Paper 101

Title:
Effect of Concomitant Cartilage Lesions on Patient-Reported Outcome After ACL-Reconstruction -A Nationwide Cohort Study from Norway and Sweden of 8470 Patients With 5-Year Follow-Up

Authors:
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Objectives: To evaluate (1) the effect of concomitant partial-thickness (International Cartilage Repair Society [ICRS] grades 1-2) and full-thickness (ICRS grades 3-4) cartilage lesions on patient-reported outcome 5 years after Anterior Cruciate Ligament Reconstruction (ACLR), and (2) the effect of debridement or microfracture (MF) compared with no treatment of concomitant full-thickness cartilage lesions on patient-reported outcome 5 years after ACLR.

Methods: All patients that underwent unilateral primary ACLR registered in the Norwegian and Swedish National Knee Ligament Registries from 2005 through 2008 (n = 15,783) were included the study. At the 5-year follow-up, 8470 (54%) patients completed The Knee Injury and Osteoarthritis Outcome Score (KOOS). A subgroup of all patients with concomitant full-thickness cartilage lesions (n = 644), treated with debridement (n = 129), or MF (n = 164), or no surgical treatment (n = 351) at the time of ACLR, was included in the treatment component of the study. At the 5-year follow-up, 368 (57%) patients completed the KOOS. Linear regression models were used to estimate the effect of concomitant focal cartilage lesions on the patient-reported outcome (KOOS) 5 years after ACLR, and to estimate the effect of surgical debridement or MF of concomitant full-thickness cartilage lesions, on patient-reported outcome 5 years after ACLR.

Results: Of the 8470 patients available for follow-up at 5 years, 2248 (27%) had 1 or more concomitant cartilage lesions at the time of ACLR, comprised of 1685 (20%) patients with 1 or more partial-thickness cartilage lesions and 563 (7%) patients with 1 or more full-thickness cartilage lesions. Of the 368 patients available for the 5-year follow-up in the treatment component of the study, 203 (55%) patients received no surgical treatment to their full-thickness cartilage lesion at the time of ACLR, 70 (19%) were treated with debridement and 95 (26%) with MF. In the adjusted analyses, partial-thickness cartilage lesions showed significant associations with inferior KOOS scores at follow-up in all subscales. Full-thickness cartilage lesions were significantly associated with inferior KOOS scores in all subscales, both in the unadjusted and the adjusted analyses. With no treatment of the concomitant cartilage lesion as the reference, no significant effects of debridement or MF were detected in the unadjusted or adjusted regression analyses in any of the KOOS subscales at the 5-year follow-up. However, there was a trend in both the unadjusted and adjusted analyses towards negative effects of MF in the KOOS subscales Sport/Rec and QoL with regression coefficient (β) of -5; 95% CI, -12.3-2.2 and -5.7; 95% CI, -12.5-1.1, respectively.

Conclusion: ACL-injured patients with concomitant full-thickness cartilage lesions reported worse outcomes and less improvement than those without cartilage lesions 5 years after ACLR. Compared to leaving concomitant full-thickness cartilage lesions untreated at the time of ACLR, debridement and MF showed no effect on patient-reported outcome at 5-year follow-up.

Paper 102

Title:
Return to Sport and Re-Operation Rates in Athletes Under the Age of 20 Following Primary Anterior Cruciate Ligament Reconstruction: Risk Profile Comparing Three Patient Groups Predicated Upon Skeletal Age.

Authors:
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Objectives: ACL injury in the skeletally immature athlete has become an increasingly significant clinical problem in recent years. The high-risk population of athletes less than 20 years of age has the lowest return to sport (RTS) rates and highest second surgery rates following ACL reconstruction (ACLR). The purpose of this prospective study is to evaluate the two-year clinical outcomes of three groups of primary ACLR in pediatric and adolescent athletes under the age of 20 based on skeletal age, school grade distribution and ACLR technique with a focus on RTS and incidence of second surgery. We hypothesize that the youngest (Group 1) and oldest (Group 3) cohorts will have lower revision ACL rates and higher RTS rates compared to the middle (Group 2) cohort of athletes.

Methods: 306 patients less than 20 years of age underwent primary ACLR in the senior authors' practice. Group 1 had 3-6 years of growth remaining and was comprised of lower and middle school athletes through 7th grade. Group 1 athletes received an all-epiphyseal (AE) hamstring autograft ACLR. Group 2 had 2-3 years of growth remaining and included predominantly 8th and 9th grade athletes. Group 2 was treated with either a partial transphyseal (PTP) or complete transphyseal (CT) hamstring autograft ACLR. Group 3 included skeletally mature high school & collegiate athletes treated with a CT ACLR using a bone-tendon-bone (BTB) autograft. Preoperative demographics, sport, mechanism of injury, intraoperative findings, RTS and second surgery data were collected. Athletes were followed for a minimum of 24 months with serial clinic visits.

Results: The three cohorts included 47 athletes (15%) in Group 1 (mean age: 12.0 $\pm$ 1.5y), 64 athletes (21%) in Group 2 (mean age: 14.3 $\pm$ 1.3y), and 195 athletes (64%) in Group 3 (mean age: 16.2 $\pm$ 1.8y). The rate of revision ACL was higher in Group 2 at 20% (13/64 athletes) as compared to Group 1 at 6% (3/47 athletes) and Group 3 at 6% (11/195 athletes) (p= 0.001). Group 2 athletes had a significantly lower RTS at 86% as compared to Groups 1 and 3 at 100% and 94% respectively (p=0.009). Group 2 athletes also had a significantly lower RTS at the same level 75% as compared to Groups 1 and 3 at 96% and 82% respectively (p=0.017). Using multivariate logistic regression, Group 2 athletes were nearly 5 times more likely to have a Revision ACLR compared to Group 3 BTB athletes (OR: 4.92, 95% CI: 1.19 - 20.34, p=0.028). Females were nearly 3 times more likely to have a contralateral ACLR as compared to males (OR: 2.83, 95% CI: 1.09 - 7.34, p=0.033).

Conclusion: As we hypothesized, the rate of revision ACLR and overall incidence of second surgery was

higher and the RTS rate lower in Group 2 athletes compared to Groups 1 and 3 athletes. Group 2 athletes may be at higher risk because upon completion of their rehabilitation and RTS clearance process they are joining a cohort of competitive, now skeletally mature high school athletes who have not lost a year of athletic competition and development of sport-specific skills. Ultimately, the athlete's skeletal age determined the choice of surgical technique, but the grade levels noted above demarcated the three surgical cohorts with only a few outliers. We believe grade level is important as this will most often dictate the level of competition that the athlete in question is exposed to after recovery and return to sport. This age and school grade risk profile is useful to counsel athletes and parents preoperatively regarding the expectations of surgery with regard to RTS and the risk of second surgery.

Paper 103

Title:
Current Return to Sport Criteria after ACL Reconstruction Fail to Identify Increased Risk of Second ACL Injury in Young Athletes

Authors:
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Objectives: The incidence of 2nd anterior cruciate ligament (ACL) injury after ACL reconstruction (ACLR) and return to sport (RTS) ranges from 25%-33% in young, active populations; with the greatest risk in the first 12 months after RTS. Recent data indicate that failure to successfully meet traditional RTS criteria, inclusive of strength, functional hop testing and patient reported outcome scores, may identify athletes at increased risk of future injury after ACLR. However, these studies have focused on adult populations and it is unknown if similar RTS criteria apply to young, adolescent, pivoting/cutting athletes. The purpose of this study was to determine if meeting all current, standard RTS criteria would identify young athletes at risk for future ACL injury after primary ACLR and RTS. The tested hypothesis was the likelihood of 2nd ACL injury in the first 2 years after RTS would be lower in patients who met all RTS criteria prior to initiation of pivoting and cutting activity compared to patients who failed to meet all RTS criteria prior to RTS.

Methods: One hundred fifty-nine subjects (112 female, 47 male) with a mean age of 17.2±2.6 years old (range: 13-25 y.o.) underwent ACLR and were released to return to pivoting/cutting sport. These patients were enrolled in a prospective, observational cohort study, completed a RTS assessment and were then tracked for occurrence of 2nd ACL after ACLR for 24 months. The RTS assessment included 6 tests: isometric quadriceps strength, 4 functional hop tests and the International Knee Documentation Committee (IKDC) patient reported outcome survey. Limb symmetry index (LSI) was calculated for strength and hop test assessments [(involved/uninvolved) *100]. The IKDC was reported on a 0-100 scale with 100 representing a perfect score. Subjects were classified into groups that successfully passed all 6 RTS tests at a level of 90 and again at 95 compared to those that failed to meet all 6 criteria. Chi Square tests were used to determine if successfully passing all 6 RTS measures at various levels of symmetry resulted in a reduced risk of 2nd ACL injury in the first 24 months after RTS.

Results: Thirty-five (22.0%) patients suffered a 2nd ACL injury, with 26 occurring in the first 12 months after RTS. At the time of RTS, 42 patients (26%) achieved LSI values of 90 or greater on all testing as well as an IKDC value of 90 or greater. The remaining 117 subjects (74%) scored below 90 on at least 1 of the 6 assessments. At this level, there was no difference in 2nd ACL injury prevalence between patients who passed all RTS criteria (12/42; 28.6%) and those who failed at least 1 criteria (23/117; 19.7%) (p=0.23). When the passing criteria was elevated to 95 on all RTS testing, only 15 subjects (9%) successfully passed all 6 tests. There was no significant difference in 2nd ACL injury prevalence between patients who passed all RTS criteria (5/15; 33%) and those who failed at least 1 test (30/144; 20.8%) (p=0.32). Sub-group

analysis which evaluated the group by graft type, also indicated no significant differences between groups ($p>0.05$).

Conclusion: Current criteria to evaluate readiness to return young athletes to pivoting and cutting sports, using quadriceps strength symmetry, functional hop performance symmetry and patient reported outcomes, may not identify young, active patients at high risk for 2nd ACL injury. Future work must identify more appropriate criteria to assess readiness to RTS in the young, athletic population and incorporate these findings into practice.

Paper 104

Title:
Anterior Cruciate Ligament Reconstruction in Young Females: Patellar versus Hamstring Tendon Autografts

Authors:
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Objectives: Female athletes are two to eight times more likely to suffer a primary ACL tear than males. Although ACL reconstruction can successfully return many athletes to their pre-injury sports, re-injury to the ipsilateral or contralateral knee can occur in over 20% of young athletes. Both female sex and younger age have been shown to be risk factors for graft failure. The optimal graft choice for this high-risk population of young female athletes remains unknown and poorly studied. We compared the clinical outcomes in young female patients who underwent ACL reconstruction at our institution using bone-patellar tendon-bone (BTB) and quadrupled hamstring (HS) autografts. .

Methods: Female patients aged 15-25 who underwent primary ACL reconstruction at our institution between January 2012 and May 2015 using either BTB or HS autograft were included in our review. Patients were further sub-divided into 2 age groups, 15-20 and 20-25. Patients with a prior history of ACL injury to either knee, or those with multiligament injury were excluded. Graft choice and fixation method were documented from a review of operative records. Medical records were reviewed to document the occurrence of chondral, meniscal or ligamentous injury to the ipsilateral or contralateral knee in the first two years following ACL reconstruction. Comparisons were made using the chi-square test with statistical significance set at $p < 0.05$.

Results: A total of 256 females were included in our review with 175 in the BTB group and 81 in the HS group. There was no difference between the groups with regards to average age or time to follow-up. The majority of patients in both groups, 80% of the BTB group and 77.8% of the HS group, were between the ages of 15-20. Interference screw fixation was used in all BTB cases and 63.0% of HS cases. In the remainder of HS cases, femoral suspension and tibial screw (27.2%), and femoral cross-pins and tibial screw (9.9%) were used. In our series, 22.2% of hamstring grafts were augmented with allograft due to inadequate size. Overall, graft re-tear occurred in 6.9% of BTB patients and 12.3% of HS patients [p=0.16]. Contralateral ACL tear occurred in 7.4% of BTB patients and 6.2% of HS patients [p=0.72]. Sub-group analysis showed that 75% of BTB and 100% of HS graft re-tears occurred in females aged 15-20. Within this group, there was a significantly lower rate of graft re-tears in the BTB group (6.4%) when compared to the HS group (15.9%) [p=0.04]. Allograft augmentation was used in four of the ten HS grafts that re-tore. The risk of failure with hamstring augmentation with allograft (4/18, 22.2%) was higher than that of hamstring autograft alone (6/63, 9.5%), but this difference was not significant [p=0.18].

Conclusion: The results of our study indicate that BTB autograft led to fewer graft re-tears compared to HS autograft following ACL reconstruction in female patients aged 15-20. However, this difference was not observed in females aged 20-25. Thus, further investigation regarding optimal graft choice is warranted in this age group.

Paper 105

Title:
Double Bundle Posterior Cruciate Ligament Reconstruction in 100 Patients at a Mean 3 Years Follow up: Outcomes were Comparable to an Anterior Cruciate Ligament Reconstructions

Authors:
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Objectives: 1) To report on the outcomes after double-bundle PCL reconstructions in isolated versus combined injuries and acute versus chronic PCL tears and 2) to compare the outcomes of isolated double-bundle PCL reconstruction (DB PCLR) to isolated ACL reconstruction. (ACLR)

Methods: All patients who underwent a primary arthroscopic assisted DB PCLR for grade-III isolated or combined PCL injuries between May 2010 and March 2015 were reviewed. Patient reported outcome scores (Lysholm, Tegner, Western Ontario and McMaster Universities Arthritis Index (WOMAC), 12 item Short Form Health Survey (SF-12) Physical Component Summary (PCS) and patient satisfaction with outcome) and objective posterior stress radiographs were collected preoperatively and at a minimum of two years postoperatively. Cohort subanalyses comparing isolated versus combined, and acute versus chronic PCL reconstructions were also performed. Patients who underwent isolated ACLR over the same inclusion period were selected as a comparison group.

Table 1: Patient demographics and preoperative outcome scores demonstrating that the initial status of both cohorts was comparable. Data presented as counts, mean • SD or median [1st quartile, 3rd quartile], unless otherwise noted. N/A=Not applicable; FET= Fisher's exact tests; (χ2)= chi-squared tests; MWU=Mann-Whitney U-tests

Variable	PCL Reconstruction Cohort (n=100)	ACL Reconstruction Cohort (n=141)	P-Value
Patients	100	141	N/A
Age	Mean 31.7 (range, 14-66)	Mean 35.2 (range, 14-81)	0.042* (MWU)
Gender	Male: 77 Female: 23	Male: 63 Female: 78	<0.001* (FET)
Follow-Up Interval (years)	Mean 2.9 (range, 2-6)	Mean 3.1 (range, 2-7)	0.289 (MWU)
Chronicity	Acute: 52 Chronic: 48	Acute: 93 Chronic: 48	0.033 (FET)
Meniscus Tear Distribution	None: 54 Medial Meniscus: 23 Lateral Meniscus: 16	None: 66 Medial Meniscus: 39 Lateral Meniscus: 21	0.590 (χ^2)

	Medial & Lateral Meniscus: 7	Medial & Lateral: Meniscus: 15	
Outerbridge Grade IV Chondral lesions (Grade, Location)	Full thickness lesions: 11	None	N/A
Preoperative Outcome Scores	**PCL Reconstruction Cohort (n=100)**	**ACL Reconstruction Cohort (n=141)**	**P-Value**
Tegner Activity Scale	2 [1, 3]	2 [1, 5]	0.135 (MWU)
Lysholm Score	49.6 ± 25.1	51.0 ± 23.2	0.691 (t-test)
Western Ontario and McMaster Universities Arthritis Index Total	38.7 ± 27.9	35.2 ± 23.1	0.333 (t-test)
Short Form-12 Physical Health Composite Score	37.6 ± 10.9	40.3 ± 9.7	0.015* (t-test)

Results: One hundred patients that underwent DB PCLR were included in this study. There were 31 isolated PCL injuries and 69 combined PCL injuries and the mean follow-up was 2.9 years (range 2-6 years). The median Tegner activity score improved from 2 to 5, Lysholm from 48 to 86, WOMAC from 35.5 to 5, and SF-12 PCS from 34 to 54.8 (all p values <0.001). The mean side-to-side difference (SSD) in posterior tibial translation on kneeling stress radiographs improved from 11.0 mm preoperatively to 1.6 mm postoperatively (p<0.001). There were no significant differences in postoperative functional scores between isolated PCL reconstructions and combined PCL reconstructions (all p values >0.229). The mean SSD in postoperative posterior tibial translation on stress radiographs was 1.2 ± 1.1 mm for isolated PCL tears and 1.7 ± 2.2 mm for combined PCL tears. The improvement in posterior tibial translation from preoperative to postoperative was significant for both the isolated and combined PCL injury groups (p<0.001). Only the Tegner score (p<0.001) and patient satisfaction (p=0.011) were significantly different postoperatively between acute and chronic reconstructions, both favoring acutely treated PCL injuries. The mean SSD in posterior tibial translation on stress radiographs improved from 11.6 ± 3.1 mm preoperatively to 1.9 ± 2.5 mm postoperatively (p<0.001) for acute PCL tears, and 10.3 ± 3.7 mm to 1.2 ± 1.0 mm (p<0.001) for chronic PCL tears. There were no significant differences in postoperative outcome scores between patients that underwent an isolated ACLR or isolated DB PCLR [all p values >0.064].

Conclusion: Significantly improved functional and objective outcomes were observed after anatomic-based DB PCLR at a mean 3 years follow-up, regardless of concomitant ligamentous pathology or timing to surgery. Posterior tibial translation was restored to near normal after DB PCLR. Additionally, contrary to previous reports, similar results were achieved compared to a control isolated ACLR cohort.

