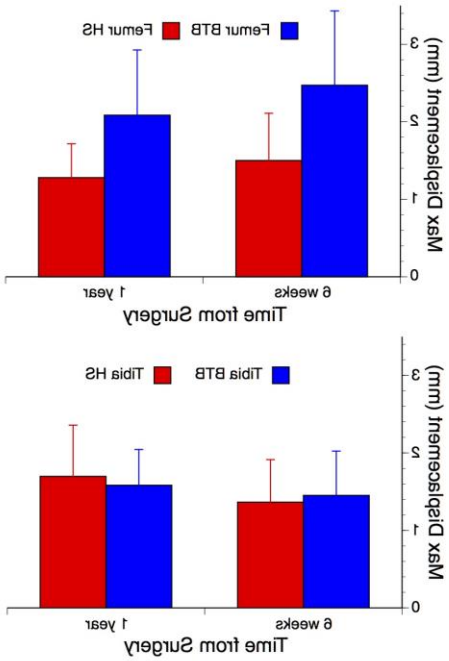
Methods: Twelve human subjects underwent anatomic single-bundle ACL reconstruction using either hamstrings (HS) or bone-patellar tendon-bone (BTB) autografts (6 in each group) and extra-cortical fixation. Six 0.8 mm tantalum beads were embedded into the grafts prior to implantation, with pairs of beads located within each bone tunnel and in the mid-substance region. At six weeks and one year after surgery, dynamic stereo X-ray (DSX) images were collected at 100 frames/s while subjects walked on an instrumented treadmill (1.3 m/s). 3D femur and tibia bone models were generated from CT scans. Tibiofemoral kinematics and graft bead positions were analyzed by combining the 3D models with DSX data. Graft-tunnel motion was assessed by determining the maximum range of motion of the most proximal femoral tunnel and most distal tibial tunnel beads along the direction of the bone tunnels during the stance phase of gait. Effects of graft type and time were assessed with a 2-factor ANOVA, with alpha = 0.05.

Results: Femoral tunnel motion (mean±s.d.) at 6 weeks was 2.47±0.96 mm (range 0.95-3.44 mm) for BTB and 1.51±0.68 mm (range 0.88-2.41 mm) for HS grafts, decreasing slightly to 2.09±0.84 mm for BTB and 1.37±0.41 for HS grafts by one year. Tibial tunnel motion was 1.45±0.57 mm (range 0.74-2.44 mm) for BTB and 1.43±0.59 mm (range 0.89-2.30 mm) for HS grafts at 6 weeks, and changed little by one year (1.58±0.46 mm for BTB and 1.52±0.57 for HS grafts). Across all time points, femoral graft-tunnel motion was significantly greater for BTB than HS grafts (p=0.004). In the tibial tunnel, there were no significant differences in motion between BTB and HS at 6 weeks or 1 year. For both graft types, there was no significant change in motion between 6 weeks and 1 year.

Conclusion: Contrary to the study hypothesis, there was a greater motion relative to the femoral tunnel wall in BTB than HS grafts during walking. Significant graft-tunnel motion also persisted one year after reconstruction. These data suggest that the graft-to-tunnel healing process may occur more slowly then

widely believed, especially for BTB grafts. However, all subjects were asymptomatic one year after surgery, and the implications of persistent, small (1-3 mm) movements of the grafts are unknown. These results, however, may have significant implications for graft choice, rehabilitation strategies and timing for return to sports.

The Authors: thank and acknowledge the OREF for the financial support of this study.



Paper 9

Early Predictors of Outcomes Following Non-Operative Management of ACL Injury: The Delaware-Oslo ACL Cohort Study

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Objectives: Identification of patient characteristics early after injury that influences long-term outcomes is needed to guide appropriate decision-making with regard to surgical management. The purpose of this study was to determine factors early after ACL injury which predict outcomes following non-operative management of ACL injury.

Methods: 59 (52.5% F; mean age 31.3±10.7 yrs) athletes completed rehabilitation to resolve knee joint range of motion, effusion, pain and gait impairments (quiet knee) after ACL injury. Patients then completed 10 additional rehabilitation sessions over 5 weeks consisting of progressive strengthening and neuromuscular training. Quadriceps strength testing, 4 single-legged hop tests, the Knee Outcome Survey Activities of Daily Living Scale (KOS), Global Rating Scale for Perceived Function (GR), and International Knee Documentation Committee 2000 form (IKDC) were completed following these 10 sessions. Two years after non-operative rehabilitation patients again completed the IKDC. “Normal” knee function was defined as an IKDC score in the top 85% of scores reported by uninjured people of the same age and sex, with “below normal” knee function equal to scores in the bottom 15% of normative data. Fisher’s exact tests and Mann-Whitney U tests were used to test differences in baseline and clinical measures after non-operative rehabilitation between those with “normal” and “below normal” knee function at 2 years. A logistic regression model was used to identify factors predictive of 2 year knee function. A prior significance level was set at $p \leq .05$.

Results: 11 patients (18.6%) reported knee function <15% on the IKDC at 2 years (Normal: 93.8±4.5%, 95% CI: 92.3-95.1; Below Normal: 72.1±12.7%, 95% CI: 63.6-80.6). No group differences existed for age (p=0.613) or sex (p=0.320) between those who scored in the normal range and those who scored <15%. Patients with self-reported IKDC knee function <15% had significantly lower IKDC scores at baseline (p=0.010; Normal: 83.0±10.0%, 95% CI: 80.1-85.9; Below Normal: 72.7±10.8%, 95% CI: 64.9-80.4) and required a greater number of days to achieve a quiet knee after injury (p=0.005; Normal: 58.5±21.9 days, 95% CI: 52.1-64.8; Below Normal: 77.6±17.7 days, 95% CI: 65.7-89.5). A trend toward significance was present for quadriceps strength (p=0.076; Normal: 93.5±9.1%, 95% CI: 90.8-96.1; Below Normal: 88.4±7.4%, 95% CI: 83.4-93.4) but no group differences were present for hop scores (single: p=0.684; crossover: p=0.630; triple: p=0.724; 6-meter timed: p=0.341), KOS (p=0.119), or GR (p=0.136). A logistic regression model including IKDC, days to achieve a quiet knee, and quadriceps strength was statistically significant with IKDC and days to achieve a quiet knee being significant predictors of knee function at 2 years (p=0.001; R2=0.433; IKDC: p=0.040, OR=0.909; days to achieve a quiet knee: p=0.014, OR=1.054; quad strength: p=0.220, OR=0.941).

Conclusion: Only 18% of active individuals managed non-operatively after ACL injury had IKDC scores <15% of norms 2 years after injury and rehabilitation. Lower baseline subjective knee function was predictive of poorer self-reported non-operative outcomes despite similar hop scores to those reporting normal knee function at 2 years. Longer time from injury to resolution of initial knee impairments also predicted poorer self-reported knee function, highlighting the importance of early rehabilitation with aggressive intervention to resolve impairments.

Paper 10

Trochleoplasty for Treatment of Patella Instability: A Prospective Study

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Objectives: Trochlear dysplasia (TD) involves an abnormality of the shape & depth of the proximal aspect of the trochlear groove, and has been found in 85% of individuals with recurrent patellofemoral instability. (ref H. Dejour, 1994). TD has several characteristics including flattening/shortening of trochlear groove, the presence of a supra-trochlear bump A trochleoplasty is a surgical procedure designed to help stabilize the patella by normalizing the shape of the trochlear groove. This study population is patients who underwent a patella stabilizing operation including a trochleoplasty, treated by a single surgeon between 12/06 &12/13.

Methods: Methods: Surgical criteria for trochleoplasty:
1) recurrent lateral patella dislocations (LPD) who failed conservative management
2) Imaging: Dejour classification B or D
3) Physical Exam: “j-sign”
4) Symptoms: Instability not pain as primary complaint
5) No full thickness cartilage wear (CW) on ***articulating trochlear cartilage***.
Patients were prospectively followed with a patient outcome assessment tool, Knee injury and Osteoarthritis Outcome Score (KOOS). Pre- & post-operative imaging analysis was performed by the author.

Results: 22 patients (28 knees) comprised the study population, representing 9% of surgeon’s population undergoing patella stabilizing surgery in same time period. Average age was 24 (range 14-47). 71% were female.
6 patients (12 knees) had bilateral (staged) procedures (6-22 mo).
21/28 (75%) patients had previous PF surgery.
8 patients had ***patella full thick CW***; none had concomitant cartilage restoration.
Concurrent surgeries: 11 Tibial tubercle osteotomies, 17 MPFL reconstructions, 7 medial imbrications. All needed lengthening of the lateral structures.
6 patients had second look arthroscopies, 3 at time of staged procedure & 3 for post-op stiffness. None had trochlear cartilage breakdown or softening.

Radiographic findings: TD classification 13 ‘B’ /15 ‘D’, indicating all had a supra-trochlear spur. Patella height : I/S range (1.1-1.6), C/D range(1.1-1.7). TT-TG range (7-29mm), Tilt range (5-55°).
All had improved sulcus angle at 20°: average deepening 9°, range 3-24°. All had elimination or reduction of supra-trochlear bump: pre-op range: 2-12mm, post-op range 0-6mm.
Follow-up : 1 year (82%), 2+ year 75% (15/20).Pre-operative KOOS scores showed substantial QOL impairment. Baseline KOOS (average): pain 74, symptoms 50, ADL 81, Sports 43, QOL 30. Post-operative KOOS scores showed clinically meaningful improvement in Sports (average 19) & Quality of Life (average

22). All patients reported improved conficence in their knee: no one reported further patella dislocating or subluxing events.

Conclusion: Trochleoplasties remain a rare surgery for those patients with recurrent LPD. Most patients in this cohort had been previously operated on; many with patella cartilage wear at the time of surgery. Pre-operatively, many subjects report little disability in ADL's but have poor QOL. Post-operative pain and symptom subscales remain stable.In the short term, trochleoplasty is a valid surgical option for patients with high grade trochleoplasty with a Supratrochlear bump, satisfactory trochlea cartilage surfaces, and a (+) J-sign. Improvement was found QOL and ADLs

Paper 11

Low Risk of Physeal Damage from a Medial Patellofemoral Ligament (MPFL) Reconstruction Technique that Uses an Epiphyseal Socket in Children

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Objectives: The purpose of this study was to assess short-term distal femoral growth plate safety associated with femoral sockets for hamstring autograft fixation in pediatric MPFL reconstruction.

Methods: We retrospectively reviewed a consecutive series of 31 patients (22 females, 9 males) that underwent MPFL reconstruction by one surgeon at a tertiary care academic medical center between 2008 and 2014. Study inclusion criteria consisted of patients who were skeletally immature at the time of surgery, who had greater than 1 year radiographic follow-up and who had a femoral socket introduced during their procedure. Femoral socket location was verified by intraoperative fluoroscopy. All patients received a post-operative x-ray and a clinical follow-up. For the 12 patients that obtained post-operative MRI, growth plate safety was assessed by examining the location of the femoral socket relative to the physis to rule out growth plate injury (Figure 1). Development of lower limb angular deformities or limb length discrepancies was evaluated by examining post-operative standing hip-to-ankle anteroposterior radiographs, patient records, and clinical assessments.

Results: The average age at surgery of 13.0 years. The average length of radiographic follow-up was 1.5 years and the average length of clinical follow-up was 1.78 years. At most recent clinical follow-up, 90% (28/31) of patients reported no subsequent patellar dislocations in the treated knee. No patients showed evidence of an angular deformity or limb length discrepancy. Of the 12 patients with postoperative MRI, all showed femoral sockets positioned distal to the physis without growth plate disturbance.
Conclusion: The use of an epiphyseal femoral socket for graft fixation presents minimal risk of physeal violation and ensures patellar stability in the majority of pediatric patients. We have demonstrated that using fluoroscopic assistance to place the femoral socket distal to the distal femoral physis is a reliable

and safe method for avoiding physeal injury in children with patellar instability.

Figure 1. Coronal proton-density MRI showing femoral socket distal to distal femoral physis.

Paper 12

Extra-articular Drilling for Adolescents with Osteochondritis Dissecans of the Talus: A Lost Cause or a Call to Develop Better Treatment?

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Objectives: To determine the radiographic outcome and need for further surgery in children with osteochondritis dissecans (OCD) of the talus treated with extra-articular drilling. Children requiring further surgery for pre-operative risk factors of the initial failure were also evaluated.

Methods: Fifty-six ankles were identified between August 2006 and August 2012 with talus OCD that underwent extra-articular talar drilling. Demographic data, mechanism of injury, conservative treatment history, surgical details of initial treatment and subsequent treatment, if necessary, was collected. Pre-operatively, radiographs were evaluated for physeal status, signs of osteoarthritis according the Kellgren and Lawrence Scale, location of the lesion, border, and size of the lesion. Each lesion was classified according to the Berndt and Harty classification for radiographs, Hepple classification for MRI, and Ferkel and Sgaglione for CT. Radiographs at each follow-up visit were evaluated by a Healing matrix that assessed serial changes in lesion length, lesion depth, perilesional sclerosis, or density of the lesion. At final follow-up, lesion size, border, Berndt and Harty classification, and signs of osteoarthritis were recorded.

Results: At final follow-up, all but one lesion showed radiographic improvement but no lesion reached complete radiographic resolution. The mean Healing matrix score at final follow-up was 59/100. Risk factors for reaching statistical significance for poor healing included closed physes ($p = 0.025$) and lesions with a distinct border ($p = 0.029$). Age, size of lesion, and length of follow-up did not correlate with healing. Comparison of pre-operative and final follow-up radiographs showed no significant change in the size or border of the lesion. For the 23% of children who underwent a second surgery, they were found to have a lower Healing matrix score after index surgery compared to those without repeat surgery, $p < 0.001$). Moreover, patients with closed physes were more likely to have second surgery, 38% vs. 14% (OR 3.7). After a second extra-articular talar drilling surgery, the mean Healing matrix score improved to match the mean of the entire cohort.

Conclusion: Extra-articular talar drilling of OCD does not appear to improve radiographic outcomes as compared with other reported techniques of intra-articular drilling. As with other joints, successful radiographic resolution is associated with open physes - highlighting that children have better OCD healing potential. Other modalities of talus OCD treatment should be explored, especially for higher-grade lesions at risk for instability, since the radiographic results of current drilling techniques are disappointing.

Paper 13

Outcomes of Lisfranc Injuries in the National Football League

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Objectives: Tarsometatarsal (Lisfranc) joint injuries commonly occur in American professional football competition; however, the career impact of these injuries is unknown. This study aims to define the time to return to competition for professional football players who sustained Lisfranc injuries and to quantify their effect on athletic performance.

Methods: Data on National Football League (NFL) players who sustained a Lisfranc injury during a ten-year time period (2000-2010) were collected for analysis. Recorded demographic variables included age, experience, position, and operative vs. non-operative management. Outcomes data collected for offensive players (running backs, wide receivers, tight ends) included time to return to competition and yearly total yards and touchdowns. Outcomes data collected for defensive players (defensive linemen, linebackers, defensive backs) included time to return to competition and yearly total tackles, sacks, and interceptions. Offensive power ratings (OPR=total yards/10 + total touchdowns x6) and defensive power ratings (DPR=total tackles + total sacks x2 + total interceptions x2) were calculated for the injury season and for 3 seasons before and after the injury season. Offensive and defensive control groups consisted of all players of similar positions without an identified Lisfranc injury that competed in the 2005 season.

Results: Lisfranc injuries were identified in 28 NFL athletes in the study period, including 11 offensive players and 17 defensive players. While 2 of 28 (7.1%) players never returned to the NFL, the remaining 26 (92.9%) athletes returned to competition at a median 11.1 (interquartile range: 10.3-12.5) months from time of injury and missed a median 8.5 (6.3-13.0) NFL regular season games. Players treated non-operatively were noted to have an earlier return to play with a median absence from play of 6.2 (1.9-10.7) months and 7.0 (4.5-8.0) games compared to those treated operatively who returned after a median 11.6 (10.7-12.6) months (p=0.02) and 10.0 (7.0-13.3) games missed (p=0.09).
Analysis of pre- and post-injury athletic performance revealed no statistically significant changes following return to sport after Lisfranc injury. The magnitude of change in median OPR for 3 seasons prior to index season compared to 3 seasons after index season observed in the Lisfranc-injured offensive study group, -34.8 (-64.4-1.4), was greater than that observed in the offensive control group, -18.8 (-52.9-31.5); however, these differences did not reach statistical significance (p=0.33). Similarly, the magnitude of change observed in the Lisfranc-injured defensive study group, -13.5 (-30.9-4.3), was greater than that observed in the defensive control group, -5.0 (-22.0-14.0); however, these differences also did not reach statistical significance (p=0.21).

Conclusion: Greater than 90% of NFL athletes who sustained Lisfranc injuries returned to play in the NFL at a median 11.1 months from time of injury. Operative treatment was associated with a longer time to return; however, this is a potential surrogate for greater injury severity. Offensive and defensive players

experienced a decrease in performance after return from injury that did not reach statistical significance when compared to their respective control groups over a similar time period.

Paper 14

Radiographic Identification of the Syndesmotic Structures of the Ankle

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Objectives: Syndesmotic ligament sprains may result in significant time lost from sport and can lead to chronic pain and instability. While syndesmotic anatomy has been well-defined, quantitative radiographic guidelines for identifying the anatomic ligament attachment sites and tibiofibular cartilage surfaces have not been adequately defined. The purpose was to define quantitative radiographic guidelines for identifying the origins and insertions of the syndesmotic ligaments and tibiofibular articulating cartilage surfaces with respect to radiographic landmarks and standard reference lines.

Methods: Twelve non-paired fresh-frozen ankles were dissected to identify the attachments of the anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL), interosseous tibiofibular ligament (ITFL), and the cartilage surfaces of the tibiofibular articulation. The center of each structure was marked with a 2 mm radiopaque sphere at the level of the cortex. Standard lateral and mortise radiographs were obtained using a fluoroscopy c-arm and calibrated using a 25.4 mm diameter radiopaque sphere positioned in the field of view. Using a picture archiving and communications system, measurements were performed twice by two independent raters to calculate intra- and inter-rater reliability via intraclass correlation coefficients (ICCs).

Results: Measurements demonstrated excellent agreement between raters and across trials (All inter- and intra-rater ICCs ≥ 0.960) for all structures and radiographic views.
On the lateral view, the AITFL tibial origin was 9.6 ± 1.5 mm superior and posterior to the anterior tibial plafond (Table 1). Its fibular insertion was 4.4 ± 1.7 mm superior and posterior to the anterior fibular tubercle. The superficial PITFL originated 7.4 ± 1.6 mm superior to the posterior plafond and inserted 22.0 ± 2.3 mm superior and posterior to the lateral malleolus. The corresponding measurements for the deep PITFL were 3.2 ± 1.5 mm superior and 15.4 ± 3.4 mm superior and posterior, respectively. The proximal and distal edges of the ITFL tibial origin were 45.9 ± 7.9 mm and 12.4 ± 3.4 mm proximal to the central aspect of the plafond respectively. The center of the tibiofibular contact area was 8.4 ± 2.1 mm posterior and superior to the anterior plafond.

On the mortise view, the AITFL tibial attachment was 5.6 ± 2.4 mm medial and superior to the lateral extent of the plafond and its fibular insertion was 21.2 ± 2.2 mm superior and medial to the lateral malleolus. The corresponding superficial PITFL measurements were 2.7 ± 1.7 mm and 21.5 ± 3.2 mm respectively. The ITFL distal tibial margin was 11.1 ± 3.5 mm proximal to the tibial plafond.

	Lateral View			Mortise View		
	Absolute Distance, mm (Mean ± SD)	Anterior(+)/ Posterior(-) Distance, mm	Superior(+)/ Inferior(-) Distance, mm	Absolute Distance, mm (Mean ± SD)	Lateral(+)/ Medial(-) Distance, mm	Superior(+)/ Inferior(-) Distance, mm
AITFL						
Tibial Attachment Center to:						
Tibial Plafond, Anterior/Lateral Corner	9.6 ± 1.5	2.4	-8.8	5.6 ± 2.4	-3.5	-2.6
Fibular Attachment Center to:						
Inferior Tip, Lateral Malleolus	22.5 ± 3.0	-10	-19.8	21.2 ± 2.2	5.1	-16.8
Anterior Fibular Tubercle	4.4 ± 1.7	2.2	-3.5	-	-	-
ITFL						
Tibial Proximal Terminus to Tibial Plafond	45.9 ± 7.9	-	-45.9	45.0 ± 9.9	-	-44.9
Tibial Distal Terminus to Tibial Plafond	12.4 ± 3.4	-	-12.4	11.1 ± 3.5	-	-11.1
Fibular Proximal Terminus to Inferior Tip, Lateral Malleolus	58.7 ± 5.6	-0.5	-58.4	59.0 ± 6.9	6.6	-58.1
Fibular Distal Terminus to Inferior Tip, Lateral Malleolus	27.0 ± 3.2	0.3	-26.6	29.5 ± 3.4	8.1	-27.4
PITFL						
Tibial Superficial Attachment to Tibial Plafond, Posterior/Medial Corner	7.4 ± 1.6	0.6	-6.9	2.7 ± 1.7	2.2	-0.9
Tibial Deep Attachment to Tibial Plafond, Posterior/Medial Corner	3.2 ± 1.5	-0.5	-2.6	7.3 ± 2.7	6.2	2.9
Fibular Superficial Attachment to Inferior Tip, Lateral Malleolus	22.0 ± 2.3	10.5	-19.0	21.5 ± 3.2	8.0	-19.5
Fibular Deep Attachment to Inferior Tip, Lateral Malleolus	15.4 ± 3.4	6.4	-13.5	18.9 ± 3.4	10.9	-15.1
Tibiofibular Contact Areas						
Tibial Facet to Tibial Plafond, Anterior/Lateral Corner	8.4 ± 2.1	5.9	-5.3	2.3 ± 1.2	-1.5	0.1
Fibular Facet to Inferior Tip, Lateral Malleolus	21.3 ± 2.5	-6.3	-19.3	22.8 ± 2.6	10.3	-16.6

Conclusion: Radiographic measurements demonstrated excellent agreement among reviewers and across trials suggesting clinical reproducibility and surgical utility of the defined parameters. Regardless of the type of surgical treatment, these parameters will assist with preoperative planning, augment intraoperative navigation, and provide additional means for objective post-operative assessment of hardware and tunnel placement. Furthermore, radiographic landmarks may be of particular use in revision or arthroscopic assisted cases where surgical landmarks may be obscured or not readily visible.

Paper 15

Do Ankle Sleeves And Lace-Up Braces Effect Neuromuscular Control And Athletic Performance?

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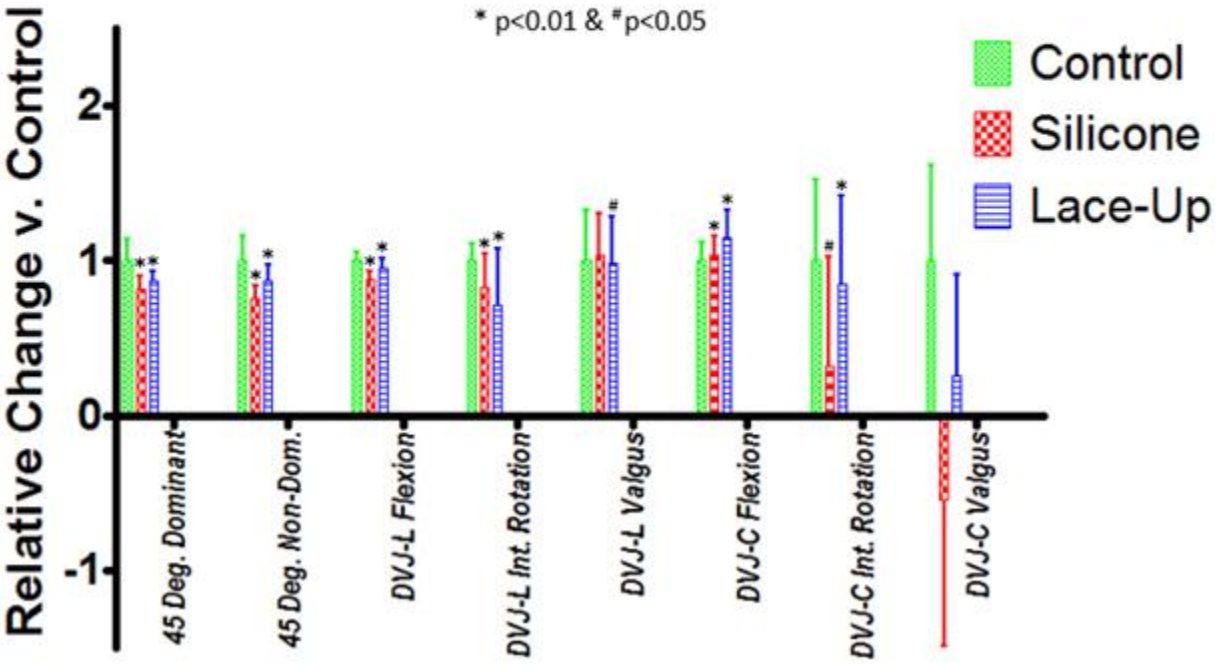
Objectives: Athletes commonly wear fitted silicone ankle sleeves (SAS) and lace-up ankle braces (LAB). There is limited data about their effect on neuromuscular control or athletic performance. Our goal is to evaluate their efficacy in a young, active population during athletic tasks using motion analysis.

Methods: Ten subjects (5 males, 5 females) without prior musculoskeletal injury were recruited. They were asked to perform the Drop Vertical Jump test (DVJ), 45 degree bound, and cutting maneuvers under three conditions: No brace, SAS, LAB. DVJ was used as a surrogate for neuromuscular control, and the 45 degree bound and cutting for athletic performance. Tasks were performed in separate sessions to minimize effects of fatigue. Markerless motion-capture technology was used for data collection. For the DVJ, knee flexion, hip internal rotation, and dynamic valgus were measured during both contact and loading phases of landing. Ankle torque and range of motion were also evaluated. For the 45 degree bound, ankle torque was measured during the initial movement to the dominant knee. Performance time for the cutting with the dominant pivot foot was recorded. Statistics were calculated using a two-tailed Student's t-test with significance set at $p=0.05$.

Results: When compared to controls for both the contact and loading phases of the DVJ, use of the SAS or LAB demonstrated significantly decreased hip internal rotation (67%, 15%, respectively), ankle torque (13%, 11% respectively), and ankle range of motion ($p<0.01$). Knee flexion was increased at initial contact in both the SAS and LAB groups compared to control ($p<0.01$). There was no significant effect of the braces on dynamic knee valgus, and no differences detected between the SAS and LAB on all parameters. When compared to controls for the 45 degree bound, ankle torque was significantly reduced for subjects wearing either SAS or LAB (24%, 13.5% respectively, $p<0.01$). The use of SAS or LAB had no significant effect on timed cutting maneuver vs. controls ($p=0.1181$, $p=0.1124$ respectively). There were no differences detected between the SAS and LAB for all parameters. See Figure 1 for results.

Conclusion: Athletes wearing ankle sleeves and lace-up braces demonstrated improvements in neuromuscular control during the DVJ (decreased hip internal rotation, increased knee flexion at initial contact), decreased ankle torque during 45 degree bounding maneuvers, and no performance time deficit versus control during cutting maneuvers. There were no differences detected in either neuromuscular control or athletic performance between the brace types. The effect that these findings have on the incidence of lower extremity injury remains largely unknown and requires further investigation.

Movement with Silicone and Lace-Up Ankle Braces



Paper 16

Arthroscopic Treatment of Posterior Impingement of the Hindfoot

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Objectives: Open and arthroscopic techniques have been utilized in the treatment of posterior impingement of the ankle and hindfoot. Because posterior impingement occurs more frequently in patients who repetitively plantarflex the ankle, this population may especially benefit from a procedure that reduces pain and results in maximal range of motion (ROM). The purpose of this study was to assess the outcome of hindfoot endoscopy in patients with posterior ankle impingement through higher level of function outcome measures and physical examination parameters, focused on analysis of ROM.