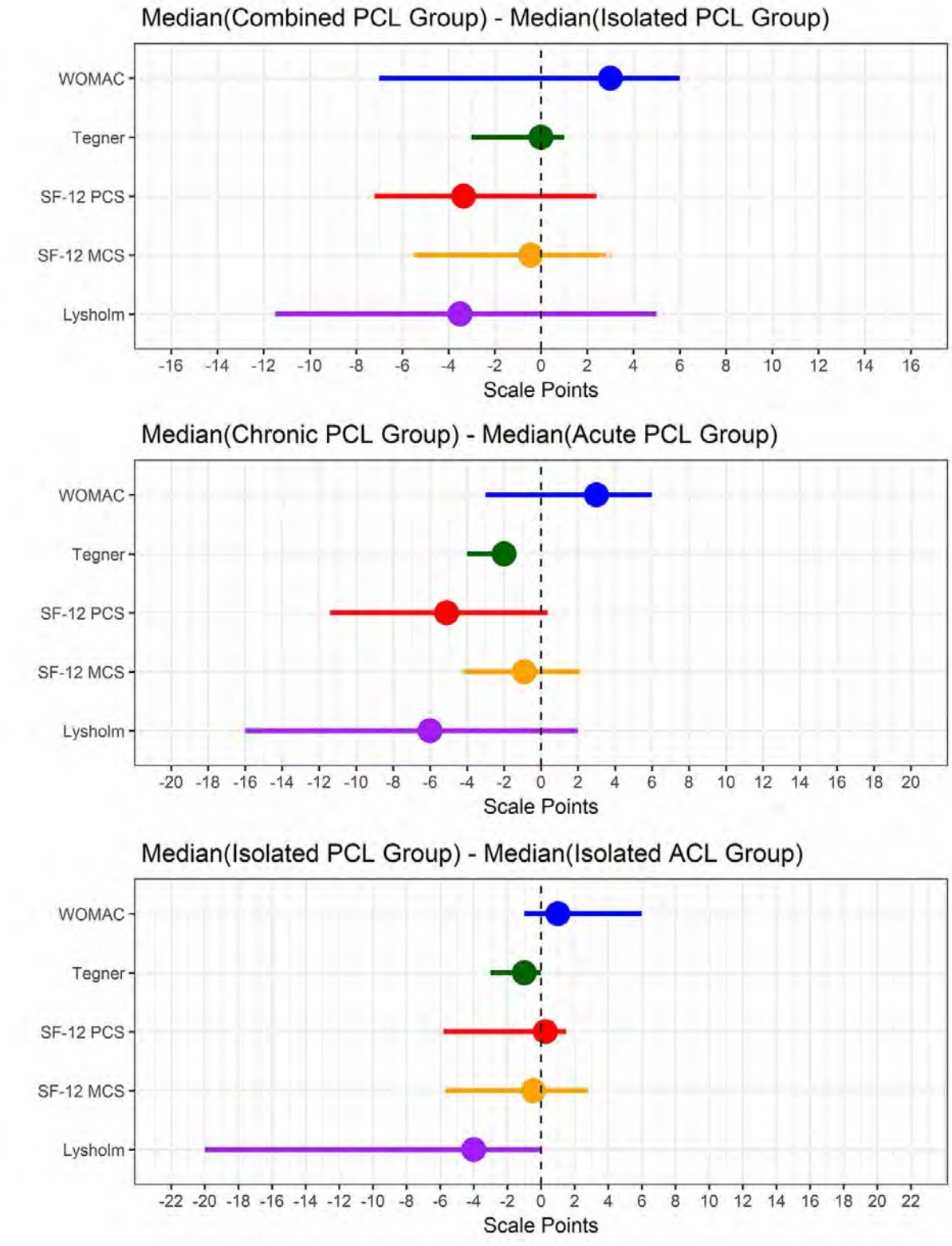

Fig 1. Difference in medians for functional outcome scales. Horizontal lines indicate 95% bootstrap confidence intervals.

Paper 106

Title:
Arthroscopic Primary Repair of Proximal Anterior Cruciate Ligament Tears: With or Without Additional Suture Augmentation?

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Objectives: Over the last years, arthroscopic primary repair of anterior cruciate ligament (ACL) tears has shown excellent results owing to appropriate patient selection (only repairing proximal ACL tears and good tissue quality), minimal invasive surgery (arthroscopy) and focus on early range of motion. Some surgeons have repaired proximal ACL tears without suture augmentation while others have used internal suture augmentation to reinforce and thus protect the repaired ligament during range of motion. No studies have yet compared the two surgical techniques. The objective of this study was to compare failure rates, reoperation rates and patient-reported outcomes of arthroscopic primary repair with versus without suture augmentation.

Methods: A retrospective search for all patients treated with suture anchor arthroscopic primary ACL repair between April 2008 and June 2016 was performed. All patients with isolated proximal ACL tears (type I) were included. Since the development of internal suture augmentation, this reinforcement was added to the repaired ACLs. Minimum follow-up length was 1.0 years.

Results: A total of 56 patients were included (mean age 33 years (range: 14 - 57), 59% male) of which 28 (50%) patients received additional suture augmentation. Mean follow-up was 2.3 years (range: 1.0-9.2). Six of all patients had reruptured their repaired ACL (10.7%), of which four underwent uncomplicated ACL reconstruction and two were treated conservatively. Four reruptures were initially treated with primary repair only (4/28, 14.3%) and two patients with additional suture augmentation (2/28, 7.1%; p = 0.431). During follow-up, three patients underwent reoperation (5.4%; two for medial meniscus tear (one in each group) and one for tibial suture anchor removal of the suture augmentation). Patient-reported outcomes have so far been collected in 20 patients without reruptures (currently collecting), with mean Lysholm score of 96, modified Cincinnati 94, SANE 93, pre-injury Tegner 6.7, postoperative Tegner 6.3 and subjective IKDC 91. Objective IKDC was A in 90%, B in 5%, C in 5%.

Conclusion: In this study, the total failure rate of arthroscopic primary ACL repair was 10.7% and was lower with additional suture augmentation (7.1%) than primary repair alone (14.3%). Patients with failed ACL repair underwent uncomplicated primary ACL reconstruction. We recommend adding suture augmentation in high-risk patients (i.e. adolescents, ones with hyperlaxity, high contact sports), to protect the repaired ligament, especially during early range of motion. These data support treating type I proximal ACL tears with arthroscopic primary repair.

Paper 107

Title:
Which Factors Increase the Risk of Re-Operation after Meniscus Surgery in the Skeletally Immature?

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Objectives: The purpose of this study is to determine which factors heighten the risk for subsequent operations in skeletally immature patients undergoing meniscus surgery.

Methods: A retrospective institutional database of 1,063 meniscus surgeries performed between 2000 and 2015 was reviewed. All procedures were performed in skeletally immature patients. Demographic and intra-operative information was recorded, as were concurrent injuries or operations and subsequent surgeries. Univariate analysis consisted of chi-square and independent-samples t-tests. Multivariate logistic regression was then performed to control for confounding factors.

Results: The mean age at initial surgery was 13.4 years (standard deviation, SD, 2.2 years) and the average follow-up duration was 47 months (SD 54 months). Overall, 314 patients (29.5%) required repeat surgical intervention. 36% of all females required subsequent surgery compared to 26% of males ($p<0.01$). Discoid menisci underwent repeat operation more frequently than non-discoid menisci (35% vs. 27%, $p=0.01$). After accounting for confounders in a multivariate model, females had 2.2 times the odds of repeat surgery than males (95% CI 1.4-3.3, $p<0.01$) and each year of increasing age resulted in 1.3 times higher odds (95% CI 1.1-1.4, $p<0.01$). The odds of subsequent surgeries were 4.2 times higher in those with flap tears (95% CI 1.8-9.7, $p<0.01$) and 2.9 times higher for discoid menisci (95% CI 1.4-6.0, $p<0.01$). Concomitant anterior cruciate ligament rupture or tibial spine fracture decreased the risk of needing additional surgeries in univariate analysis, but lost statistical significance in the multivariate model.

Conclusion: Even when accounting for other factors in a multivariate model, female sex, increasing age, flap tears, and discoid meniscus were risk factors for subsequent procedures after meniscus surgery in skeletally immature patients. The re-operation rate in this population may be higher than previously reported. This study describes, for the first time, risk factors for repeat operations in skeletally immature patients undergoing meniscus surgery. These results can be used to counsel and monitor patients accordingly.

Paper 109

Title:
Non-Weight Bearing versus Partial Controlled Early Weight Bearing after Reconstruction of the Fibular Collateral Ligament: A Randomized Control Trial

Authors:
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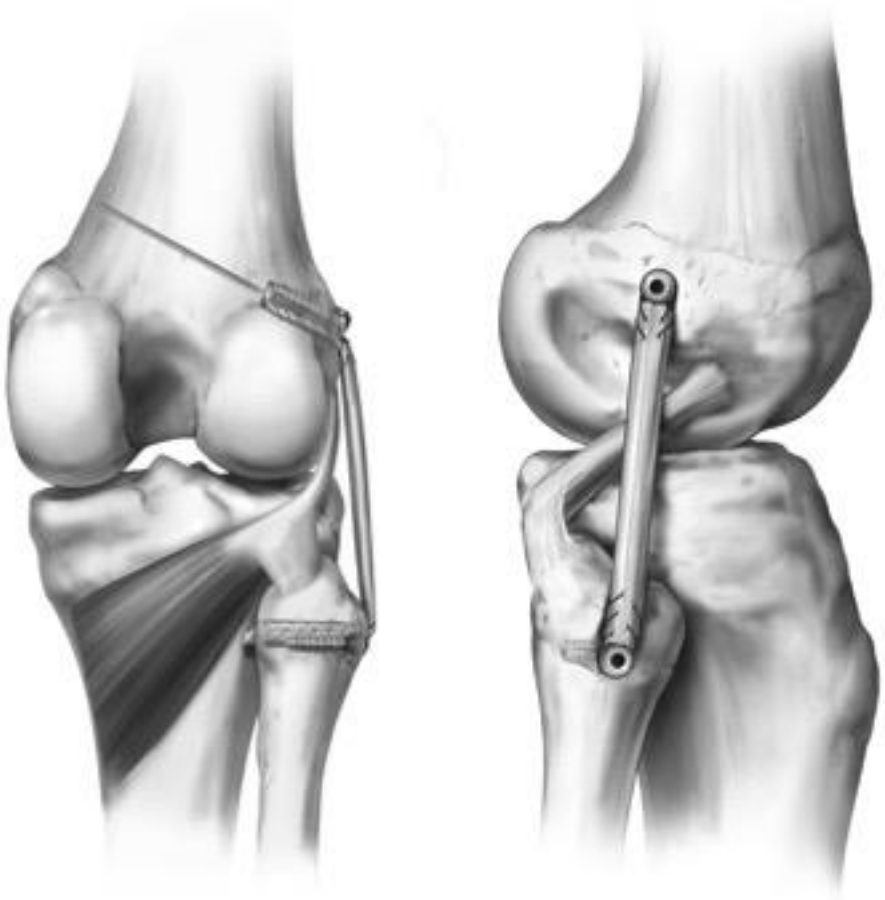
Objectives: To 1) determine if early protected weight bearing after an FCL reconstruction was safe based upon an objective difference in laxity on varus stress radiographs at six months postoperatively between patients who were non-weight bearing versus partial controlled weight bearing during the first six weeks of postoperative rehabilitation and 2) determine if there was a difference in pain, edema, and range-of-motion between these two groups at three different time points.

Methods: Patients were prospectively enrolled from January 2014 to April 2017. Patients were included in the study if they were undergoing an isolated FCL reconstruction or combined ACL and FCL reconstructions. Patients were randomly assigned to either a control group, which was non-weight bearing for 6 weeks, or a treatment group with partial controlled weight bearing at 40% body weight with crutches for 6 weeks. Patients were excluded if they were less than 18 years of age, pregnant, undergoing a revision FCL reconstruction, concurrent medial collateral and/or posterior cruciate ligament reconstruction, radial or root meniscal repairs, genu varus alignment in patients with chronic FCL tears, or had a body mass index ≥ 35 kg/m^2.

Results: Thirty-nine patients were enrolled in the study, with 6 month follow-up obtained in 36 patients (92%). Twenty-five patients (69.4%) had an acute injury (≤ 6 weeks) and 11 patients (30.6%) had a chronic injury (> 6 weeks). The mean time from injury to surgery was 2.3 ± 1.9 weeks and 41.5 ± 37.4 weeks for acute and chronic patients, respectively. There were no significant differences in patient age ($p = .157$) or BMI ($p = .534$) between the control and treatment groups. Postoperatively (0-6 months), there were no complications reported and no surgical re-interventions for ligamentous reconstruction failure or arthrofibrosis in either group. There was a significant difference between the preoperative side-to-side difference (SSD) (2.4 ± 1.0) and postoperative SSD (0.2 ± 1.0) for lateral compartment gapping on varus stress radiographs in all patients ($p < .001$). For the control group, the lateral compartment SSD on varus stress radiographs was reduced from 2.4 ± 1.1 to 0.1 ± 1.1 from preoperative to 6 months postoperative ($p < .001$). For the treatment group, the SSD on varus stress radiographs reduced from 2.3 ± 0.8 to 0.2 ± 0.8 from preoperative to 6 months postoperative respectively ($p < .001$). There were no significant differences between the preoperative SSD and postoperative SSD on varus stress radiographs between the control and treatment groups. All patients demonstrated significant improvements in subjective outcome scores (IKDC, WOMAC pain, WOMAC stiffness, WOMAC physical function, WOMAC total, Lysholm, and Tegner scores) between the preoperative and 6 months

postoperative conditions ($p < .001$). There were no significant differences for the outcome measures of pain, edema, and knee range of motion between control and treatment groups at any time points. **Conclusion:** There were no significant differences between patients who were non-weight bearing compared to early weight bearing at 6 months postoperatively regarding knee stability, pain, swelling, and range-of-motion. We recommend early partial weight bearing following an isolated FCL reconstruction or when combined with an ACL reconstruction because our study found it did not compromise the integrity of the FCL reconstruction graft.



Comparison of outcome measures between control (n=18) and treatment (n=18) groups.

Outcome Measure	**Control** *Day One*	**Treatment** *Day One*	**P Value**	**Control** *6 Weeks*	**Treatment** *6 Weeks*	**P Value**	**Control** *6 Months*	**Treatment** *6 Months*	**P Value**
Pain (0-10)	4.1 ± 2.0	2.7 ± 2.2	.061	0.6 ± 0.7	0.6 ± 1.0	.979	0.1 ± 0.3	0.2 ± 0.4	.684
Edema(Joint Line, cm)	4.2 ± 2.0	4.3 ± 1.6	.832	2.8 ± 1.1	2.4 ± 0.6	.061	0.5 ± 0.9	0.1 ± 0.4	.077
Edema(10cm Above	1.9 ± 1.8	2.1 ± 1.8	.804	1.3 ± 3.0	1.5 ± 1.2	.756	0.2 ± 1.2	0.5 ± 1.0	.425

Joint Line, cm)									
Knee Extension (degrees)	0.2 ± 0.5	0.1 ± 0.4	.888	-1.0 ± 0.5	-1.1 ± 0.4	.862	-1.5 ± 0.7	-1.5 ± 0.6	.988
Knee Flexion (degrees)	52.5 ± 13.1	54.9 ± 9.4	.600	118.5 ± 14.9	121.4 ± 13.0	.534	136.4 ± 6.8	135.1 ± 8.6	.627

Paper 111

Title:
Bacterial Biofilms Are Associated with Tunnel Widening In Failed ACL Reconstructions

Authors:
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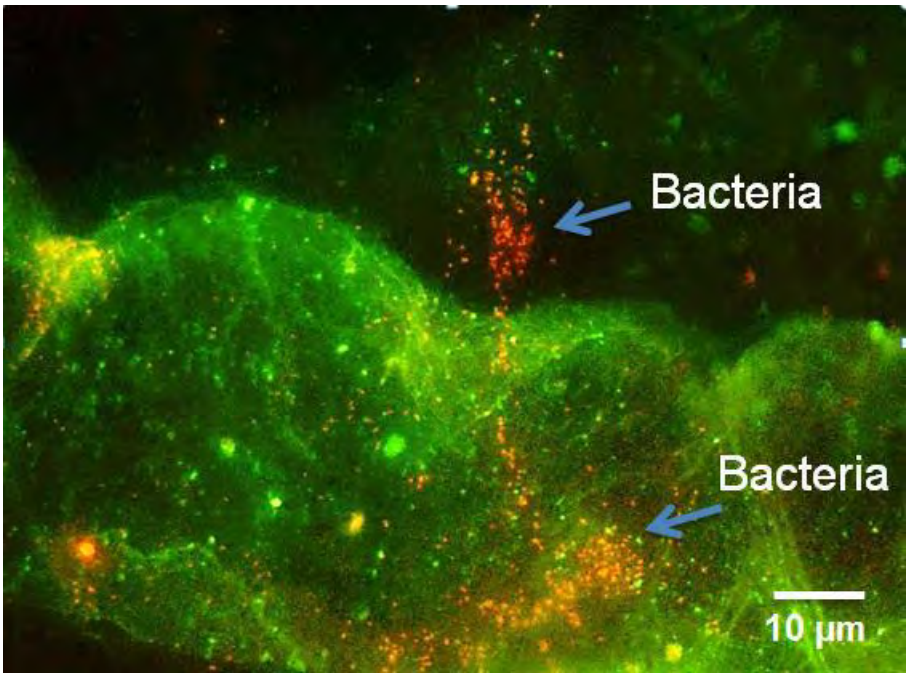
Objectives: Technical errors, traumatic re-injury, and biologic failure all play a potential role in failure after ACL reconstruction (ACLR). Recent work has demonstrated the frequent presence of biofilms on failed ACLR grafts. Tunnel widening is commonly observed upon presentation for revision ACLR but the relationship between biofilm presence and tunnel widening is unclear. The purpose of this study is to determine whether tunnel widening is associated with bacterial biofilms in failed ACL reconstructions.

Methods: 34 consecutive revision ACLR cases and 5 primary ACLR controls were included. Tissue biopsies were obtained from tibial, femoral, and intra-articular segments of revision cases and torn native ligament as well as excess hamstring graft after fixation from primary ACLR controls. Clinical cultures as well as PCR for bacterial DNA with a universal primer were obtained on all patients. Fluorescence microscopy was used to visually confirm presence of biofilm. No patients had clinical signs of infection. Tunnel diameters were measured on pre-operative 3-dimensional imaging.

Results: Bacterial DNA was present in 87% of cases and 20% of controls. Cultures were only positive (coagulase negative *staphyloccous* sp.) in one revision case, the widest measured tunnel diameters were in this same case (20.1 mm for the tibial tunnel and 16.9 mm for the femoral tunnel) Bacterial DNA was positively associated with wider femoral tunnels (median 10.6 mm with detectable bacterial DNA, median 7.6 mm without detectable bacterial DNA; p=0.04 Wilcoxon rank-sum). There was a trend toward higher rates of bacterial DNA in tibial tunnels with diameters greater than 12.5 mm (LR chi square p= 0.12). Fluorescence microscopy confirmed presence of staphylococcal biofilms adherent to the soft tissue graft surface (Figure 1) as well as inert fixation material including monofilament suture, braided suture, and PEEK and metal interference screws.