Methods: 20 ankles (19 patients) were followed prospectively at a minimum 1 year follow-up (mean 38.2 months). 19 of 20 patients were competitive athletes. Patients completed a minimum of 3 months of nonoperative treatment. Diagnoses included os trigonum, tibial exostosis, talar exostosis, loose body or fracture nonunion, and ganglion cyst removal.

Patients underwent arthroscopic treatment utilizing a posterior approach; all relevant pathology was addressed. Post-surgery, patients were placed in a splint for 3 to 7 days then placed in a CAM boot for 2 to 3 weeks, weight bearing as tolerated. Physical therapy was initiated within 7-10 days; strengthening exercises were initiated postoperatively at 1 month.

Results: At most recent follow-up, VAS Pain and AOFAS Hindfoot scores showed significant improvement ($p<0.01$) pre to post-operatively; Tegner score remained unchanged ($p=0.888$). 3 patients were professional athletes; all returned to their previous level of professional activity. ROM variables between affected and unaffected sides reached statistical similarity at most recent follow-up. 15% of patients reported post-operative neuritis. No other complications were reported.

Conclusion: Posterior ankle arthroscopy allows for maintenance or restoration of anatomic ROM of the ankle and hindfoot, ability to return to at least previous level of activity, and improvement in objective assessment of pain relief and higher level of function parameters. Complications associated with this procedure are minimal.

Paper 17

The Use of Micronized Allograft Articular Cartilage (BioCartilage) and Platelet Rich Plasma to Augment Marrow Stimulation in an Equine Model of Articular Cartilage Defects

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Objectives: Microfracture continues to be a dominant treatment strategy for symptomatic articular cartilage defects. Improving the histologic and clinical outcomes with biologic adjuncts offers promise to enhance this widely utilized technique. Specifically, the use of a novel scaffold that is potentially conductive and inductive such as micronized allograft articular cartilage (BioCartilage-BC) combined with platelet rich plasma (PRP) was investigated as an adjunct to microfracture in an equine model of articular cartilage defects.

Methods: Five adult horses were anesthetized and 2 - 10mm diameter full thickness cartilage defects were created in the trochlear ridge in both knees; one proximal (high load) and another distal (low load). In one knee, microfracture (MFx) followed by grafting with BioCartilage(BC). BioCartilage was mixed with PRP and injected into the defect with a touhey needle and sealed with fibrin under CO2 arthroscopy. The opposite limb served as a control and received MFx only. Horses were euthanized at 13 months post-operatively. Outcome was assessed with serial arthroscopy, 3T T2 and T1rho MRI, microCT, and histology. Statistics were performed using a mixed effect model with response variable contrasts. $P \leq 0.05$ was considered significant.

Results: No complications such as joint inflammation, infection or lameness were encountered. The score for overall repair (12=normal, 0=complete degeneration) in both the proximal and distal defects was significantly better in the BC group compared to MFx (proximal BC 7.4±0.51, MFx 4.8±.1; p=0.041)(distal BC 5.6±0.98, MFx 2.6±1.5; p=0.022). All significant findings on histology (100=normal, o=complete degeneration) were confined to the proximal, high load defects. Graft perimeter integration (BC 96±8.9, MFx 68±19; p=0.02), graft base integration (BC 100+/- 0.0, MFx 70±37;p=0.044), subchondral bone architecture under the graft (BC 66±18, MFx 34±16; p=0.050) and collagen type II BC 82+/-8, MFx 58±11; p=0.051. There were no significant differences between BC and MFx in MRI or uCT analyses.

Conclusion: Micronized allograft articular cartilage (BioCartilage) and PRP improve cartilage repair compared to marrow stimulation alone in an equine model of articular cartilage defects. This technology offers promise for the use of homologous allograft tissue as a low-cost and safe augmentation procedure for traditional microfracture surgery.

Paper 18

The Effect of Recombinant Human Parathyroid Hormone (rhPTH) on Tendon-to-Bone Healing in a Rat Rotator Cuff Model

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Objectives: Successful rotator cuff tendon repair is predicated upon secure tendon-to-bone healing. A recent study has shown that recombinant human parathyroid hormone (rhPTH) treatment results in improved tendon-to-bone healing at the latter stages of healing, but not at early time points. We hypothesized that delaying administration of rhPTH until after the acute inflammatory phase would improve tendon-to-bone healing at all time points in a rat rotator cuff repair model.

Methods: One hundred and eight male Sprague Dawley rats underwent detachment and subsequent repair of the supraspinatus tendon based on an a priori power analysis. Fifty four rats underwent repair alone and 54 rats received repair plus daily subcutaneous injections of 10 µg/kg of rhPTH beginning on postoperative day 7 and continuing for 12 weeks. Rats were sacrificed at 2 and 16 weeks postoperatively for biomechanical testing or histologic and immunohistochemical analysis. Histologic slides were digitized, and the enthesis was evaluated quantitatively using NIH Image J and VisioMorph software.

Results: At 2 weeks postoperatively, the rhPTH group had significantly higher load to failure than the control group (10.85 versus 5.16 N; $p = 0.003$). At 16 weeks, there was no significant difference in load to failure between the two groups (Figure 1). With respect to stiffness of the repair, there was no significant difference between the two groups at either time point, but there was a trend toward increased stiffness in the rhPTH group at 2 weeks postoperatively compared to the control group (5.09 vs. 3.77 N/mm; $p = 0.12$). Histologically, the rhPTH specimens had more fibrocartilage and osteoblasts at all time points, with significantly better collagen fiber orientation at 2 weeks.

Conclusion: Administration of rhPTH significantly increased load to failure at 2 weeks postoperatively in a rat rotator cuff repair model, with improved collagen fiber organization and increased fibrocartilage formation. Delaying administration of rhPTH until postoperative day number 7, after the resolution of the acute inflammation from surgery had subsided, improved rotator cuff healing in the early postoperative period while maintaining later-stage mechanical strength.

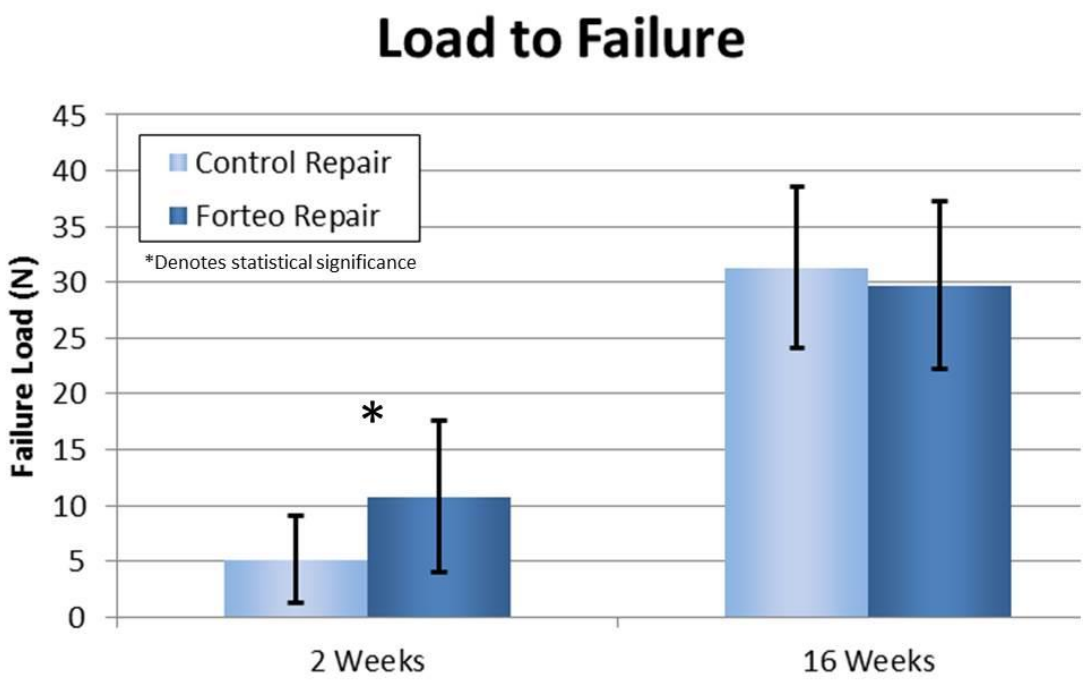
Load to Failure
Failure Load (N)
45
40
35
30
25
20
15
10
5
0
Control Repair
Forteo Repair
*Denotes statistical significance
*
2 Weeks
16 Weeks

Figure 1

Paper 19

The Cost-Effectiveness of Utilizing Platelet-Rich Plasma During Rotator Cuff Repair

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Objectives: A certain percentage of repaired rotator cuffs do not heal postoperatively. There has been significant interest in enhancing the healing potential of repaired rotator cuffs using biologic factors such as cytokines, gene therapy, scaffolds, mesenchymal stem cells, etc. Platelet-rich plasma (PRP) has been one of the most studied of these biologic factors. The purpose of this study was to determine whether or not PRP augmentation of rotator cuff repair (RCR) is cost-effective.

Methods: Utility values, retear rates, and transition probabilities were derived from the best evidence available in the literature regarding rotator cuff tears, their repair, and the augmentation of the repair with PRP. Costs were determined by examining the typical patient undergoing treatment for a full-thickness rotator cuff tear in a private orthopaedic clinic and outpatient surgery center. (Table 1) A Markov decision model was constructed using this data to perform a cost-effectiveness analysis. (Figure)

Results: The cost per quality-adjusted life year ($/QALY) of RCR with and without PRP was $6775/QALY and $6612/QALY respectively. In the base case scenario, the use of PRP to augment RCR was not cost-effective as it had exactly the same "effectiveness" as RCR without PRP augmentation while being associated with a higher cost (additional $750). Sensitivity analysis revealed that in order to achieve a willingness-to-pay threshold of $50,000/QALY, the addition of PRP would need to be associated with a 9.1% reduction in retears. If the cost of PRP were increased to $1000, the retear rate would need to be reduced 12.1% in order to reach this same threshold. This compared to a reduction of only 6.1% if the additional cost of PRP was $500. (Table 2)

Conclusion: This cost-effectiveness analysis reveals that, currently, the use of PRP to augment RCR is not cost-effective. Sensitivity analysis evealed that PRP augmented repairs would have to show a reduced retear rate of at least 9.1% before its additional cost would be considered cost-effective. Future research needs to show a significant and reliable reduction in retear rates or improvement in outcomes before PRP augmented RCR can be considered cost-effective.

Table 1 - Table of Utility Values, Transition Probabilities, and Costs Utilized in the Study

Model Inputs			
		Range	Source
Utility Values			
Symptomatic rotator cuff tear	0.67	0.552-0.803	Vitale et al[26] Mather et al[19]
Intact following RCR	0.78	0.74-0.851	Vitale et al[26] Mather et al[19]
Asymptomatic retear following RCR	0.78	Assumed to be equal to intact repair[8,19]	
Symptomatic retear following RCR	0.67	Assumed to be equal to symptomatic RTC tear[8,19]	
Transition Probabilities			
Rotator cuff retear	31%		Chahal et al[5]
Rate of patients with asymptomatic retears becoming symptomatic	5%		Mather III et al[19]
Rate of patients with symptomatic retears electing to undergo revision RCR	10%		Genuario et al[8]
Costs			
Rotator cuff repair without PRP augmentation	$30,572		Local data
Revision RTC repair	$16,453		Local data
Cost of PRP augmentation	$750		Local data

RCR - rotator cuff repair; PRP - platelet-rich plasma

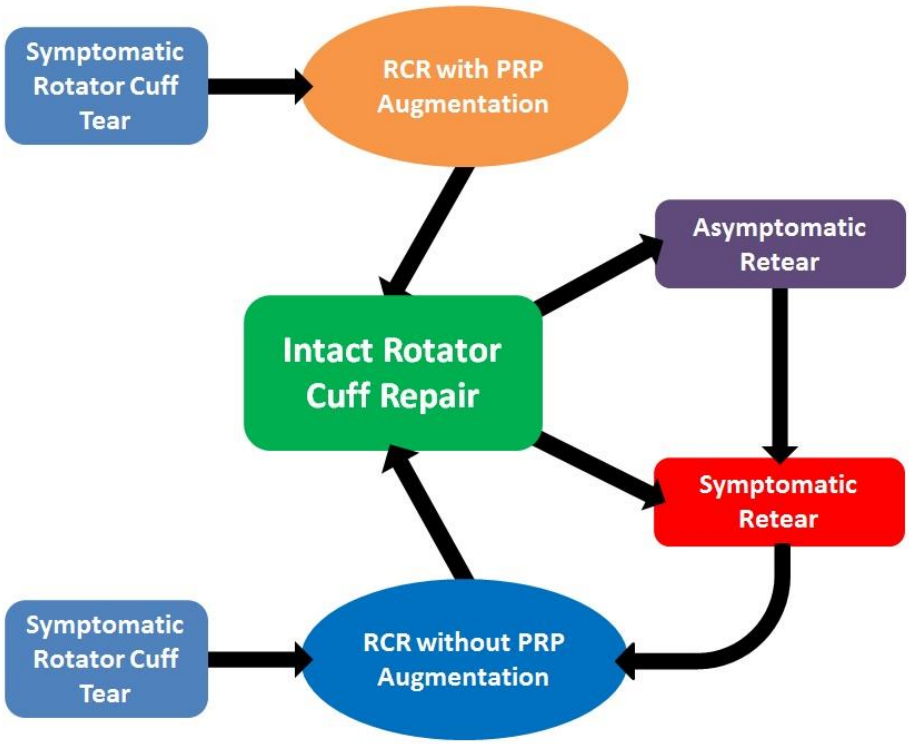

Table 2 - Results of Sensitivity Analysis Regarding the Cost of PRP Augmentation and the Associated Improvement in Retear Rates Following Rotator Cuff Repair

Sensitivity Analysis Regarding Cost of PRP and Reduction in Retear Rate Needed to Reach Cost-Effectiveness (ICER < $50,000/QALY)	
Cost of PRP	**Reduction in retear rate needed compared to without PRP (baseline - 31%)**
$250	3.2%
$500	6.1%
$750	9.1%
$1000	12.1%
$1500	18.2%

PRP - platelet-rich plasma; ICER - incremental cost-effectiveness ratio

Paper 20

The Effects of Latarjet Reconstruction on Glenohumeral Instability in the Presence of Combined Bony Defects

Authors: Ronak Maneklal Patel, MD[1], Piyush Walia, MS[2], Lionel Gottschalk, MD[3], Morgan H. Jones, MD[2], Stephen D. Fening, PhD[4], Anthony Miniaci, MD[5]
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Objectives: Recurrent glenohumeral instability is often as a result of underlying bony defects in the glenoid and/or humeral head. Anterior glenoid augmentation with a bone block (i.e. Latarjet) has been recommended for glenoid bone loss in the face of recurrent instability. However, no study has investigated the effect of Latarjet augmentation in the setting of both glenoid and humeral head defects (Hill-Sachs Defects (HSD)). The purpose of this study was to evaluate the stability achieved through a Latarjet procedure in the presence of combined bony defects.

Methods: Eighteen fresh-frozen cadaveric specimens were tested at all combinations of glenohumeral abduction (ABD) angles of 20°, 40°, and 60° and three external rotation (ER) levels (0°, 40°, and 80°). Each experiment comprised of anterior dislocation by translating the glenoid under a 50N medial load applied on the humerus, simulating the static load of soft tissues. Translational distance and medial-lateral displacement of the humeral head, along with horizontal reaction forces were recorded for every trial. Specimens were tested in an intact condition (no defect), different combinations of defects, and with Latarjet augmentation. The Latarjet was performed for 20% and 30% glenoid defects by transferring the specimen's coracoid process anterior to the glenoid flush with the articulating surface. Four different humeral head defects were created of sizes 6%, 19%, 31%, and 44% of humeral diameter. Repeated measures analysis of variance (ANOVA) was performed with statistical significance set at $p < 0.05$.

Results: Results are summarized in Fig. 1. The vertical axis represents the normalized distance to dislocation with respect to the values of the intact joint. The horizontal axis represents the varying sizes and combinations of bony defects. At 20° ABD and 0°ER, increasing HSD size did not affect percentage of intact translation with a constant glenoid defect of 20% before and after Latarjet augmentation (Fig. 1A). However, at an arm position of 60° ABD and 80° ER increasing HSD size led to a decrease in stability for both the defect state and post-Latarjet trials (Fig. 1B). Nevertheless, Latarjet augmentation helped in regaining stability for every combination of bony defects. With a HSD size of 44% the defect state had 0% intact translation for all 18 specimens.

Conclusion: Clinically, these results demonstrate that some degree of stability can be regained for combined bony Bankart and Hill-Sachs defects with a Latarjet procedure. However, for humeral defects larger than 30%, the rotational effect of the HSD led to persistent instability. Thus, directly addressing

the humeral defect to restore the articular surface should be considered in these cases. In conclusion, this study demonstrated that Latarjet procedure can restore the stability for combined defects, however for humeral defects greater than 31% may need attention.

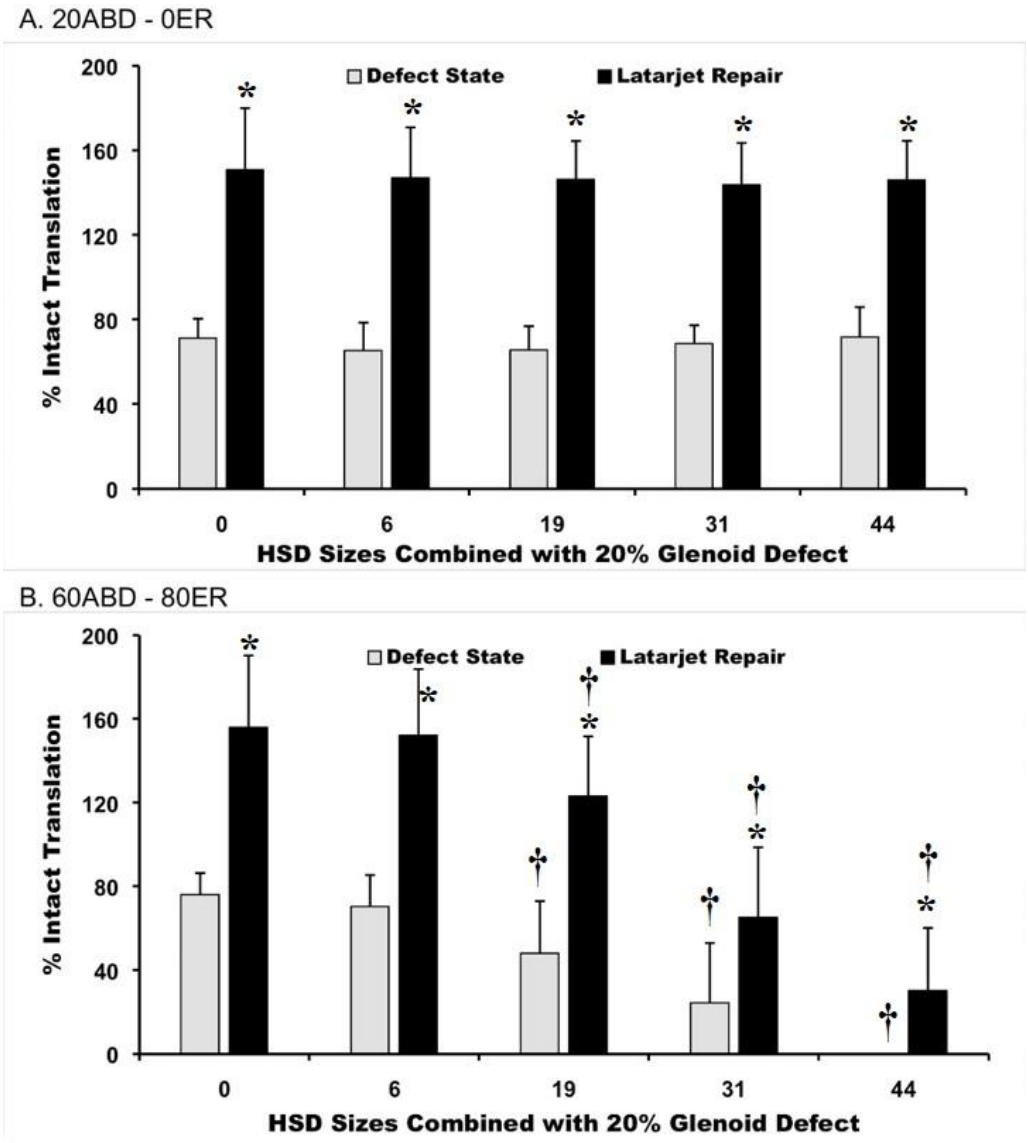

Figure 1: Percent intact translation for the listed defect state with and without Latarjet augmentation for a 20% glenoid defect combined with HSD sizes of 0, 6, 19, 31, and 44% at arm positions of (A) 20° ABD and 0° ER and (B) 60° ABD and 80° ER, where * signifies the significant difference between the defect state and Latarjet repair for each defect combination and † signifies the significant effect of increasing defect size with $p < 0.05$.

Paper 21

Clinical Outcomes Following Revision Anterior Shoulder Stabilization: Arthroscopic Revision Stabilization versus Latarjet

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Objectives: The purpose of this study was to determine the clinical outcomes following revision anterior shoulder stabilization performed either via all-arthroscopic soft tissue repair or via Latarjet coracoid transfer.

Methods: A retrospective review of prospectively collected data on 91 shoulders undergoing revision anterior shoulder stabilization was performed. All patients underwent prior soft tissue stabilization; those with prior open bone grafting procedures were excluded. For patients with 25% glenoid bone loss, Latarjet was performed (n=28). Patients were queried regarding recurrent instability (subluxation or dislocation). Clinical outcomes were evaluated using validated patient reported outcome questionnaires including the American Shoulder and Elbow Surgeons (ASES) score, Simple Shoulder Test (SST), visual analog scale (VAS) for pain, and Western Ontario Shoulder Instability Index (WOSI).

Results: A total of 63 shoulders in 62 patients (46 males, 16 females) with an average age of 23.2 ± 6.9 years were included in the revision arthroscopy group. At an average follow-up of 46.9 ± 16.8 months (range, 15 to 78), the mean WOSI score was 80.1 (range, 15.0 to 100), and there were significant improvements ($p<0.001$) in ASES (63.7 to 85.1), SST (6.2 to 9.1), and VAS pain scores (2.89 to 0.81). Recurrent instability occurred in 12 of 63 shoulders (19%); the number of prior surgeries and baseline hyperlaxity were significant risk factors for failure ($p<0.001$ and $p=0.04$, respectively). No patients developed clinical or radiographic evidence of arthritis. A total of 28 shoulders in 28 patients (21 male, 7 female) with an average age of 27.5 years (range 14 to 45) were included in the Latarjet group. Thirteen (46%) had more than one previous stabilization attempt.), the average WOSI score was 71.9, and there were significant improvements ($p<0.001$) in ASES (65.7 to 87.0), SST (7.2 to 10.3), and VAS (3.1 to 1.1). Recurrent instability occurred in 2 of 28 shoulders (7%), including 1 patient with symptomatic subluxation and 1 patient with a recurrent dislocation resulting in rapid arthrosis requiring revision to hemiarthroplasty at 20 months after Latarjet.

Conclusion: Both arthroscopic revision stabilization and Latarjet coracoid transfer result in satisfactory outcomes in patients who have failed previous arthroscopic capsulolabral repair. Recurrent instability rates were higher in the all-arthroscopic group (19% versus 7%). Longer-term studies are required to determine whether similar results are maintained over time, and to provide guidance on focused clinical indications for this challenging patient population.

Paper 22

Treatment And Results Of Combined Mild Bone Loss Instability With The Modified Laterjet

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Objectives: Recurrent anterior glenohumeral dislocation in the setting of an engaging Hill-Sachs lesion is high. The Latarjet procedure has been well-described for restoring glenohumeral stability in patients with over 25% glenoid bone loss. However, the treatment for patients with combined humeral head and mild (<25%) glenoid bone loss remains unclear. We report on the outcomes of the modified Latarjet for this population.

Methods: Modified Latarjet was performed in twenty three patients with recurrent anterior shoulder instability, engaging Hill-Sachs by exam confirmed with arthroscopy, and less than 25% anterior glenoid bone loss. The mean follow-up was 3.5 years. All patients were assessed for their risk of recurrence using the Instability Severity Index Score (ISIS), had pre-operative 3D imaging to assess humeral and glenoid bone loss. Single Assessment Numeric Evaluation (SANE), Western Ontario Shoulder Instability Index (WOSI), recurrence rate, radiographs, range of motion and dynamometer strength were used to assess outcomes.

Results: Average pre-operative instability severity index score was 6.2 (range 4-9). Pre-operative glenoid bone loss averaged 15.1% (range 5-25%). The humeral defect averaged 40.4% in width and 13.7% in depth on axial computed tomography scan, with an average Hill-Sachs angle of 28°. The mean WOSI index was 457 of 2100 (range 0-1398). The mean SANE score was 81.2 (range 60-100). Five out of ten competitive athletes returned to play for at least one season. There were no recurrent dislocation and three patients had a single episode of recurrent subluxation. Loss of external rotation at the side averaged 8°, and there was no significant loss of abduction. Subscapularis, abduction and external rotation strength averaged greater than 85% of the contralateral shoulder. Fourteen patients on average had 1.4 (range 1-4) previous open or arthroscopic stabilization procedures prior to the Latarjet, nine others had Latarjet done primarily. WOSI scores correlated directly with number of previous surgery ($r=0.81$, $p=0.02$). Average WOSI score was 239 (range 0-510) in primary Latarjet, 495 (range 42-1024) in patients with one previous stabilization procedure, and 674 (range 192-1398) in patients with two or more previous stabilization procedures (ANOVA $p<0.001$). There were three deep infections, two graft fractures, two painful hardware, one broken screw with graft malunion, and one radiographic graft nonunion. All infections, malunion and nonunion occurred in patients with failed previous stabilization procedures. No long-term nerve palsies were found. Resorption of the graft at the superior screw was seen in 28% of patients.

Conclusion: The modified Latarjet is a reasonable choice for the treatment of an engaging Hill-Sachs lesion with concomitant mild anterior glenoid bone loss in this very demanding group of patients. However, the complication rate is significant.

Paper 23

Improved Return to Play in Intercollegiate Contact Athletes following Arthroscopic Stabilization for Anterior Shoulder Instability: A Prospective Multicenter Study

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Objectives: Debate continues regarding the optimal treatment of intercollegiate contact athletes with in-season anterior shoulder instability. Comparative evaluation of successful return to play (RTP) without recurrence in subsequent seasons after the index instability event has not been prospectively evaluated in this patient population. The purpose of this study was to examine return to sport and recurrent instability in the season that follows the index anterior in-season instability event.

Methods: Over two academic years, 45 contact intercollegiate athletes treated nonoperatively or with arthroscopic stabilization were prospectively followed in a multicenter observational study to evaluate RTP and recurrent instability in the intercollegiate season following an initial in-season anterior glenohumeral instability event. The primary outcome of interest was successful RTP, defined as the ability to return to sport in the subsequent season without recurrent instability. Baseline data collection included sport played, previous instability events, direction of instability, type of instability (subluxation or dislocation), and treatment method (nonoperative or arthroscopic stabilization). The decision to pursue operative or nonoperative treatment was made at the discretion of the patient and surgeon. All nonoperatively treated athletes underwent a standardized accelerated rehabilitation program without shoulder immobilization. Surgical stabilization was performed arthroscopically in all cases and successful RTP was evaluated during the next competitive season after complete rehabilitation. All subjects were actively monitored during the course of their competitive season to determine return to play success and recurrent instability events.

Results: A total of 45 intercollegiate contact athletes were treated for in-season anterior shoulder instability. Thirty-nine athletes had remaining NCAA eligibility and were followed through the subsequent competitive season. Of these, 10 elected to be treated nonoperatively while 29 elected for surgical repair. Of the group selecting nonoperative treatment, only 4 (40%) successfully RTP without recurrence during the subsequent season. Of the 29 athletes treated surgically, 26 (90%) were able to successfully RTP without recurrence the following season. Two athletes were cut from the team and one athlete sustained a recurrent instability event requiring revision stabilization. Athletes who underwent surgical reconstruction prior to the following season were 5.8 (95%CI: 1.77, 18.97, p=0.004) times more likely to complete the subsequent season without recurrent instability. Of the 29 athletes electing

surgical stabilization, there was no difference (RR=0.95, 95%CI: 0.10, 9.24, p=1.00) in RTP between the 9 stabilized following a single instability event (90% RTP) and the 20 stabilized following multiple in-season recurrent instability events (89% RTP).

Conclusion: Collegiate collision athletes with in-season shoulder instability are significantly more likely to successfully return to sport without subsequent instability events the following season if they undergo surgical repair in the off season.

Paper 24

The Epidemiology of Primary Anterior Shoulder Dislocations in Patients Aged 10-16 Years and Age-Stratified Risk of Recurrence

Authors: Timothy Leroux, MD, MEd[1], darrell ogilvie-harris[2], Christian Veillette, MD, MSc, FRCSC[1], Jaskarndip Chahal, MD, FRCSC[3], Tim Dwyer, MD[1], Patrick Henry, MD, FRCSC[1], Amir Khoshbin, MD[4], Nizar Mahomed, MD, ScD, MPH, FRCSC[1], David Wasserstein, MD, MSc, FRCSC[5]
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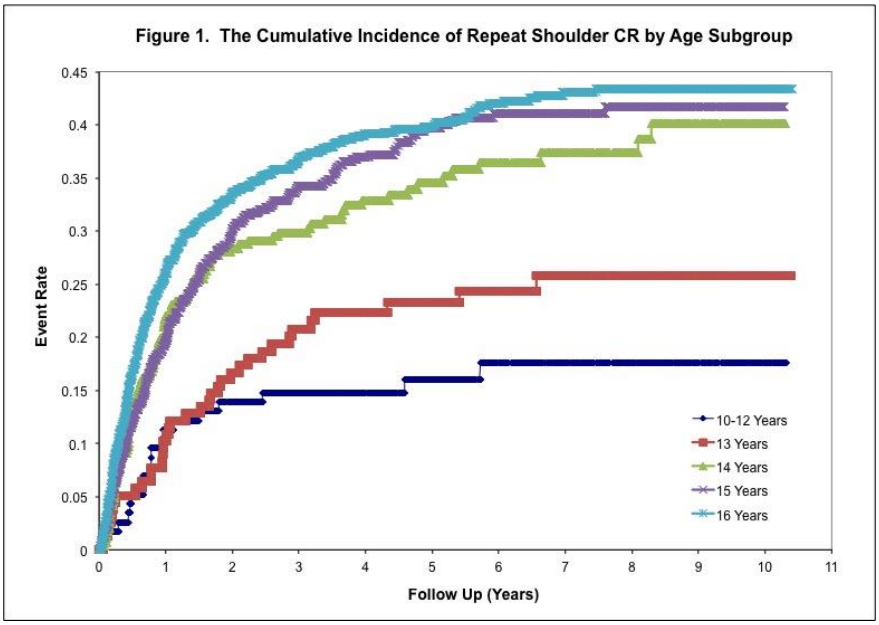
Objectives: Most clinical studies pertaining to shoulder dislocation use age cutoffs of 16 years, and at present, only small case series of patients aged 10-16 years guide our management. Using a general population cohort aged 10 to 16 years, we sought to: 1) determine the overall and demographic-specific incidence density rate (IDR) of primary anterior shoulder dislocation requiring closed reduction (CR), and 2) determine the rate of and risk factors for repeat shoulder CR.

Methods: Using administrative databases, we identified all patients who underwent CR of a primary anterior shoulder dislocation by a physician in Ontario between April 2002 and September 2010 (the index event). Exclusion criteria included age (16 years), posterior dislocation, and prior shoulder dislocation or surgery. The IDR was calculated for the entire cohort and compared by age and sex subgroups. The main outcome, repeat shoulder CR, was sought until September 2012. A time-to-event analysis (cumulative incidence function) was used to determine the incidence of repeat shoulder CR at six-months, one-year, two-years, and five-years for the entire cohort and subgroups based on age (10-12, 13, 14, 15, and 16 years). A competing risk model identified risk factors for repeat shoulder CR, which were reported using hazard ratios (HR) with 95% confidence intervals (CI).

Results: We identified 2,066 patients aged 10-16 years who underwent CR following a primary anterior shoulder dislocation, of which, 1,937 met the exclusion criteria. The median age was 15.0 years and 79.7% were male. The IDR was 20.1 per 100,000 person-years, and was highest among 16 year-old males (164.4 per 100,000 person-years). In contrast, primary anterior shoulder dislocation was rare among patients aged 10-12 years [5.9% (N=115) of all primary dislocations]. Repeat shoulder CR was observed in 740 patients (38.2%) after a median of 0.8 years. The overall cumulative incidence of repeat shoulder CR at six-months, one-year, two-years, and five-years was 13.0%, 21.3%, 29.2%, and 36.2%, respectively; however, the cumulative incidence by age (Figure 1) revealed the rate of repeat shoulder CR to be highest among 14-16 year-olds (37.2-42.3%), and considerably less among patients aged 10-13 years (0-25.0%). Male sex (HR 1.2, p=0.04; interpreted as a 20% increased risk for males as compared to females) and patient age (HR 1.2, p<0.001; interpreted as a 20% increased risk for each year over age 10) significantly influenced the risk of a repeat shoulder CR. Overall, 31.2% (N=604) of patients underwent shoulder stabilization, of which, half underwent surgery following the index shoulder CR (49.9%, N=369).

Conclusion: Primary anterior shoulder dislocations are common among 14-16 year olds, and the rate of recurrence in this age group following non-operative management mirrors that of 17-20 year olds in previously published data. In contrast, both the incidence of primary anterior dislocation and rate of recurrence are considerably lower for patients aged 10-13 years. Going forward, clinicians should treat and counsel patients aged 14-16 years, particularly males, as they do older adolescents (17-20 years); however, patients 13 years of age or younger should be counselled regarding their low risk for recurrence.



Paper 25

Outcomes Following Arthroscopic Pancapsular Shift for the Treatment of Multidirectional Instability

Authors: Martin Brett Raynor, MD[1], Marilee P. Horan, MPH[2], Joshua A. Greenspoon, BSc[2], Peter J. Millett, MD, MSc[3]
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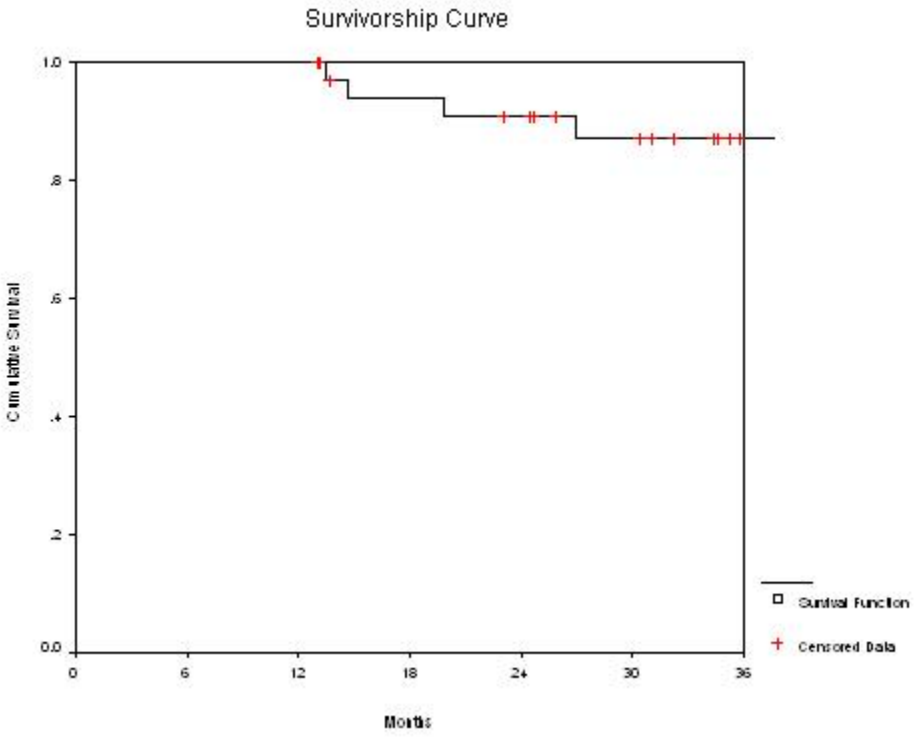
Objectives: Multidirectional instability of the shoulder (MDI) is a clinical diagnosis that can be difficult to both diagnose and treat. Arthroscopic management of MDI has been used to treat patients with MDI and has the advantage of being able to treat the anterior, posterior, and inferior parts of the capsule. Few studies have presented outcomes with this approach. The purpose of this study is to examine mid-term outcomes after arthroscopic management of multidirectional glenohumeral instability.

Methods: In this IRB approved study, patients who underwent arthroscopic stabilization for MDI and were at least 2 years out from surgery were included. MDI was defined by symptomatic glenohumeral instability in 2 or more directions, one of which was inferior. Patients were excluded if they were treated with open surgery or if they had a previous stabilization procedure performed on that shoulder. All patients underwent a pancapsular shift that included tightening posteriorly, inferiorly, and anteriorly with multiple suture anchors and high strength sutures. Patient-reported subjective data was prospectively collected and retrospectively reviewed and included patient satisfaction, instability symptoms, American Shoulder and Elbow Society shoulder index, Single Assessment Numeric Evaluation (SANE), quick Disabilities of the Arm, Shoulder, and Hand score (Quick-DASH), and Short-Form 12 (SF-12) scores. Additional patient-reported information regarding shoulder instability was also collected in the same fashion. Kaplan-Meier survivorship analysis was performed with self-reported postoperative dislocation status. Level of significance was set at $p<.05$.

Results: Forty-one patients (45 shoulders) with MDI were treated with arthroscopic stabilization and were at least 2 years out from surgery. Of these patients, 32/39 (82%) reported a preoperative instability event while participating in a recreational or competitive sport. There were 25 men and 16 women with a mean age at the time of surgery of 26 (range, 16-65 years) with an average subjective follow-up of 2.9 years. Men were significantly older than women at time of surgery (mean age 28 vs 20: $p=.001$) but no differences was seen in outcome scores between genders. Four patients (4/45) progressed to another instability surgery at a mean of 25 months (range, 13-68 months). Kaplan Meier survivorship analysis at 1 year was 100% and 90.7% at 2 years (Figure 1). Feelings of subluxation significantly improved postoperatively from pre-op levels ($p=.017$). Overall, all patient-derived subjective outcomes scores improved significantly from preoperative levels. In a subgroup analysis, outcomes scores of patients with a traumatic onset of instability all improved from preoperative levels ($p<.05$). However, patients with atraumatic onset of instability had ASES scores that significantly improved from preoperative levels, while their QuickDASH, SANE and SF-12 Physical Component scores did not. At final follow-up, patients with traumatic onset of instability were significantly more satisfied with outcomes (10 vs 9: $p=.028$) than those with an atraumatic onset.

Conclusion: Even though MDI has historically been difficult to diagnose and treat, arthroscopic surgery in our cohort showed promising results. Improvement in outcomes was more predictable in those patients with traumatic onsets of instability, while those with atraumatic onsets benefited from surgery but had less predictable outcomes.



Paper 26

Outcomes of Hip Arthroscopy for Patients with Symptomatic Borderline Dysplasia: A Comparison to a Matched Cohort of Patients with Symptomatic FAI

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Objectives: The outcomes of hip arthroscopy in the treatment of dysplasia are variable. Arthroscopy in severe dysplasia (LCEA<18°) results in poor outcomes and iatrogenic instability. However, in milder forms of dysplasia, favorable outcomes have been demonstrated at short-term follow-up. The purpose of this study was to compare outcomes of hip arthroscopy in borderline dysplastic patients to a control group of non-dysplastic patients undergoing hip arthroscopy for femorocetabular impingement (FAI).

Methods: Between March 2009 and May 2012, 1381 patients (1593 hips) undergoing hip arthroscopy for intra-articular hip disorders were prospectively enrolled into a registry. From this cohort, a borderline dysplasia (BD) group comprising 44 patients (46 hips) with a LCEA ≥ 18° and ≤ 25° and a minimum of 2 years follow-up, was identified. A control group of 100 patients (123 hips) was also identified that had a LCEA ≥ 26° and ≤ 40°, and a minimum of 2 years follow-up. Patient-reported outcome scores, including the Modified Harris Hip Score (mHHS), the Hip Outcome Score-Activity of Daily Living (HOS-ADL), the Sport-specific Subscale (HOS-SSS), and the International Hip Outcome Tool (iHOT-33), were obtained preoperatively and at 6 months, 1, 2, and 3 years postoperatively. Continuous and categorical variables were compared with independent-samples t-tests and chi-square or Fisher's exact tests (as appropriate) respectively. Changes in outcomes scores within groups were assessed via paired t-tests.

Results: The mean age (±SD) of the BD and control groups was 29.3 ± 9.2 years and 29.1 ± 10.1 years respectively. There were 24 females (55%) in the BD group and 53 females (53%) in the control group (p=0.86). The mean LCEA was 21.8° (range, 18°-25°) in the BD group and 31.7° (range, 26°-40°) in the control group (p<0.001). The mean Tönnis angle was 6.2° (range, 1°-12°) in the BD group and 2.6° (range, -10°-12°) in the control group (p<0.001). The mean preoperative alpha angle was 63.7 ± 10.3° in the BD group and 58.6 ± 13.9° in the control group (p=0.02). A subgroup analysis of alpha angle by sex showed that females had significantly lower alpha angles than males (59.2° vs 69.1°; p=0.001). Labral re-fixation and a complete capsular closure was performed in over 70% and 90% of patients in both groups respectively. At a mean follow-up of 33.2 months (range, 24-58), there was significant improvement (p<0.001) in all patient reported outcome scores in both groups. However, BD patients had smaller mean improvements in all outcomes scores, and for HOS-SSS this difference was large (difference:-6.8; p=0.112). After adjustment for age, sex, alpha angle, and pre-operative score via multiple regression there was no significant difference between the BD and control groups. Importantly, female sex did not appear to be a predictor for inferior outcomes. One patient in the BD group was revised at 13 months and is awaiting a PAO. One patient in the control group required a revision arthroscopy at 30 months.

Conclusion: While we recommend caution in treating symptomatic dysplasia with hip arthroscopy, our results indicate that in borderline dysplasia, favorable outcomes can be expected when a careful approach of labral re-fixation and capsular closure is employed. These outcomes are similar to non-dysplastic patients undergoing hip arthroscopy at a mean of 33 months follow-up. Further follow-up in larger cohorts is necessary to prove the durability and safety of hip arthroscopy in this challenging group.

Paper 27

Is MRI Subchondral Acetabular Edema or Cystic Change a Contraindication for Hip Arthroscopy in Patients with FAI?

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Objectives: Arthroscopic treatment for femoroacetabular impingement (FAI) generally has good results, but the outcome can worsen with increasing arthritis, largely defined as joint space narrowing. There remains a subset of hips with maintained joint space but with subchondral edema and cystic change of the acetabulum on MRI, with unknown outcome. Therefore, the purpose of this study was (1) to determine if postoperative outcome was worse for patients with subchondral edema on preoperative MRI compared to a matched control group and (2) to identify risk factors on MRI leading to inferior outcome.

Methods: A review of patients who underwent arthroscopic hip surgery for FAI between 2007 and 2013 identified 530 patients. Of these, 39 patients had evidence of subchondral edema or subchondral cyst on the preoperative MRI with maintained joint space on preoperative radiographs. Lesions were characterized by grade, location and type using an established radiographic MRI classification system. A matched cohort of patients without evidence of subchondral edema or cyst was identified, and 2:1 matching was based on patient age, surgeon, surgery year within one year, surgical procedure, Tegner activity score, and Tonnis grade osteoarthritis changes on preoperative x-ray. Outcome was compared using the Hip Outcome Score and Modified Harris Hip Score between the two groups. Risk factors were then analyzed for type of lesion, grade and location of bone marrow lesion.

Results: Thirty-nine patients (20 males, 19 females) showed preoperative MRI evidence of subchondral edema, and were followed for a mean of 23 months postoperatively (range, 12 - 60 months). Patients had an average age of 41 years (range, 19 - 67) and a preoperative Tegner score of 3.8 (range, 1 - 9). 87% of patients with subchondral cystic change had evidence of a grade IV full thickness cartilage lesion at the time of hip arthroscopy. Average Modified Harris Hip Scores were inferior for the subchondral group (79.9 ± 18.7) compared to the control group (86.6 ± 12.5; $p = 0.027$). In addition, Sport sub-scales of the Hip Outcome Score showed significantly lower scores for the subchondral group for both score (69.1 ± 27.0 vs. 79.5 ± 21.4, $p = 0.018$) and rating (66.7 ± 27.5 vs. 78.0 ± 20.8, $p = 0.044$). No radiographic risk factors, including type, location, or size of lesion were significant predictors of outcome. Two patients in the subchondral group were later converted to a total hip replacement.

Conclusion: The presence of a subchondral acetabular cyst on MRI is indicative of a full thickness cartilage lesion at the time of arthroscopy. These patients have inferior outcomes for arthroscopic treatment of FAI compared to patients with similar age and activity level without MRI subchondral changes. Therefore, we recommend caution with consideration of hip arthroscopy in this patient subset.

Paper 28

Arthroscopic Treatment of FAI in Adolescent Athletes

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Objectives: Athletic activities are implicated in the development of symptomatic FAI in adolescents as reflected by a high prevalence of sports participation among young individuals who present with this problem. The purpose of this study is to report the outcomes of arthroscopic treatment.

Methods: All patients undergoing arthroscopy are prospectively assessed with a modified Harris hip score. 104 athletes (117 hips) were identified among 108 consecutive adolescents (122 hips) less than 18 years of age who had undergone arthroscopic surgery for FAI and had achieved minimum one-year follow-up. This cohort of athletes represents the substance of this report.

Results: Follow-up averaged 28 months (range 12-60 months). Average age was 16 years (range 12-17 years). There were 47 males and 57 females. The average improvement was 22 points (preop 73; postop 95) with 113 hips (97 %) improved with 112 (96%) good & excellent results. Eighty-eight athletes (84%) returned to their sport. Among the 16 that did not return to sports, 5 were unable, 6 chose not, and 5 had completed their high school athletic careers. Most common sports were football 15, soccer 13, basketball 13, dance 11, volleyball 7, cross-country 7, swim 7, gymnastics 5, baseball 4, softball 4, and lacrosse 4. FAI correction was performed for 33 cam, 17 pincer, and 67 combined lesions. 107 labral tears underwent 82 refixations and 24 debridements. There were 99 acetabular chondral lesions (42 Grade I, 18 Grade II, 34 Grade III, 5 Grade IV) with four microfractures. There were 3 femoral chondral lesions (1 Grade II, 2 Grade III). Seven loose bodies were removed and 19 lesions of the ligamentum teres were debrided. Concomitant extra-articular procedures included 13 iliopsoas tendon releases, two iliotibial band tendoplasties, and one trochanteric bursectomy. There were two complications, transient pudendal neurapraxias, that resolved within two weeks. Four patients underwent repeat arthroscopy and one a PAO.

Conclusion: Athletic activities are implicated in the development of symptomatic FAI at a young age, and this study reports favorable outcomes of arthroscopic treatment of FAI among adolescent athletes. A high portion was improved, although only 84% actually returned to their sport. Return to sport may be influenced by factors other than just the success of the procedure.

Paper 29

The Impact Of Preoperative Planning Software On Arthroscopic Correction Of Femoroacetabular Impingement

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Objectives: Femoroacetabular impingement (FAI) likely represents the most common mechanism that leads to early cartilage and labral damage in the nondysplastic hip. Recently, hip arthroscopy has been used as a surgical approach to address both labral pathology and osteochondral deformities. Incomplete correction of femoral offset and sphericity is the leading cause for revision surgery for symptomatic FAI. Due to the technical difficulty of arthroscopic assessment of the hip, pre-operative planning and understanding of the underlying deformity is critical for successful treatment.
The purpose of this study is to assess the utility of a novel CT-based three-dimensional software program for pre-operative planning for arthroscopic treatment of femoroacetabular impingement. Our hypothesis is that pre-operative planning using a 3-D CT software program results in improved accuracy of correction and will reduce the incidence of under-resection.

Methods: Arthroscopic femoral neck osteoplasty and acetabular rim resection with labral repair or refixation was performed in all patients with symptomatic FAI that have failed nonsurgical management. Patients were distributed into two treatment groups: 36 patients in the Plan group utilized preoperative planning using a 3-D CT-based, computer software program (Dyonics Plan®, Smith and Nephew); and 30 patients in the control group utilized our standard preoperative assessment of plain radiographs and a CT scan with 3-D reconstructions. Pre- and post-operative AP alpha angle, extended neck lateral (Dunn) alpha angle, anterior head-neck offset, and beta angle were compared between both groups to assess the degree of deformity correction. Under-resection was defined as a post-operative alpha angle > 50° or a reduction < 20° for cases of very large alpha angles.

Results: Mixed model analysis of variance was used to compare radiographic indices between the control and Plan groups. There were no significant differences between the two groups at baseline. Both groups had a statistically significant improvement in all radiographic measurements after surgery. The Dunn alpha angle improved an average of 17.9° in the Plan group as compared to an average of 12.6° in the control group (p=0.003). The anterior head-neck offset improved a mean of 4.8 mm in the Plan group as compared to 3.5 mm in the control group (p=0.007). The number of patients with radiographic evidence of under-resection improved from 26.7% in the control group to 2.8% in the Plan group (p=0.009). The maximum alpha angles obtained from pre-operative CT scans were an average of 3° greater than the maximum alpha angles on the AP and Dunn X-ray views (p=0.007)

Conclusion: Arthroscopic osteoplasty utilizing the preoperative planning software resulted in a significant decrease in the rate of inadequate resection and an improvement in accuracy of deformity correction. Additionally, radial imaging with CT scan and the planning software measured a significantly greater maximum alpha angle than AP and Dunn view X-rays. With an improved accuracy of resection, preoperative planning using a 3-D CT software program may help to minimize the frequency of under-resection and thereby decrease the incidence of revision surgery.

Paper 30

The Role of MRI in Diagnosing Biceps Chondromalacia

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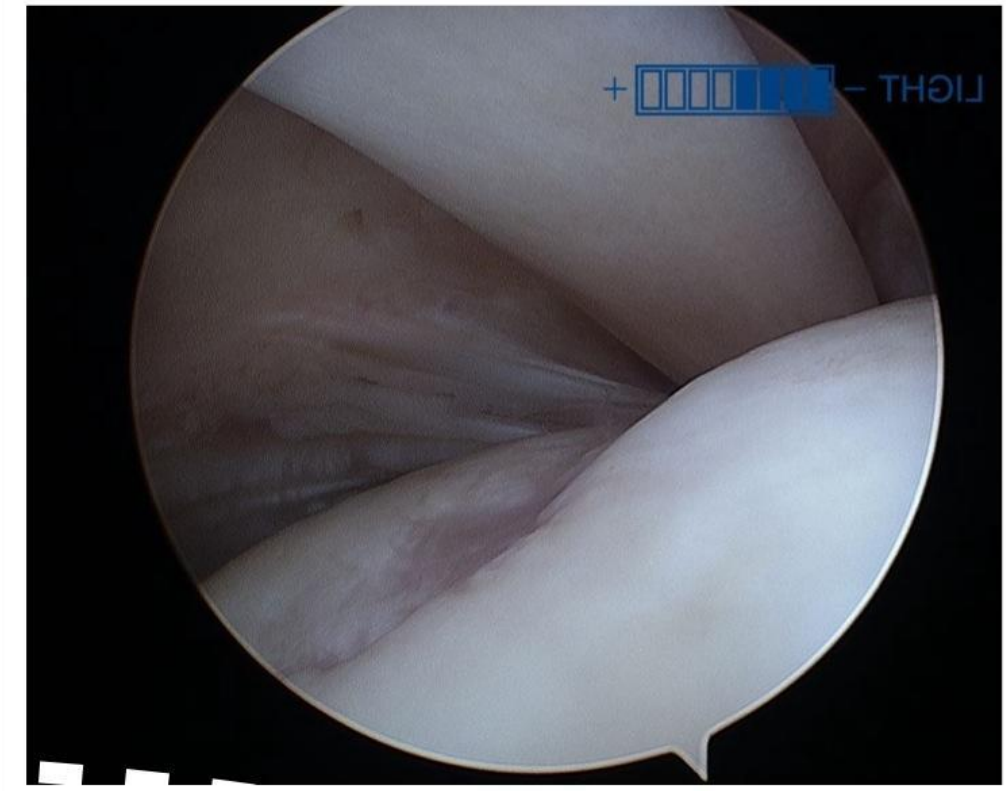
Objectives: Sisterman described the "Biceps Footprint", Castagna et al reported on "Chondral Imprints," and Kuhn et al identified "Humeral Head Abrasions."[1],[2],[3] These can be considered types of biceps chondromalacia (BCM), as we define it, which is an attritional lesion on the humeral head, caused by abrasion of the LHBT over time. BCM occurs in two distinct types: "Junctional" or "Medial". Junctional BCM (Figure 1) is found along the articular margin of the humeral head where the biceps tendon exits the joint. Medial BCM (Figure 2) is found on the anteromedial portion of the articular surface and may result from chronic "incarceration" of the LHBT between the humeral head and glenoid, a dynamic lesion elicited by the arthroscopic active compression test.[4] The pre-operative assessment of BCM has never been addressed. The purpose of the study was to evaluate the ability of pre-operative MRI to diagnose BCM.