Conclusion: Bacterial biofilms are commonly encountered on failed ACLR grafts. These biofilms do not cause clinically apparent infection symptoms but are associated with tunnel widening and may contribute to biologic failure.


Bacteria
Bacteria
10 µm

Paper 112

Title:
Internal Brace ACL Repair is Associated with High Failure Rate in the First Two Years Post-Surgery

Authors:
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Objectives: To compare graft/internal brace survival, self-reported functional outcomes, and joint laxity in adolescents who underwent quadriceps tendon patellar autograft (QPA) reconstruction versus ACL repair with internal brace ligament augmentation.

Methods: We identified all adolescent and pediatric subjects who underwent primary ACL reconstruction or repair with internal brace augmentation between January 2013 and January 2016. Only subjects with a minimum of 6 months of follow-up were included. Graft failure, range of motion (ROM), complications, and demographic information including age and gender was collected. Failure was defined as the need for revision surgery or MRI-confirmed graft/internal brace failure. Subjects were prospectively contacted by telephone and were invited to either schedule a follow-up appointment or to complete research questionnaires over the phone. Objective joint laxity measures, KT1000, were obtained from a subset of subjects (N=25 QPA and N=6 repair group) that completed the research visit. Wilcoxon rank sum tests were used to compare IKDC and joint laxity measure. Multi-variable Cox proportional hazards regression analyses were used to compare failure-free survival in the two groups during the first 24 months post-surgery.

Results: The final cohort included 132 patients in the QPA group (52% female) and 19 patients in the repair group (53% female). The repair group tended to be younger (mean: 14.1 yrs, ±2.9 vs 15.5 yrs, ±1.8). Median duration of follow-up was 2.1 years [range: 0.5-4 years] in the repair group compared to 1.2 years [range: 0.5-4 years] in the QPA group. Within the first 24 months post-surgery, the cumulative incidence of failure was 3.8% (5/132) in the QPA group compared to 52.6% (10/19) in the repair group. After adjusting for age, the hazard of failure in the repair group was 22.1 [95% CI: 6.7 to 73.2, p <0.0001] times the hazard of failure in the QPA group. KT-1000 side-to-side joint laxity measures in the repair group [Median: 2.5mm, range: -1mm to 7mm] were significantly [p=0.0212] higher than the joint laxity measures in the QPA group [Median: 1.0mm, range: -1mm to 4mm]. There was no difference [p= 0.3826] in IKDC scores in the repair group [N=53, median: 97, range: 58-100] compared to the QPA group [N=10, median: 94, range: 32-100].

Conclusion: Failure rate and joint laxity measures were significantly increased in the internal brace repair group relative to the QPA group. Failure-free survival in the repair group was less than 50% at two years. The high failure rate in the repair group should be considered when selecting the appropriate intervention for the pediatric adolescent athlete with an ACL injury.

Paper 113

Title:
Non-Operative Management of Femoroacetabular Impingement: A Prospective Study

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Objectives: Little attention has been given to the non-operative management of femoroacetabular impingement (FAI) in the literature despite a rapidly expanding body of research on the topic. The purpose of the current project was to perform a prospective study utilizing a non-operative protocol on a consecutive series of patients presenting to our clinic with FAI.

Methods: Between 2013 and 2016, patients referred to our clinic for hip pain that had a positive impingement sign were prospectively recruited in a non-operative FAI study. The protocol consisted of an initial trial of rest, physical therapy, and activity modification with a focus on avoidance of high hip flexion (Activity Mod group). Patients who remained symptomatic were then treated with an image-guided intra-articular steroid injection (Injection group). Patients with residual symptoms were then offered arthroscopic treatment (Surgery group). Outcome scores were collected at 12 and 24 months. Statistical analysis was performed to identify risk factors for failure of non-operative treatment.

Results: 129 symptomatic hips in 100 patients were enrolled. After our exclusion criteria were applied, 110 hips in 84 patients remained with a mean follow-up of 25.5 months. Eighty-one hips (73.6%) were managed with PT, rest, and activity modification alone. Thirteen hips (11.8%) required a steroid injection, but did not progress to surgery. Sixteen hips (14.5%) required arthroscopic management. All three groups saw similar improvements in modified Harris hip score (mHHS)($p=0.706$) and non-arthritic hips score (NAHS)($p=0.712$). Initial, and most recent, mHHS and NAHS can be found in Table 1. Labral tears were distributed similarly among the three groups ($n=41$, $p=0.09$) and saw similar improvements in outcomes ($p>0.5$) as hips without labral tears. The surgical patients attempted non-operative treatment for a mean of 8.8 months prior to surgical intervention. Delays in surgery were not associated with worse outcomes. Cam lesion size, acetabular coverage, and the presence of a labral tear were not associated with non-operative treatment failure ($p=0.579$).

Conclusion: A large majority of adolescent patients presenting with FAI can be managed nonoperatively with significant improvements in outcomes scores and continuation of sport at a mean follow up of two years. This is the first prospective study evaluating the outcomes of a standardized non-operative protocol for the management of FAI. Our results show that a commitment to non-operative care can work for a large percentage of patients. We will be following these patients further into the future to examine the durability of these results.

Table 1. Mean±Standard deviation of intial and most recent modified Harris hip score and non-arthritic hip score

	Modified Harris Hip Score		Non-Arthritic Hip Score	
	Initial	Most Recent	Initial	Most Recent
Activity Mod	70.0±13.3	89.8±12.2	74.2±16.4	87.1±14.8
Injection	67.9±11.2	91.3±9.2	72.2±13.1	86.1±10.2
Scope	67.6±9.3	87.9±11.4	72.7±11.3	89.2±9.3
p-value	0.748	0.676	0.699	0.433

Paper 114

Title:
Pre-operative Predictors of Return to High Functional Status After Hip Arthroscopy for Femoroacetabular Impingement At 2-year Minimum Follow-up

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Objectives: Pre-operative predictors of high functional level at two years following hip arthroscopy are unclear. We hypothesized that smoking status, comorbid disease (hypertension, diabetes, mental health diagnoses, prior surgeries, and spine pathology) would negatively affect outcomes at two-year follow-up while younger age, decreased body mass index (BMI), increased physical activity and shorter preoperative symptom duration would be able to predict outcomes after hip arthroscopy for femoroacetabular impingement (FAI)

Methods: A prospectively collected registry was analyzed for all patients treated for FAI from 2012 to 2015. All patients had a minimum of 2-year follow-up with patient reported outcomes [PROs, including modified Harris Hip Score (mHHS), Hip Outcome Score (HOS)-Activities of Daily Living (ADL), HOS-Sport Specific (HOS-SS), Visual Analog Score (VAS)-Pain and satisfaction. Inclusion criteria were skeletally mature patients at the time of arthroscopy, signs and symptoms consistent with a diagnosis of FAI. Individuals with prior hip surgery, inflammatory arthropathy, and/or advanced osteoarthritis were excluded. Univariate and correlation analyses were performed to identify significant association and multivariate logistic regression analysis was used to identify significant predictors. Significance was set at $\alpha \leq 0.05$.

Results: Of 1042 qualifying patients, 830 completed 2-year minimum follow-up (80%); mean age and body mass index (BMI) were 33.6±12.8 years and 25.4±11.3 respectively. The majority of patients were female (549, 66.1%), non-smokers (741, 89.3%), who participated in regular recreational sports (623, 75%). One-third (278, 33.5%) experienced preoperative symptoms longer than two-years while 157 (18.9%) experienced symptoms for one-to-two years, with 265 (31.9%) for 4-to-12 months, and 108 (13%) less than 4 months. Mean alpha angle and lateral center edge angle were 61.2±10.1 and 33.1±7.02, respectively. All patients demonstrated significant improvements in PROs following surgery: HOS-ADL (65.20±0.72 to 86.54±0.61; p<0.0001), HOS-SS (42.84±0.89 to 73.98±1.0; p<0.0001), and mHHS (57.4±0.58 to79.92±0.68; p<0.0001). In addition, VAS Pain was significantly decreased from 53.35±1.3 to 19.44±0.86 (p=0.032) with high two-year satisfaction at 81.11±28.28. Regression analysis identified the strongest predictors for high functioning outcomes in the HOS-SS were patients without a history of a mental health diagnoses (anxiety or depression; importance 0.29, p<0.0001) followed by younger age (importance 0.18; p<0.0001). Predictors for improved two-year HOS-ADL outcomes included shorter duration of symptoms (importance 0.22; p<0.0001) and decreased BMI (importance 0.164; p=0.001). Predictors for an improved mHHS included no pre-operative narcotic use (importance 0.19; p=0.001) and no history of a mental health diagnoses (importance 0.18; p=0.001). Predictors of HOS-ADL and

mHHS were also significant predictors of a greater HOS-SS score (p=0.001 for all).

Conclusion: Our results support the hypothesis that patients with mental health diagnoses, increased age and BMI, as well as prolonged preoperative symptom duration are predictors for inferior post-operative functional status at mid-term follow-up. Our results suggest that there are both modifiable and non-modifiable pre-operative factors that have the potential to predict a return to high functional status after hip arthroscopy for FAI.

Paper 115

Title:
Hip Arthroscopy vs Physical Therapy for Acetabular Labral Tears: Analysis of a Prospective Randomized Controlled Trial

Authors:
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Objectives: Hip arthroscopy is an effective surgical intervention for patients with symptomatic labral tears of the hip. However, there is debate as to which patients benefit from this procedure. Studies have shown that outcomes following arthroscopic labral repair in older patients have been unpredictable compared to the more predictable, positive outcomes commonly seen in younger populations. These older patients, who often have variable degrees of osteoarthritis, may benefit from non-surgical management, such as physical therapy, as a viable treatment modality. The purpose of this study was to compare the efficacy of physical therapy to hip arthroscopy for patients age 40 and older with a symptomatic labral tear.

Methods: After IRB approval, patients were prospectively identified and randomized into one of two study arms: arthroscopic surgery (AS) or physical therapy (PT). A third study arm, dependent upon improvement with PT, was created as patients crossed over (CO) from PT to AS after a lack of improvement after a minimum of 8 weeks of PT. Criteria for eligibility included patients over the age of 40 with an MRI-confirmed symptomatic acetabular labral tear and limited radiographic arthritis, with exclusion of Tonnis grade 3 arthritis. AS consisted of labral repair or debridement if repair was not possible, and PT consisted of a uniform, comprehensive PT protocol guided by designated physical therapists. Demographic information, imaging studies, and baseline patient reported outcome measures (PROM) including the Modified Harris Hip Score (mHHS), Hip Outcome Score (HOS), Non-Arthritic Hip Score (NAHS), International Hip Outcome Tool (iHOT-33), and the Lower Extremity Function Score (LEFS) were collected at enrollment and at intervals of 6, 12, and 24 months after initiation of treatment. Statistical analysis was used to compare the AS, PT, and CO groups with respect to PROMs.

Results: Of the 72 patients currently enrolled, 53 (73.6%) patients have completed at least 6-month follow-up, with an average follow-up of 15.2 months. Mean age was 47.0±4.8, and the mean Tonnis grade arthritis was 0.72±0.68 (range, 0-2). At the time of analysis, 13 (44.8%) of the 29 patients originally enrolled in the PT group crossed over (CO) to surgery. The AS and CO groups showed statistically significant improvements from enrollment to follow-up in all 6 PROMs; however, the PT group only showed statistically significant improvement from enrollment to follow-up in 1 PROM (Tables 1-3). When improvements of all three cohorts (AS, PT, CO) were compared, a statistically significant difference among the groups was observed in 4 of the 6 PROMs, and the surgical groups (AS and CO) outperformed the PT group (Table 4). Analysis of improvement between groups showed that CO significantly outperformed PT, while the data only approached statistical significance when AS

outperformed PT.

Conclusion: Although patients who undergo non-surgical management, such as PT, have shown potential to improve, results indicate that surgical intervention may be preferred over PT for patients over the age of 40 with symptomatic acetabular labral tears and limited radiographic arthritis. Additional patients and longer follow-up is necessary to confirm these findings.

PROM	Enrollment (n=24)	Follow-Up (n=24)	p-value
mHHS	53.5 (49.0-57.5)	86.0 (71.5-87.0)	.0006**
HOS-ADL	0.705 (0.595-0.833)	0.956 (0.848-0.971)	.0031**
HOS-SSS	0.333 (0.236-0.573)	0.852 (0.489-0.967)	.0005**
NAHS	65.00 (51.88-73.75)	91.88 (80.63-93.75)	.0006**
LEFS	67.5 (59.0-78.5)	88.5 (78.0-96.0)	.0014**
IHOT-33	32.64 (29.00-49.72)	83.87 (59.51-91.19)	.0015**

Table 1. Enrollment vs AT LEAST 6-month follow-up PROMs for Arthroscopic Surgery (AS) group
All data is presented as Median (IQR) unless stated otherwise.
* p<.05
** p<.01

PROM	Enrollment (n=16)	Follow-Up (n=16)	p-value
mHHS	59.5(49.0-65.5)	68.5 (56.0-79.5)	.1200
HOS-ADL	0.669 (0.600-0.809)	0.734 (0.632-0.890)	.3255
HOS-SSS	0.337 (0.264-0.625)	0.500 (0.214-0.764)	.4206
NAHS	58.75 (50.63-78.13)	70.00 (58.13-83.75)	.0700
LEFS	66.5 (53.5-77.5)	67.0 (54.5-83.5)	.8359
IHOT-33	34.51 (23.18-43.32)	49.78 (31.50-77.72)	.0113*

Table 2. Enrollment vs AT LEAST 6-month follow-up PROMs for Physical Therapy (PT) group
All data is presented as Median (IQR) unless stated otherwise.
* p<.05
** p<.01

PROM	Enrollment (n=13)	Follow-Up (n=13)	p-value
mHHS	62.0 (51.0-69.0)	84.0 (76.0-87.0)	.0064**
HOS-ADL	0.719 (0.594-0.844)	0.912 (0.868-0.953)	.0107*
HOS-SSS	0.556 (0.139-0.650)	0.714 (0.600-0.893)	.0024**
NAHS	65.00 (55.00-76.25)	87.50 (83.75-93.75)	.0057**
LEFS	66.0 (50.0-79.0)	83.0 (76.0-94.0)	.0052**
IHOT-33	35.24 (25.22-51.09)	77.48 (74.03-80.42)	.0019**

Table 3. Enrollment vs AT LEAST 6-month follow-up PROMs for Crossover (CO) group
All data is presented as Median (IQR) unless stated otherwise.
* p<.05
** p<.01

PROM	Arthroscopic Surgery (n=24)	Physical Therapy (n=16)	Crossover (n=13)	p-value
mHHS	21.0 (11.0-30.5)	7.0 (-5.0-15.5)	17.0 (13.0-35.0)	.0241*
HOS-ADL	0.143 (0.044-0.250)	0.022 (-0.037-0.617)	0.193 (0.103-0.406)	.0408*
HOS-SSS	0.352 (0.038-0.580)	0.014 (-0.097-0.250)	0.243 (0.194-0.444)	.0340*
NAHS	18.13 (8.13-33.75)	6.25 (-0.63 -20.00)	22.50 (15.00-45.00)	.0518
LEFS	13.0 (6.0-28.5)	1.5 (-7.0-6.5)	20.0 (10.0-43.0)	.0157*
IHOT33	41.94 (4.03-60.50)	6.00 (2.89-24.24)	41.66 (32.29-56.31)	.0627

Table 4. Comparison of the improvements from enrollment to follow-up of the AS, PT, and CO groups through Kruskal-Wallis Test
All data is presented as Median (IQR) unless stated otherwise.
* $p<.05$

Paper 116

Title:
My First 100 Compared to My Last 100 Labral Reconstructions- The Role of Patient Selection in Increasing Survivorship

Authors:
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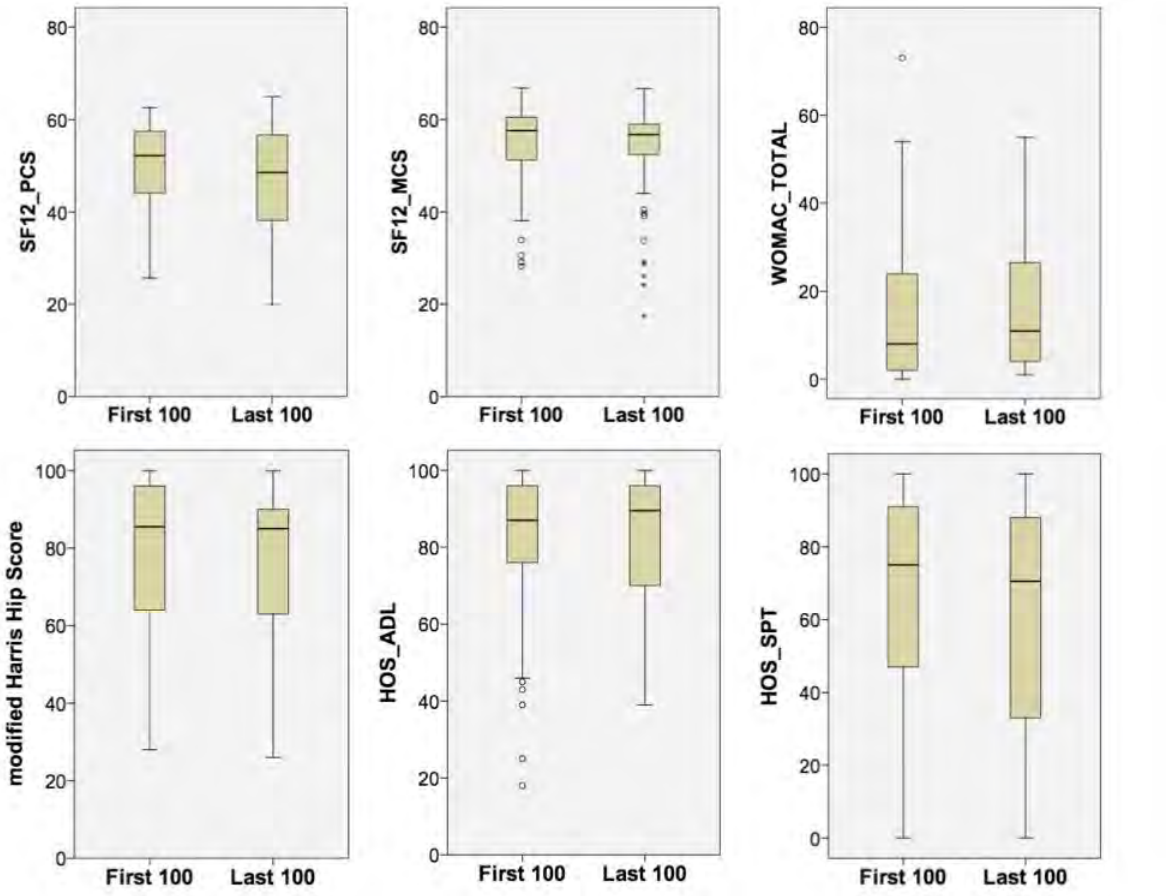
Objectives: Hip labral reconstruction has been reported with short-term improvement in patient-reported outcomes and functional scores postoperatively; however, its mid-term outcomes and the risk factors of total hip replacement (THR) conversion are still unclear. The purpose of this study was to evaluate the results of patients who underwent labral reconstruction with iliotibial band autograft comparing our first 100 patients to the last 100 patients. We hypothesized that patient selection had been changed between the 2 cohorts and the last 100 patients achieved better clinical outcomes than the first 100 patients.

Methods: The Skeletally mature patients (>17 years) who underwent hip labral reconstruction with autologous iliotibial band were evaluated preoperatively and postoperatively with a minimum 2 years follow-up. The first consecutive 100 patients (Group 1, between September 2005 and December 2008) and the last 100 patients (Group 2, between August 2011 and October 2014) were retrospectively compared. Radiographic evaluations were performed preoperatively. Conversion ratio to THR, necessity of a revision hip arthroscopy, and 7 kinds of outcome scores were evaluated postoperatively. Student t-test, chi-square test was used to compare 2 groups. Logistic regression analysis and receiver operating characteristic (ROC) curve analysis were performed to detect the risk factors of THR conversion.

Results: Overall follow-up rate (> 2 years) was 94% (Group 1 v Group 2, 96% v 91%, P = 0.25). The follow-up period of Group 1 was significantly longer (year, 4.8 v 2.8, P < 0.001). Mean age of Group 1 was significantly higher than that of Group 2 (year, 37.1 v 33.5, P = 0.032). In Group 2, 69 surgeries out of 100 were revision hip arthroscopies, which was significantly higher rate than Group 1 (48%, P = 0.003). Group 1 had significantly higher rate of THR conversion (23% v 5%, P = 0.001). Revision hip arthroscopy was performed 11% of Group 1 and 9% of Group 2 (P = 0.751) (**Table**). Clinical outcomes of the patients who did not require further surgery were similar between 2 groups (all P > 0.15, **Figure**). In logistic regression analysis, only higher age was significant risk factor of THR conversion, while grouping, primary surgery was not significant (age: P < 0.001, odds ratio 1.15 [95%, 1.08-1.22], Group 1: P = 0.09, primary surgery: P = 0.06). Cut off value of age calculated by ROC curve was 45.5 years, and 47% of the overall patients older than 46 years had THR after surgery (5% in the patients younger than 45 years, P < 0.001). The rate of the patients older than 46 years in Group 1 was significantly higher than that in Group 2 (30% v 17%, P = 0.030).

Conclusion: Patient selection had been changed between the first 100 and the last 100 cohorts. Higher age, especially older 46-year-old, was significantly associated with higher conversion rate to THR.

Although autologous labral reconstruction was a promising procedure with success rate of up to 80% in this mid-term investigation, patient selection was considered to be the key to increase the survivorship.



Comparison between first 100 and last 100 labral reconstruction

	First 100 labral reconstruction (Group1)	Last 100 labral reconstruction (Group2)	P value
Age, y	37.1	33.5	0.032
Gender (Male), %	62	56	0.338
Follow-up, y	4.8	2.8	<0.001
Primary surgeries, %	52	31	0.003
Alpha angle, degrees	71.0	67.4	0.114
Center edge angle, degrees	35.7	33.3	0.039
Minimum joint space, mm	3.6	3.6	0.733
Total hip replacement conversion, %	23	5	0.001
Revision hip arthroscopy required, %	11	9	0.751

Paper 117

Title:
Relationship Between Pitcher Fatigue and Medial Elbow Torque in Baseball Pitchers: A Simulated Game Analysis

Authors:
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[1]Henry Ford Hospital, Novi, MI, USA, [2]Henry Ford Hospital, Detroit, MI, USA, [3]Wayne State University, Detroit, MI, USA, [4]Henry Ford Hospital, Royal Oak, MI, USA, [5]Columbia University, New York, NY, USA, [6]Henry Ford Medical Group, Novi, MI, USA.

Objectives: The incidence of overuse injury to the elbow in baseball pitchers continues to rise, despite exhaustive efforts at pitch count regulations and emphasis on proper throwing mechanics. The goal of this study was to determine if the medial elbow experiences increased torque levels as the pitcher fatigues through the course of a simulated game.

Methods: Competitive baseball pitchers were recruited for this simulated game study. Medial elbow torque was assessed using a validated mobile sensor that recorded medial elbow torque during the throwing motion. A radar gun was used to capture pitch velocity for each recorded pitch. Each pitcher completed a simulated game consisting of 6 innings and a standardized pitching scheme of fastballs, curveballs, and change-ups. Visual analog scores (VAS) measuring fatigue were recorded in between each inning. In total, each pitcher threw 90 pitches. Data was recorded every pitch to include ball velocity, medial elbow torque, arm speed, arm rotation, and arm slot.

Results: A total of 11 pitchers (average age 17.6 years; range 15-20 years) completed the study. No adverse outcomes were noted with use of the mobile sensor. VAS scores increased 0.716 points per inning pitched ($p<0.001$). Medial elbow torque also was found to increase with successive innings, with an increase of 0.836 Nm each inning ($p<0.001$), while average pitch velocity was found to decrease as the game progressed (0.28 mile per hour decrease per inning; $p<0.001$). Fastballs generated the highest amount of medial elbow torque. There were no differences found in arm rotation or arm speed as the game progressed. However, the arm slot was found to decrease with each successive inning (0.731 degree decrease per inning; $p<0.001$).

Conclusion: In this simulated game analysis, pitchers were noted to experience increase fatigue after each successive inning. While the average fastball velocity decreased from inning-to-inning, the medial elbow torque was found to increase, signifying a possible risk factor for overuse injury to the medial elbow.

Paper 118

Title:
Fatigue Increases ACL Injury Risk in Youth Athletes: Risk Assessment Study Using Drop-jump Test

Authors:
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Objectives: The impact of fatigue on injury risk to the anterior cruciate ligament (ACL) in adolescent athletes is unknown. Identifying athletes who demonstrate increased risk for injury may help determine who would benefit from early neuromuscular control intervention for injury prevention. The goal of this study was to determine if fatigue increases ACL injury risk in adolescent athletes using the drop-jump test to assess dynamic valgus.

Methods: Youth and adolescent competitive athletes were recruited for this video analysis study. Participants were recorded performing the standard drop-jump test assessing dynamic valgus on landing three times. They then completed a standardized fatigue protocol consisting of a timed period of high-intensity aerobic tasks. A set amount of fatigue was quantified and achieved using a maximum vertical jump, which was compared to pre-fatigue values. The drop-jump test was then repeated three additional times post-fatigue. All drop-jump recordings (six in total) were randomized by order and scored for dynamic knee valgus by three independent reviewers. A multivariable analysis was performed to assess the correlation between demographic variables and injury risk.

Results: Forty-seven female patients and thirty-eight male athletes were included in the study. The average age was 15.4 years (age 14-18). Athletes were found to have significantly higher ACL injury risk post-fatigue when compared to pre-fatigue ($p = .001$). Thirty-five athletes were found to change from low/medium injury risk pre-fatigue to medium/high risk post fatigue. No demographic variables were found to contribute to ACL injury risk.

Conclusion: In adolescent athletes, fatigue appears to increase risk of ACL injury through drop-jump testing. Age, BMI, and hip width were not found to contribute to ACL injury risk. Implementation of neuromuscular or conditioning programs for at-risk athletes may reduce injury risk.

Paper 119

Title:
Utility of Merchant View Radiographs for Assessment of Tt-tg: A Comparison to MRI

Authors:
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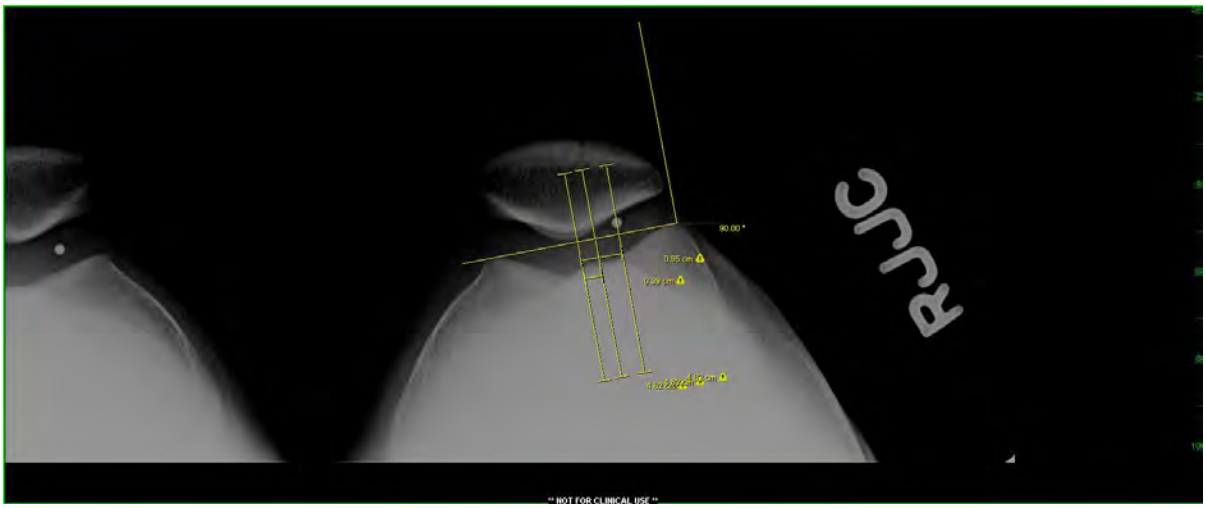
Objectives: Lateralization of the tibial tubercle plays a significant role in the pathophysiology of patellar instability and is most often assessed by the tibial tubercle to trochlear groove distance (TT-TG) measured on CT or MRI with the knee in extension. However, tracking of the patella in 30 to 45 degrees of flexion has been suggested to be of greater clinical significance. Merchant radiographs can demonstrate the position of the tibial tubercle relative to the trochlear groove in this range of flexion and thus may serve as a valuable tool in the assessment of patellar tracking. The purpose of the current study was (1) to validate radiographic assessment of the merchant view TT-TG and (2) to determine the correlation with MRI-based measurements.

Methods: To validate Merchant TT-TG as a marker of the position of the tibial tubercle, 41 patients between the ages of 10-18 had standardized Merchant radiographs in 45 degrees flexion yielding imaging of 82 knees. Lead markers were placed upon the skin centered over the tibial tubercle based on palpation. Radiographs were collected and analyzed. The TT-TG was measured as the distance between lines centered over the deepest point of the trochlear groove and the center of the tibial tubercle and perpendicular to the anterior condylar axis. In order to correlate Merchant TT-TG to MRI TT-TG, 16 additional patients were added to reach a total of 30 patients with a Merchant radiograph and MRI, as power calculation determined 29 knees needed to detect a Pearson correlation coefficient (PCC) of .500. There was excellent interobserver reliability between two readers for Merchant TT-TG with and without use of a radiographic marker (ICC = .975 and .923 respectively).

Results: The tibial tubercle could be identified on Merchant radiograph in 67 images (81.7%). Merchant TT-TG measured with use of a marker was very strongly correlated measurement based on bony landmarks alone (PCC = .848). The Merchant TT-TG measured with bony landmarks alone was strongly correlated to MRI TT-TG (PCC = .602). The strength of this correlation was increased by standardizing TT-TG by patellar width (PCC = .710). MRI TT-TG was increased in patients with patellar instability at 13.9mm compared to 10.5mm ($p < .01$); Merchant TT-TG was also increased in patients with patellar instability at 9.1mm compared to 1.9mm ($p < .001$).

Conclusion: Standardized Merchant radiographs without radiographic markers allow for assessment of TT-TG in the majority of patients. Merchant TT-TG strongly correlates with MRI TT-TG but measured 5-8mm smaller than MRI TT-TG.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Paper 120

Title:
The Role of Abnormal Tibiofemoral Rotation in Pediatric and Adolescent Patellar Instability

Authors:
David Bernholt[1], Joseph D. Lamplot, MD[2], Eric Eutsler[3], **Jeffrey J. Nepple, MD**[4].
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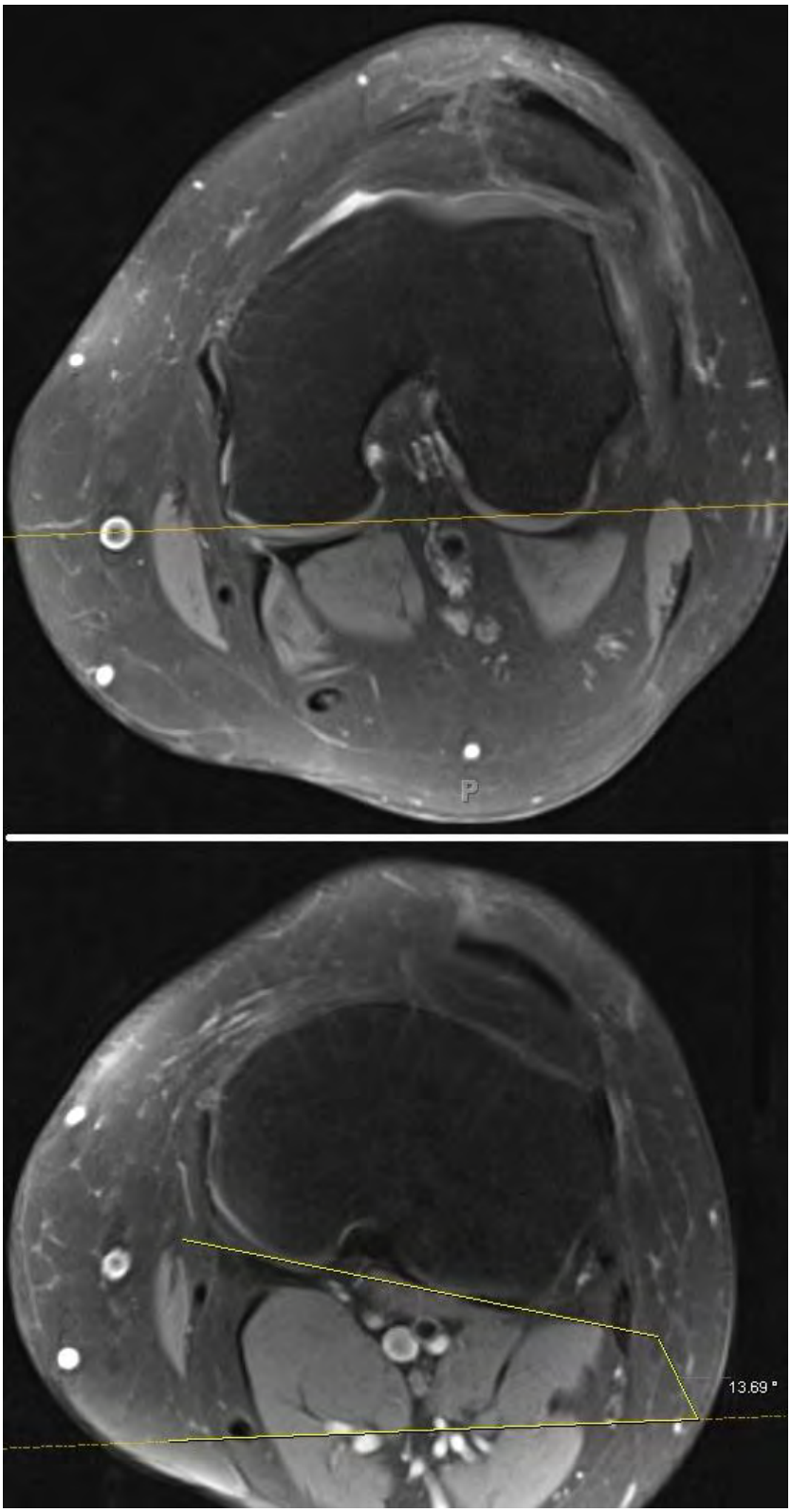
Objectives: Abnormal patellofemoral tracking has been implicated in patellar instability and can be influenced by the bony anatomy and alignment of the femoral trochlea, patella, and tibial tubercle. Tibiofemoral joint rotation has been recently suggested to play a role in patellofemoral kinematics but there has been little investigation of its contribution to patellar instability, including in pediatric and adolescent patients.

Methods: A retrospective case-control design was utilized. 30 patients aged 9-18 with a prior patellar dislocation and an MRI of the involved knee were included. Cases were matched for age and gender with controls without patellar instability. Patients with ACL tears, tibial eminence or tubercle fractures, or prior surgery in the involved extremity were excluded. There was no difference in gender, age, height, but BMI was higher in the case group. MRI images taken with knee in extension were analyzed. Tibial tubercle-trochlear groove (TT-TG), tibial tubercle-posterior cruciate ligament (TT-PCL), and tibiofemoral rotation were measured. All measurements were performed by a single reader with excellent intra and interobserver reliability for tibiofemoral rotation (ICC-intra > .954 and ICC-inter > .905) demonstrated in a subset of patients.

Results: The TT-TG was increased in patients with patellar instability at 16.3mm compared to 10.9mm in controls ($p < .001$) as was also the TT-PCL at 19.4mm cases versus 17.6mm ($p=0.02$). Tibiofemoral rotation was increased in patients with patellar instability with a mean 6.9° of tibial external rotation compared to 0.8° of tibial internal rotation in controls ($p < .001$). Overall, 30/41 (75.6%) of patients with patellar instability had tibiofemoral rotation >5° external rotation versus only 3/41 controls (7.3%). There was a strong correlation between TT-TG and tibiofemoral rotation (PCC = 0.776) and a moderate correlation between TT-TG and TT-PCL (PCC = .661). There was only a weak correlation between tibiofemoral rotation and TT-PCL.