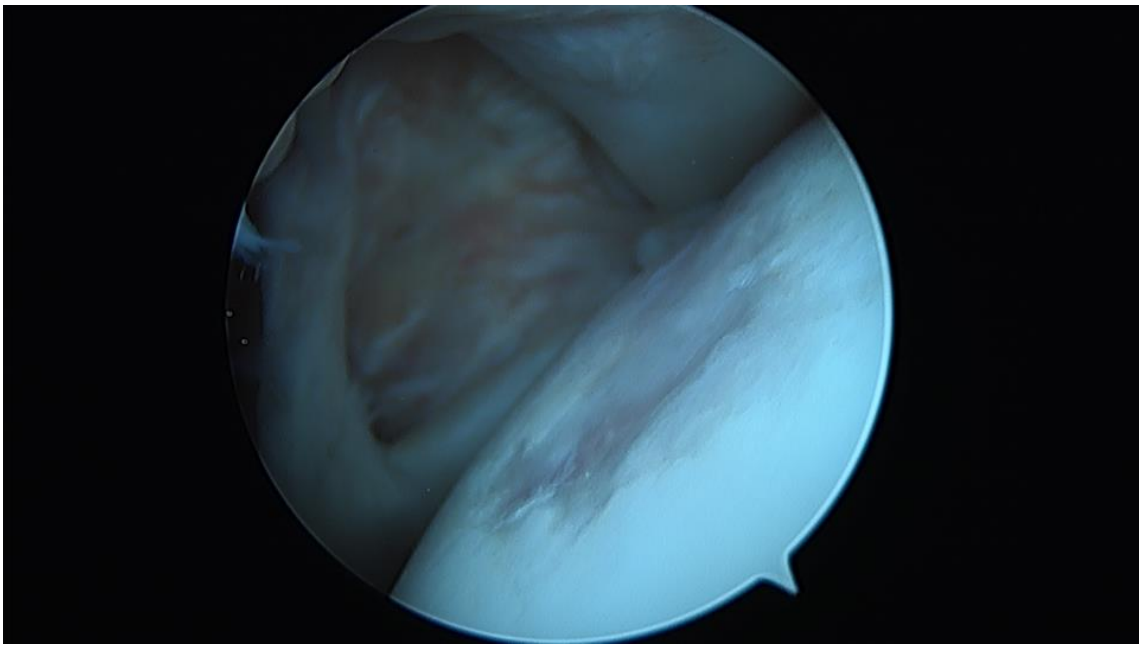
Methods: A retrospective review was conducted looking at preoperative MRI and intra-operative digital photos comparing three groups: 1) patients operated on for painful BLC lesions with demonstrable BCM seen at surgery (n=34); 2) patients operated on for painful BLC lesions without demonstrable BCM seen at surgery (n=21); and 3) patients without clinical BLC pain operated on for shoulder instability (n=29), who were used as a control group against the BLC pain groups. Groups one and two were age matched, both with a mean age of 42 years, while the average age of patients in group 3 was 29. The MRI's were scored once by an orthopedic surgeon, who graded based on presence or absence of a visible lesion, and again by an experienced radiologist, who blindly and independently scored the MRI's based on chondral loss, bone marrow edema, subchondral signal change, and tendinosis or fraying of the biceps tendon.

Results: In group 1, 85% of patients had cartilage loss, 64% had subchondral signal changes, and 85% had a pathological signal in the proximal biceps. In group 2, 86% of patients had cartilage loss, 52% had subchondral signal changes, and 81% had a pathological signal in the proximal biceps, even though no BCM was grossly identified at surgery. In group 3, however, only 51% of patients had cartilage loss, 34% subchondral signal change, and 44% pathological signal in the proximal biceps tendon.
Groups 1 and 2 were statistically similar to each other, but varied significantly when compared to group 3. This was particularly true with regard to cartilage loss ($p=0.004$), signal in proximal biceps ($p=0.001$), and subchondral signal change ($p=0.041$).

Conclusion: MRI is a valuable pre-operative assessment tool that can alert the surgeon to the presence of BCM even if such a lesion has not yet become grossly apparent at arthroscopy. BCM characteristics on MRI include abnormal signal in the proximal biceps, subchondral bone, and cartilage loss. MRI findings consistent with BCM should prompt the physician to consider the biceps as the source of the patient's

pain. This is especially relevant when differentiating between a labral tear and the LHBT as inciting pathology. It should be noted, for example, that Provencher et al reported 28% of patients with type II SLAP tears, ultimately underwent a biceps surgery for persistent symptoms. [1] This study adds to our collective diagnostic acumen related to the biceps labral complex and highlights the utility of preoperative MRI.





Paper 31

Open-Access Video-Based Orthopaedic Instructional Content is Inaccurate

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Objectives: The internet has an increasing role in both patient and physician education. While several recent studies critically appraised the quality and accuracy of web-based written information available to patients, no studies have evaluated such parameters for open access video content designed for provider use. The present study sought to determine utilization of video resources by orthopaedic residents and assess the quality and accuracy of their content.

Methods: Surveys were distributed to orthopaedic surgery residents to to determine their use of open access instructional video content. An assessment of quality and accuracy of said video content was performed using the basic shoulder examination as a suragate for the “best-case scenario” due to its widely accepted components that are stable over time. Three search terms (“shoulder”, “examination” and “shoulder exam”) were entered into the four online video resources most commonly accessed by orthopaedic surgery residents (VuMedi, G9MD, Orthobullets, and YouTube). Videos were captured and independently reviewed by three orthopedic surgeons. Quality and accuracy were assessed in accordance with previously published standards.

Results: Of the 72 orthopaedic residents surveyed, 70% use open-access videos as a resource monthly and 25% weekly. Over 70% or respondents perceived the video content to be accurate and informative. We reviewed 39 unique video tutorials on physical examination. Of the 39 videos, 61% rated poor (<25% accurate) or fair (<50% accurate). Specific shoulder tests such as Hawkins, O’Brien Sign, and Neer Impingement were accurately demonstrated in only 50%, 36%, and 27% of videos respectively. Inter-rater reliability was excellent (mean Kappa 0.80, range 0.79-0.81).

Conclusion: We demonstrated that orthopaedic surgery residents often turn to open-access video tutorials as a supplemental education tool. While the majority residents believed the content is accurate, our results suggest an alarming inaccuracy of these video tutorials. Trainee exposure to inaccurate information has far reaching implications on the education process. As such, training programs should help guide their residents to pre-screened or peer-reviewed video resources.

Paper 32

Use of an Objective Structured Assessment of Technical Skill (OSATS) after a Sports Rotation

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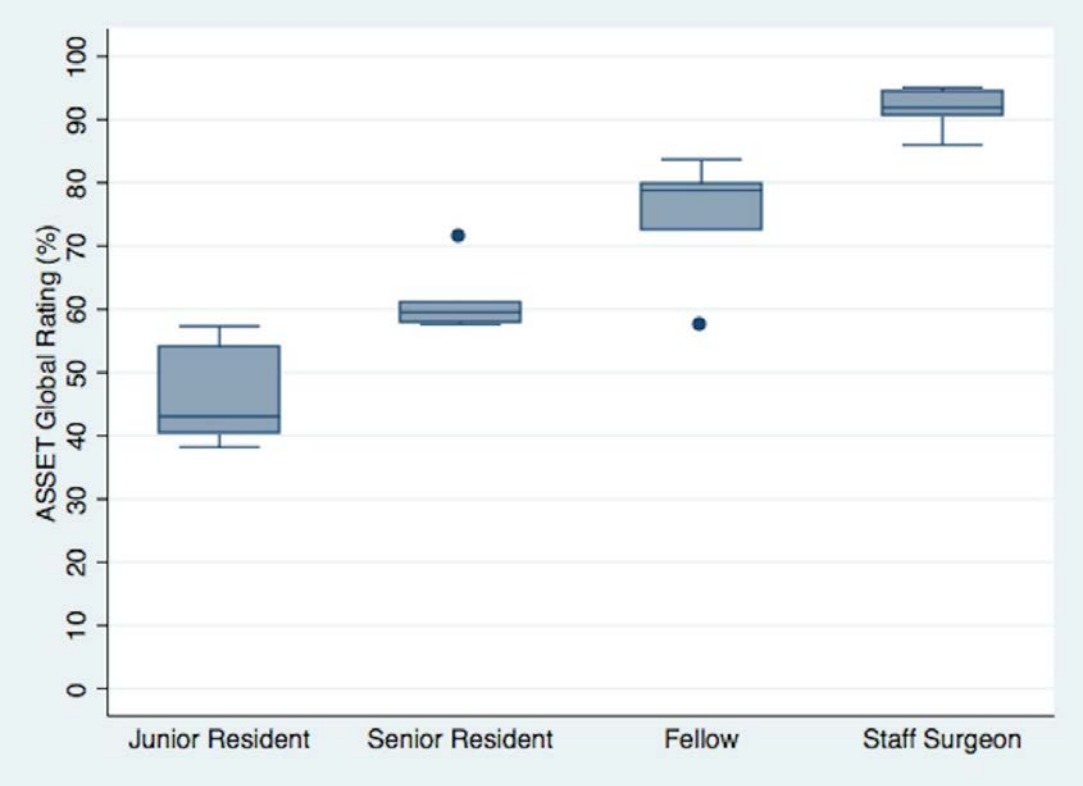
Objectives: While the acquisition of competent technical skill is a defining characteristic of surgery, it is not measured systematically in residency. As all post-graduate medical training slowly shifts to a competency-based model, effective assessments of surgical and other technical skills after modules will become necessary. However, the best method for of assessing competence in technical skill in this setting is unknown, and is limited by both cost and access to resources. We hypothesized that a multi-station Objective Structured Assessment of Technical skill (OSATS), using sawbones models, would be a valid and reliable method of assessing resident competence in surgical skills after a sports medicine rotation.

Methods: At the start of their three-month sports medicine rotation, each resident was provided a list of 10 surgical skills in which they were expected to demonstrate competence (Table 1). At the end of the rotation, each resident undertook an OSATS comprised of six randomly chosen stations - low-fidelity sawbones models were used in all stations. Residents were evaluated by faculty / staff surgeons using a previously validated global rating scale (the Arthroscopic Surgical Skill Evaluation Tool (ASSET)), as well as task-specific checklists created using a modified Delphi procedure, and a final five-point global rating scale (GRS) using the Drefus model of skill acquisition (1=novice, 2=advanced beginner, 3=competent, 4=proficient, 5=expert). All arthroscopic procedures were recorded, and all hand movements were videotaped - the videos were reviewed by a single, blinded observer, and correlation sought between the faculty ratings and the observer ratings.

Results: Over 18 months, 27 residents (19 junior, 8 senior) sat the OSATS after their rotation, as well as seven sports medicine staff and seven fellows, for a total of 41 participants. The overall reliability of the OSATS as measured by Cronbach's Alpha was very high (0.9). A significant difference by year in training was seen for the overall GRS, the total ASSET score, and the total checklist score, as well as for each individual technical skill (p&lt0.001) - this difference was also seen for all stations. Post hoc analysis demonstrated a significant difference in the total ASSET score between junior (PGY1-3) and senior (PGY4&5) residents, senior residents and fellows, as well as between fellows and faculty (p&lt0.05)(Figure 1). A high correlation was seen between the faculty assessments and the blinded observer assessments for each station (&gt0.8).

Conclusion: The results of this study demonstrate that an OSATS using dry models is a valid and reliable means of assessing technical skill in orthopaedic residents after a sports medical rotation. Interestingly, junior residents were not able to perform technical skills as well as senior residents despite an identical rotation, suggesting that overall surgical experience and exposure is as important as intensive teaching.

List of Technical Skills
Drill tibial tunnel
Drill anteromedial femoral tunnel
Drill transtibial femoral tunnel
Insertion glenoid anchor
Insertion rotator cuff anchor
Passage labral suture
Passage rotator cuff suture
Tie arthroscopic knot
Prepare hamstring graft
Perform arthroscopic partial meniscectomy



Paper 33

Validation Of A Dry Model For The Assessment Of Resident Performance Of Anterior Cruciate Ligament Reconstruction (ACLR).

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Objectives: As the demand increases for demonstration of competence in surgical skill, the need for validated assessment tools also increases. The purpose of this study was to validate the use of a sawbones model for the assessment of performance of anterior cruciate reconstruction (ACLR) by residents. We hypothesized that the combination of a checklist and a previously validated global rating scale be a valid and reliable means of assessing ACLR when performed by residents in a dry model.

Methods: All residents, sports medicine staff and fellows were invited to perform an ACLR on an ACL Sawbones model. Demographics regarding previous exposure to knee arthroscopy and ACLR were collected. All participants were asked to perform a hamstring ACLR using an anteromedial portal with Endobutton fixation on the femur - a detailed surgical manuscript and technique video was sent to all residents prior to the study. Residents were evaluated by faculty using a task-specific checklist created using a modified Delphi procedure, and the Arthroscopic Surgical Skill Evaluation Tool (ASSET) global rating scale. Each procedure was recorded, with videotaping of the hand movements and arthroscopic video recordings of the intra-articular procedure. These videos were scored by a fellow blinded to the year of training of each resident.

Results: A total of 29 residents, six staff and five faculty performed an ACLR on the sawbones model (40 total). The overall reliability (Cronbach's Alpha) of the test using the total ASSET score was very high (&gt0.9). The reliability for the femoral checklist was 0.75, for the tibial checklist was 0.78, and 0.68 for the graft passage and fixation. One-way analysis of variance for the total ASSET score and the total checklist score demonstrated a difference between residents based upon year of training (p&lt0.001). Post hoc analysis demonstrated a significant difference in global ratings and checklist scores between junior residents (PGY1-3) and senior residents (PGY4&5), seniors and fellows, and fellows and staff (p&lt0.05). A good correlation was seen between the total ASSET score and prior exposure to knee arthroscopy (0.73) and ACLR (0.65). The inter-rater reliability (ICC) between faculty rating and blinded assessor for the total ASSET score was very high (&gt0.8).

Conclusion: The use of a sawbones models to assess resident performance of ACLR using the ASSET global rating scale is valid and reliable. These models may be used to ensure a minimal level of competence prior to resident performance of ACLR in the operating room.

Paper 34

Assessing Improvement in Diagnostic Knee Arthroscopic Skill During the AAOS Fundamentals of Knee and Shoulder Arthroscopy Course for Orthopaedic Residents

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Objectives: The purpose of the AAOS Fundamentals of Knee and Shoulder Arthroscopy Course for Orthopaedic Residents is to provide an opportunity for orthopaedic trainees to practice and improve basic arthroscopic surgical skills. During the course, residents spend the majority of their time in the Orthopaedic Learning Center laboratory performing basic arthroscopic procedures on cadaveric specimens under the direction of an expert faculty. Residents are also exposed to various didactic lectures during this intensive three-day course. Historically, feedback from the course has been extremely positive from both resident participants and faculty, however no attempt has previously been made to more objectively determine the degree to which improvement in resident skill has occurred. The purpose of this study is to determine whether participation in the AAOS Fundamentals of Arthroscopic Surgery Course for Residents led to improved diagnostic knee arthroscopy performance. We hypothesized that scores on post course assessments of knee arthroscopy skills and confidence would be higher in comparison to scores on the same assessments prior to the course.

Methods: 46 orthopaedic surgical residents enrolled in the AAOS Fundamentals of Arthroscopic Surgery Course volunteered to participate in the study. Participants were asked to perform a diagnostic knee arthroscopy on a cadaveric knee specimen both before and immediately after the conclusion of the knee portion of the course. Diagnostic knee arthroscopy performance was assessed using the Arthroscopic Surgical Skill Evaluation Tool (ASSET). Residents were also assessed before and after the course using the TolTech virtual reality simulator which enables the objective assessment of several measures that correlate with arthroscopic proficiency. Confidence, before and after the course, for several arthroscopic procedures was also assessed via a self-reported questionnaire.

Results: Following the course, residents demonstrated a 9.2% improvement in mean ASSET score (p=0.001). ASSET score improved most (13.2%) for those with less than 20 arthroscopic cases (p=0.007). On the TolTech virtual reality simulator, mean scores demonstrated significant improvements for multiple measures of proficiency including: Time, which improved 18% (p=.01), Arthroscope path distance, which improved 13% (p=.02), Probe path distance, which improved 16% (p=.05), Smoothness, which improved 10% (p=.001), and excessive probe pressure, which improved 440% (p=.02). Overall completeness improved 1.8%, but this was not significant (p=0.11). Confidence in performing arthroscopic partial menisectomy improved 13% (p=.002) and confidence in performing ACL reconstruction improved 9% (p=.01).(Table 1).

Conclusion:

It was feasible to assess several outcomes related to resident proficiency and confidence within the structure of the AAOS Fundamentals of Arthroscopic Surgery Course. Resident participation in the course resulted in modest improvements for many of the outcomes measured demonstrating the value of this and similar courses. This data will be critically evaluated to determine curricular changes in an effort to maximize course benefit for future participants.

Table I: Pre and Post Course Resident Scores for Selected Outcome Variables

Varible	Pre-Course Mean	Post-Course Mean	Percent Change	Significance
ASSET Score	20	23.5	+9.2%	P=0.001
Confidence Arthroscopic Menisectomy	2.39	3.04	+13%	P=0.002
Confidence ACL Reconstruction	1.83	2.28	+9%	P=0.01
Time (Minutes:Seconds)	5:40	4:44	+18%	P=0.01
Path Length Scope	3183	2816	+13%	P=0.02
Path Length Probe	2797	2408	+16%	P=0.05
Smoothness	34.1	30.9	+10%	P=0.002
Probe Pressure	1.54	0.35	+440%	P=0.02
Completeness	82.4%	84.2%	+1.8%	P=0.11

Paper 35

The Fate Of Meniscus Tears Left in situ At The Time Of Anterior Cruciate Ligament Reconstruction: A 6-year Follow-up Study From The Moon Cohort.

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Objectives: Meniscus tears frequently accompany acute anterior cruciate ligament ruptures. Management of meniscus tears is highly variable and includes repair, meniscectomy, and non-treatment of tears identified at the time of ACL reconstruction. The purpose of this study is to determine the rate of subsequent reoperation and clinical outcome of meniscal tears left in situ without treatment at the time of ACL reconstruction with a minimum follow-up of 6 years.

Methods: Patients with meniscus tears left untreated at the time of primary ACL reconstruction were identified from a multicenter study group between 2002 and 2004 with minimum 6-year follow-up. Patient demographic variables, comorbidities, meniscus tear characteristics, and information on subsequent surgery were obtained. The primary endpoint of the study was need for reoperation for meniscal pathology. Univariate and multivariate analyses were used in order to determine patient demographic variables and meniscus tear characteristics that served as risk factors for reoperation.

Results: There were 1440 primary ACL reconstructions performed during the timeframe of the study. There were 955 patients (66.3%) with concomitant meniscal tears identified. Of these, 143 (15.3%) had meniscal tears left in situ at the time of surgery. There were 11 patients (7.9%) who underwent reoperation for meniscal pathology within the same compartment as the meniscal tear left in situ (Table 1). Reoperation was performed more frequently for medial meniscus tears as compared to lateral meniscus tears (17.6% vs. 4.3%, $p = 0.048$). Medial meniscus tears and tears ≥10 mm in length were identified as risk factors for reoperation.

Conclusion: Lateral and medial meniscus tears left in situ at the time of ACL reconstruction did not require reoperation at minimum 6-year follow-up in 95.7% and 82.4% of patients, respectively. Our results suggest that surgeons should consider alternative treatment for medial meniscus tears and tears ≥ 10 mm in length at the time of ACL reconstruction.

Table 1. Number and Frequency of Meniscus Reoperations after ACL Reconstruction with Meniscus Tears Left *in situ*

	Compartment(s)			Total
	Lateral	Medial	Both	
Number at index ACL Reconstruction†	93 (66.9%)	34 (24.4%)	12 (8.6%)	139
Any Reoperation	12 (12.9%)	6 (17.6%)	2 (16.7%)	20 (14.4%)
Any Meniscal Reoperation	5 (5.4%)	6 (17.6%)	1 (8.3%)	12 (8.6%)
Repair		1 (2.9%)		1 (0.72%)
Partial Meniscectomy	4 (4.3%)	5 (14.7%)	1 (8.3%)	10 (7.2%)
Both	1 (1.1%)			1 (0.72%)
Same Compartment Meniscal Reoperation	4 (4.3%)	6 (17.6%)	1 (8.3%)	11 (7.9%)
Repair		1 (2.9%)		1 (0.72%)
Partial Meniscectomy	4 (4.3%)	5 (14.7%)	1 (8.3%)	10 (7.2%)
Both				

†Number and percent of total. All other values listed as number and percent within compartment

Paper 36

Association of Meniscal Status And Lower Extremity Alignment With Chondrosis At The Time Of Revision Acl Reconstruction

Authors: Robert H. Brophy, MD[1], Amanda Haas, MA[2], Laura J. Huston, MS[3], Samuel K. Nwosu[4], Mars Group[5], Rick W. Wright, MD[6]
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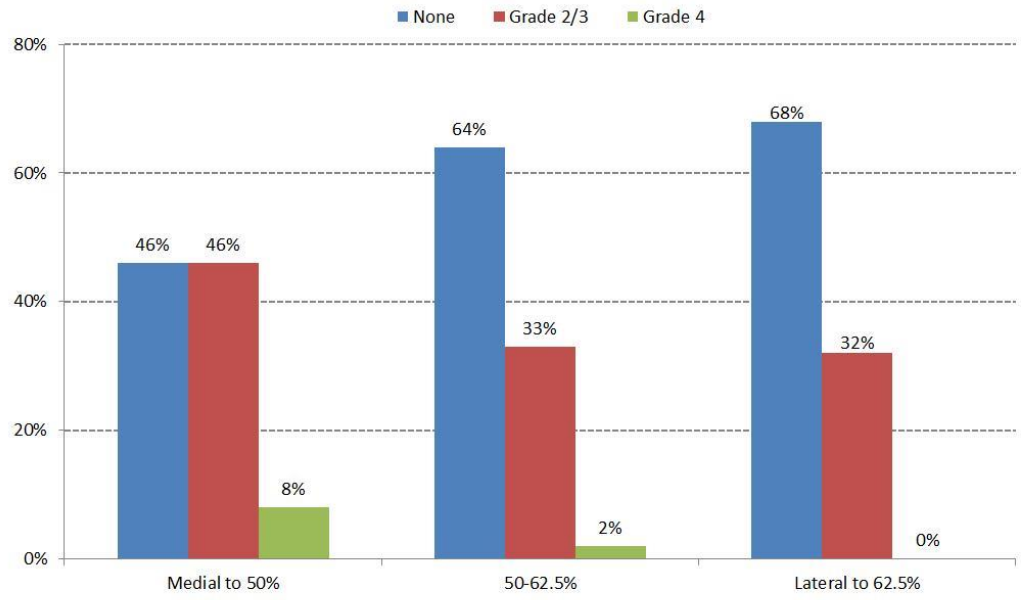
Objectives: Knees undergoing revision ACL reconstruction (rACLR) have a high prevalence of articular cartilage lesions. The purpose of this study was to test the hypothesis that the prevalence of chondrosis at the time of rACLR is associated with meniscus status and lower extremity alignment.

Methods: Data from the prospective Multicenter ACL Revision Study (MARS) cohort was reviewed to identify patients with pre-operative lower extremity alignment films. Lower extremity alignment was defined by the weight bearing line (WBL) as a percentage of the tibial plateau width, while the chondral and meniscal status of each weight bearing compartment was recorded at the time of surgery. Multivariable proportional odds models were constructed and adjusted for relevant factors in order to examine which risk factors were independently associated with the degree of medial and lateral compartment chondrosis.

Results: The cohort included 246 patients with lower extremity alignment films at the time of rACLR. Average (SD) patient age was 26.9 (9.5) years with a BMI of 26.4 (4.6). The medial compartment had more chondrosis (Grade 2/3: 42%, Grade 4: 6.5%) than the lateral compartment (Grade 2/3: 26%, Grade 4: 6.5%). Disruption of the meniscus was noted in 35% of patients on the medial side and 16% in the lateral side. The average (SD) WBL was measured to be 0.43 (0.13). Medial compartment chondrosis was associated with BMI ($p=0.025$), alignment ($p=0.002$)(see figure), and medial meniscus status ($p=0.001$). None of the knees with the WBL lateral to 0.625 had Grade 4 chondrosis in the medial compartment. Lateral compartment chondrosis was significantly associated with age ($p=0.013$) and lateral meniscus status ($p<0.001$). Subjects with 'intact' menisci were found to decrease their odds of having chondrosis by 64-84%.

Conclusion: The status of articular cartilage in the tibiofemoral compartments at the time of rACLR is related to meniscal status. Preserving the meniscus at the time of ACL reconstruction has the potential to be chondroprotective, particularly in patients who go on to require rACLR. Lower extremity alignment and BMI are associated with medial compartment chondrosis, suggesting that optimizing alignment and minimizing weight gain may be important in these patients.

Distribution of chondrosis in medial compartment by lower extremity alignment



Location of weight bearing axis on the tibial plateau

(percent of tibial plateau width)

Paper 37

Outcomes after Anterior Cruciate Ligament Reconstruction using the Norwegian Knee Ligament Registry of 14,142 Patients: How does Meniscal Repair or Resection Affect Short-Term Outcomes?

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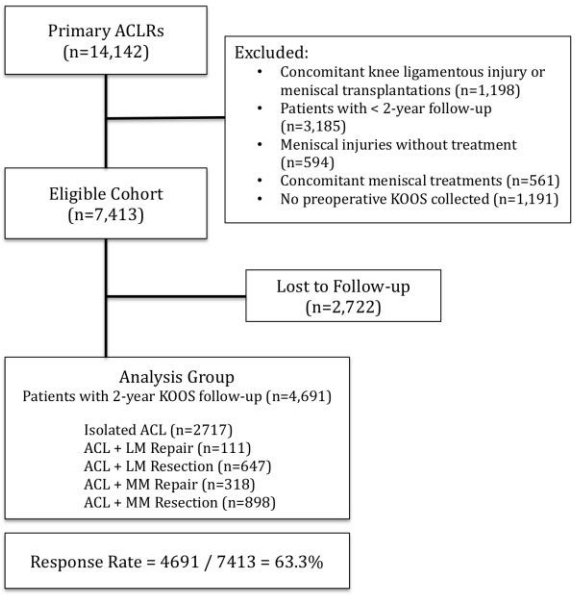
Objectives: While the effects of concurrent meniscal resection and anterior cruciate ligament reconstruction (ACLR) are known to decrease patient outcomes and increase the rate of osteoarthritis over the long-term, overall short-term patient functional outcomes in a large cohort of patients are not well known. Therefore, the purpose of this study is to compare the preoperative and two-year postoperative Knee Injury and Osteoarthritis Outcome Score (KOOS) subscale scores after ACLR with and without meniscal injury. In comparison to an isolated ACLR, we hypothesized that patients with a medial meniscal (MM) or lateral meniscal (LM) resection with an ACLR would have significantly decreased two-year postoperative KOOS outcomes, while those with an ACLR with a MM or LM repair would be indistinguishable to isolated ACLR.

Methods: The Norwegian Knee Ligament Registry (NKLR) was used to evaluate outcomes for a total of 14,142 patients with primary ACLR. The KOOS scoring system was used to evaluate patients on 5 subscales (Pain, Other Symptoms, Activities of Daily Life (ADL), Sport and Recreation Function (Sport/Rec), and Quality of Life (QoL) at time of surgery and at two-year postoperative follow-up. Patients with isolated ACLR and ACLR with LM repair, LM resection, MM repair or MM resection were compared using multiple linear regression modeling.

Results: Preoperatively, in comparison to isolated ACLR, patients that had an ACLR with either a MM repair or MM resection had significantly lower scores for all KOOS subscores and LM repair had significantly decreased scores on the Other Symptoms, Pain, and ADL subscales. Postoperatively, in comparison to isolated ACLR, two-year KOOS outcomes were not significantly different between patients with ACLR and either LM repair, MM resection, or LM resection; however, those with MM repair had significantly lower scores on the Other Symptoms and QoL subscales.

Conclusion: For the majority of study groups, patients with meniscal repairs or resections with concomitant ACLR had postoperative KOOS scores that were not significantly different from an isolated ACLR. Patients with ACLR with meniscal resections do not exhibit decreased clinical outcomes at two years postoperatively. It is recommended that clinicians follow patients with ACLR and concurrent meniscal treatment for longer than two years postoperatively.

Figure 1. Flow chart of the Norwegian Knee Ligament Registry of 14,142 patients describing the exclusions and patients lost to follow-up that led to the final analysis group. ACL = Anterior Cruciate Ligament, KOOS = Knee Injury and Osteoarthritis Outcome Score, LM = Lateral Meniscus, MM = Medial Meniscus.



Paper 38

Cabaud Award Presentation: Transcriptomic Signatures of Meniscal Tears and Articular Cartilage from Knees Undergoing Arthroscopic Partial Meniscectomy Show Evidence for Early Osteoarthritis

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Objectives: Despite clinical evidence demonstrating that meniscus tears are early events in the initiation and propagation of knee osteoarthritis (OA), the biology of how meniscus injury leads to changes in the articular cartilage is not well studied. Therefore, we compared the molecular biology of articular and meniscal cartilage within the same knees undergoing partial meniscectomy to advance our understanding of early molecular events in the knee that contribute to the development of OA following a meniscus tear. The purpose of this study was to test the hypothesis that meniscal and articular cartilage from knees undergoing arthroscopic partial meniscectomy will demonstrate molecular signature representative of early OA.