Conclusion: Increased tibiofemoral rotation is present in patients with patellar instability and may play a role in the pathophysiology of patellar instability. Increased tibiofemoral rotation can lead to an increased TT-TG even when TT-PCL is normal.



Comparison of MRI TT-TG, TT-PCL, and tibiofemoral rotation measurements based on presence of patella

		N	p-value	STE	STE
TT-TG	No patellar instability	41		.6	.6
	Patellar instability	41	<0.001	.6	.6
TT-PCL	No patellar instability	41		.6	.6
	Patellar instability	41	0.02	.5	.5
Tibiofemoral rotation	No patellar instability	41		.6	.6
Tibiofemoral rotation	Patellar instability	41	<0.001	.7	.7

Paper 121

Title:
Complications of Tibial Tubercle Surgery

Authors:
Anna Lundeen, ATC, Elizabeth A. Arendt, MD, Kristin Mathson, Julie Agel, MA, ATC, **Jeffrey A. Macalena, MD**.
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Objectives: Tibial tubercle osteotomy (TTO) is a common procedure that is frequently used in the treatment of recurrent patellar instability and/or patellar chondrosis. Medialization of the tubercle decreases the lateral quadriceps vector of the patella resulting in load shifting away from the lateral patella. Distalization of the tubercle decreases patella height and allows for earlier containment of the patella in the bony walls of the trochlear groove. Anteriorization has been shown to be an effective treatment to unload the inferior lateral patella when chondrosis of the patella is present in this region. Current estimates of this procedure's complication rates range from 0% to 11%. The purpose of this study was to review the complication rate following TTO performed within an academic sports medicine practice. The hypothesis was that complication rate for TTO is greater than 10% and that the rate of complications with distalization exceeds that of medialization alone.

Methods: All patients between May 2009 and May 2015 who underwent a TTO were retrospectively identified. Those with at least 6 months of follow up or a complication within the first 3 months were included for data analysis. Complications were identified and labeled as either major or minor. Major complications were defined as fracture of the tibia, deep infection requiring surgical debridement, nonunion requiring revision fixation, delayed union requiring bone graft, bone stimulation, or screw exchange, arthrofibrosis requiring manipulation under sedation and/or open lysis of adhesions, loss of fixation of the tubercle fragment, and deep vein thrombosis (DVT) whereas minor complications were defined as removal of symptomatic hardware, superficial wound infection, disturbance of cutaneous sensation, and delay in wound healing not requiring surgery.

Results: During the study period, 126 TTO were performed. Representing the study cohort are 111 patients, who have at least 6 months of follow up or a complication within 3 months. The mean follow up was 23 months. There were 62 of 126 (49.2%) TTO performed for patellofemoral instability and 23 of 126 (18.2%) for patellofemoral chondral damage. Thirty-eight osteotomies were performed for both instability and cartilage damage (30.2%). Two osteotomies were performed solely for patella alta and one TTO was performed for unspecified reason (2.4%). Of the complications, 28 came following distalization of the tubercle and 4 of these complications represent subsequent tibia fracture. Overall, the complication rate was 28.7 percent; major (17.1%) and minor (11.6%) complication rates are shown in Table 1. Subgroup analysis shows a complication rate of 54% for tubercles that were distalized versus 46% for medialization alone.

Table 1: Complication Frequency

Major Complication	**17.1%**
Fracture of Tibia	3.3%
Deep Infection	0.0%
Loss of Fixation	1.7%
Nonunion	0.6%
Delayed Union	2.8%
DVT	1.1%
Arthrofibrosis requiring surgery	8.3%
Concomitant Intraarticular Procedures	33.3%
Concomitant Extraarticular Procedures	66.7%
Minor Complication	**11.6%**
Removal of Hardware	9.4%
Superficial Infection	1.7%
Loss/Decrease of Cutaneous Sensation	3.9%
Wound Dehiscence	0.6%

Table 1 shows major and minor complication rates of tibial tubercle osteotomies. Arthrofibrosis sub-categories refer to the percentage of patients who underwent concomitant intra and extraarticular procedures. Intraarticular procedures include cartilage reconstruction and trochleoplasty. Extraarticular procedures include lateral retinacular release/lengthening, MPFL repair/reconstruction, and medial imbrication. If both intra and extraarticular procedures were performed, the patient was recorded as intraarticular.

Conclusion: The rate of total complication for TTO was 28.7%, this is greater than the estimated rate of complication in the current literature. Further, the rate of complications when the tibial tubercle was distalized was greater than when medialized alone suggesting that special considerations be made with this cohort. This high rate of complication is accompanied by a high rate of arthrofibrosis when compared to current literature suggesting the need for preoperative discussion as well as a detailed plan for postoperative rehabilitation to improve motion in patients and decrease the need for subsequent intervention. This study's findings may redirect patient and physician discussions regarding risks of tibial tubercle osteotomies.

Paper 122

Title:
Isolated Medial Patellofemoral Ligament Reconstruction for Patellar Instability Regardless of the Tibial Tubercle Trochlear Groove Distance: Outcomes at 1 and 2 Years

Authors:
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Objectives: Background: Several surgical options exist for treatment of recurrent patellar instability. The treatments can be divided into ligamentous and bony procedures. It is currently unclear which patients require a bony procedure in addition to a soft tissue reconstruction. **Purpose:** To report the one and two-year outcomes of patients following medial patellofemoral ligament (MPFL) reconstruction performed in isolation regardless of the patellar height, tibial tubercle trochlear groove distance (TT-TG) or trochlear dysplasia. **Hypothesis:** Patients will have <5% re-dislocation rate and significant improvements in patient reported outcome measures (PROMs) following isolated MPFL reconstruction.

Methods: All patients with recurrent patellar instability and without significant unloadable chondral defects, failed previous surgery or pain greater than or equal to 50% as their chief complaint, were prospectively enrolled beginning March of 2014. All patients underwent a primary, unilateral, isolated MPFL reconstruction regardless of concomitant bony pathology for treatment of recurrent patellar instability. Patients were followed at standard intervals. PROMs were collected at one year and two year follow up visits. Information on recurrent subjective instability, dislocations, and ability to return to sport (RTS) was recorded. TT-TG and patellar height (using the Caton-Deschamps index) were measured on magnetic resonance images.

Results: Overall, 90 patients (77% female; average age 19.4 +/- 5.6 years) underwent a MPFL reconstruction from March 2014 to August 2017; 63 (70%) of whom reached one year follow up, and 35 of these patients (39%) reached 2-year follow-up. No patient experienced a redislocation; 96% of patients at one year and 100% of patients at two years had no subjective patellofemoral instability. RTS rates at one and two years were 59% and 75% respectively. No patient experienced a complication at one year. All patients had a clinically and statistically significant improvement from baseline to 1-year follow-up in the following PROMs: Knee injury and Osteoarthritis Outcome Score Quality of Life (KOOS QOL) (32.7 to 72.0; $p<0.001$), International Knee Documentation Committee (IKDC) (51.4 to 82.6; $p<0.001$) Kujala (62.2 to 89.5; $p<0.001$), and all general health PROM. No clinically and statistically significant change was seen between 1- and 2-year follow-ups in all outcome scores (all $p>0.05$). A non-statistically significant increase was seen in sporting activity of the Pediatric Functional Activity Brief Scale (Pedi-FABS) (13.9 to 16.7 $p=0.292$) at 2 years. Average patient satisfaction was 9.3 of 10 (10 being most satisfied) at 1- and 2-year follow-up. Average TT-TG was 15.1 +/- 4.0. Average patellar height was 1.25 +/- 0.17.

Conclusion: Isolated MPFL reconstruction is an effective treatment for patellar instability and provides significant improvements in PROMs with a low redislocation/instability rate at early 1 and 2 year follow up, regardless of bony pathologies including TT-TG, Caton-Deschamps Index and trochlear dysplasia. The goal of this ongoing prospective study is to follow these patients out for 5 to 10 years to assess what radiologic and physical examination factors predict failure of isolated MPFL reconstruction.

Paper 123

Title:
Minimum Five-Year Outcomes and Clinical Survivorship Following Arthroscopic Double-Row Repair for Full-thickness Supraspinatus Tears

Authors:
Jonas Pogorzelski, MD[1], Erik M. Fritz, MD[1], Marilee P. Horan, MPH[1], Zaamin B. Hussain, BA[1], Christoph Katthagen, MD[2], Jonathan A. Godin, MD, MBA[1], Peter J. Millett, MD, MSc[3].
[1]Steadman Philippon Research Institute, Vail, CO, USA, [2]Union Munster Hospital, Muenster, Germany, [3]Steadman Clinic, Vail, CO, USA.

Objectives: Rotator cuff tears lead to significant morbidity due to pain and decreased function. Despite the prevalence of cuff repairs, mid-term outcomes have been scarcely reported. The purpose of this study is to report minimum 5-year outcomes and clinical survivorship after double-row rotator cuff repair for full-thickness supraspinatus tendon tears.

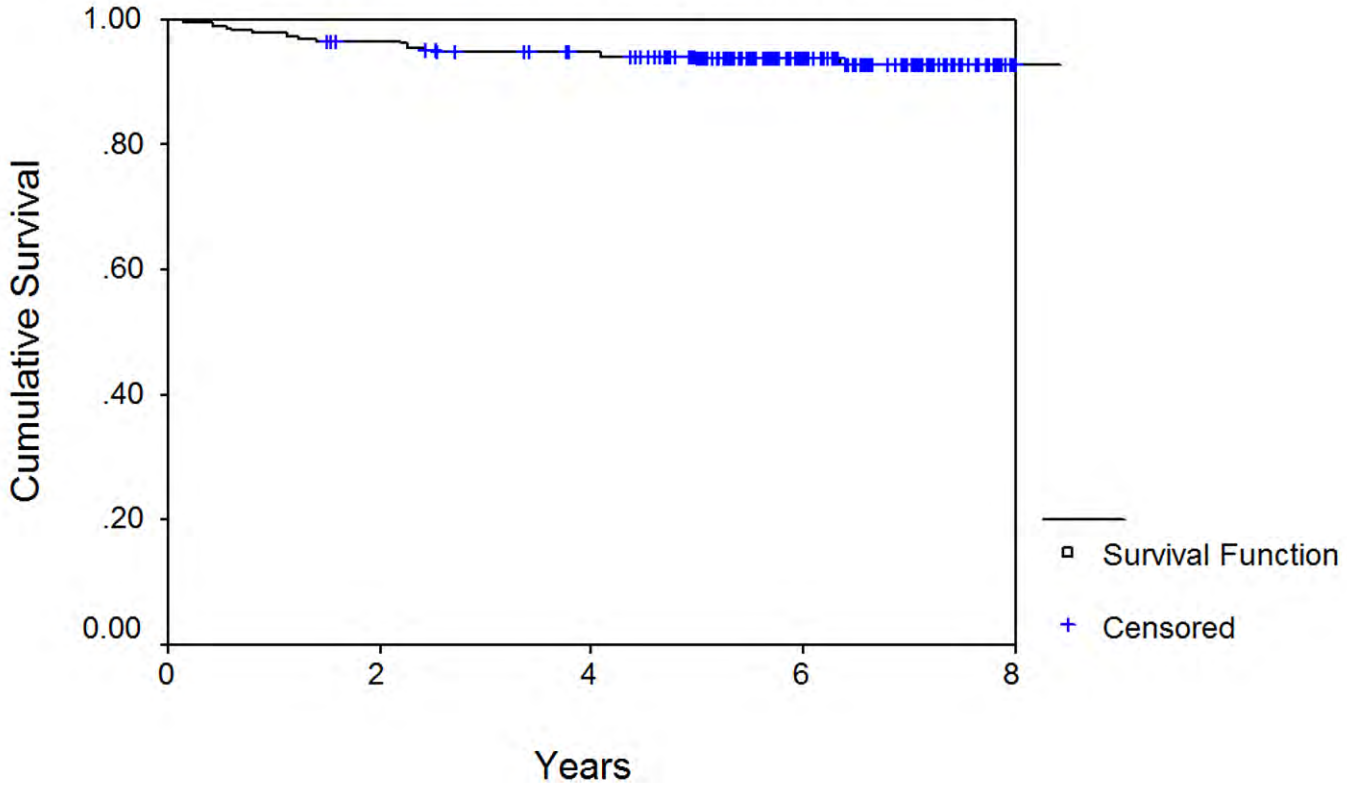
Methods: Patients at least five years out from arthroscopic double-row repair for a full-thickness cuff tear involving the supraspinatus tendon were included. Pre- and postoperative ASES, SF-12 PCS, QuickDASH, SANE, and satisfaction scores were collected. The relationship between outcomes and (1) tear chronicity, (2) number of tendons involved, (3) type of repair, and (4) primary versus revision procedure, was also evaluated. Kaplan-Meier survivorship analysis was conducted defining failures as progression to revision rotator cuff surgery.

Results: From November 2005 to February 2012, a total of 189 shoulders were eligible for inclusion. Fifteen shoulders (7.9%) underwent revision rotator cuff repair and were considered failures. Outcomes data were reported at a mean follow-up of 6.6 (range, 5.0-11.0) years. All outcome scores significantly improved from pre- to postoperative time point, including mean ASES (57.9 to 92.9, $P < 0.001$), SF-12 PCS (43.4 to 52.0, $P < 0.001$), QuickDASH (35.2 to 10.5, $P < 0.001$), and SANE scores (61.5 to 86.5, $P < 0.001$). Acute tears demonstrated significantly better ASES and SANE scores than chronic tears (ASES 95.1 ± 8.9 versus 91.7 ± 11.2, $P = 0.025$; SANE 89.6 ± 19.9 versus 85.7 ± 21.3, $P = 0.042$). No other analyzed variable had a significant association with outcomes scores ($P > 0.05$). Survivorship analysis demonstrated a postoperative clinical survivorship of the repair of 96.5% at two years and 93.8% at five years (Figure 1).

Conclusion: Patients can expect excellent clinical outcomes and a low failure rate following arthroscopic double-row repair of full-thickness supraspinatus tears at mid-term follow-up. The repair of acute tears and primary repairs were associated with better postoperative outcomes.

Double Row Repair

Clinical Survivorship Curve



Paper 124

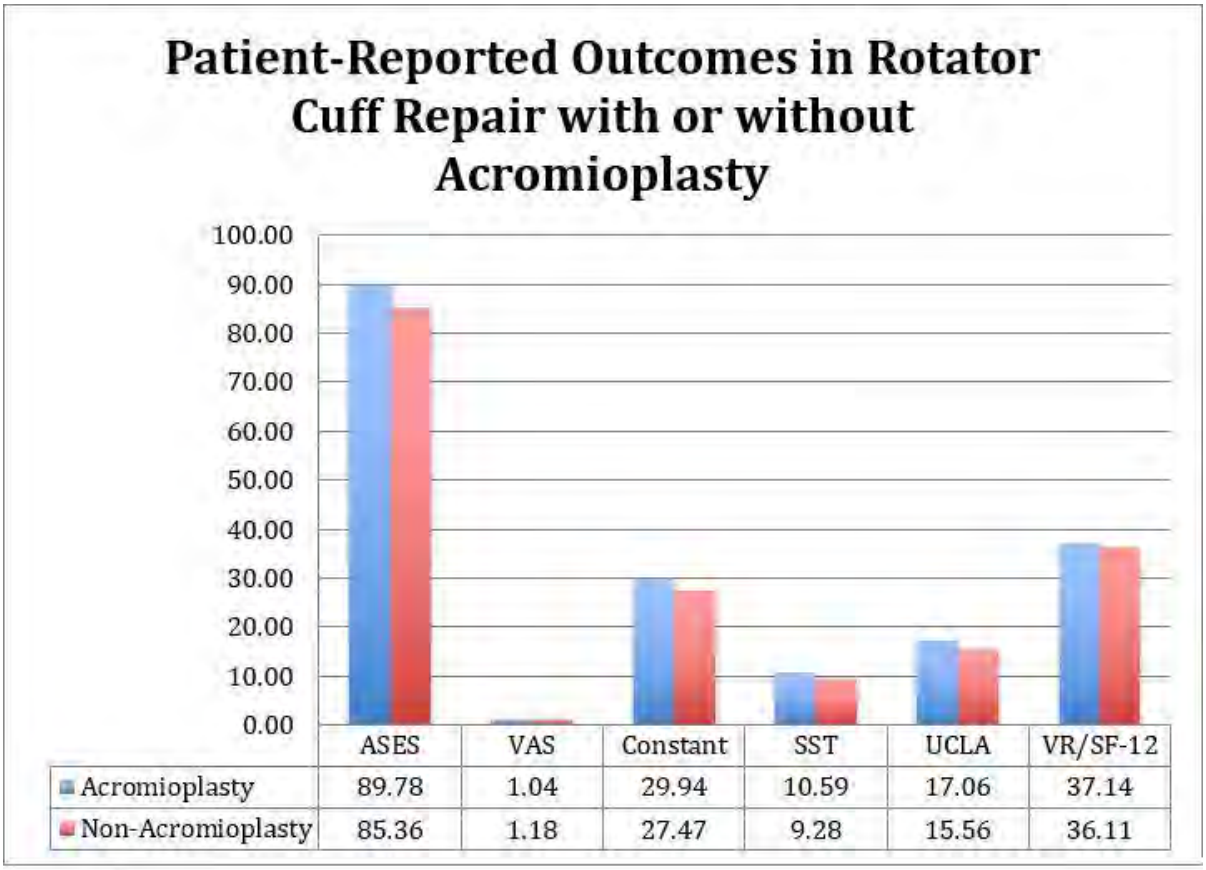
Title:
Randomized Prospective Trial of Arthroscopic Rotator Cuff With or Without Acromioplasty: No Difference In Patient-reported Outcomes At Long-term Follow-up

Authors:
Brian Robert Waterman, MD[1], Jonathan Newgren, MA[2], Anirudh K. Gowd, BS[2], Brandon C. Cabarcas, BS[2], Bernard R. Bach, MD[2], Brian J. Cole, MD, MBA[2], Anthony A. Romeo, MD[2], Nikhil N. Verma, MD[2].
[1]Wake Forest University School of Medicine, Winston Salem, NC, USA, [2]Midwest Orthopaedics at Rush, Chicago, IL, USA.

Objectives: To evaluate long-term clinical outcomes after arthroscopic rotator cuff repair with and without acromioplasty.

Methods: Between 2007-2011, prospectively-enrolled patients undergoing arthroscopic repair for full-thickness rotator cuff tears were previously randomized into either acromioplasty or non-acromioplasty groups. Patients with death, advanced neurologic conditions, or subsequent shoulder arthroplasty were excluded. Baseline and long-term follow-up questionnaires, including the American Shoulder and Elbow Surgeons (ASES), Simple Shoulder Test (SST), University of California-Los Angeles (UCLA), Visual Analog Scale (VAS) for pain, and Constant scores were obtained. Rates of revision rotator cuff surgery, or secondary reoperation were recorded. Averages with standard deviation (SD) were calculated, and t-tests were utilized to compare outcomes of interest between cohorts.

Results: After exclusion of 5 additional patients from the short-term follow-up study, 66 of 90 patients (73.3%) were available at 92.4 months (±10.5). Comparison of baseline demographics and intraoperative information revealed no significant differences, including age, gender, workers compensation, acute mechanism of injury, tear size, degree of retraction, and surgical technique (e.g. single- vs. double-row). At final follow-up, there were no statistically significant differences according to ASES (p=0.33), VAS pain (p=0.79), Constant (p=0.17), SST (p=0.05), UCLA (p=0.19), and SF-12 (p=0.79) in patients with and without acromioplasty (**Figure 1**). One patient with acromioplasty (2.9%) and two patients without acromioplasty (6.3%) sustained atraumatic recurrent rotator cuff tear with secondary repair (p=0.99).



	ASES	VAS	Constant	SST	UCLA	VR/SF-12
Acromioplasty	89.78	1.04	29.94	10.59	17.06	37.14
Non-Acromioplasty	85.36	1.18	27.47	9.28	15.56	36.11

Figure 1

Conclusion: Combined acromioplasty and rotator cuff repair offer no significant long-term benefits in patient-reported outcomes or secondary surgery when compared to arthroscopic rotator cuff repair alone.

Paper 125

Title:
Shoulder Injection Prior to Rotator Cuff Repair is Associated with Increased Risk of Subsequent Surgery

Authors:
Sophia Traven, MD, Daniel Brinton, MHA, MAR, Kit Simpson, DrPH, Zachary Adkins, MD, Alyssa Althoff, John Andrew Palsis, MD, Harris Slone, MD.
Medical University of South Carolina, Charleston, SC, USA.

Objectives: Corticosteroid injections (CSI) are frequently utilized in the nonoperative management of rotator cuff tears. However, recent literature suggests that injections may reduce biomechanical strength of tendons and ligaments in animal models and increase the risk of postoperative infections following surgery. The goal of this study was to determine if the timing of CSI is associated with an increased risk of reoperation following primary rotator cuff repair (RCR).

Methods: A retrospective analysis of claims data of privately-insured subjects from the MarketScan® database for the years 2010-2014 was conducted. A cohort of subjects aged 18-64 who were diagnosed with a rotator cuff tear and underwent repair in 2011 was identified. Multivariable logistic regression models were used to compare the odds of reoperation between groups.

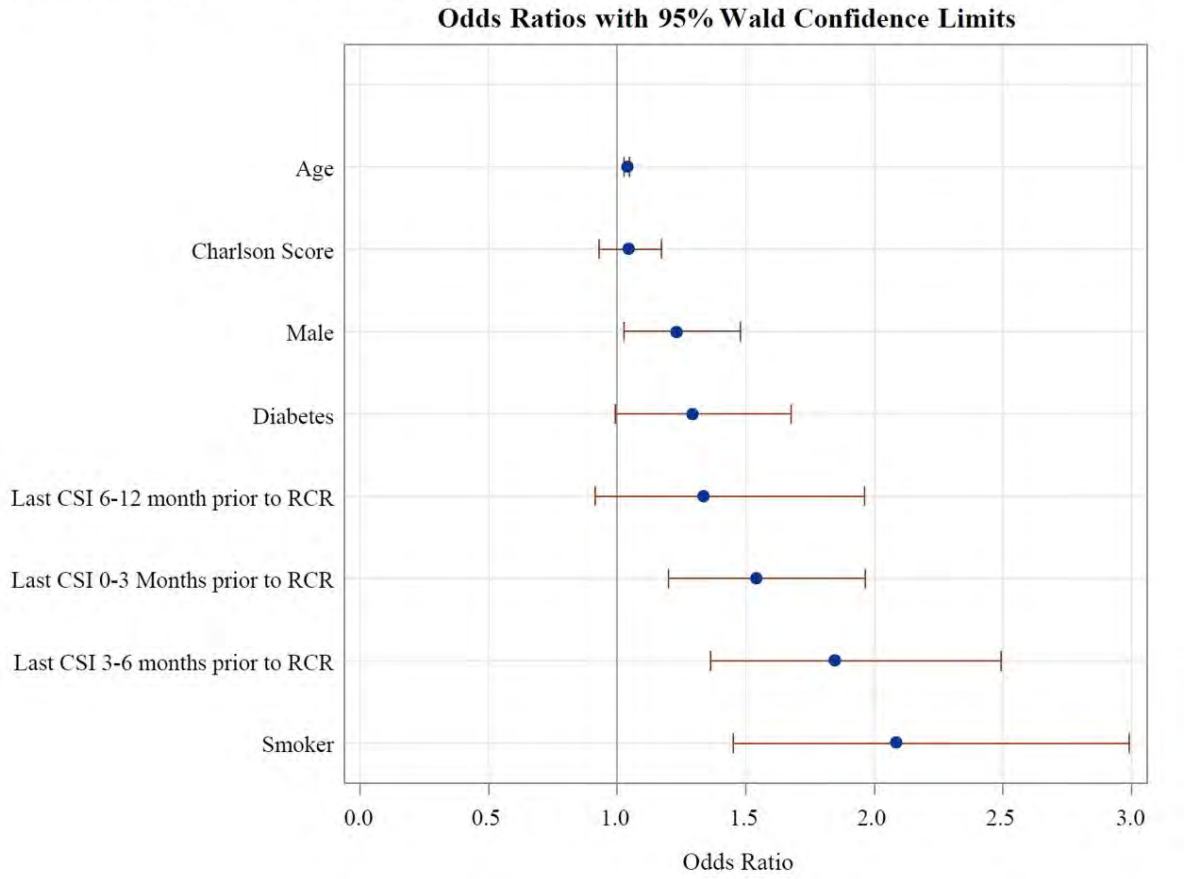
Results: A total of 4,959 subjects with an arthroscopic RCR were identified. Of this, 550 subjects required reoperation within the following 3 years. Patients who had a CSI within 6 months preceding the RCR were at a much higher risk of undergoing reoperation: 0-3 months prior, AOR 1.536 (95% CI: 1.201-1.965); 3-6 months, AOR 1.843 (95% CI: 1.362-2.494); and 6-12 months AOR 1.339 (95% CI: 0.914-1.962). Of those patients that underwent a reoperation, the most common surgery performed was revision rotator cuff repair followed by arthroscopic debridement (48.5% versus 38.9%, respectively).

Conclusion: Patients who had received a CSI within 6 months prior to RCR were much more likely to undergo a subsequent reoperation within the following 3 years. These odds diminished as more time passed between CSI and primary repair. Consideration should therefore be given to delaying primary rotator cuff repair for 6 months following injection.

Table 1. Unadjusted rate of reoperation, with and without previous CSI.

Group	# of Failures	# in Group	Failure Rate
Any reoperation, no CSI	356	3649	9.76%
Any reoperation, with CSI	197	1310	15.04%
Revision cuff repair, no CSI	254	3649	7.0%
Revision cuff repair, with CSI	138	1340	10.3%

Figure 1 Odds of reoperation following primary rotator cuff repair (RCR) among those who received a corticosteroid injection (CSI) in the 12-months prior to surgery.



Paper 126

Title:
The Use of a Bio-Inductive Collagen Patch to Supplement Repair of Large and Massive Rotator Cuff Tears Including Revisions: Clinical and Radiographic Outcomes at 2-year Follow Up

Authors:
Stephen Thon, MD[1], Lawrence K. O'Malley, MD[2], Michael John O'Brien, MD[3], Felix H. Savoie, MD[3].
[1]Tulane University Program, New Orleans, LA, USA, [2]MSMOC/Tulane, Jackson, TN, USA, [3]Tulane University, New Orleans, LA, USA.

Objectives: Failures of large, massive, and revision rotator cuff repairs is a challenging problem within orthopedics. Poor tendon tissue and vascularity are known causes for failure of rotator cuff repairs. The purpose of this study was to assess the outcomes and healing rates when large and massive rotator cuff repairs are augmented with a bio-inductive collagen scaffold patch.

Methods: Twenty-three patients undergoing repair of large (two tendon) or massive (three tendon) rotator cuff tears augmented with a bio-inductive collagen patch were followed prospectively for 2 years. Postoperative ultrasound (US) assessed tendon thickness at 3, 6, 12, and 24 months. MRI was utilized to confirm healing and tendon thickness at least 6 months post-operatively.

Results: 16 of 23 patients had previous failed rotator cuff repairs. Eleven patients had large rotator cuff tears while twelve patients had massive rotator cuff tears. 21 of 23 patients successfully healed their rotator cuff repairs and new tissue formation was appreciated in all 23 patients. Ultrasound rotator cuff thickness ranged from 4.5-9mm at most recent follow-up. Overall, a 91% (21/23) success rate was confirmed on US and MRI.

Conclusion: Clear indications for the use of this bio-inductive collagen scaffold have yet to be established. Our results show that it may have utility in improving the healing rates of large and massive rotator cuff repairs. New tendon formation was apparent on both US and MRI with relatively high healing rates at two years. While these early results are promising, long term-follow up is needed to identify the proper indications for its use. **Level of Evidence**: Level IV - Case series

Paper 127

Title:
Why Do Patients Decide to Have Surgery for Their Symptomatic Rotator Cuff Tear? A Prospective Study

Authors:
Danielle Weekes, MD[1], Weilong Jeffrey Shi[2], Christopher Hadley[3], Kevin B. Freedman, MD[4], Matthew D. Pepe, MD[5], Bradford S. Tucker, MD[6], Fotios P. Tjoumakaris, MD[1].
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Objectives: While rotator cuff pathology may be amenable to conservative therapy, patients with full thickness tears not improving with non-operative treatment are indicated for repair. The decision to undergo surgery is often multifactorial with pain, loss of function, and concern for progression all factoring in the decision-making process. The purpose of this investigation was to evaluate patients main determining factors in deciding to have surgery for their rotator cuff tear, correlate these factors with strength of surgeon recommendation and clinical outcomes.

Methods: One hundred and fifty patients undergoing arthroscopic rotator cuff repair (ARCR) were enrolled prospectively. Patients received a questionnaire preoperatively to determine why they decided to proceed with surgical repair. This 13-question survey was developed based on evidence-based review of rotator cuff repair literature and the Delphi technique. Patients were asked to rate each factor with regard to importance in their decision to proceed with repair. Surgeons were given a similar Likert Scale and were queried on how strongly they would recommend surgery for their patients based upon various factors such as MRI findings, age, etc. Pre- and post-operative shoulder function was assessed with the American Shoulder and Elbow Society (ASES) Score. Descriptive statistics were used to evaluate the reasons to proceed with surgery and correlated with outcomes based on ASES scores.

Results: The most influential patient reported factors for proceeding with surgical repair were: limited functionality of the shoulder (81%), surgeon recommendation (80%), and daily chronic pain (77%). Patients improved from 42.6 to 77.0 on the ASES from baseline to 6-months ($p<0.001$). Patients who listed that they were unable to play a favorite sport or hobby as their top reason for surgery demonstrated a significant increase in their ASES score relative to other factors at the 3 month time point ($p=0.0014$); otherwise, there was no significant difference in outcomes for any other time point based on category importance. Subgroup analysis of males and females and older v. younger patients demonstrated significant findings. Females were more likely to proceed with repair due to inability to sleep and daily, chronic pain ($p<.005$) relative to males. Younger patients were more likely to proceed with repair for the inability to play a sport/hobby and increased demands of work relative to older patients ($p<.005$). There was no correlation between any decision factor and final outcome of ASES scores. Younger patients and male patients both demonstrated higher baseline ASES scores ($p<.05$); however, there was no difference in outcome measures at final follow-up.

Conclusion: Prior studies have shown that rotator cuff repair is best at alleviating pain for full thickness rotator cuff tears and may not be as impactful for improving function. Despite this evidence, the majority of patients undergoing rotator cuff repair in our study did so to improve function of their shoulder. While pain, inability to sleep, and inability to participate in ones favorite hobby/sport were important to our patient population, a strong surgeon recommendation had no correlation with our patients decision to proceed with repair. Surgeons should be mindful of these differences between gender and age when counseling patients pre-operatively. Outcomes of ARCR do not appear to be determined by pre-operative decision making on the part of the patient.

Paper 128

Title:
Ulnar Collateral Ligament Repair with Internal Brace Augmentation in Amateur Overhead Throwing Athletes

Authors:
Jeffrey R. Dugas, MD[1], **Christopher A. Looze, MD**[2], Christopher Michael Jones, MD[3], Brian L. Walters, MD[4], Marcus A. Rothermich, MD[2], Benton A. Emblom, MD[1], Glenn S. Fleisig, PhD[5], Kyle Aune, MPH[5], E. Lyle Cain, MD[1].
[1]Andrews Sports Medicine & Orthopaedic Center, Birmingham, AL, USA, [2]ASMI/Trinity/Lemak Sports Medicine Program, Birmingham, AL, USA, [3]University of South Alabama, Mobile, AL, USA, [4]American Sports Medicine Institute (St. Vincent's) Program, Birmingham, AL, USA, [5]American Sports Medicine Institute, Birmingham, AL, USA.

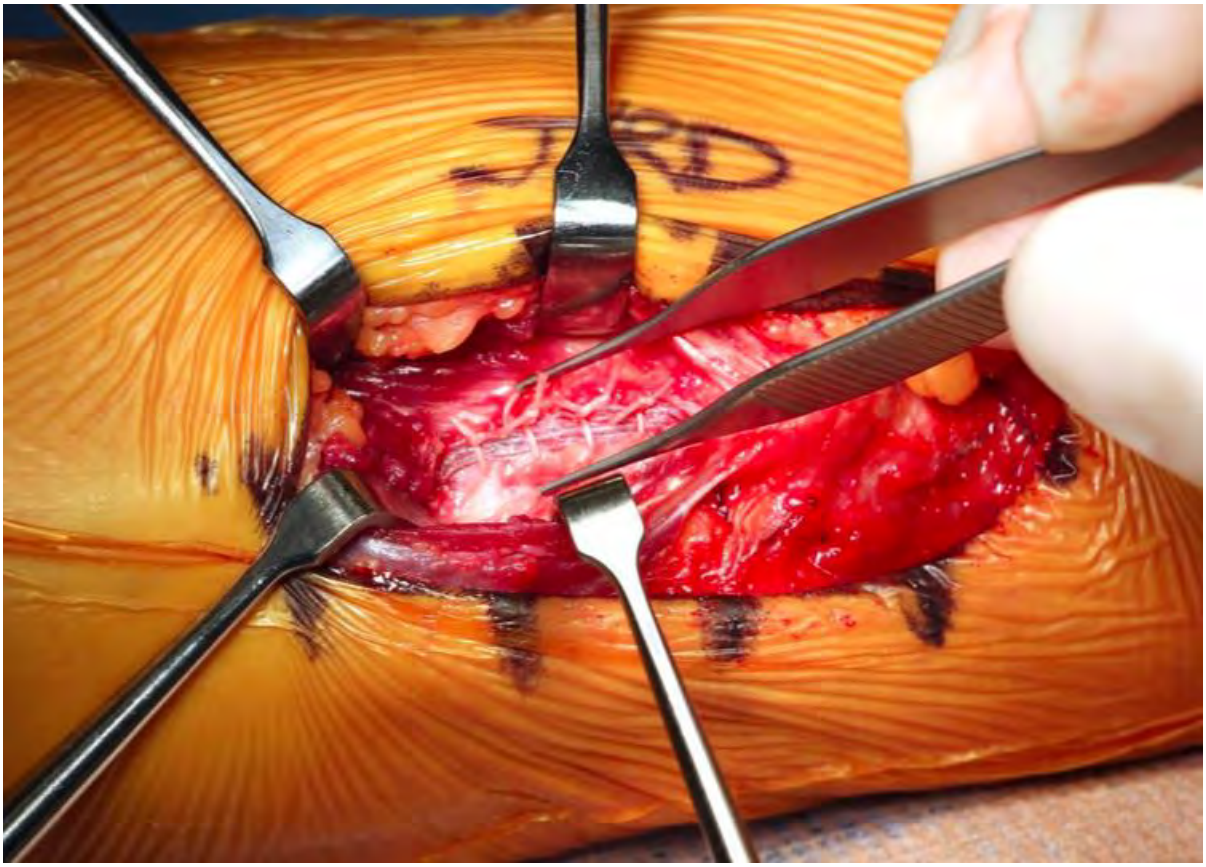
Objectives: There has been a renewed interest in UCL repair in overhead athletes. This is largely due to greater understanding of UCL pathology, improvement in fixation technology and the extensive rehab required to return from UCL reconstruction. Initial data regarding UCL repair in overhead athletes was poor and therefore UCL repair was largely abandoned in favor of reconstruction. However, recent literature examining UCL repair with anchor only fixation demonstrated an excellent rate of return to play, reduced time to return to play and a low complication rate. Based on this promising data, we have developed a novel technique of UCL repair with internal brace augmentation that we have used in overhead throwing athletes. We performed a prospective study evaluating the outcomes of this procedure with respect to return to play, time to return to play, functional outcome score and complications.

Methods: Overhead athletes undergoing UCL repair with internal brace augmentation were prospectively followed for a minimum of one year. Patients were carefully selected from those who would traditionally be considered for UCL reconstruction. Initially, patients were considered if they had an avulsion of the UCL with otherwise healthy UCL tissue and had a vested interest in shortened rehab. As the study progressed, interest in shortened rehab became a less stringent criteria. Demographic and operative data were collected at the time surgery. This data was compiled for both desciption and comparison between subgroups. Patients were then contacted 1 year postoperatively and assessed for return to play, time to return to play and KJOC scores. Complications were documented and patients having complications were detailed.