Methods: Patients (n=12) with a known isolated medial meniscus tear without any knee chondrosis or radiographic OA were consented prior to surgery. During arthroscopic partial meniscectomy, a sample of their injured meniscus and a small fragment of their articular cartilage off the medial femoral condyle were procured. The transcriptome signatures measured through Affymetrix microarray were compared between the two tissues and underlying biological processes were explored computationally.

Results: 3566 gene transcripts, representing several underlying biological processes, including extracellular matrix organization, wound healing, cell adhesion, chemotaxis, blood vessel morphogenesis, and angiogenesis, were differentially expressed between meniscus and articular cartilage.

Conclusion: Articular cartilage and meniscus exhibit molecular events associated with OA at the time of partial meniscectomy despite no gross evidence of degeneration in the knee. These findings identify early effects of meniscus injury on meniscus and articular cartilage, which likely lead to the development of knee OA.

Paper 39

Inter- and Intra-Rater Reliability of Predictive Models for the Non-Operative Healing Potential of Stable Juvenile Osteochondritis Dissecans (JOCD) Knee Lesions

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Objectives: While juvenile osteochondritis dissecans (JOCD) lesions have greater healing potential than equivalent lesions in adults, only 50% of JOCD lesions demonstrate radiographic healing after 6 months of non-operative treatment. Krause et al. (2013) and Wall et al. (2008) have described models to predict a patient's probability of healing with non-operative treatment based on patient and lesion characteristics. The Wall et al. nomogram incorporates normalized lesion length, normalized lesion width, and pain type, while the Krause et al. model includes normalized lesion width, patient age, and the size of concurrent cyst-like lesions. The purpose of this study was to determine inter- and intra-observer reliability of the predictive nomograms.

Methods: We retrospectively evaluated a consecutive series of children with open physes, who underwent non-operative treatment for stable JOCD lesions. Thirty-four patients (40 knees) were included in the study. At two time points at least one week apart, two medical students, two orthopaedic surgeons, and a radiologist made measurements of the JOCD lesions as described by Wall and Krause. These measurements, along with patient ages and pain type, were used to generate a point value for each lesion based on both the Krause and Wall models. Intra-class correlations (ICC) were calculated using the point value data obtained from the nomograms to determine inter- and intra-rater reliability.

Results: Based on the Landis & Koch (1977) threshold, we found near perfect intra-rater correlation for all raters in terms of individual OCD measurements, as well as total point score as calculated by both Krause and Wall methods (Table 1). Additionally, amongst the five raters there was near perfect inter-rater reliabilities in total scores, as well as substantial to near perfect reliability in measuring the individual components of the scores (Table 2).

Conclusion: There is high inter- and intra-rater reliability for both the Krause and Wall point systems for predicting healing of JOCD lesions. These models appear to be important tools for helping doctors and patients reliably predict the healing potential of non-operative management of JOCD lesions.

Table 1: Intra-Rater Reliability of Wall et al. and Krause et al. nomograms

	ICC Score	95% CI
Wall et al.		
Pain Score[1]	N/A	N/A
Width Score	0.828	0.669, 0.911
Length Score	0.886	0.818, 0.934
Total Score	0.857	0.773, 0.917
Krause et al.		
Age Score	1.000	1.000,1.000
Cyst Score	0.780	0.644, 0.875
Width Score	0.929	0.885, 0.960
Total Score	0.843	0.747, 0.910

[1]All patients showed evidence of pain symptoms and were classified equally.

Table 2: Inter-Rater Reliability of Wall et al. and Krause et al. nomograms

	ICC Score	95% CI
Wall et al. Total Score		
Rater 1	0.937	0.882, 0.967
Rater 2	0.974	0.951, 0.986
Rater 3	0.842	0.702, 0.917
Rater 4	0.880	0.773, 0.937
Rater 5	0.831	0.681, 0.911
Krause et al. Total Score		
Rater 1	0.772	0.565, 0.880
Rater 2	0.814	0.645, 0.902
Rater 3	0.721	0.467, 0.854
Rater 4	0.875	0.763, 0.934
Rater 5	0.901	0.813, 0.948

Paper 40

Importance Of Donor Chondrocyte Viability in Osteochondral Allografting

Authors: James P. Stannard, MD[1], James L. Cook, DVM,PhD[2], Aaron M. Stoker, PhD[2], Chantelle C. Bozynski, DVM[2], Keiichi Kuroki, DVM[2], Cristi R. Cook, DVM[2], Ferris Pfeiffer, PhD[3]
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Objectives: Osteochondral allografting (OCA) provides a biologic treatment option for functional restoration of large articular cartilage defects in multiple joints. While successful outcomes after OCA have been linked to viable donor chondrocytes, the importance of donor cell viability has not been comprehensively validated. The purpose of this study was to use a canine model to determine the importance of donor chondrocyte viability at the time of implantation with respect to functional success of femoral condylar OCAs based on gross, cell viability, histologic, biochemical, and biomechanical outcome measures.

Methods: With IACUC approval, adult female dogs (n = 16) were implanted with 8-mm cylindrical osteochondral allografts from male dogs in the lateral and medial femoral condyles of one knee. Osteochondral allografts were preserved for 28 or 60 days after procurement and chondrocyte viability was quantified prior to implantation. Two different storage media, temperatures and time points were used in order to obtain a spectrum of %chondrocyte viability at the time of implantation. A successful outcome was defined as an osteochondral allograft that was associated with graft integration, maintenance of hyaline cartilage, lack of associated cartilage disorder, and lack of fibrillation, fissuring, or fibrous tissue infiltration of the allograft based on subjective radiographic, arthroscopic, gross, and histologic assessments at 6 months after implantation.

Results: Chondrocyte viability ranged from 23% to 99% at the time of implantation. All successful grafts had greater than 70% chondrocyte viability at the time of implantation and no graft with chondrocyte viability <70% was associated with a successful outcome. Live-dead stained sections and histologic findings with respect to cell morphology suggested that successful grafts were consistently comprised of viable chondrocytes in lacunae, while grafts that were not successful were comprised of non-viable chondrocytes with infiltration of fibroblasts from the surrounding recipient tissues. In situ PCR (FISH) assays were performed in an attempt to distinguish donor (male) cells from recipient (female) cells. Unfortunately, this technique was exceptionally difficult to perform on intact articular cartilage sections, and consistent, repeatable data could not be obtained from this testing. However, the data did support histologic and live-dead data, which strongly suggested that successful grafts retained viable donor (male) chondrocytes and unsuccessful grafts degraded and were replaced by fibrous tissue populated with recipient (female) fibroblasts.

Conclusion: Viable chondrocytes in osteochondral allografts at the time of transplantation are primarily responsible for maintenance of donor articular cartilage health long term. Optimizing chondrocyte

viability in all aspects of osteochondral allografting - including procurement, processing, storage, transportation, and surgical implantation - needs to be a primary focus for clinical use of OCA.

Paper 41

Decellularized Osteochondral Allograft for the Treatment of Cartilage Lesions in the Knee

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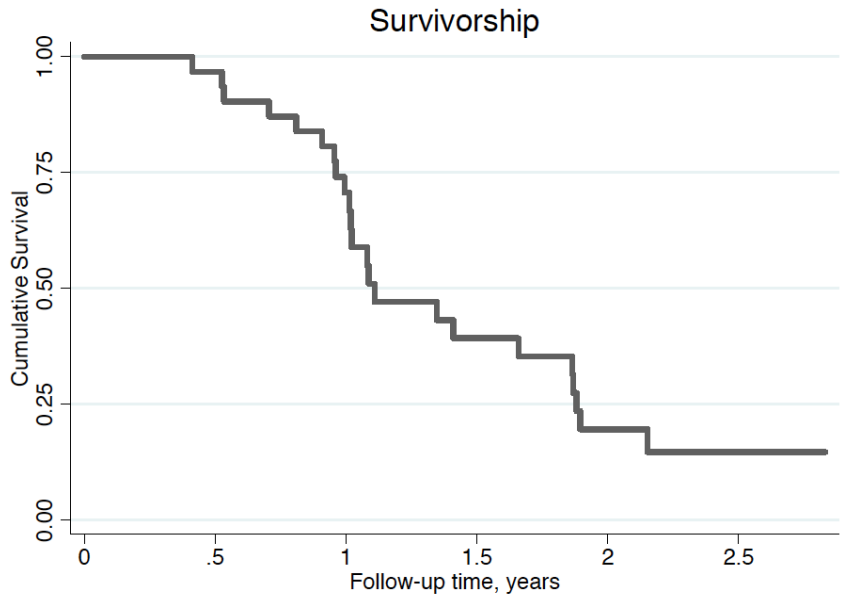
Objectives: Chondrofix® is a pre-shaped cylindrical, decellularized and sterilized osteochondral allograft (OCA). The purpose of this study was to evaluate functional outcomes and graft survivorship among patients treated with this implant for cartilage injuries in the knee.

Methods: An IRB-approved database was used to identify a prospective series of 32 patients who had been treated with the Chondrofix implant. The surgeries were performed in two centers by two surgeons. The mean age ± Standard Deviation (SD) of the patients was 35.1 ± 10.6 years; 59% were male. Twenty-four (75%) knees had previous surgery. The mean defect area ± SD was 2.9 ± 2.0 cm^2 . The mean allograft size ± SD was 13.18 ± 2.3 mm (6 grafts ≤ 9 mm and 59 grafts ≥11mm). The number and type of reoperations were assessed. Failure was defined as structural damage of the graft diagnosed by arthroscopy or magnetic resonance imaging and any reoperation resulting in removal of the allograft. Patients were evaluated pre- and postoperatively using the Knee Injury and Osteoarthritis Outcome Score (KOOS) scale and Marx Sports Activity Scale.

Results: Twenty-three of the 32 knees (72%) were considered failures, and 14 of the 32 knees (43%) had further surgery following the index procedure. Implant survivorship was 19.6% at 2 years(Graphic). The mean follow-up duration was 1.29 years (range 0.11- 2.8 years). KOOS Pain, ADL, Sports and Knee-related Quality of Life (QOL) improved significantly from the preoperative visit to latest follow-up (Table). Age was significantly predictive of failure with hazard ratio of 1.68 per 1SD older (95% CI, 1.05 to 2.68, p = 0.030).

Conclusion: The decellularized and sterile osteochondral allograft implant demonstrated a 72% failure rate within the first 2 years of implantation in these two institutions.



Pain and Function Measured Preoperatively and at Follow-up

Measure	Preoperative (mean and Sd)	Postoperative (mean and Sd)	p-value*
KOOS symptoms	54.5±15.7	62.6±20.6	0.19
KOOS pain	49.2±14.1	62.2±21.1	0.01
KOOS ADL	57.9±15.8	72.5±17.9	0.003
KOOS sport/rec	19.2±17.6	32.8±25.8	0.01
KOOS QOL	20.6±19.1	34.6±25.8	0.01
Marx	3.7±5.4	1.6±3.3	0.13

Paper 42

Two-Year Outcomes Following Arthroscopic Rotator Cuff Repair in Recreational Athletes Over 70 Years of Age

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[1]Steadman Philippon Research Institute Program, Vail, CO, USA, [2]Steadman Philippon Research Institute, Vail, CO, USA, [3]Steadman Philippon Research Institute (COOR), Vail, CO, USA, [4]Steadman Clinic, Vail, CO, USA

Objectives: Outcomes following arthroscopic rotator cuff repair in active individuals over 70 years old is presently unclear. The purpose of this study was to evaluate clinical outcomes and prognostic factors affecting outcomes following arthroscopic repair of full thickness rotator cuff tears in recreational athletes aged 70 years or older.

Methods: IRB approval was obtained prior to initiation of this study. Data was collected prospectively and retrospectively reviewed. From December 2005 to November 2012 44 patients (49 shoulders) that were 70 years or older who were recreational athletes and who had undergone a primary or revision arthroscopic repair of full-thickness supraspinatus tears with or without infraspinatus and subscapularis tendon involvement were identified from a surgical registry. Demographic information, surgical data, acromion-humeral distance and Goutallier classification of fatty infiltration were collected. Pre and post-operative clinical outcomes scores were collected including the American Shoulder and Elbow Surgeons' (ASES) scores, Single Assessment Numeric Evaluation (SANE) scores, Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) scores, and Short-Form 12 Physical Component Summary (SF-12 PCS) scores. Patient satisfaction (range, 1-10,10=best) and reasons for activity modification was collected at final follow-up.

Results: The mean age was 73 years (range,70-82 years) in 49 shoulders (33 men,11 women,5 bilateral) with a mean acromion-humeral distance of 9.2 mm (range,3.0 -15.9 mm). Four shoulders (8%) were revision procedures of a prior rotator cuff repair. Twenty-eight shoulders (57%) had full thickness tears of two tendons and one shoulder (2%) had full thickness tears of three tendons. Twelve shoulders (25%) had osteoarthritis with Outerbridge criteria of 3 or 4. All patients had a Goutallier classification of 2 or below. No patients required revision rotator cuff surgeries; however, 1 patient had surgical treatment for stiffness. Mean follow-up was 3.6 years (range, 2.0 - 6.9 years) in 43/49 (88%) shoulders. All postoperative outcomes measures demonstrated significance when compared to their preoperative baselines. The ASES scores improved by 34.3 points from 56.0 preoperatively to 90.3 postoperatively ($p<0.001$) with significant improvements in both pain and function components. The SANE score improved from 63.1 to 85.1 ($p=0.034$), QuickDASH from 34.1 to 11.3 ($p< 0.001$), and SF-12 PCS from 43.0 to 51.6 ($p<0.001$). There was significant improvement in the impact of pain affecting ADLs ($p< 0.001$), recreational sporting activities ($p< 0.001$), and sleeping ($p< 0.001$). Median satisfaction was 10/10 (range,1-10). Patients who modified their recreational activities due to postoperative weakness were significantly less satisfied (6 vs 10; $p=.018$). In this study, 24/31 (77%) were able to return to their sport

at a similar level of intensity to preinjury levels.

Conclusion: Arthroscopic rotator cuff repair was highly effective at reducing pain, improving function and returning patients to sport in high demand elderly individuals over 70 years of age.

Paper 43

Factors Related to Improved Quality of Life in Operative and Non-operative RCT Patients

Authors: Christopher Robbins, PhD[1], James E. Carpenter, MD[2], Asheesh Bedi, MD[3], Joel Joseph Gagnier, ND, PhD[1], Bruce S. Miller, MD, MS[3]
[1]University of Michigan, Ann Arbor, MI, USA, [2]University of Michigan Hosp, Ann Arbor, MI, USA, [3]MedSport, Univ of Michigan, Ann Arbor, MI, USA

Objectives: To examine factors that influence quality of life (QOL) outcomes for those with full thickness rotator cuff tears based on surgical versus non-surgical intervention.

Methods: A convenience sample of participants (N=212) presenting to an orthopaedic clinic and identified as having full thickness rotator cuff tears were invited to participate in a prospective cohort study. Participants provided baseline demographic information and completed patient satisfaction, pain VAS, shoulder activity level, functional comorbity, WORC and ASES instruments, and the Veterans Rand 12-item health survey (VR-12). Participants were tracked for operative vs. non-operative intervention and completed the same measures as baseline at 4, 8, 16, 32, 48, and 64 weeks. Descriptive and inferential analysis was conducted using SPSS v. 21.0 (IBM Corp, Armonk, NY) Chi-square analysis and student's t-test was used to examine differences between categorical and continuous variables and baseline and 64 week scores. ANOVA was used to test differences between groups. Generalized estimating equations (GEE) were used to examine the effects of fixed factors on quality of life such as gender, BMI, age, diabetes, smoking, tear size, pain VAS, functional comorbidity, ASES, and WORC scores longitudinally from baseline to 64 weeks.

Results: Participant demographics consisted of 126 males and 86 females with a mean age of 60 ±9.6. There were 93 non-operative subjects and 119 in the operative group. Baseline characteristics between groups indicated a significant difference in age ($p<.001$), gender ($p<.05$), and cause of injury ($p<.001$). Among baseline scores there were differences in pain VAS ($p<.05$), shoulder activity level ($p<.01$), functional comorbidity ($p<.05$), ASES ($p<.05$), and WORC ($p<.05$), with all baseline scores indicating "worse" scores for the operative group. There were no significant differences noted between groups for baseline PCS ($p=.508$) and MCS ($p=.862$) scores.

Paired samples t-tests within the non-operative group indicate no difference between baseline and 64 week PCS ($p=.434$) and MCS ($p=.203$) scores. The operative group PCS and MCS scores were both significantly different from baseline to 64 week scores ($p<.001$, $p<.001$) respectively. Between groups results show there was no significant difference in 64 week MCS scores ($p=.539$), however there was a significant difference in 64 week PCS scores noted ($p<.001$). Factors predictive of higher MCS scores were non-diabetic ($\beta=4.82$, $p<.05$), non-smoker ($\beta=4.52$, $p<.05$), lower functional comorbidity ($\beta= -1.22$, $p<.05$), higher baseline pain VAS ($\beta=.087$, $p<.05$), and a lower WORC score ($\beta= -.011$, $p<.001$). Factors predictive of higher PCS scores were surgical intervention ($\beta=2.96$, $p<.01$), non-diabetic ($\beta=2.87$, $p<.05$), lower functional comorbidity ($\beta= -1.18$, $p<.001$), higher baseline ASES ($\beta=.128$, $p<.01$), and lower baseline WORC ($\beta= -.005$, $p<.01$).

Conclusion: Surgical intervention had no effect on MCS score but there was evidence to support the efficacy of operative treatment for improving PCS score. Of these patients that elected operative intervention their long-term QOL outcomes were improved.

Paper 44

Clinical Outcomes And Structural Healing After Arthroscopic Rotator Cuff Repair Reinforced With A Novel Absorbable Biologic Scaffold: A Prospective, Multicenter Trial

Authors: Scott Barbash, MD[1], Claire Denny, PA-C[2], Philippe Collin, MD[3], Timothy Reish, MD[4], Joseph M. Hart, PhD, ATC[2], **Stephen F. Brockmeier, MD**[2]
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Objectives: Arthroscopic rotator cuff repair has been demonstrated to provide reliable clinical outcomes, but the rate of retear remains high (11% to 94%). Retears are associated with poorer outcomes and the majority of retears have been shown to occur within 6 months after surgical repair. Improving the mechanical and/or biological environment during index repair is a common strategy utilized to reduce retear rate. Biofiber© is a bi-layer, absorbable reinforced poly (4)-hydroxybutyrate scaffold that can be used to reinforce rotator cuff repair. Rotator cuff repairs augmented with Biofiber appear to have improved biomechanical properties as compared to standard repair constructs in cadaveric study. Therefore, BioFiber augmented rotator cuff repair may be a viable consideration for patients with larger tears, poorer tissue quality, or in revision repairs. The purpose of this prospective multi-center clinical trial is to evaluate the clinical outcomes and rates of successful healing by ultrasound evaluation in patients undergoing augmented arthroscopic rotator cuff repair using a BioFiber scaffold.

Methods: A cohort of 50 patients were prospectively enrolled from three study sites in the US (2 sites) and France (1 site). Patients with an imaging demonstrated and arthroscopically confirmed full-thickness rotator cuff tear who underwent arthroscopic rotator cuff repair augmented with a BioFiber scaffold were included in the study. All patients were evaluated clinically at baseline prior to surgery, and subsequently at 6 months and 1 year post-operatively using functional outcomes evaluation (Constant Score and WORC Index), ROM, and strength testing. Ultrasound evaluation at 6 months and 1 year was also carried out to assess repair integrity.

Results: The average patient age of the cohort was 61 ± 9 years with an average BMI of 28.4. There were 27 female (54%) and 23 male (46%) patients; 10% of those enrolled were worker's compensation patients, 12% were undergoing revision rotator cuff repair. The average AP tear length was 25.2mm ± 1.8mm with an average retraction of 17.1mm ± 1.2mm from the greater tuberosity. Arthroscopic repairs were achieved in all 50 patients using either double-row (78%) or single-row (22%) constructs. The total surgical time for the procedure averaged 77 minutes, with a mean time required for placement of the Biofiber scaffold of 17 minutes. At 6 months post-operatively, the mean adjusted Constant Score was 94.0 (baseline 61.0) and the mean WORC Index was 82.1 (baseline 37.5). Ultrasound evaluation demonstrated intact repairs in 96% of the evaluated patients at the 6 month time point, with no additional evidence of repair failure at 1 year.

Conclusion: This interim analysis suggests that reinforcement of rotator cuff repairs with Biofiber may result in a mechanically superior repair leading to a high rate of tendon healing. Tear size and quality of repair have been the best predictors for tendon healing in rotator cuff surgery, with recent studies demonstrating improved Constant scores when tendon healing is seen on ultrasound. This cohort had 96% rate of repair integrity on ultrasound evaluation. Furthermore, functional outcome scores after Biofiber-augmented repair were equal to or better than those recently reported for similar populations. Given this data, arthroscopic rotator cuff repair using a BioFiber augmented repair may provide a promising option in the treatment of patients with full-thickness rotator cuff tears.

Paper 45

Patients With An Isolated Pcl Injury Improve As Much As The Acl Patients From Surgery Measured By Koos After 2 Years

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Objectives: Background: Isolated posterior cruciate ligament (PCL) injuries are severe knee injuries, often caused by a sports injury or a traffic accident and can be treated either conservatively (with a brace and exercises) or by reconstructive surgery. Results reported after reconstructive surgery contain a mixture of isolated and combined knee ligament injuries. Consequently the results after such surgery are not documented thoroughly.
Hypothesis: Patients undergoing PCL reconstruction demonstrate the same improvements as patients treated with ACL reconstruction measured by Knee Osteoarthritis Outcome Score (KOOS) two years postoperatively.
Study Design: The study is a prospective cohort study based on registry data. Evidence level II.

Methods: The Norwegian Knee Ligament Registry contains data including patient reported KOOS values on 295 PCL injuries (71 isolated PCL injuries) and some 10.000 ACL injuries registered between 2004 and 2010. The changes in KOOS scores from preoperative values to two years follow up after surgery were compared by paired sample t-test in each of the two patient grooups. The main outcome measure was patient reported outcome measured by changes in the KOOS quality of life (QoL) subscale. Then the changes for the PCL patients were compared to the corresponding changes for the ACL patients.

Results: The delay to surgery was significantly longer for PCL patients compared to the ACL patients (median 21.5months vs 8.0 months). Most surgeries were performed using single bundle hamstring graft for both PCL and ACL reconstruction. PCL reconstructed patients had an improved patient reported knee function postoperatively measured by KOOS at two years with improvement in all KOOS subscales as follows; Pain: 15.1, CI (8.5-21.8), p<0.01. Symptoms: 0.9, CI (-6.6-8.3), p=0.82. ADL: 13.2, CI (6.6-13.9), p<0.01. Sports: 20.7, CI (11.8-29.4), p<0.01. QoL: 26.6, CI (18.9-34.2), p<0.01. The reported results for the ACL patients were; Pain: 10.5, CI (10.2-11.5), p<0.01. Symptoms: 5.1, CI (4.1-5.2), p<0.01. ADL: 8.1, CI (7.7-8.6), p<0.01. Sports: 23.0 CI (22.2-23.8), p<0.01. QoL: 31.7, CI (31.0-32.4), p<0.01. The increments in KOOS for the PCL patients are similar to those of the ACL patients. For the KOOS subscale pain the improvements was larger than for ACL treated patients but no significant difference was found.

Conclusion: Patients undergoing PCL reconstruction with single bundle hamstring graft can expect the same improvements in KOOS as patients undergoing ACL reconstruction. However the PCL patients start out with an average inferior score in all subscales and consequently end up at a lower score compared to the ACL patients for all KOOS subscales. Clinical Relevance: The present study provides relevant information on what results to expect after single bundle PCL reconstruction. PCL reconstructed patients

can achieve similar improvements to ACL reconstructed patients measured by KOOS. Improvements in surgical techniques might result in restoration of knee function to the same level as ACL injured knees. Candidates for PCL reconstruction, could be informed about these results during the decision making process. To our knowledge, this study comprises the largest material available on isolated PCL injuries treated with reconstructive surgery.

Paper 46

Quality of Life and Functional Outcomes after Multi-Ligament Knee Reconstruction

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Objectives: Although dislocation of the knee is rare, the high-energy nature of most injuries often results in high morbidity and sometimes limb-threatening injury. Literature regarding knee dislocations tends to focus upon management. There is a lack of research investigating quality of life for patients having undergone multi-ligament knee reconstruction. The purpose of our study was to review quality of life and functional outcomes as well as examine preoperative variables that may affect these outcomes for patients having undergone multi-ligament knee reconstruction.

Methods: Retrospectively, we identified a total of 31 patients who underwent a standardized method of surgical reconstruction for multi-ligament knee injuries since 2006 at a single institution. A single surgeon performed all operations. A total of 28 knees (26 patients) were included in the final analysis. We contacted patients at a minimum of 12 months postoperatively (mean: 40.5 months; range: 12-111 months) and administered the Multi-ligament Quality of Life Questionnaire (ML-QOL), 2000 International Knee Documentation Committee Subjective Knee Form (IKDC), and Lysholm Knee Scoring Scale. We performed independent two-sample t-tests to examine the difference in quality of life and functional measures for the following factors: age (≤ 40 vs. > 40), sex, mechanism of injury, time to surgery (3 weeks), vascular injury, nerve injury, concomitant fracture, other injuries, Schenk classification for knee dislocation, manipulation, surgical release, previous knee ligament surgery, and subsequent revision. We then performed age-adjusted multivariable linear regression analysis, including factors that we found to be statistically significant in univariate analysis. A p-value of 0.05 was used for statistical significance and all analysis was performed using STATA (College Station, TX).

Results: For ML-QOL, we found that patients who had undergone previous knee ligament surgery had significantly worse mean scores relative to patients who had not undergo previous knee ligament surgery (122.9 vs. 80.2; p = 0.001) (higher score indicates worse quality of life). All other differences in ML-QOL scores were not statistically significant. IKDC and Lysholm scores did not differ significantly with regards to the studied variables. After stratifying patients by history of previous knee ligament surgery (7 vs. 21), we found that patients with Schenk classifications of III or IV had significantly worse mean ML-QOL scores relative to patients with Schenk classifications of I or II (91.3 vs. 62.1; p = 0.0152).

Conclusion: To our knowledge, our study is the first to investigate both quality of life and functional outcome measures for patients undergoing multi-ligament reconstruction after knee dislocation. We found that patients with a previous history of knee ligament surgery had a significantly worse quality of life relative to those with no history of knee ligament surgery. Among patients with no history of knee ligament surgery, higher Schenk classification was associated with worse ML-QOL scores.

Paper 48

Variation in Surgical Treatment of Knee Osteochondritis Dissecans (OCD) Among High-Volume OCD Surgeons

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Objectives: Clinical practice guidelines (CPG) for osteochondritis dissecans (OCD) of the knee have demonstrated lower levels of evidence for treatment of this condition. Elucidating variation in treatment is a national priority within healthcare, due to evidence demonstrating that reduction of unnecessary variation can improve outcomes, lower costs, and increase value. The purpose of this study was to assess surgical treatment variation for OCD amongst 20 surgeon-investigator members of an international multi-center OCD study group.

Methods: Using a validated arthroscopy classification system, surgeons were queried as to which, amongst 5 different surgical treatment 'principles' should be applied for each of 6 different arthroscopic OCD presentations in both skeletally immature and mature patients. The process was repeated with an expanded set of 12 different surgical 'techniques' for each of the arthroscopy categories. Intra-class correlation coefficients (ICC) were calculated across all surgeons amongst 5 'principles' and amongst 12 'techniques', as well as for each individual arthroscopic presentation.

Results: When assessing the most prevalent treatment 'principles' overall, agreement between surgeons was excellent (ICC = 0.79, 95% CI 0.58-0.96) for skeletally immature knees and good (ICC = 0.74, 0.51-0.95) for skeletally mature knees. Agreement of selected treatment 'principles' for each individual arthroscopic presentation ranged from excellent to poor, with more advanced-stage lesion presentations yielding poorer agreement. For selection of specific surgical 'techniques', agreement was poor for both for skeletally immature knees (ICC = 0.27, 0.09-0.71) and skeletally mature knees (ICC = 0.0, 0.0-0.95), and fair to poor for the individual arthroscopic presentations.

Conclusion: High volume OCD surgeons demonstrated good to excellent agreement on the optimal treatment 'principles' to apply for the various arthroscopic presentations of knee OCD, but agreement worsens as lesion stage becomes more advanced. Agreement on application of specific surgical 'techniques' is consistently poor, suggesting high variation in surgical approaches, even amongst high volume surgeons.Substantiating agreement for surgical 'principles' of knee OCD with higher levels of evidence is important, given what the CPG has revealed about literature on OCD. More importantly, the lack of agreement regarding surgical techniques makes multi-center investigations into outcomes following different techniques a critical research initiative in the future. Higher quality prospective research may reduce variation and improve outcomes in surgical techniques for OCD.

Paper 49

Revision Meniscus Surgery In Children And Adolescents: the Effect Of Skeletal Immaturity

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Objectives: The purpose of this study was to investigate the incidence and risk factors for revision meniscus surgery in a pediatric population as well as to describe mechanisms of failure and subsequent operative management.

Methods: A retrospective review was performed of all patients under 20 years who had arthroscopic management for meniscus pathology at a single institution between 2008 and 2012. Demographic data and intraoperative findings at the time of the initial surgery were documented. All patients undergoing a second procedure on the same meniscus were further analyzed to calculate the incidence and risk factors for revision surgery. The mechanism and date of reinjury as well as subsequent surgical management were documented. Patients with persistent pain following the initial operation were considered a non-traumatic surgical failure. Multivariate logistic regression with purposeful selection was performed to identify independent risk factors for revision meniscus surgery.

Results: Arthroscopic knee surgery was performed on 293 patients and 324 menisci, including 129 repairs, 149 meniscal debridements, and 46 discoid saucerizations. With a minimum follow-up period of 17 months, 13% of the cohort required a revision procedure. The primary repair group had the highest failure rate (18%) followed by the discoid saucerization group (15%) and the meniscus debridement group (7%). Multivariate analysis indicated that meniscus repair was predictive of re-tear (OR = 2.04, 95%CI 1.01-4.1, p=0.046), and children with an open physis and a bucket handle tear had the highest retear rate of 46% (p=0.039). Independent variables shown to have no significant relationship to revision meniscus surgery included: age, gender, BMI, laterality, time to repair, tear location, and associated ligament injury. The most common indication for revision surgery was an acute traumatic re-injury during physical activity. Revision procedures were performed at an average of 14 months after the index surgery and the majority of failures (69%) were identified within a year. 44% of patients undergoing a revision surgery underwent a further debridement whereas 56% underwent a repair.

Conclusion: Revision meniscus surgery is not uncommon in pediatric and adolescent patients especially those undergoing a primary repair of a bucket-handle meniscus tear when the physes are still open. Most failures are the result of a traumatic injury and nearly half will require further debridement of the torn meniscus. Surgeons treating meniscal lesions in this young population, as well as children and their families, should be aware of the short-term rate of revision meniscus surgery, especially when they are still skeletally immature.

Paper 50

All-inside, All-epiphyseal ACL Reconstruction In Skeletally Immature Athletes: Incidence Of Second Surgery And Two-year Clinical Outcomes

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Objectives: Anterior cruciate ligament (ACL) injuries in skeletally immature athletes are increasing secondary to multiple factors that include increased participation and level of competition within sports, sports specialization and societal factors. Conservative treatment of these injuries has a poor natural history due to recurrent instability with meniscal and articular cartilage damage. The purpose of this study was to evaluate the 2 year clinical outcomes of an all-inside, all-epiphyseal ACL reconstruction in skeletally immature athletes with 3-6 years of remaining growth, with a focus upon return to play and the incidence of second surgery.

Methods: Twenty-three skeletally immature athletes (mean chronologic age 11.8 yrs, [range 10-13]) were prospectively evaluated following an all-inside, all-epiphyseal ACL reconstruction utilizing hamstring autograft. The mean bone age (Greulich and Pyle method) was 12.1 years. There were 6 females and 17 males. Five athletes were involved in recreational sport and 18 participated competitively. Lacrosse (40%) and Soccer (27%) were the two most common sports associated with ACL injury in our cohort. All athletes were evaluated with a physical examination, KT-1000 arthrometry, isokinetic testing, and validated outcome scores including the International Knee Documentation Committee score (IKDC), the Lysholm score and Marx activity rating scale. Standing radiographs and SPGR MRI analysis was performed at 6, 12 and 24 months post-op depending upon skeletal age. A Return to Play performance analysis was also analyzed where symmetry, alignment control and the ability to decelerate were assessed during progressively challenging movement patterns encountered in sport.

Results: At a minimum follow-up of 2 years (range 2-4.5), the mean IKDC score was 94.5 ± 5.4, the mean Lysholm score was 98.1 ± 4.1 and the mean Marx activity rating scale score was 12.8 ± 3.1. Lachman and pivot shift testing was negative in all patients. The mean side-to-side difference in the KT-1000 arthrometry was 1.0 ± 0.6 mm, with the maximum difference in the cohort being 2 mm. Isokinetic testing showed a mean deficit of 4.3% in extension torque and 9.1% in flexion torque at a repetition speed of 180 degrees per second. No angular deformities, significant leg length discrepancy or physeal disturbances were observed on postoperative radiographs or MRI. Two athletes (8.6%) required a second surgery: 1 (4.3%) had a traumatic graft disruption at 10 months and underwent revision ACLR and 1 (4.3%) required meniscectomy for an incompletely healed meniscal repair at 13 months. There were no contralateral injuries in this cohort of athletes. The mean time for return to unrestricted competitive activity after successful completion of the Return to Play analysis was 12.5 +/- 1.25 months from the time of surgery.

Conclusion: An all-inside, all-epiphyseal ACL reconstruction technique using hamstring autograft demonstrates excellent subjective and objective clinical outcomes in skeletally immature athletes without growth disturbance. Return to Play assessment is an important tool to guide the young athlete and his or her family regarding resumption of competitive sports. In our experience, young athletes were on average released for full return to sport after 1 year from ACL reconstruction.

Paper 51

The Displacement of the Clavicle is a Better Predictor of Surgical Intervention in the Non-Operatively Treated Acromioclavicular Dislocation than the Increase in Coracoclavicular distance.

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Objectives: Acromioclavicular (AC) joint injuries are common and constitute approximately 3.2% of all shoulder injuries. Traditionally Rockwood Types I and II are treated conservatively, Type III dislocations are controversial, and Types IV, V, and VI AC dislocations are indicated for surgery. Little is known about nonoperative treatment of Type V AC dislocations especially in active populations. The purpose of this study was to compare the outcomes between Type V AC dislocations treated initially with acute surgical intervention versus those treated conservatively and to identify potential risk factors associated with failure of non-operative treatment.

Methods: A retrospective review was conducted using an automated search of electronic patient medical records from January 2007 through December 2012 for patients diagnosed with an AC dislocation in the Tripler Army Medical Center Department of Orthopedics. A Type V injury was defined as greater than 100% increase in the coracoclavicular (CC) distance compared to the contralateral side. Patients were excluded if there were no bilateral radiographs, who did not present acutely or who were tertiary referrals.

Results: 25 patients were identified as having acute Type V dislocations. Acute surgical AC reconstruction was selected in 8 patients and initial conservative therapy 17. In the conservative group: 8 patients (57%) returned to duty without surgery (average 90.3 days); 4 patients had delayed surgery and returned to full duty (average 238.75 days from initial injury); 2 refused surgery and changed careers; and 3 patients were lost to follow up. In the acute surgical group: 6 patients (75%) returned to full duty in an average of 207 days with 3 of those requiring revision surgery; 1 patient was lost to follow up, and 1 patient failed to return to full duty. There was no significant difference in time to return to duty between the acute surgical group and those who underwent delayed surgical reconstruction (p=0.62). In the conservatively treated group, patients who failed conservative treatment and elected for surgery had a mean increase in CC distance of 144% (range 118%-166%) with a mean 22.5mm displacement of the clavicle above the acromion (19.3- 25.1 mm). In conservative group that did not undergo surgery there was an average 141% increase in CC distance (range 102% - 217%) with a mean 17.3mm displacement (12.5-24.22 mm). There was a significant difference in mm of displacement of the clavicle above the acromion in conservatively treated patients who underwent surgical correction and those who did not (p=.035) while there was no significant difference between the CC distance in this same group (p=0.9).

Conclusion: No study has compared initial conservative vs. operative management in type V AC joint dislocations. This study demonstrates that initial nonoperative treatment returns a majority of active patients to full duty faster than acute surgical reconstruction. Patients who undergo early operative management do not return at a higher rate, experience a similar rate of revision surgery, and time to return to duty is not significantly shorter than their initial conservative counterparts. Thus, we recommend that type 5 AC joint injuries, even in an active population, should be managed initially conservatively, as it is effective in the majority of patients, and initial surgery offers no advantage.

Paper 52

Outcomes of Operatively Treated Non-unions and Symptomatic Mal-unions of Adolescent Diaphyseal Clavicle Fractures

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Objectives: The purpose of the study was to review the clinical characteristics and outcomes of adolescent diaphyseal clavicle fractures treated surgically for non-union, impending non-union, or symptomatic mal-union, which are rare complications of primary non-operative treatment.

Methods: Records of all patients 10-18 years-old who underwent surgery at a tertiary-care children's hospital between 2003-2013 for a symptomatic mal-union, non-union (no bony bridging >6 mo post-fx), or impending non-union (no callus 1-6 mo post-fx) of a clavicle shaft fracture were reviewed. Demographic data, radiographic features, operative details, and post-operative course were analyzed and compared to an age-matched, sex-matched, and fracture pattern-matched control group of adolescents who underwent plate fixation as primary fracture treatment.

Results: Sixteen patients (56% male; mean age 15.4 years, range 12.4-17.7 years) met inclusion/exclusion criteria, most of whom (87.5%) were initially treated at an outside hospital. Plate fixation, with or without osteotomy, was performed in 14 cases (87.5%), with bone grafting in 13 cases (81.3%), including iliac crest autograft (n=4), local bone graft (n=4), cancellous allograft (n=1), or local graft + cancellous allograft (n=4). Two mal-union cases (12.5%) underwent ostectomy only. Comparisons of mean time between injury and surgery, time to healing, duration between surgery and return to sports, and rate of removal of hardware (excluding the two ostectomy patients) are detailed in Table 1.

Conclusion: Adolescents who underwent surgery for diaphyseal clavicle fracture non-union, impending non-union or symptomatic mal-union demonstrated bony healing and returned to sports within 2-4 months, with a comparable post-operative course and rate of subsequent hardware removal to patients treated with plate fixation for their primary clavicle fracture. To address the rare instance of slow, failed, or painful healing following non-operative management of diaphyseal clavicle fracture in adolescents, surgical treatment, which may be more technically challenging and often requires bone grafting, has clinical and radiographic results that are comparable to primary fracture fixation.

Table 1

(Mean values, in months)	All (1+2+3) (n=16)	1.Non-union (n=6)	2. Impending (n=6)	3. Malunion (n=4)	CONTROL (n=15)	p-value
Injury to Surgery	9.3	9.4	2.2	19.8	0.4	<0.001
Time to union	2.8	4.1	2.7	2.9	2.9	0.99
Surgery to Sports	3.6	4.3	3.6	2.6	--	--
Rate of ROH	21% (3/14)	0% (0/5)	50% (3/6)	0% (0/2)	20% (3/15)	1.00

Paper 53

Clinical Results Following Non-operative Management for Grade III Acromioclavicular Joint Injuries: Does Eventual Surgery Affect Overall Outcomes?

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Objectives: The management of grade III acromioclavicular (AC) joint injuries remains controversial. Good to excellent results have been reported with nonsurgical management; however, some patients report persistent pain related to the AC joint following non-operative treatment and may eventually seek surgical management. The purpose of this study was to compare the clinical outcomes in patients who completed non-operative (non-op) therapy to those who failed non-operative therapy and proceeded to AC reconstruction.

Methods: This is a level 3 study. Institutional Review Board approval was obtained prior to initiation of this study. 38 patients were initially treated non-op for acute grade III AC joint injuries with physical therapy. Demographic and surgical data along with pre- and post-treatment clinical outcomes scores including ASES, SF-12 PCS, QuickDASH, and SANE scores were collected a minimum of two years after initial presentation. Non-op failure occurred when a patient underwent AC reconstruction before final follow-up.

Results: 38 patients with a mean age of 38 years (range, 22-79 years) were included. 28/38 (74%) successfully completed non-op treatment whereas 10/38 (26%) failed after a median of 44 days (range, 6 days-17 months) from the initiation of physical therapy. Of the 10 patients who failed, 9 (90%) sought treatment >30 days after the injury. Two of these patients had a subsequent surgery before final follow-up and were therefore not included in outcomes analysis. Follow-up was available for the remaining 7/8 patients (87.5%) who failed non-op treatment and for 22/28 patients (78%) who were successfully treated non-op. Mean follow up was 3.3 years (range, 2.0-5.9). There were no significant differences in all outcomes scores between groups ($p>0.05$): Mean SF-12 PCS was 56.1 (range, 52.4-61.4) in those who successfully completed non-op treatment compared to 56.2 points (range, 53.1-58.0) in those who finally underwent surgery ($p=0.680$). Mean SANE score was 96 points (range, 65-100) in those who successfully completed non-op treatment compared to 95 points (range, 24-98) in those who finally underwent surgery ($p=0.175$). Mean ASES score was 95.5 points (range, 51-100) in patients with successful non-op treatment and 97.1 points (range, 91.6-100) in patients with eventual surgery ($p=0.348$). The mean QuickDASH score was 2.2 points in both groups with a range of 0-41 for those with successful non-op treatment and a range of 0-14 for those with eventual surgery ($p=0.756$). Patients who sought treatment >30 days after injury demonstrated decreased postoperative SANE scores ($p = 0.002$) and had 13.8 fold greater relative risk for failure of non-op treatment.

Conclusion: Surgical decision making for patients with acute grade III AC joint injuries is evolving. According to our results, (1) a trial of non-op treatment is warranted as successful outcomes can be

expected even in those that eventually opt for surgery, and (2) patients who present >30 days after their injury are much less likely to complete nonoperative treatment successfully.

Paper 54

Humeral Torsion as a Risk Factor for Shoulder and Elbow Injury in Professional Baseball Pitchers

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Objectives: Participation in baseball causes increased mechanical stress to the throwing arm and has been linked to alterations in shoulder range of motion (ROM) and bony morphology. Range of motion changes, specifically GIRD, has been associated with increased shoulder injury. However, the role of humeral torsion is unclear in shoulder injury. The purpose of this study was to prospectively compare humeral torsion (HT) in professional pitchers who remain healthy as compared with those who go on to suffer shoulder injuries.

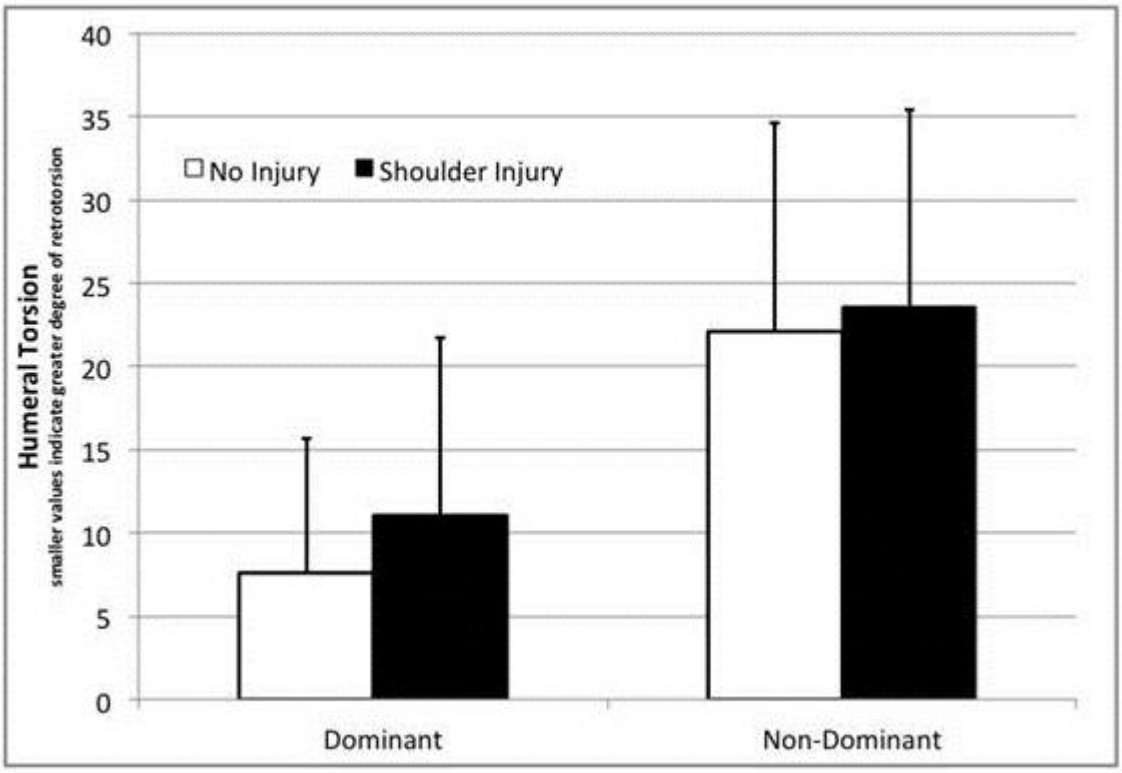
Methods: We prospectively measured and observed 255 professional pitcher-player seasons prior to 2009-2013 spring training. Bilateral HT was assessed in pitchers who were currently asymptomatic and participating without restriction, in all training, and practices. Humeral torsion was assessed via validated, indirect ultrasonography. Two trials of HT were averaged for data analysis. The side-to-side difference in HT was calculated by subtracting the dominant arm (D) HT from the non-dominant (ND) HT. The pitchers were then followed for the development of shoulder injury over the course of each season. Separate mixed model ANOVAs(side X injury) were used to compare pitchers' dominant and non-dominant HT between those who suffered shoulder injury to those who did not miss games due to arm injury (α=0.05). Tukey's Post-Hoc tests were used to determine minimum significant differences for significant interaction effects.

Results: We observed 30 shoulder injuries. Pitchers with previous elbow injuries(n=30) were excluded from the comparison.(Table 1) Pitchers who suffered a shoulder injury displayed 3.5° less D humeral retrotorsion compared to those pitchers without injury(n=195; P=0.04).(Figure 1).

Conclusion: This study showed that pitchers with decreased humeral retrotorsion had a significantly increased risk of shoulder injury. Decreased humeral retrotorsion may hinder the ability of the shoulder to obtain needed ROM, thus increasing stress to the shoulder in late cocking and follow through. Our results should be viewed in context of the relatively small injury numbers but provide preliminary

evidence that the influence of HT should be closely examined when considering shoulder injury risk in professional pitchers.

Figure 1. Pitchers with shoulder injury had less dominant humeral retrotorsion



Paper 56

Association Between Scapular Asymmetry And Shoulder Pain In Juvenile Baseball Players

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Objectives: Scapular dyskinesis, defined as an alteration in scapular position and motion, has been suggested as a risk factor for upper extremity injuries. Assessing scapular asymmetry is a simple and easy way to identify scapular dyskinesis that is typically associated with throwing-related injuries. Despite the large number of investigations identifying scapular asymmetry in patients with shoulder pathology, little research has examined the incidence of scapular asymmetry and its association with shoulder injury in young, skeletally immature baseball players. The purpose of this study was to determine the incidence of scapular asymmetry in juvenile baseball players and investigate its association with shoulder injuries.

Methods: Two hundred and twenty-three juvenile baseball players aged 9-12 years were included in this study. Each participant submitted a self-completed questionnaire and underwent a physical examination and an imaging assessment of scapular asymmetry. Questionnaire items included the subject's sex, age, position, years of baseball experience, practice frequency and duration, and shoulder pain during throwing over the past 1 year. Tenderness of the proximal humeral epiphysis and pain during maximum external rotation were also assessed on the physical examination. Digital photos of each participant's upper body were taken from behind, first with their arms held straight out to the sides and then with their hands in the air. Scapular asymmetry was evaluated using a computerized image analysis system (Image J version 1.33u; National Institute of Mental Health, Bethesda, MD, USA). Inter- and intra-observer reliability for scapular asymmetry was 0.65 and 0.77, respectively. All analyses were conducted using JMP 10 (SAS Institute, Cary, NC, USA) and p values <0.05 were considered statistically significant.

Results: Fifty-three of the 223 subjects had experienced shoulder pain while throwing in the past 1 year. Of these 53 symptomatic subjects, 28 (52.8%) had experienced shoulder pain twice or more in that year, whereas 42 (79.2%) had some kind of throwing disability. The incidence of shoulder pain significantly increased with age and was significantly higher in pitchers than in players of other positions. There was no significant association between shoulder pain and years of baseball experience or amount of practice. Scapular asymmetry was observed 171 (76.7%) subjects. The scapula of the throwing side tended to tilt anteriorly, deviate inferiorly and medially, and rotate downwardly in both the arms at side and hands up positions compared with the scapula on the non-throwing side.

Age- and position-adjusted logistic regression analysis revealed that scapular superior deviation and anterior tilting significantly increased the risk of shoulder pain as evidenced by odds ratios (95% confidence interval) of 2.41(1.17-4.98) and 2.36 (1.20-4.67), respectively.

Conclusion: Our study demonstrated that approximately three-quarters of juvenile baseball players under the age of 12 years already had scapular asymmetry and that 24% experienced shoulder pain. Scapular superior deviation and anterior tilt, which might be induced by tightness of the pectoralis

minor muscle, leads to increased rotational torque at the proximal humeral epiphysis by restricting the scapular posterior tilt during late cocking to the acceleration phase.

Scapular position of the throwing side compared with non-throwing side

Scapular position	number of subjects	percentage
anterior tilt	70	31.4
posterior tilt	63	28.3
superior deviation	60	26.9
inferior deviation	87	39.0
abduction	31	13.9
adduction	52	23.3
upward rotation	50	22.4
downward rotation	72	32.3

Association between shoulder pain and scapular asymmetry

scapular position	odds ratio	95% confidence interval	p-value
anterior tilt	2.37	1.20-4.67	0.01
superior deviation	2.41	1.17-4.98	0.02
adduction	1.66	0.78-3.46	0.19
downward rotation(arm at side position)	1.27	0.61-2.59	0.52
downward rotation (hands up position)	1.80	0.92-3.57	0.09

Paper 57

Professional Pitchers Display Differences in Ulnar Collateral Ligament Morphology and Elbow Gapping Following UCLR Compared to Uninjured Pitchers

Authors: Michael J. Kissenberth, MD[1], Charles A. Thigpen, PT, PhD, ATC[2], Lane Brooks Bailey, DPT[3], Mark L. Schweppe, MD[4], Derik J. Geist, MD[5], Douglas J. Wyland, MD[6], Richard J. Hawkins, MD, FRCSC[1], Thomas J. Noonan, MD[7], Ellen Shanley, PhD[2]
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Objectives: Ulnar collateral ligament reconstruction(UCLR) of the elbow has received much attention given the rise in incidence among all pitchers. Recent studies have demonstrated stress ultrasonography is a critical tool in the evaluation of the UCL. . No study, has dynamically evaluated the UCL in uninjured professional pitchers under stress, nor has any study evaluated the ability of UCL reconstruction (UCLR) to restore normal kinematics. The purpose of this study was to compare ulnohumeral gapping and UCL thickness in both uninjured professional pitchers and those who had undergone UCLR during a moving valgus stress test. We hypothesized that the UCL will be thicker and the ulnohumeral joint will display adaptive gapping in D arms compared to ND arms. Furthermore we hypothesized that UCLR would restore gapping and UCL morphology.

Methods: Ultrasonography was used to assess the UCL of 70 asymptomatic professional baseball pitchers during spring training (history of UCLR, n=6). A 5-MHz linear-array transducer was used to capture images of the dominant (D) and non-dominant (ND) throwing elbows at the maximal cocking position under two loaded conditions within the moving valgus stress test arc:(1) gravity stress and (2)-10 lbs of valgus force using a dynamometer. Ulnohumeral gapping and UCL thickness was measured on sagittal images using the OsiriXTM platform. All measures displayed reliability with intraclass correlation coefficients (ICC) ranging from ICC(2,1)=0.94 -0.98 with Standard error of measure (SEM) of 0.14-0.26 mm for intra-rater and ICC(2,k)= 0.82-0.87; SEM=0.38-0.65mm for inter-rater reliability. Separate mixed model ANOVAs(side X UCL) were used to compare pitchers' D and ND arm variables between those with UCLR to those who never had a UCL injury.(α=0.05).

Results: The D arms of uninjured pitchers demonstrated increased gapping compared to ND arm (5.4 ± 1.2vs4.7± .86 p=0.001) Players with a UCLR demonstrated decreased gapping compared to both the ND and uninjured D arms of professional pitchers. (2.6±2.9 vs 4.2±1.2; P=0.002), Furthermore, the UCLR elbows demonstrated greater D arm ligament thickness when compared to D arms in pitchers without UCL injury history(.17±.07vs.11 ±.08;P=0.03).

Conclusion: This is the first study to our knowledge evaluating stress ultrasonography of the UCL during the moving valgus stress test in professional pitchers. Our data demonstrates that the UCLR results in a thicker, stiffer construct with less medial elbow gapping than even the normal condition. Using

ultrasound to evaluate the UCL it was shown to be reliable, more efficient and provides a clinically feasible method to assess UCL thickness, loaded joint gapping, and stiffness post-UCLR. Future studies may consider this approach to evaluate surgical techniques and graft types for UCL reconstruction.

Paper 58

Return to Sports in a General Hip Arthroscopy Cohort: Minimum Two-Year Follow-Up

Authors: Benjamin G. Domb, MD[1], Kevin F. Dunne, BS[2], Tim Martin, MA[2], Chengcheng Gui, BSE[2], Nathan Finch, MA[2], Christine E. Stake, DHA[3]
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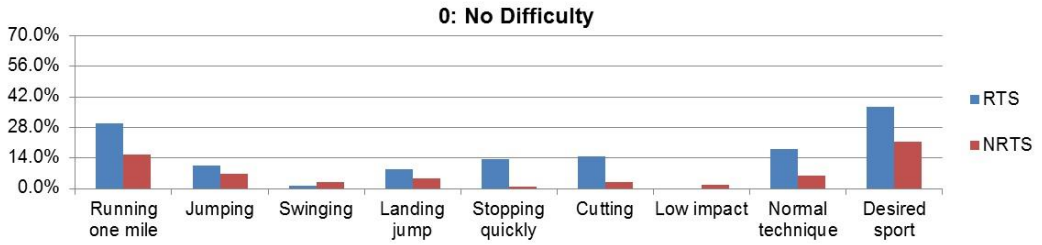
Objectives: Previous studies have assessed elite athletes' level of return to sport, but few have investigated a general hip arthroscopy cohort. The study purpose was to compare patient-reported outcomes (PRO) scores and ability to perform sports-related movements between a group of patients that returned to sport (RTS) and a group that did not return to sports (NRTS).