Results: 66 overhead athletes underwent UCL repair with internal brace augmentation during the study period. 8 were lost to follow up, leaving 58 athletes included in the study. Average age at the time of surgery was 17.9 years old. There were 43 baseball pitchers, 8 baseball position players, 4 softball players, 2 football quaterbacks, and 1 javelin thrower. 96% (54/56) of those who desired to return to the same or higher level of competition were able to do so at an average time of 6.1 months (range 3.2-12 months). 65% of these were able to return in less than 6 months. Many of those who took longer than 6 months did so due to timing within the season. Average KJOC score was 90.2 at 1-year follow-up. 3 patients required return to the operating room, 2 of which were eventually able to return to their previous level of play. There was 1 late failure over 3 years from the index procedure. Comparative

subgroup data is presented in table 1.

Conclusion: UCL repair with internal brace augmentation is a viable option for overhead throwers with selected UCL pathology who wish to return to sport in a shorter time frame than allowed by traditional UCL reconstruction.



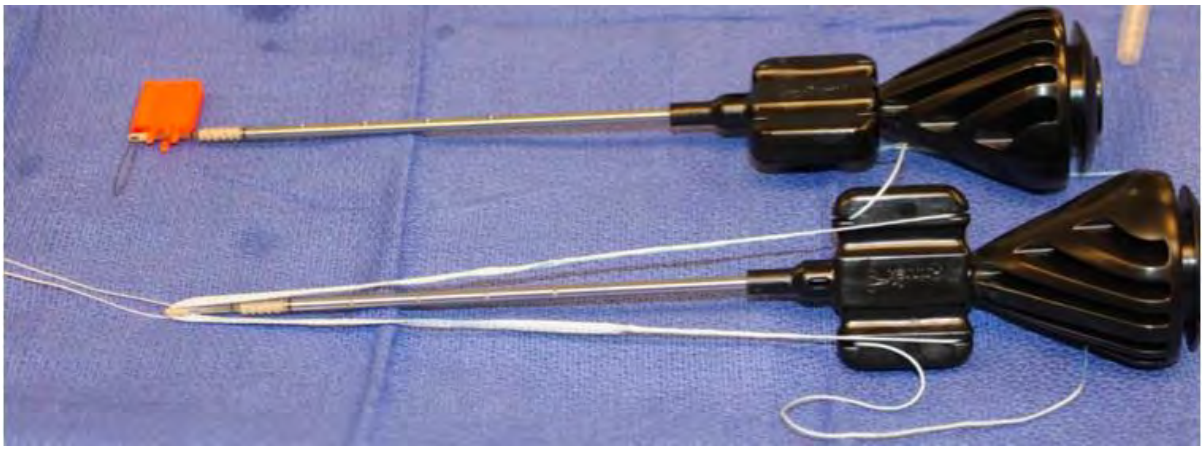


Table 1

Comparative Analysis of Subgroups

	N	KJOC	P-value	Time to return to play (Months)	P-value
Location of tear					
Distal	34	89.6		6.00	
Proximal	24	90.6	P=0.71	6.19	P=0.74
Severity of tear					
Partial	35	89.5		6.14	
Complete	23	91.4	P=0.51	6.08	P=0.86
Ulnar Nerve Transposition					
UNT performed	32	90.9		6.40	
UNT not performed	26	89.4	P=0.17	5.75	P=0.16
Overall	58	90.2		6.13	

Paper 129

Title:
Radiographic Predictors of Elbow Injury and Surgery in Major League Baseball Pitchers

Authors:
Grant Garcia, MD[1], Anirudh K. Gowd, BS[1], Brandon C. Cabarcas, BS[2], Joseph N. Liu, MD[1], Anthony A. Romeo, MD[1], **Nikhil N. Verma, MD**[1].
[1]Midwest Orthopaedics at Rush, Chicago, IL, USA, [2]Midwest Orthopedics at Rush, Chicago, IL, USA.

Objectives: To evaluate predictive ability of asymptomatic screening MRI's of Major League Baseball (MLB) pitchers and compare associated findings with future DL placement, pitching statistics, and elbow surgery.

Methods: A total of 40 consecutive asymptomatic elbow MRI's in MLB pitchers at a single organization were analyzed from 2005 - 2017. Asymptomatic MRI was defined as a screening MRI at time of contract signing having been performed at least 6 months prior to DL placement for any elbow-related injury. Publicly available DL data, career innings pitched, career games started, career pitch count, and career max velocity of pitch were obtained. A blinded investigator examined each MRI for pathological signals. Data was analyzed on players that were eventually placed on the DL compared to those with no DL placement.

Results: 40 consecutive elbow MRIs of MLB players were reviewed. The average age of the injured cohort was 28.3 ± 3.2 years (16 players) and 28.8 ± 5.5 years (24 players) for the non-injured cohort. There was no statistical difference in age, handedness, height, weight, or pitching stats between the injured and non-injured cohorts. Abnormal radiographic signal intensity in the UCL ($p<0.001$) and humeral elevation of the UCL ($p=0.01$) were significantly associated with future DL placement. Those injured spent an average of 200.7 days and 191.7 days in the DL with signal in the UCL and those with humeral elevation of the UCL, respectively. Ulnar elevation/signal of the UCL ($p=0.06$), and posteromedial impingement ($p=0.08$) were approaching statistical significance. Of those injured 68.8% (11/16) underwent elbow surgery. Findings of ligament signal intensity ($p<0.001$), ulnar-sided UCL elevation ($p=0.018$), humeral-sided UCL elevation ($p=0.002$), and posteromedial impingement ($p=0.042$) were all significantly associated with future surgery. There was no significant correlation between injury and radiocapitellar or ulnohumeral chondral lesion, bone edema, loose bodies, or flexor-pronator mass muscle defect. The presence of a flexor-pronator mass muscle defect was associated with a significantly reduced number of innings pitched (53.7 ± 74.3 vs. 304.4 ± 305.5 innings, $p=0.0317$), games started (5 ± 7.1 vs. 40.1 ± 49.0 games, $p=0.004$), and pitch count (680.5 ± 919.9 vs. 40.1 ± 49.0 pitches, $p=0.022$). The presence of ligament signal (26.2 ± 37.1 vs. 51.7 ± 56.5 games, $p=0.036$) and ulnar elevation (6.3 ± 9.3 vs. 41.2 ± 9.3 games, $p=0.003$) was associated with significantly fewer games started. The presence of bone edema was associated with significantly decreased pitch count (1451.2 ± 1746.8 vs. 4128.0 ± 4718.0 pitches, $p=0.023$). There was no association between humeral UCL elevation, flexor-pronator mass tendon, or posteromedial impingement with innings pitched, games started, or pitch count.

Conclusion: The heavy demand placed on the elbow joint in professional pitching produces degenerative changes visible on MRI prior to any symptoms, as demonstrated in previous studies.

Specific degenerative changes in the UCL Ligament, particularly humeral sided elevation of the UCL, are significantly associated with future injury.

Radiographic Findings on Elbow MRI as Related to Placement on Disabled List and Pitching Stats

	N (%): Injury vs. Non-Injury	Relation to Injury (p)	Relation to DL days (p)	Relation to Future Surgery (p)	Relation to inningsPitched (p)	Relation to GamesStarted (p)	Relation to Pitch Count (p)	Relation to Max Pitching Velocity (p)
Radiocapitellar Chondral Lesion	Diffuse: 1 (6.25%) 0 (0%) Focal: 2 (12.5%) 3 (12.5%) None: 13 (81.3%) 21 (87.5%)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Ulnohumeral Chondral Lesion	Diffuse: 0 (0%)0(0%) Focal: 1 (6.25%) 0 (0%) None: 15 (93.8%) 24 (100%)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
ArticularCartilage Bone Edema	3 (18.8%) 3 (12.5%)	0.6678	0.5961	1	0.5661	0.9471	**0.0227**	*0.0788*
UCL Ligament Signal Heterogeneity/Hyperintensity	15 (93.8%) 1 (4.2%)	**p < 0.001**	N.S.	**p < 0.001**	*0.0563*	0.1487	**0.0357**	0.8186

Ulnar-Sided Elevation/Signal	3 (18.8%) 0 (0%)	*0.063 73*	0.359 1	**0.017 7**	0.1010	**0.0032**	0.182 9	0.8683
Humeral-Sided Elevation/Signal	9 (56.3%) 3 (12.5%)	**0.010 3**	0.724 0	**0.001 8**	0.7778	0.7134	0.216 7	0.9052
Frank UCL Tear	0 (0%)0 (0%)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Flexor-Pronator Mass Defect	1 (6.3%)1 (4.2%)	1	N.S.	1	**0.0317**	**0.0035**	**0.022 3**	N.S.
Flexor-Pronator Mass Tendon Signal	8 (50%)2 (29.2%)	0.204 6	**0.026 1**	1	0.8311	0.7951	0.965 7	0.7875

Paper 130

Title:
Comparative Analysis of the Nonoperative Treatment of Elbow Ulnar Collateral Ligament Injuries in Professional Baseball Players with and without Platelet-Rich Plasma

Authors:
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[1]Scripps Clinic, San Diego, CA, USA, [2]Mayo Clinic, Rochester, MN, USA, [3]Hospital for Special Surgery/Cornell Medical Center Program, New York, NY, USA, [4]Hospital for Special Surgery, New York, NY, USA, [5]Major League Baseball, New York, NY, USA, [6]Rothman Institute at Thomas Jefferson University Hospital, Philadelphia, PA, USA, [7]Scripps Clinic Medical Group, La Jolla, CA, USA.

Objectives: In the setting of ulnar collateral ligament (UCL) injury, surgical reconstruction of the UCL is not always selected, as it leads to a prolonged recovery time and return to play rates between 67-95%. To date, there is limited data on outcomes following nonoperative treatment in this population. Orthobiologics, such as platelet-rich plasma (PRP), have recently been used as an adjunct therapy for standard nonoperative treatment including rest and physical therapy for UCL injuries. The objective of this study was to determine if the addition of PRP injections in professional baseball players with UCL injuries reduces recovery time, lowers the likelihood of surgery, and increases the return to play rate compared to traditional nonoperative treatment.

Methods: The Health and Injury Tracking System (HITS) database was searched from 2011-2015 for Major and Minor league baseball players with Grade I, II or III UCL injuries. Standard demographic, injury, and return to play data was obtained for all players. MRI's for 353 athletes were reviewed by a musculoskeletal radiologist and graded accordingly. Outcomes were compared between players who received PRP injections in addition to traditional nonoperative treatment (PRP group) and players who received traditional nonoperative treatment alone (No PRP group). Statistical analysis was performed using Student's T-test and Chi-square for parametric data. Kaplan Meier's analysis was used for estimating longevity of the treatment.

Results: A total of 544 Major and Minor League Baseball players with UCL tears underwent an initial course of nonoperative treatment (active rest & rehabilitation) for their injury between 2011-2015. Of these, 133 underwent PRP injections plus rehab and 411 underwent rehab alone. There was a significantly higher proportion of Major League Baseball players in the PRP group compared to the No PRP group (25.6% vs 9.0%, $P<0.001$). There was no difference between the two cohorts in regard to the grade of UCL tear (Figure 1). The players in the PRP group had a significantly longer time before returning to a throwing program compared to the No PRP group (64 days vs 51 days, $P<0.001$). The mean time from injury date to PRP injection was 14.5 days, which may explain the difference in time to return to throwing. The return to play rate in a live game without surgery was significantly lower in the PRP group compared to the No PRP group (46% vs 57%, $P=0.03$). There was no difference in the proportion of athletes requiring UCL reconstruction (58% vs 51%) or the time to surgery (154 days vs 178 days) between the two groups. Kaplan Meier survivor analysis showed no difference between the

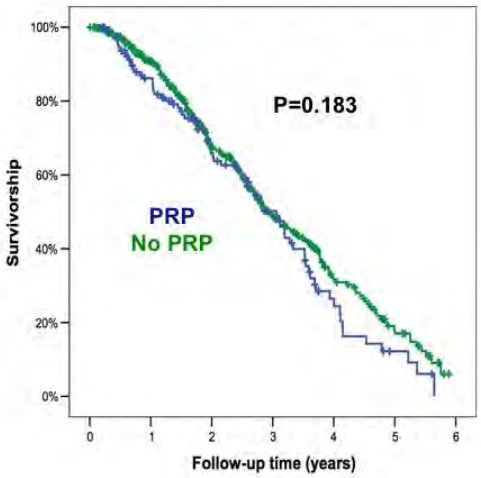
PRP and No PRP groups with regard to longevity of the native UCL (Figure 2).

Conclusion: Among Major and Minor League Baseball players who were treated nonoperatively for a UCL injury between 2011-2015, 24% underwent PRP injections prior to rehab. Compared to traditional nonoperative rehab alone program, players who received PRP injections experienced a significantly longer time before returning to throwing, which may be in part due to the delay between the injury date and PRP injection. PRP injections did not appear to have a significant effect on the likelihood of surgical intervention.

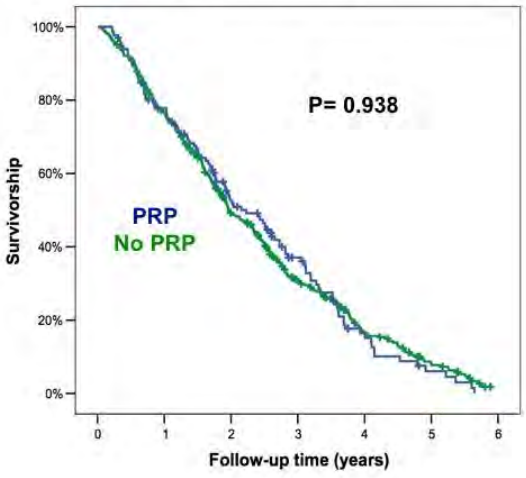
Demographics		PRP	No PRP
Age* (p < 0.001)	<20	6.8%	18.2%
	20-25	61.7%	66.9%
	>25	31.6%	14.8%
League Status* (p < 0.001)	Minor League	74.4%	91.0%
	Major League	25.6%	9.0%
Player Position	Position Player	17.3%	18.5%
	Relief Pitcher	29.3%	29.2%
	Starting Player	53.4%	52.3%
Injury, Treatment Data, Return to Play Data			
MRI Grade of UCL Tear	Grade I	37.3%	34.9%
	Grade II	49.0%	47.9%
	Grade III	13.7%	17.2%
Return to Throwing Program	Returned	87%	86%
	Unable to Return	13%	14%
Return to Throwing Program (Days) * (p<0.001)		64	51
Return to Competitive Play (p = 0.03)	Returned without Surgery	46.2%	57.2%
	Failed Nonoperative Treatment	53.8%	42.8%
Final Treatment Outcome	UCL Reconstruction	58%	42%
	No Surgery	51%	49%
Time between Injury and Surgery (days) after Failed Nonoperative Treatment		154	178

Kaplan-Meier Analysis for Native UCL Survivorship

Surgery or Reinjury as an Endpoint



Surgery, Reinjury, Retirement/Release as an Endpoint



Paper 131

Title:
Comparison of Outcomes Based on Graft Type and Tunnel Configuration for Primary Ulnar Collateral Ligament Reconstruction in Professional Baseball Pitchers

Authors:
Timothy B. Griffith, MD[1], Christopher S. Ahmad, MD[2], Michael G. Ciccotti, MD[3], John D'Angelo[4], Joshua S. Dines, MD[5], David W. Altchek, MD[6], Christopher L. Camp, MD[7].
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Objectives: Professional baseball pitchers are at high risk for tears of the ulnar collateral ligament (UCL) of the elbow, often requiring subsequent surgical reconstruction. Despite acceptable published return to play outcomes, multiple techniques and graft types have been described. There is a paucity of clinical data in the current literature comparing UCL reconstruction surgical technique and graft type. Even less is known about the risks for subsequent injury, surgery, or revision UCL reconstruction. Accordingly, this study compares UCL reconstruction outcomes based on tunnel configuration and graft type.

Methods: Following approval from our institutional review board and Major League Baseball (MLB), 566 professional baseball pitchers who underwent UCL reconstruction between 2010 and 2014 were identified and included. The following patient demographics were analyzed: age, pitching role (starter vs. reliever), level of play (MLB vs. Minor League Baseball [MiLB]), and throwing side dominance. Surgical factors analyzed included reconstruction technique (Docking vs. Modified Jobe), graft type (palmaris longus autograft vs. gracilis autograft), and concomitant procedures. Primary outcome measures consisted of: the ability to return to play at any level (RTP), to return to the same level of play (RSL), the time to return, subsequent elbow injuries, and the need for subsequent or revision elbow surgery. The impact of the patient and surgical factors on outcomes were analyzed using multivariate linear and logistic regression modeling.

Results: The overall RTP was 79.9% and RSL was 71.2%. There were no significant differences in the time to RTP or RSL based on reconstruction technique or graft type. RTP rates were similar for the Docking vs. Modified Jobe techniques (80.1% vs. 82.4%; p=0.537) and for the two primary graft types (83.1% for palmaris vs. 80.7% for gracilis; p=0.596). The risk of subsequent elbow surgery was 10.5% for the Docking Technique vs. 14.8% for the Modified Jobe (p=0.203); and the risk for subsequent UCL revision reconstruction surgery was 2.9% vs. 6.2% for the Docking vs. Modified Jobe Techniques, respectively (p=0.128). Significant trends towards an increasing use of palmaris autograft (p=0.023) and the docking technique (p=0.006) were observed. MLB pitchers were more likely than MiLB pitchers to RTP (p<0.001) and to RSL (p<0.001), but they required a longer time to return (mean difference 35 days; p=0.039), had a higher likelihood of subsequent elbow (OR 3.58; 95% CI 2.055 to 6.231; p<0.001) and forearm injuries (OR 5.695; 95% CI 1.99 to 16.302; p=0.004), but not subsequent elbow surgery. No specific variables were noted to be predictive of subsequent elbow or revision surgery in the multivariate analysis.

Conclusion: Surgical outcomes in professional baseball players are not significantly influenced by ulnar collateral ligament reconstruction technique or graft type usage. Major League players are more likely to RTP and RSL, but they have a higher frequency of subsequent elbow and forearm injuries. Both the Docking Technique and palmaris autograft are increasing in popularity amongst surgeons treating professional baseball players.