Methods: Between September 2008 and April 2012, 1343 patients underwent hip arthroscopy, of which, 157 patients (168 hips) reported playing a sport before surgery and also indicated their postoperative involvement in sports. Of these, 148 patients (158 hips, 94%) had two-year follow-up. Four PROs were used. The Hip Outcome Score - Sports Specific Subscale (HOS-SSS) was the primary measure to assess return to sports and ability to perform sport-related movements.

Results: In the overall cohort of 148 amateur and professional athletes (158 hips) who underwent hip arthroscopies, 25 (17%) did not return to sports due to hip-related issues. An additional 32 patients (22%) did not return to sports due to non-hip-related issues, while three patients did not return sports for unidentified reasons. These 60 patients (65 hips) were considered the NRTS group. The remaining 88 patients (93 hips) were defined as the RTS group. Average ages for the RTS and NRTS groups were 30.7 and 30.4 years, respectively. Both groups demonstrated significant improvements from preoperative to postoperative scores based on all PRO measures. While there was no significant difference between groups for HOS-SSS scores preoperatively, the RTS group had significantly higher HOS-SSS scores at one year and two years post-surgery. Postoperatively, patients in the RTS group had significantly better ability to: run one mile, jump, land from a jump, stop quickly and perform cutting/lateral movements ($p<0.05$). Patients with HOS-SSS>20 at two years post-surgery were 2.3 times as likely to return to sport as those with HOS-SSS < 20.

Conclusion: In a mixed group of hip arthroscopy athletes, 84% returned to sport or discontinued participation due to non-hip related issues. Patients who returned to sport demonstrated significantly higher HOS-SSS scores and abilities to perform several sport-related movements. movements.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42.0%
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Running one mile
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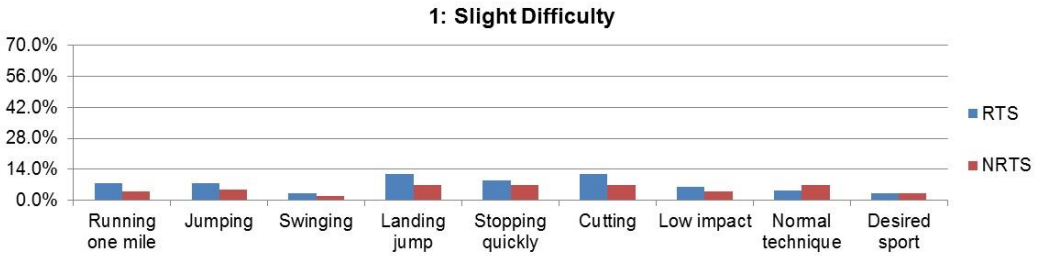
Landing jump
Stopping quickly
Cutting
Low impact
Normal technique
Desired sport
RTS
NRTS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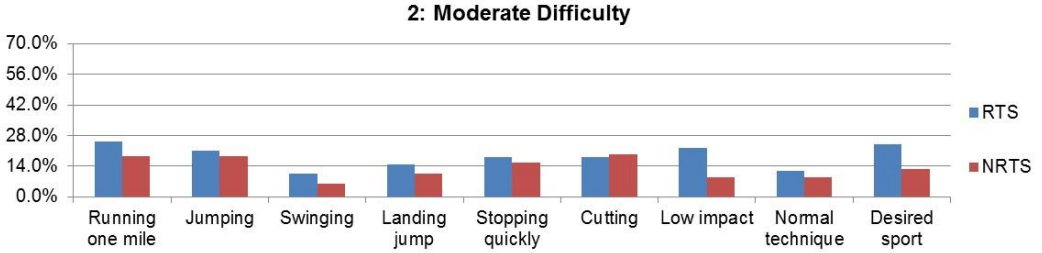
RTS
NRTS


2: Moderate Difficulty
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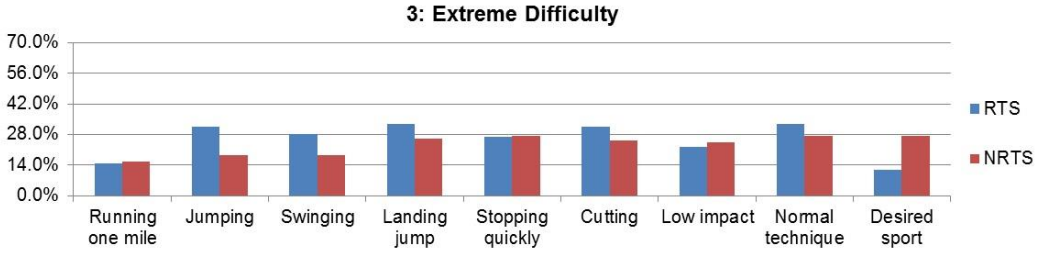
Normal technique
Desired sport
RTS
NRTS


3: Extreme Difficulty
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Running one mile
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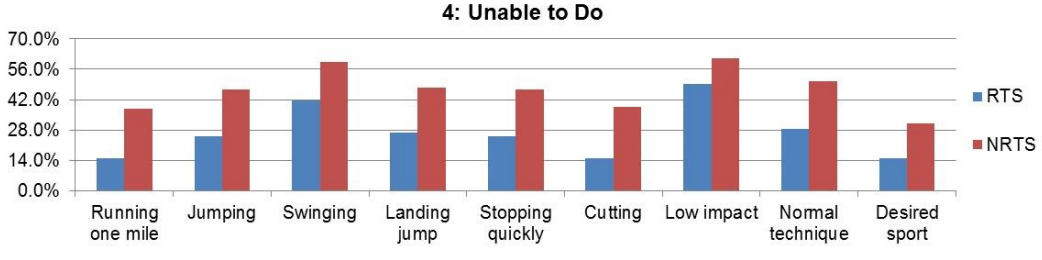
4: Unable to Do
70.0%
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Low impact
Normal technique
Desired sport
RTS
NRTS

The American Orthopaedic Society for Sports Medicine

AOSSM Annual Meeting 2015

Paper 59

Pre-Operative Femoral Nerve Block for Hip Arthroscopy: A Randomized Controlled Trial

Authors: Jerry G. Xing, MD[1], Faraj W. Abdallah, MD[2], Stephanie Oldfield[3], Andrew Dold, MD[4], Michael Lucas Murnaghan, MD[3], Richard Brull, MD[3], **Daniel B. Whelan, MD**[3]
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Objectives: : Arthroscopy has become a standard method of treatment for a variety of intra-articular hip pathologies. While most arthroscopic hip procedures are performed as day-surgeries, patients can still experience significant post-operative pain and opioid-associated side-effects. Our group has shown the potential benefits of preoperative femoral nerve block (FNB) in a previous retrospective review. It was our objective to confirm these findings in a prospective study.

Methods: Fifty patients undergoing hip arthroscopy were included in this prospective, single centre, double-blinded, randomized controlled trial. All patients received a pre-operative ultrasound-guided femoral nerve block with either 20 mL of 0.5% bupivacaine (treatment group, n=27) or normal saline (control group, n=23). Nerve blockade was confirmed via standardized sensory testing prior to the induction of general anaesthesia. Groups were compared with respect to patient sex, age, body mass index (BMI), physical status classification according to the American Society of Anaesthesiologists (ASA); procedure performed; and opioid requirements. The primary endpoint was total oral morphine equivalent consumption in 24 hours. Secondary endpoints included visual analog pain scores; Quality of Recovery (QoR-27) score at 24 hours; incidence of nausea and vomiting; patient satisfaction; and block-related complications.

Results: There were no significant differences between groups with respect to sex, age, weight, height, BMI, ASA classification, or type of procedures performed. Total oral morphine consumption at 24 hours was similar between groups. Patient-reported pain scores were lower at all times points in the femoral nerve block group compared to the placebo group with statistical significance reached at 30 minutes, 1 hour, 2 hour, 4 hour, and 6 hours post-operatively. There was no difference in the rates of nausea and vomiting after surgery, Quality of Recovery score at 24 hours, time to discharge, or symptoms of itching, weakness, and injection site bruising and pain. The placebo group had a significantly higher rate of reported constipation at 48 hours. 6 out of 27 patients in the femoral nerve block reported falls (without injury) at 24 hours compared to 0 out of 23 patients in the placebo group. The satisfaction score, however, was similarly high in both groups at all time-points.

Conclusion: Pre-operatively administered femoral nerve blocks lead to decreased pain scores in the early post-operative phase without affecting opioid consumption or opioid-related side effects. Patient satisfaction with pain control was similarly high between groups. Given the rate of falls observed in this study, we cannot recommend the routine use of femoral nerve blocks for outpatient hip arthroscopy.

Paper 60

Magnetic Resonance Arthrography And The Prevalence Of Acetabular Labral Tears In Patients 50 Years Of Age And Older: Is It Really Indicated?

Authors: Rohit Jayakar, BA[1], Alexa Merz, MD[1], Benjamin Plotkin, MD[2], Dean Wang, MD[1], Leanne L. Seeger, MD[2], Sharon L. Hame, MD[1]
[1]UCLA Department of Orthopaedic Surgery, Los Angeles, CA, USA, [2]UCLA Department of Radiology, Los Angeles, CA, USA

Objectives: Arthroscopy for acetabular labral tears has minimal impact on pain and function in patients older than 50 years of age in the setting of concomitant osteoarthritis. Despite this, many physicians continue to seek diagnoses of labral tears in older arthritic patients with magnetic resonance arthrography. The inefficacy of surgical management and the suggested high prevalence of this condition in both symptomatic and asymptomatic patients call into question the utility of diagnosis through an invasive and expensive imaging modality. The purpose of this study is to assess the frequency of acetabular labral tears in patients aged 50 years and older with hip pain and to correlate the likelihood of a labral tear with the severity of osteoarthritis as visualized on conventional radiograph.

Methods: From 2004-2013, 208 patients aged 50 years and older who underwent hip MR arthrogram and hip radiographs within a 12-month period were identified. Age, gender, grade and location of labral tear, hip alpha angle, hip Tönnis grade, and hip joint space width were documented for each patient. Labral tears and alpha angle were identified and measured on MR arthrogram. Tönnis grade and joint space width were measured on hip radiographs by a musculoskeletal radiologist.

Results: On MR arthrography, labral pathology was identified in 93% of patients (73.1% labral tearing, 20.2% labral fraying or degeneration). In patients with moderate to severe osteoarthritis (Tönnis grade 2-3), 100% had labral pathology (73.1% labral tearing, 26.9% labral fraying or degeneration). Similarly, in patients with joint space width ≤ 2mm, 100% had labral pathology (81.2% labral tearing, 18.8% labral fraying or degeneration). There were no statistically significant correlations between labral tear grade and Tönnis grade or joint space width.

Conclusion: Given the high frequency of tears, as well as the questionable efficacy of arthroscopic surgical intervention in these patients, only good surgical candidates with chronic hip pain and minimal evidence of osteoarthritis (joint space width > 2mm, Tönnis grade 0-1) on initial radiographic evaluation should be considered for magnetic resonance arthrography.

Paper 61

Labral Reconstruction with Iliotibial Band Autograft and Semitendinosus Allograft Improves Hip Joint Contact Area and Contact Pressure: An In-Vitro Analysis

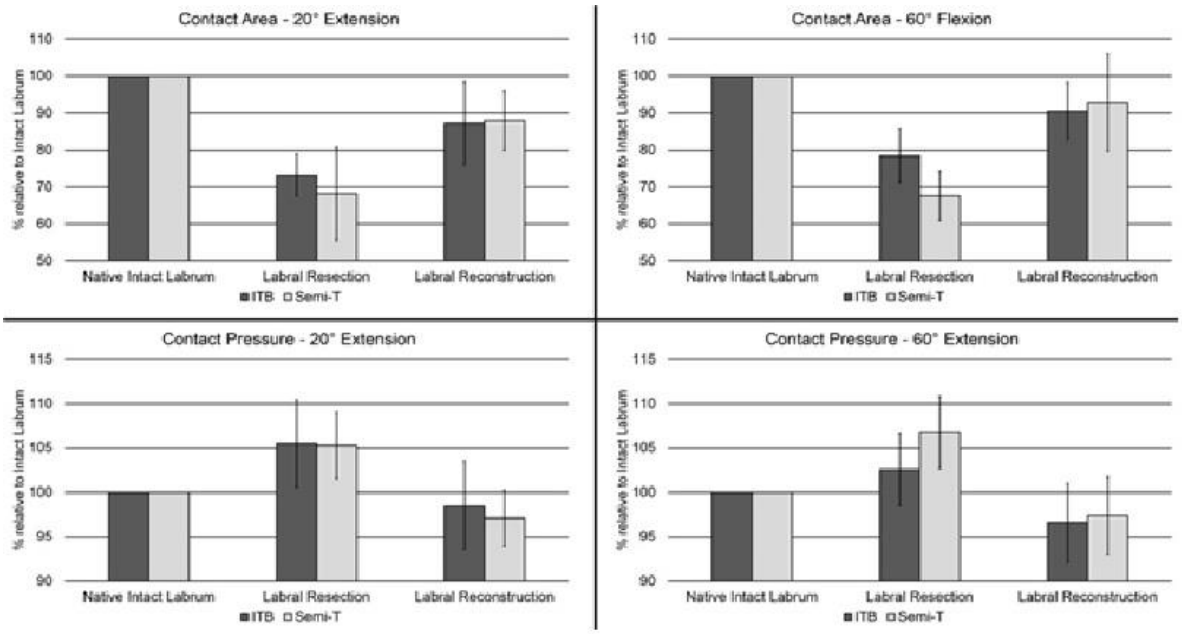
Authors: Simon Lee, MPH[1], Thomas H. Wuerz, MD[2], Elizabeth Shewman, MS[3], Francis McCormick, MD[4], Michael Jonathan Salata, MD[5], Marc J. Philippon, MD[6], **Shane Jay Nho, MD, MS**[1]
[1]Rush University Medical Center, Chicago, IL, USA, [2]Rush University Medical Center Program, Chicago, IL, USA, [3]Rush Medical Center, Chicago, IL, USA, [4]Harvard Medical School, Cambridge, MA, USA, [5]University Hospitals Case Medical Center, Shaker Heights, OH, USA, [6]Steadman Clinic, Vail, CO, USA

Objectives: Labral reconstruction using iliotibial band (ITB) autograft and semitendinosus (Semi-T) allograft have recently been described in cases of labral deficiency. The current study seeks to understand the biomechanical effects of an intact labrum, segmental labral resection, and labral reconstruction on joint contact area, contact pressure, and peak force.

Methods: Ten fresh-frozen human cadaver hips were analyzed utilizing thin-film piezoresistive load sensors to measure contact area, contact pressure, and peak force 1) with the native intact labrum, 2) after segmental labral resection and 3) after graft labral reconstruction with either ITB autograft or Semi-T allograft. Each specimen was examined at 20° extension and 60° flexion. Statistical analysis was conducted through one-way ANOVA with post-hoc Games-Howell tests.

Results: For the ITB group, labral resection significantly decreased contact area (20°: 73.2%±5.38, *P*=0.0010; 60°: 78.5%±6.93, *P*=0.0063) and increased contact pressures (20°: 106.7%±4.15, *P*=0.0387; 60°: 103.9%±1.15, *P*=0.0428). ITB reconstruction improved contact area (20°: 87.2%±12.3, *P*=0.0130; 60°: 90.5%±8.81, *P*=0.0079) and contact pressures (20°: 98.5%±5.71, *P*=0.0476; 60°: 96.6%±1.13, *P*=0.0056) from the resected state. Contact pressure at 60° flexion was significantly lower compared to the native labrum (*P* = 0.0420). For the Semi-T group, labral resection significantly decreased contact area (20°: 68.1±12.57, *P*=0.0002; 60°: 67.5%±6.70, *P*=0.0002) and increased contact pressures (20°: 105.3%±3.73, *P*=0.0304; 60°: 106.8%±4.04, *P*=0.0231). Semi-T reconstruction improved contact area (20°: 87.9%±7.95, *P*=0.0087; 60°: 92.9%±13.2, *P*=0.0014) and contact pressures (20°: 97.1%±3.18, *P*=0.0017; 60°: 97.4%±4.39, *P*=0.0027) from the resected state. Comparative analysis demonstrated no statistically significant differences between either graft reconstruction in relation to contact area, contact pressure, or peak forces. (Figure 1).

Conclusion: Segmental anterosuperior labral resection results in significantly decreased contact area and increased contact pressures, while labral reconstruction partially restores time-zero acetabular contact areas and pressures as compared to the resected state. Although labral reconstruction improved the measured biomechanical properties as compared to the resected state, some of these properties remained significantly different compared to the native intact labrum.


Contact Area - 20° Extension
% relative to Intact Labrum
110
100
90
80
70
60
50
Native Intact Labrum
Labral Resection
Labral Reconstruction
ITB
Semi-T
Contact Area - 60° Flexion
% relative to Intact Labrum
110
100
90
80
70
60
50
Native Intact Labrum
Labral Resection
Labral Reconstruction
ITB
Semi-T
Contact Pressure - 20° Extension
% relative to Intact Labrum
115
110
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95
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Native Intact Labrum
Labral Resection
Labral Reconstruction
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Semi-T
Contact Pressure - 60° Extension
% relative to Intact Labrum
115
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Native Intact Labrum
Labral Resection
Labral Reconstruction
ITB
Semi-T

Paper 62

A Comparison of Non-Operative and Operative Treatment of Complete Proximal Hamstring Ruptures

Authors: Joshua Olsen, MD[1], Ethan L. Kellum, MD[2], Edward Lacerte, PT, MEd, SCS, ATC/L, CSCS[3], Suzanne Laura Miller, MD[4]
[1]NEBH, Boston, MA, USA, [2]New England Baptist Hospital Program, Boston, MA, USA, [3]New England Baptist Hospital, Waltham, MA, USA, [4]Boston Sports and Shoulder Center, Chestnut Hill, MA, USA

Objectives: Early repair of acute proximal hamstring ruptures provides better clinical results than delayed repairs. However, it is unclear how the non-operative treatment compares to the operative treatment of these injuries. We compare the clinical results of non-operative and operative treatment of acute proximal hamstring ruptures.

Methods: A retrospective case-control study of patients with a complete, retracted, proximal hamstring rupture was performed from 2007 to 2013. All patients were given the option of a proximal hamstring repair at the time of initial evaluation. Patients at least 12 months from the time of surgery or injury were included for evaluation. Acute proximal hamstring injuries were included; and partial proximal hamstring tears and chronic injuries repaired were excluded. The primary outcome measure was the lower extremity functional score (LEFS). Secondary outcome measures included the SF-12 physical and mental component scores, a single leg hop (average of three jumps), the patient's perception of strength (0-100%), and ability to return to activity.

Results: A total of 25 patients were enrolled. The 14 patients treated surgically sustained injuries at 46.98 ± 9.73 years of age, were repaired at 28.14 ± 14.06 days, and evaluated at 50.62 ± 10.11 years of age. The 11 patients treated non-operatively sustained injuries at 55.6 ± 10.45 years of age ($p = 0.05$), attempted therapy an average of 4.6 ± 3.22 months, and were evaluated at 58.4 ± 8.31 years of age ($p= 0.06$). The LEFS for the surgical and non-surgical groups was 74.71 ± 5.38 and 68.5 ± 7.92 ($p = 0.04$), respectively. SF-12 mental and physical components scores were similar between groups. The average single leg hop of the injured extremity in the surgical and non-surgical groups was 119.1 ± 27.68 cm and 56.1 ± 31.2 cm ($p = 0.0001$), respectively. When compared to the uninjured leg, the average single leg hop in the injured leg was 5.1 ± 12.1 cm and 1.2 ± 17.2 cm ($p = 0.51$) shorter in both the surgical and non-surgical groups, respectively. The LEFS had a weak correlation with the average single leg hop and age in the surgical ($R2 = 0.2478$ and 0.0664, respectively) and non-surgical ($R2 = 0.0023$ and 0.052, respectively) groups. The patient's perception of strength was similar between the surgical and non-surgical groups (86.07 ± 12.12% and 83.6 ± 14.15%, $p = 0.64$). All patients in the operative group were able to return to pre-injury activities whereas three were unable to in the non-operative group (chi-square stat = 4.33, $p = 0.03$).

Conclusion: Patients with acute proximal hamstring ruptures treated surgically have better lower extremity function and a higher likelihood of returning to pre-injury activities than patients treated non-surgically.

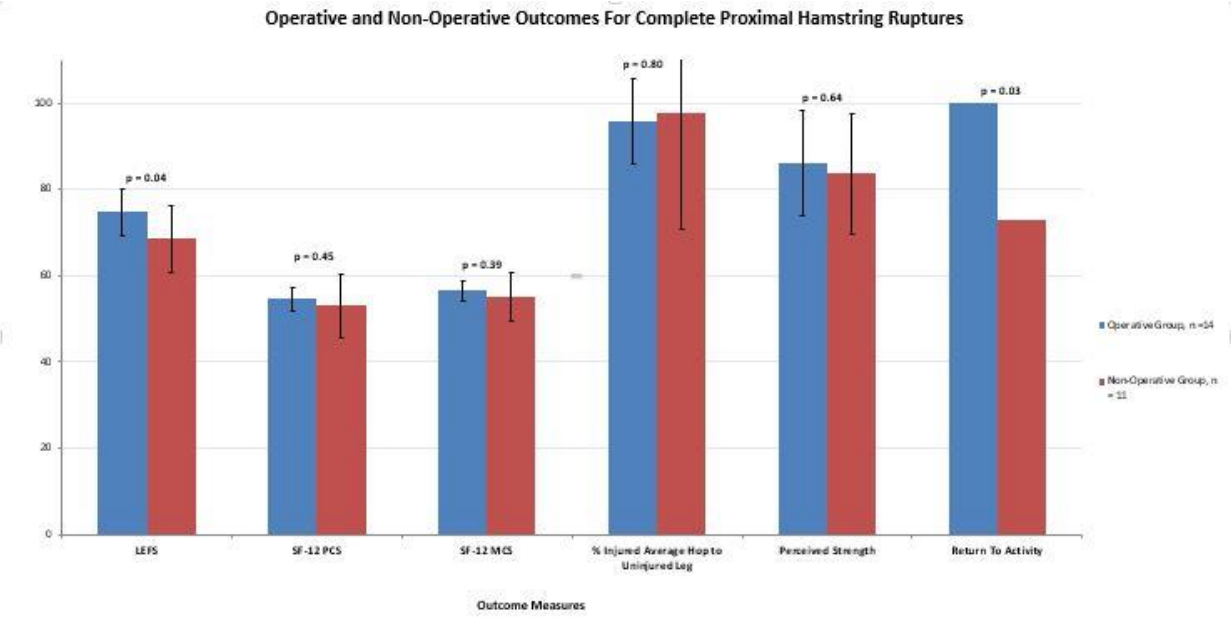

Figure 1. Operative and Non-Operative Outcomes for Complete Proximal Hamstring Ruptures. LEFS = lower extremity functional score; PCS = physical component score; MCS = mental component score

Paper 63

A Comparison of Open and Endoscopic Repair of Full-Thickness Tears of the Gluteus Medius Tendon at a Minimum of 2 Years Follow-up

Authors: Danyal H. Nawabi, MD[1], Catherine Wentzel, MD[1], Anil S. Ranawat, MD[1], Asheesh Bedi, MD[2], **Bryan T. Kelly, MD**[1]
[1]Hospital for Special Surgery, New York, NY, USA, [2]MedSport, Univ of Michigan, Ann Arbor, MI, USA

Objectives: Historically, tears of the gluteus medius tendon were repaired via an open approach yielding excellent outcomes. With the advent of hip arthroscopy, endoscopic techniques have been developed to repair abductor tears which have shown favorable early outcomes. The open technique may still be preferred for large tears with retraction (>4cm), but there is a paucity of data comparing open and endoscopic approaches. The purpose of this study was to compare the outcomes of open and endoscopic repair of full-thickness tears of the gluteus medius tendon. We hypothesized that the outcomes of the two approaches would be similar but that the open technique would have shorter surgical times.

Methods: Between March 2010 and June 2012, 1267 patients (1518 hips) undergoing a hip preservation procedure were prospectively entered into a registry. From this cohort, we identified 27 patients (30 hips) that had undergone repair of the gluteus medius tendon with a minimum of 2 years follow-up. Nine patients (9 hips) had an open repair and 18 patients (21 hips) had an endoscopic repair. Patient-reported outcome scores, including the Modified Harris Hip Score (mHHS), the Hip Outcome Score-Activity of Daily Living (HOS-ADL), and the Sport-specific Subscale (HOS-SSS) were obtained preoperatively and at 1, 2, and 3 years postoperatively. Surgery time was obtained using operating room records. The femoral neck shaft angle (FNSA) and lateral center-edge angle (LCEA) were measured on preoperative radiographs. Continuous and categorical variables were compared between endoscopic and open abductor repair patients using independent-samples t-tests and chi-square or Fisher's exact tests (as appropriate), respectively. Given the limited sample size, no adjusted or matched analyses were performed.

Results: The mean age (±SD) of the open and endoscopic groups was 62.0 ± 9.9 years and 51.6 ± 13.6 years respectively (p=0.05). There were 6 females (67%) in the open group and 17 females (94%) in the endoscopic group (p=0.09). Seven hips (78%) in the open group had varus necks (FNSA30°) compared to 15 hips (54%) in the endoscopic group (p=0.93). At a mean follow-up of 38.1 months (range, 24-87 months), there were large (> 35 points) and significant improvements (p0.8). One patient (11.1%) in the open group had a poor clinical outcome compared to 2 patients (11.1%) in the endoscopic group that required revision abductor repairs at 5 and 24 months respectively. The mean surgical time was 98.7 ± 21.3 minutes in the open and 122.0 ± 26.8 minutes in the endoscopic group (p=0.003).

Conclusion: This study demonstrates that an open gluteus medius tendon repair results in a significant improvement in clinical outcome, that is similar to the scores seen after endoscopic repair. Varus femoral necks and acetabular overcoverage are common features of hips with abductor tears and may

be useful diagnostic aids. The surgical time for an open technique is significantly shorter than the endoscopic technique. We recommend an open technique where an intra-articular hip arthroscopy is not required, or in those patients with large and retracted tears.

Paper 64

Predictive Value and Clinical Validation of the "On-Track" vs. "Off-Track" Concept in Bipolar Bone Loss in Anterior Glenohumeral Instability

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Objectives: Bone loss is a well-described risk factor for failure with arthroscopic stabilization. The isolated importance of bone loss on both the glenoid and humeral side has been increasingly studied. A more recent evolution considers how both the glenoid and humeral bone loss interact to determine whether their combination results in an "on-track" or "off-track" lesion, which may be more predictive of recurrent instability than looking at either side individually. While the biomechanics of this concept have been elucidated, no study has tested this theory in a clinical population. The purpose of this study is to compare a series of arthroscopic Bankart reconstructions stratified by whether they are "on-track" or "off-track" with regard to bipolar bone loss and to compare their rates of recurrence and functional outcome scores.

Methods: Over a two year period, all isolated, primary Bankart reconstructions performed at a single facility by one of three fellowship trained Orthopaedic Sports Surgeons were included in this study. All patients had preoperative advanced imaging and had postoperative outcome measures including SANE and WOSI scores, as well as data return to work status. Glenoid bone loss, Hill-Sachs lesion size and location, as well as a radiographic measurement of the glenoid track were measured. Patients were stratified according to whether they sustained a subsequent recurrence of their instability, and these groups were analyzed according to their bone loss status, specifically whether they were "on-track" or "off-track".

Results: 57 shoulders met inclusion criteria. The average age was 25.5 years (range 20-42) at the time of surgery. Average follow up was 28.4 mos. There were 10 recurrences (18%). Patients in the recurrent group had WOSI and SANE scores that were roughly half as good as the group that did not recur ($p=0.003$ and $p=0.002$ respectively). Of the 49 on-track patients, 4 (8.2%) failed. Conversely, of the 8 off-track patients, 6 (75%) failed ($p=0.0001$). Six of the 10 (60%) of the patients who sustained a recurrence of their instability after arthroscopic stabilization were off-track at the time of their surgery. In contrast, in the 47 patients who remained stable at latest follow-up, only 2 (4.3%) were off-track ($p=0.0001$). Eight of 47 patients (17%) in the non-recurrent group had glenoid bone loss greater than 20%; two of 47 stable patients (4%) were off-track. The positive predictive value (PPV) of the off-track measurement was 75% which was significantly higher than the predictive value of glenoid bone loss >20% (PPV=43%, $p=0.02$).

Conclusion: This is the first study to apply the on-track vs. off-track assessment of bipolar bone loss to a clinical population. In this study, being off-track was a significant predictor of recurrent instability after isolated Bankart reconstruction, correctly predicting failure in 75% of cases. This was superior to the predictive value of glenoid bone loss >20% alone, which correctly predicted failure 43% of the time. Recurrence correlated with worse functional outcomes scores. Bipolar bone loss as measured by the track method is quite accurate in predicting success and failure after arthroscopic Bankart reconstruction in a clinical population. This method of assessment is encouraged as a routine part of the preoperative evaluation of all patients under consideration for arthroscopic anterior stabilization.

Paper 65

Loss of Anterior Stability of Shoulder Across a Range of Motion Due to Combined Bony Defects: A Cadaveric Study

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Objectives: Previous studies have analyzed only the effects of isolated glenoid or humeral head defects at limited arm positions. Literature data also suggests that instability might vary for envelop of motion. The aim of this study was to evaluate the effect of combined bony lesions on shoulder instability through varying glenohumeral positions.We hypothesized that the shoulder stability would significantly decrease with increasing defect size, and in the presence of combined defects. Furthermore, instability secondary to a humeral head defect will be magnified at functional arm positions.

Methods: All experiments were performed at glenohumeral abduction angles (ABD) of 20°, 40°, and 60° and external rotations (ER) of 0°, 40°, and 80° for 18 specimens. Each experiment comprised of translating the glenoid in a posterior direction in order to cause an anterior dislocation under a 50N load. Translational distance of the glenoid and medial-lateral displacement of the humeral head, along with horizontal reaction force were recorded for every trial. Since it was not possible to test every defect combination in a single specimen, three different pathways were chosen (4 levels of glenoid defect and 5 levels of humeral defect) to maximize defect combinations. The sizes of humeral head lesions and glenoid defect were chosen similar to previous studies.

Results: At 60° ABD and 80° ER, stability decreased from 100% to 85.2% and 73.7 % with isolated glenoid defect sizes of 10% and 20%, respectively. A combination of a 44% humeral head defect with 20% and 30% glenoid defect resulted in 1.6% and 1.4% intact translation, respectively. At 20° ABD and 0° ER, % intact translations were 69.0 ± 9.7, 64.3 ±12.9, 64.9 ± 11.1, 66.7 ± 8.8, 69.3 ± 13.9 for humeral defect sizes of 0%, 6%, 19%, 31%, 44% with a 20% glenoid defect, respectively. However, at a functional position of 60° ABD and 80° ER these values were significantly different ($p < 0.05$) for humeral head defects of size 19%, 31%, and 44% with translation values of 48.6 ± 24.2, 26.6 ± 25.2, and 1.6 ± 3.6, respectively. The % intact translation values for glenoid defects sizes 20% and 30% were significantly different ($p < 0.05$) for all arm positions. Combination of a smaller 6% humeral defect with increasing glenoid defects of size 0%, 10%, 20% and 30% has translation values 103.0 ± 2.9, 82.6 ± 16.4, 65.2 ± 12.9, and 40 ± 20.7, respectively. These values were similar at different arm positions.

Conclusion: This study demonstrated that a smaller glenoid defect size of 10% combined with a 19% humeral head defect, can lead to a significant instability. Additionally, it was shown that a significant glenoid defect would lead to loss of translation independent of changes in the arm position. However, the loss of stability from a humeral head defect would lead to loss of translational stability significantly at a functional arm position of increased abduction and external rotation rather than a resting arm

position. This rotational dependency of a humeral head defect further leads to a magnified instability during combined defects.

		Glenoid Defects			
		0%	10%	20%	30%
Humeral Defects	0%	100.0 (±0)	85.2 (±8.5)	73.7 (±10.9)	*
	6%	102.6 (±4.3)	85.2 (±11.6)	70.0 (±14.6)	43.3 (±9.7)
	19%	78.8 (±13.0)	69.0 (±9.7)	48.6 (±24.1)	33.7 (±17.9)
	31%	*	*	26.6 (±25.2)	11.4 (±15.3)
	44%	*	*	1.6 (±3.6)	1.4 (±4.9)

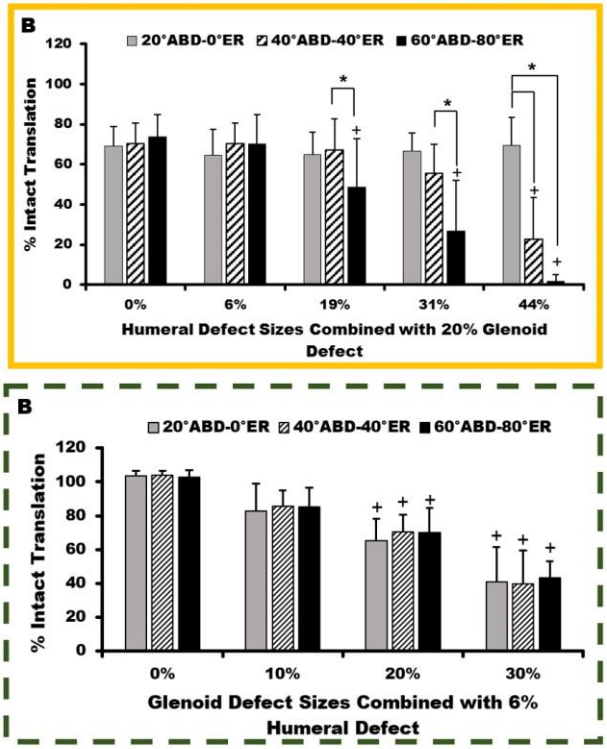

Figure 1. % Intact stability at apprehension position with color gradient, darker color signifies lower stability (A), % of Intact translation for(B),bony Bankart defect sizes of 10%, 20%, and 30% combined with 6% humeral defect and(C), 20% glenoid defect combined with four Hill-Sachs lesions (6%, 19%, 31%, and 44%) at 3 different arm positions.

Paper 66

Surgical Trends in Treatment of Meniscus Tears:
Analysis of Data from the American Board of Orthopaedic Surgery Certification Examination Database

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Objectives: The indications and criteria for meniscal repair are expanding in parallel with new understanding in pathophysiology, biomechanics and novel surgical techniques. In learning from the previous management of meniscal tears with total meniscectomy, there is growing concern for preservation of meniscus and its implication in the development of osteoarthritic changes, specifically in the young population. The American Board of Orthopaedic Surgery (ABOS) has developed a comparative effectiveness program that intends to assist in the geographic variation in various orthopaedic practices, trends in practice patterns for the treatment of various conditions, and the differential effectiveness of certain procedures in the treatment of various conditions. The objective of this study is to analyze the surgical management trends of meniscal pathology from 2004-2012 among recent orthopaedic graduates.

Methods: A query of the American Board of Orthopaedic Surgery (ABOS) database was used to identify patients from 2004-2012 who underwent meniscal repair and partial meniscectomy with and without anterior cruciate reconstruction. The specialty training of the surgeon, the age of the patient, the region where the surgery was performed, and the complications were collected from the case database.

Results: Among meniscal procedures the frequency of repair has increased from 5% to 7.3% from 2004-2012. However, within this context, partial meniscectomies have decreased disproportionately to the increase in meniscal repair. In contrast, when performed in combination with ACL reconstruction, the frequency of meniscal repairs has increased from 14.9% to 22.3%, while the incidence of partial meniscectomy has increased from 34.8% to 39.3%. When comparing sports fellowship and non-sports trained physicians, there is no significance difference in these procedure trends. There is no variability in region with regards to the type of meniscal procedure being performed. The total complication rate of all ABOS queried meniscal procedures was 5.9% and the implant failure rate was 0.4%. The complication rate was 6.5% in sports trained physicians vs. 5.0% in the non-sports trained physicians.

Conclusion: Partial meniscectomies are being performed at a significantly decreasing rate in proportion to the increasing rate of meniscal repairs amongst candidate ABOS member surgeons. In combination with ACL reconstruction, both repair and meniscectomy are being performed at an increasing incidence. There is no difference in the rate at which these procedures are being performed based on age, geography, and surgeon training from 2004-2012. These trends may be a reflection of the new

understanding of meniscus healing potential, advances in techniques and technology, and new resident core competencies.

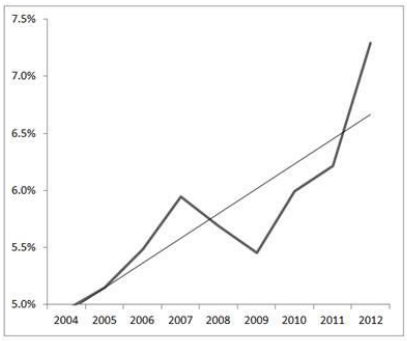

Figure 1 – Incidence (percentage of meniscal procedures performed) of Meniscal Repairs 2004-2012 by All Orthopaedic Surgeons. (p<0.001)

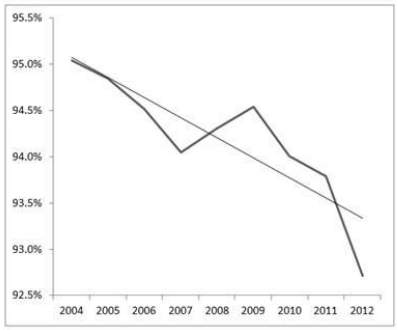

Figure 2 – Incidence of Partial Meniscectomy 2004-2012 by All Orthopaedic Surgeons. (p<0.00

FIGURES AND TABLES

Year of Surgery	Meniscal Repair	ACL Reconstruction with Meniscal Repair	Partial Meniscectomy	ACL Reconstruction	ACL Reconstruction with Partial Meniscectomy
2004	386 (5.0)	390 (14.9)	7403 (95.0)	1312 (50.3)	908 (34.8)
2005	385 (5.2)	293 (13.2)	7089 (94.8)	1135 (51.2)	789 (35.6)
2006	371 (5.5)	365 (15.5)	6395 (94.5)	1175 (49.7)	822 (34.8)
2007	437 (5.9)	402 (17.2)	6909 (94.1)	1058 (45.3)	874 (37.4)
2008	352 (5.7)	352 (17.5)	5834 (94.3)	872 (43.4)	783 (39.0)
2009	323 (5.5)	440 (18.7)	5596 (94.5)	1006 (42.8)	903 (38.4)
2010	345 (6.0)	480 (20.6)	5414 (94.0)	1010 (43.4)	835 (35.9)
2011	359 (6.2)	432 (18.7)	5418 (93.8)	996 (43.1)	881 (38.2)
2012	369 (7.3)	488 (22.3)	4693 (92.7)	841 (38.4)	862 (39.3)
TOTAL	3327	3642	54751	9405	7657

Table 1 – Overview of ABOS data from 2004-2012 All Orthopaedic Surgeons

Paper 67

United States Trends in Medial Ulnar Collateral Ligament Reconstruction: A retrospective Review of a Large Private-Payer Database from 2007 to 2011

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Objectives: Purpose: Overuse injuries to the elbow in the throwing athlete are common. Ulnar collateral ligament reconstruction (UCLR), commonly known as Tommy John surgery, is performed on both recreational and high-level athletes. There is no current literature regarding the incidence and demographic distribution of this surgical procedure in relation to age, location within the Unites States (U.S.), and gender. The purpose of this study is to determine the current demographic distribution of UCLR within the U.S.

Methods: Methods: A retrospective analysis of private payer database using the PearlDiver Supercomputer (Warsaw, IN) was performed to identify UCLR procedures performed between the years of 2007-2011. The Current Procedural Code (CPT) 24346 (reconstruction of the ulnar collateral ligament of the elbow with the use of a tendinous graft) was used. Statistical analysis was performed as appropriate using STATA (Version 12.1; Statacorp; College Station, TX, USA).

Results: Results: Between 2007-2011, 790 patients underwent UCLR. The overall average annual incidence was 2.16+/- 0.27 per 100,000 patients, but was 31.9 +/-3.9 for patients aged 15-19. The average annual growth was 5.72%. There were 695 males and 95 females. Fifteen to 19 year olds accounted for significantly more procedures than any other age group 56.8% ($p<0.001$), followed by 20 to 24 year olds 23.4%. The incidence of UCLR in the 15-19 year old group increased at an average rate of 6% per year (incidence rate ratio = 1.06, $p=0.025$). The south region performed significantly more UCLR than any other region $p<0.001$. The number of procedures significantly increased over time ($p=0.039$).

Conclusion: Conclusion: UCLR was performed significantly more in patients aged 15-19 than any other age group. The average annual incidence of UCLR per 100,000 people for patients aged 15-19 is 31.9. The number of UCLR is increasing over time. Further work should address risk-reduction efforts in this at-risk population.

Paper 68

Extremity Fractures Associated With ATVs and Dirt Bikes: A 6 Year National Epidemiological Study

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Objectives: All-terrain vehicle (ATV) and dirt bike use is increasing in the US and is associated with risk of traumatic injury. Extremity fractures are common injures associated with these vehicles. The purpose of this study is to compare and contrast the patterns extremity fractures associated with ATVs and dirt bikes. Our hypothesis is that these different vehicles will result in similar rates of high impact injuries, but differences in vehicle stability will result in greater proportions of upper extremity fractures associated with ATV use.

Methods: The National Electronic Injury Surveillance System (NEISS) was used to acquire data for extremity fractures related to ATV (3-wheels, 4-wheels, and number of wheels undefined) and dirt bike use from 2007-2012. Locations were coded as shoulder, upper arm, elbow, lower arm, wrist, hand, upper leg, knee, lower leg, ankle, foot, and toe. The data were stratified according to age and gender for each year. Incidence rates were calculated on a per vehicle basis using previous estimates of the number of ATVs and dirt bikes in the country.

Results: The database yielded an estimate of 229,362.52 extremity fractures from 2007-2012. An estimated total of 130,319.20 fractures were associated with ATVs, while 99,043.37 were associated with dirt bikes. The incidence rates of extremity fractures associated with ATV and dirt bike use were 3.87 and 6.85 per 1000 vehicle-years. Most fractures were in patients 10-19 years of age, after which the number of fractures decreased with age. The largest proportion of all fractures occurred in the shoulder (27.19%), followed by the wrist and lower leg (13.77% and 12.36%, respectively). This distribution of fractures was consistent among ATV use for all age groups except in the 0-9 year olds, where the lower arm and wrist were the most commonly fractured locations. Fracture distribution associated with dirt bike use also followed this general pattern, with the exception of 0-9 and 10-19 year olds having increased proportions of lower arm fractures. When comparing the genders, males had much larger proportions of fractures than females at all locations, except for the upper arm. When comparing the specific injury locations for different vehicle types, there were no differences in the distribution of the location of fractures among 4-wheeled or unspecified ATVs. However, 3-wheeled ATVs and dirt bikes had much larger proportion of lower leg, foot and ankle fractures compared to the other vehicle types.

Conclusion: Extremity fractures are among the most common type of injury resulting from ATV and dirt bike use. Our results demonstrated a pattern of injury where the shoulder and lower arm were the most commonly injured locations. This pattern was inconsistent among females, the very young, and 3 wheeled ATVs and dirt bikes. These differences could be due to both rider related factors and vehicle design factors. Knowing commonly fractured locations, the use of additional protective equipment specific to these injuries may be beneficial. Additionally, participants should be cautioned of the

increased risk of fractures associated with dirt bike use, as well as the unusual pattern of injuries of 3-wheeled ATVs implying instability of these vehicles.

Paper 69

Effect on Patient-Reported Outcome of Debridement or Microfracture of Concomitant Full-Thickness Cartilage Lesions in Anterior Cruciate Ligament-Reconstructed Knees
A Nationwide Cohort Study from Norway and Sweden of 357 Patients with 2-Year Follow-up

Authors: Jan Harald Røtterud, MD[1], Einar Sivertsen, MD,PhD[2], Magnus L. Forssblad, MD,PhD[3], Lars Engebretsen, MD, PhD[4], Asbjorn Aroen, MD, PhD[1]
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Objectives: To evaluate the effect of debridement or microfracture compared with no treatment of concomitant full-thickness (International Cartilage Repair Society [ICRS] grades 3-4) cartilage lesions on patient-reported outcome after ACL reconstruction in a large population-based cohort study.

Methods: 644 patients with a primary unilateral ACL reconstruction and a concomitant full-thickness cartilage lesion treated simultaneously by debridement (n=78) or microfracture (n=88), or receiving no treatment (n=191) of the cartilage lesion, registered in the Norwegian and the Swedish National Knee Ligament Registry during 2005-2008 were included. Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to measure patient-reported outcome. At a mean follow-up of 2.1 years (SD, 0.2) after surgery, 357 (55%) patients completed the KOOS. Linear regression analyses were used to evaluate the effect of debridement or microfracture on KOOS. The multiple regression analyses were adjusted for gender, age, previous knee surgery, time from injury to surgery, concomitant ligament injury, concomitant meniscal lesion(s), type of ACL graft, area of cartilage lesion, ICRS grade of cartilage lesion, location of cartilage lesion and preoperative KOOS scores.

Results: No significant effects of debridement were detected in the unadjusted or adjusted regression analyses on any of the KOOS subscales at 2-year follow-up. Microfracture treatment of the cartilage lesions had significant negative effects at 2 year follow-up on the KOOS subscales Sport/Recreation (regression coefficient [β] = -8.9; 95% CI, -15.1 to -1.5) and Knee-Related Quality of Life (QoL) (β = -8.1; 95% CI, -14.1 to -2.1) in the unadjusted analyses. When adjusting for confounders, microfracture had significant negative effects on the same KOOS subscales, Sport/Recreation (β = -9.1; 95% CI, -16.9 to -1.2), and QoL (β = -7.3; 95% CI, -13.7 to -0.9). For the remaining KOOS subscales Pain, Symptoms and Activity of Daily Living (ADL) there were no significant unadjusted or adjusted effects of microfracture.

Conclusion: Microfracture of concomitant full-thickness cartilage lesions showed adverse effects on patient-reported outcome at 2-year follow-up after ACL reconstruction. Debridement of concomitant full-thickness cartilage lesions showed neither positive nor negative effects on patient-reported outcome at 2-year follow-up after ACL reconstruction.

Paper 70

Excellence Award: Neuromuscular Performance Varies with Baseline Neurocognition: Implications for Anterior Cruciate Ligament Injury Risk and Prevention

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Background: Neurocognitive performance may be a risk factor for anterior cruciate ligament injury, and may influence risk via changes in neuromuscular performance; however, there are no existing data the relationship between neurocognition and neuromuscular performance during complex athletic tasks. Hypothesis: Athletes with low baseline neurocognitive performance would demonstrate worse neuromuscular performance during the completion of an unanticipated jump landing task compared to athletes with high baseline neurocognitive performance.
Study Design: Controlled laboratory study.

Methods: 3-dimensional kinematic and kinetic data of the dominant limb were collected for 37 recreational athletes while performing an unanticipated jump landing task. Subjects were screened using a computer-based neurocognitive test into high (HP) and low (LP) performing groups (HP=20, LP=17). The task consisted of a forward jump onto a force plate with an immediate jump to a second target that was assigned 250msec prior to landing on the force plate. Kinematic and kinetic data were obtained during the first jump landing.

Results: The LP group (Mean±SD of LP vs HP) demonstrated significantly altered neuromuscular performance during the landing phase while completing the jump landing task, including significantly increased peak vertical ground reaction force (1.81±0.53BW vs 1.38±0.37BW, $p<0.01$), peak anterior tibial shear force (0.91±0.17BW vs 0.72±0.22BW, $p<0.01$), knee abduction moment (0.47±0.56BW*BH vs 0.03±0.64BW*BH, $p=0.03$), and knee abduction angle (6.1±4.7o vs 1.3±5.6o, $p=0.03$), and well as decreased trunk flexion angle (9.6±9.6o vs 16.4±11.2o, $p<0.01$).

Conclusion: Athletes with lower levels of baseline neurocognition possess worse neuromuscular performance during a challenging jump landing task. Clinical Relevance: Neurocognitive testing and neuromuscular assessment during dual-attention conditions may improve anterior cruciate ligament injury risk screening, while incorporating neurocognitive challenges into neuromuscular-based training programs may improve injury prevention and rehabilitation.

Paper 71

Predictors of Orthopaedic Surgery in NCAA Athletes

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Objectives: Orthopaedic injury and surgery is relatively common in National Collegiate Athletic Association (NCAA) athletes and can have devastating career consequences. However, there is a paucity of data regarding predictors of orthopaedic surgery in collegiate athletes. The purpose of this study was to analyze player-related predictors of orthopaedic surgery, including that of the shoulder, hip, and knee, in NCAA athletes.

Methods: All NCAA Division I collegiate athletes at a single institution who began participation from the 2003-2004 through 2008-2009 seasons were retrospectively identified. Player-related factors, including gender, sport, and any pre-college upper or lower extremity orthopaedic surgery, were elicited through pre-participation evaluations (PPEs). Athletes who underwent an orthopaedic surgery in college were identified through the Sports Injury Monitoring System and medical records. All patient-related independent variables were included in a multiple Cox regression model. Exposure time was calculated from the date of PPE to the date of surgery (event) or to the end of the collegiate athletic career (censored). Hazard ratios (HRs) with 95% confidence intervals (CIs) were calculated. Significance was set at $P < 0.05$.

Results: In total, 1,142 athletes in 12 sports (baseball/softball, basketball, football, golf, gymnastics, rowing, swimming & diving, soccer, tennis, track & field/cross country, volleyball, water polo) were identified. There were 262 documented orthopaedic surgeries, including those involving the shoulder (n = 34), hip (n = 25), and knee (n = 72), in 182 athletes. Using the multiple Cox regression model, pre-college lower extremity surgery was an independent predictor of orthopaedic ($P = 0.004$, HR = 1.88) and knee ($P < 0.001$, HR = 3.91) surgery, and type of sport was an independent predictor of orthopaedic ($P < 0.001$), shoulder ($P = 0.002$), and knee surgery ($P < 0.001$) (Table 1). Participation in gymnastics, basketball, and volleyball were the strongest predictors of orthopaedic surgery. Similarly, participation in volleyball, gymnastics, and baseball/softball were the strongest predictors of shoulder surgery, and participation in basketball, football, and volleyball were the strongest predictors of knee surgery. Lastly, athletes with a history of a pre-college orthopaedic surgery were more susceptible to another surgery in the same extremity during college ($P = 0.046$, HR = 2.18). Gender was not a significant predictor of any surgery. No independent predictors of hip surgery were identified.

Conclusion: NCAA athletes who underwent a pre-college lower extremity surgery were more likely to undergo orthopaedic and knee surgery during their collegiate careers. Those in overhead sports (e.g., volleyball, baseball/softball) were more likely to undergo shoulder surgery, and those in cutting and jumping sports (e.g., basketball, football) were more likely to undergo knee surgery. Furthermore, athletes with a history of a pre-college orthopaedic surgery were more likely to undergo another surgery in the same extremity during college, suggesting inadequate rehabilitation or less than full return of function after surgery. The time lost from athletic participation due to an orthopaedic surgery and its

potential career impact underscores the need for injury prevention and improved surgical outcomes in the amateur athlete.

Table 1. Multiple Cox Regression Analysis of Player-Related Predictors of Orthopaedic Surgery in NCAA Athletes

Variable	HR	95% CI	P value
Gender (males/females)	0.95	0.65-1.40	0.807
Pre-college upper extremity surgery[1]	1.15	0.65-1.88	0.608
Pre-college lower extremity surgery[2]	1.88	1.24-2.78	0.004
Sport			
Baseball / Softball	3.82	0.74-69.89	0.123
Basketball	14.84	3.05-267.38	<0.001
Football	10.33	2.23-183.56	0.001
Golf[3]	1.00		
Gymnastics	15.38	3.03-280.58	<0.001
Rowing	3.37	0.59-63.45	0.184
Swimming & Diving	1.90	0.24-38.63	0.560
Soccer	8.29	1.75-148.30	0.003
Tennis	3.21	0.47-62.91	0.239
Track & Field / Cross Country	3.58	0.75-64.25	0.125
Volleyball	10.69	2.23-191.75	0.001
Water Polo	3.79	0.72-69.69	0.130
Surgery on previously operated extremity[4]	2.18	1.01-4.79	0.046

HR, hazard ratio; CI, confidence interval.

[1]Reference group = no pre-college upper extremity surgery

[2]Reference group = no pre-college lower extremity surgery

[3]Reference group in analysis

[4]Reference group = surgery on other extremities

Paper 72

Physician And Non-physician Inter- And Intra-observer Reliability Of A Field-based Drop Vertical Jump Screening Test For ACL Injury Risk

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Objectives: There is an epidemic of ACL injuries in pediatric and adolescent athletes. Poor neuromuscular control is an easily modifiable risk factor for ACL injury, and can be screened for by observing dynamic knee valgus on landing in a drop-vertical jump test. This study aims to validate a simple, clinically useful population-based screening test to identify at-risk athletes prior to participation in organized sports. We evaluated the inter- and intra-rater reliability of risk assessment by various observer groups, including physicians and non-physicians, commonly involved in the care of youth athletes.

Methods: The screening involves observers watching a simple drop vertical jump in sports field conditions, without the use of additional analytic equipment. 15 athletes age 9-17 were filmed performing a drop vertical jump test. These videos were viewed by 242 observers including orthopaedic surgeons, residents/fellows, coaches, athletic trainers (ATC), and physical therapists (PT), with the observer asked to subjectively estimate the risk level of each jumper. Analytical objective injury risk was calculated using normalized knee separation distance (measured using Dartfish, Alpharetta, GA), based on previously published studies. Risk assessments by observers were compared to each other to determine inter-rater reliability and to the objectively calculated risk level to determine sensitivity and specificity. 71 observers repeated the test at a minimum of 6 weeks later to determine intra-rater reliability.

Results: Overall, between groups (ATCs, attending physicians, coaches, residents/fellows, and PTs), the inter-rater reliability was high, $\kappa = 0.92$ (95% CI 0.829-0.969, $p<0.05$), indicating that no one group gave better (or worse) answers, including comparisons between physicians and non-physicians. With a screening cutoff of only jumpers identified by observers as “high risk”, the sensitivity was 63.06% and specificity 82.81%. Reducing the screening cutoff to also include jumpers identified as “medium risk” increased sensitivity to 95.04% and decreased the specificity to 46.07%. Intra-rater reliability was substantial, $\kappa = 0.55$ (95% CI 0.49-0.61, $p<0.05$), indicating that individual observers made reproducible risk assessments.

Conclusion: This study supports the use of a simple, field-based observational drop vertical jump screening test to identify athletes at higher risk for ACL injury. Among those who could potentially be involved in this screening process, our study shows good inter- and intra-rater reliability and high sensitivity, and can be performed without significant training by coaches and athletic trainers in addition to healthcare professionals. Identification of these high-risk athletes may play a role in enrollment in

appropriate preventative neuromuscular training programs, which have been shown to decrease the incidence of ACL injuries in this population.