Paper 132

Title:
Incidence and Clinical Significance of Posterior Glenoid Deficiency in Patients with Posterior Glenohumeral Instability

Authors:
Michael Elsenbeck, MD[1], Jared Wolfe, MD[1], Kyle E. Nappo, M.D.[1], Daniel Christensen, MD[1], Robert A. Waltz, MD[2], Lance E. LeClere, MD, LCDR, MC, USN[3], Jonathan F. Dickens, MD[1].
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Objectives: Posterior glenohumeral instability accounts for 10-40% of instability repairs yet the degree posterior bone deficiency contributing to labral repair failure is unclear. The purpose of this study is to determine the incidence, characteristics, and clinical impact of posterior glenohumeral bone deficiency in patients undergoing posterior shoulder stabilization.

Methods: All consecutive patients undergoing isolated soft tissue only posterior labral repairs from 2008-2016 at our institution were identified via review of surgical case logs. Posterior bone deficiency was calculated using the best fit circle method along the inferior 2/3s of the glenoid by two independent observers. The intra-observer and inter-observe reliability ICC of this method was .96 and .86, respectively. Patients were divided into three groups, no bone loss (0-5%), minimal bone loss (5-13.5%) and moderate posterior bone deficit (>13.5%). Our primary outcome, was reoperation for any reason, secondary outcomes were military separation due to the operative shoulder, and placement on permanent restricted duty due to the operative shoulder. Additional comparisons between the groups were made on the basis of preoperative clinical and radiographic characteristics.

Results: We identified 66 patients that met our inclusion and exclusion criteria. Our median follow up time was 22 months (range 7-144months). 39 of the 66 patients had no measureable bone deficiency while 18 patients had between 5 and 13.5%, and 9 patients had greater than 13.5%. The greatest amount of bone deficiency in a patient was 27%. The reoperation rates were 7.7% in the no bone deficiency group, 16% in the minimal bone deficiency group, and 33% in the moderate group, this difference was statistically significant (p=.036). There was no difference in rates of military separation, or restricted duty between groups. Additionally, patients with posterior glenoid bone deficiency, were more likely to complain of instability instead of pain on initial presentation (p=.002), and were more likely to have a positive posterior load shift test (p=.027).

Conclusion: Posterior glenoid bone deficiency is common and potentially under recognized in patients undergoing surgery for posterior glenohumeral instability with over one-third of our patients having some degree of bone deficiency. In patients with moderate glenoid bone deficiency (>13.5%), soft tissue only stabilization procedures may have higher reoperation rates then in patients without bone deficiency. On preoperative evaluation the primary complaint of instability instead of pain and a positive posterior load shift were predictive of the presence of posterior glenoid bone deficiency.

Paper 133

Title:
Automated 3D MRI Allows for Accurate Evaluation of Glenoid Bone Loss as Compared to 3D CT

Authors:
Drew A. Lansdown, MD[1], Robert Dawe[2], Gregory L. Cvetanovich, MD[3], Nikhil N. Verma, MD[3], Brian J. Cole, MD, MBA[4], Bernard R. Bach, MD[4], Gregory P. Nicholson, MD[4], Anthony A. Romeo, MD[4], Adam Blair Yanke, MD[3].
[1]University of California, San Francisco, San Francisco, CA, USA, [2]Rush University, Chicago, IL, USA, [3]Midwest Orthopedics at Rush, Chicago, IL, USA, [4]Midwest Orthopaedics at Rush, Chicago, IL, USA

Objectives: Glenoid bone loss is frequently present in the setting of recurrent shoulder instability. The magnitude of bone loss is an important determinant of the optimal surgical treatment. The current gold-standard for measurement of glenoid bone loss is three-dimensional (3D) reconstruction of a computed tomography (CT) scan. CT scans, however, carry an inherent risk of radiation and increased cost for a second modality. Magnetic resonance imaging (MRI) offers excellent soft tissue contrast and may allow resolution of bony structures to generate 3D reconstructions without a risk of ionizing radiation. We hypothesized that automated 3D MRI reconstruction would offer similar measurements of glenoid bone loss as recorded from a 3D CT scan in a clinical setting.

Methods: A retrospective review was performed for fourteen patients who had both pre-operative MRI scan and CT scan of the shoulder. All MR scans were performed on a 1.5 T scanner (Siemens) utilizing a Dixon chemical shift separation sequence and the out-of-phase images with 0.90 mm slice thickness. Reconstructions of the glenoid were performed from axial images (Figure 1A) using an open-platform image processing system (3D Slicer; slicer.org). A single point on the glenoid was selected and a standard threshold was used to build a 3D model (Figure 1B). High-resolution CT scans underwent 3D reconstruction in Slicer based on Houndsfield Unit thresholding. Glenoid bone loss on both scans was measured with the Pico method by defining a circle of best fit using the inferior 2/3 of the glenoid and determining the percent area missing from this circle. Pearson's correlation coefficient was utilized to determine the similarity between MR and CT based measurements. Statistical significance was defined as $p<0.05$.

Results: The correlation between 3D MR and CT-based measurements of glenoid bone loss was excellent ($r = 0.95$, $p<0.0001$). The mean bone loss as measured by the 3D MR was 13.2 +- 7.2% and was 12.5 +- 8.6% for the 3D CT reconstruction ($p=0.32$). Bone loss in this cohort ranged from 3.7-25.4% on 3D MR and 1.4-26.0% on 3D CT. The root-mean-square difference between measurements was 2.7%.

Conclusion: There was excellent agreement between automated 3D MR and 3D CT measurements of glenoid bone loss and minimal differences between these measurements. This reconstruction method requires minimal post-processing, no manual segmentation, and is obtained with widely-available MR sequences. This method has the potential to decrease the utilization for CT scans in determining glenoid bone loss.

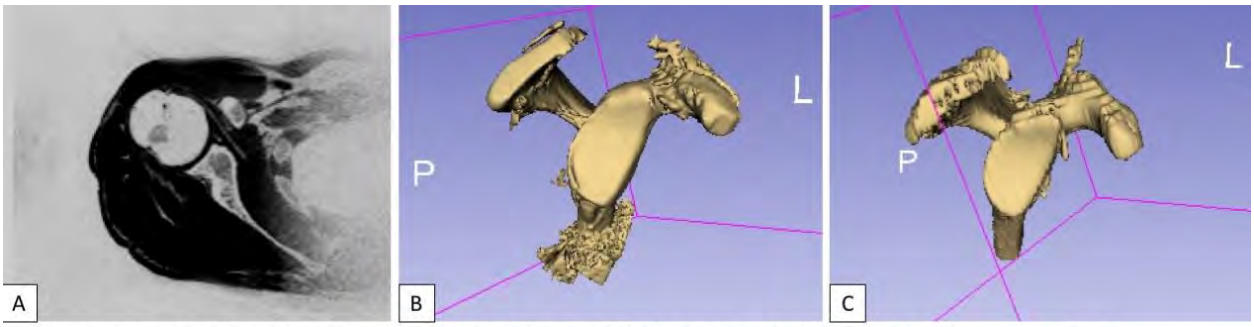

Figure 1. (A) An axial T1-weighted Dixon subtraction MR image of the glenoid is used to develop a three-dimensional reconstruction of the glenoid. The three-dimensional reconstruction is shown for one patient for both MR scan (B) and CT scan (C), both produced in 3D Slicer with a single click on the glenoid and a threshold-based reconstruction method.

Paper 134

Title:
90-Day Complications Following the Anterior Glenoid Bone Grafting for Shoulder Instability

Authors:
Rachel M. Frank, MD[1], Catherine Richardson, BS[2], Bonnie Gregory, MD[3], Shelby Sumner, MPH[4], Michael C. O'Brien, MA[2], Emon Bernardoni, MS[3], Nikhil N. Verma, MD[3], Brian J. Cole, MD, MBA[3], Gregory P. Nicholson, MD[3], Matthew T. Provencher, MD[5], Anthony A. Romeo, MD[3].
[1]University of Colorado School of Medicine, Aurora, CO, USA, [2]Rush University Medical Center, Chicago, IL, USA, [3]Midwest Orthopaedics at Rush, Chicago, IL, USA, [4]Rush University Medical Center - Chicago, IL, Chicago, IL, USA, [5]The Steadman Clinic, Vail, CO, USA.

Objectives: To describe complications occurring within 90-days following the distal tibia allograft (DTA) procedure.

Methods: Consecutive patients undergoing DTA for anterior glenohumeral instability by fellowship-trained surgeons were included for analysis. Indications for DTA included primary or recurrent anterior instability with clinically significant anterior glenoid bone loss, failed prior arthroscopic stabilization, and/or failed prior Latarjet. All complications that occurred within 90-days of surgery were analyzed and correlated with demographic factors.

Results: A total of 63 consecutive patients (average age 26.4±8.2 years, 90% male) were included. Fifty patients (79%) had undergone prior ipsilateral shoulder surgery, including 8 undergoing prior Latarjet (13%). The average glenoid bone loss prior to DTA was 29±7%. There were 5 total complications within 90 days of surgery, for an overall short-term complication rate of 7.9%. The 58 patients without complications had an average age of 26.2±7.9 years (95% male), with 45 (78%) having had prior shoulder surgery. Three of these 5 required subsequent surgery, including 1 revision DTA for hardware failure, 1 subscapularis repair, and 1 debridement for retained foreign body. The remaining 2 complications were transient and resolved with non-operative treatment, including 1 patient with postoperative pain requiring a subacromial injection, and 1 patient with a stitch abscess treated with oral antibiotics. The 5 patients experiencing complications had an average age of 29.0±11.5 years (40% male), with all 5 (100%) having had prior shoulder surgery. There were no episodes of recurrent instability.

Conclusion: The overall 90-day complication rate following DTA is 7.9%, substantially lower than the previously described rate of 25% in patients undergoing Latarjet, despite the majority of patients having had at least 1 prior ipsilateral shoulder surgery. This information can be used to counsel patients on the risks of early complications following DTA.

Paper 135

Title:
Efficacy of Osteochondral Allograft Transplantation in the Knee in Adults Forty Years and Older

Authors:
Katlyn Robinson, BS, **Dennis C. Crawford, MD**.
Oregon Health and Science University, Portland, OR, USA.

Objectives: Fresh osteochondral allograft transplantation (FOCA) have been used successfully to treat large chondral and osteochondral defects of the knee. The purpose of the present study was to determine the efficacy of this treatment in patients older than 40, in comparison to a cohort 39 and younger.

Methods: We utilized a prospective database of 107 consecutive patients, with baseline PRO data receiving osteochondral allograft transplantation to the knee from a single surgeon practice over 8 years (March 2007-July 2015). Patient and donor characteristics were routinely collected, as were patient annual PRO measures, principally International Knee Documentation Committee (IKDC) and the Knee Injury and Osteoarthritis Outcome Score (KOOS). Table 1 summarizes cohort demographics; 68 patients completed surveys at a minimum of 24-month follow-up and were categorized into two cohorts based on age at surgery. Group A (study group) consisted of 33 patient's forty years of age and greater, 8 women and 25 men, with a mean age of 52.8 years (40-68) and average final up of 3.5 years. Group B (control group) consisted of 35 patient's less than forty years, 12 women and 23 men, with a mean age of 27.8 years (15-39) and average final follow up of 2.6 years.

Results: Both groups showed a significant improvement in outcome KOOS and IKDC scores at 12 months, 24 months and final follow up. 11 patients (31%) in the control cohort and 8 patients (24%) in study cohort underwent a second surgery on the index knee after the OCA transplantation. A statistically significant improvement in the study group from baseline to final follow-up ($p<.02$) was seen for all KOOS sub scores (Symptom: + 4.83, Pain: +13.05, ADL: +17.44, Sports: +14.48, QOL: +25.3) and IKDC (+22.46). A statistically significant improvement in the control group from baseline to final follow-up ($p<.02$) was seen for all 5 KOOS sub scores; (Symptom: +15.22, Pain: +8.68, ADL: +18.52, Sports: +30, QOL: +32.71) and IKDC (+32.9). In the study group, the maximum improvements (112% of baseline, 45% of baseline) were seen in the KOOS QOL and sports respectively. Similar changes in the control group included 138% improvement from baseline KOOS QOL and 83.3% for sports. Despite this, there was no significant difference between the two groups with respect to any average KOOS subscore or IKDC score, at any time during the observation period.

Conclusion: There was no significant difference between the group's outcomes data at final follow up. This implies the efficacy of OCA transplantation in adults forty years of age and older is similar to that of younger adults. Interestingly, we saw the greatest improvement in each of the two cohorts in the quality of life subscale of the KOOS. Significant sustained improvements in the symptom, ADL and pain subscales of the KOOS and IKDC were also observed in both groups. Overall, patients over 40 years

benefit in a similar manner to younger patients after FOCA and these benefits appear greatest for Quality of Life.

Patient Information and Clinical Assessment

Clinical Information	Study Group	Control Group
No. of patients studied	33	35
Mean age at time of surgery (range)	52.8 (40-68)	27.8 (15-39)
Body Mass Index, kg/m^2 (range)	28.1 (22.3-38.4)	26.5 (19.4-34.0)
No. of knees with previous surgery (%)	27 (81)	33 (94)
Mean No. of previous surgeries (range)	1.1 (1-3)	1.1 (1-3)
Location of graft, No.		
Lateralfemoral condyle	8	20
Medial femoral condyle	21	11
Other	4	4

Paper 136

Title:
Bone Marrow Concentrate Does Not Improve Osseous Integration of Osteochondral Allograft Transplants in the Knee: A Comparative Magnetic Resonance Imaging Analysis

Authors:
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Objectives: Fresh osteochondral allograft transplantation (OCA), which transfers viable, mature hyaline cartilage and subchondral bone into full-thickness chondral defects, has demonstrated good long-term results in the knee. However, incomplete osseous trabecular integration of allograft bone with the host bone is correlated with inferior patient-reported outcomes (Williams et al, JBJS, 2007) and can lead to graft failure. As a result, augmentation of OCA with bone marrow aspirate concentrate (BMAC) has been hypothesized to improve osseous incorporation of the allograft compared to OCA alone. The purpose of this study was to compare the appearance of osseous integration at the host-graft junction on magnetic resonance imaging (MRI) in patients treated with BMAC+OCA versus patients treated with OCA alone.

Methods: Between February 2013 and June 2016, 29 patients with full-thickness cartilage defects were treated with BMAC+OCA (n = 10) or OCA alone (n = 19) and followed prospectively with an MRI at approximately 12 months after surgery. Intraoperatively, bone marrow aspirate was harvested from the ipsilateral iliac crest (Magellan, Arteriocyte), and the allograft plug was soaked in BMAC prior to implantation. No patients received a concomitant meniscus allograft transplantation, realignment osteotomy, or anterior ligament reconstruction. Bone, cartilage, and ancillary features on postoperative MRI were assessed and graded using the Osteochondral Allograft MRI Scoring System (OCAMRISS) by a blinded musculoskeletal radiologist. This is a system that scores subchondral bone plate congruity, bone marrow signal intensity, osseous integration, and cystic changes of the graft and host-graft junction as part of the bone features assessment (Meric et al, Cartilage, 2015) (Table 1). Comparisons of demographic characteristics and OCAMRISS scores between groups were performed with the Mann-Whitney test.

Results: The mean ages of the BMAC and control groups were 32.9 and 33.4 years, respectively (p = 0.95). Males comprised 60% of the BMAC group and 68% of the control group (p = 0.70). MRIs for the BMAC and control groups were obtained at a mean of 11.2 (range, 9-14) and 11.3 (range, 8-15) months after surgery, respectively (p = 0.87). Mean total OCAMRISS scores were not significantly different between groups (BMAC - 7.8, control - 8.0; p = 0.93). Furthermore, mean bone (BMAC - 2.3, control - 2.8; p = 0.22), cartilage (BMAC - 3.3, control - 3.0; p = 0.55), and ancillary (BMAC - 2.2, control - 2.3; p = 0.92) feature scores were not significantly different between groups. Imaging for 5 patients (50%) in the BMAC and 11 patients (59%) in the control groups (p = 0.71) demonstrated a persistent discernible cleft without crossing trabeculae at the host-graft junction (Figure 1). Almost all grafts (over 90%) demonstrated persistent subchondral marrow edema relative to the epiphyseal bone.

Conclusion: The addition of autogenous BMAC to OCA did not enhance osseous integration and bony features at the host-graft junction compared to OCA alone at 12 months. Although more MRI follow-up

of patients treated with BMAC+OCA is needed to confirm this finding, these results suggest that any augmentative biologic effect of BMAC for OCA, if one exists, is likely to be small.

Table 1. Osteochondral Allograft Magnetic Resonance Imaging Scoring System (OCAMRISS) (adapted from Meric et al)

	MRI Feature	MRI Score
Bone Features	1. Subchondral bone plate congruity of graft and host-graft junction	0: Intact and flush; 1: Disrupted or not flush by >1 subchondral thickness
	2. Subchondral bone marrow signal intensity of graft relative to epiphyseal bone	0: Normal; 1: Abnormal (bone marrow edema pattern or hypointensity on all sequences)
	3. Osseous integration at host-graft junction	0: Crossing trabeculae; 1: Discernible cleft
	4. Presence of cystic changes of graft and host-graft junction	0: Absent; 1: Present
Cartilage Features	5. Cartilage signal of graft	0: Normal; 1: Altered intensity (either hypointense of hyperintense, but not fluid); 2: Fluid signal intensity on all sequences
	6. Cartilage "fill" of graft (percentage of volume)	0: 76-100%; 1: 51-75% or >100%; 2: <50%
	7. Cartilage edge integration at host-graft junction	0: No discernible boundary; 1: Discernible boundary; 2: Discernible fissure >1 mm
	8. Cartilage surface congruity of graft and host-graft junction	0: Flush; 1: <50% offset of host cartilage; 2: >50% offset of host cartilage
	9. Calcified cartilage integrity of graft	0: Intact, thin, and smooth; 1: Altered (disrupted, thickened, or blurred)
Ancillary Features	10. Opposing cartilage	0: Normal; 1: Abnormal
	11. Meniscal tears	0: Absent; 1: Present
	12. Synovitis	0: Absent; 1: Present
	13. Fad pad scarring	0: Absent; 1: Present

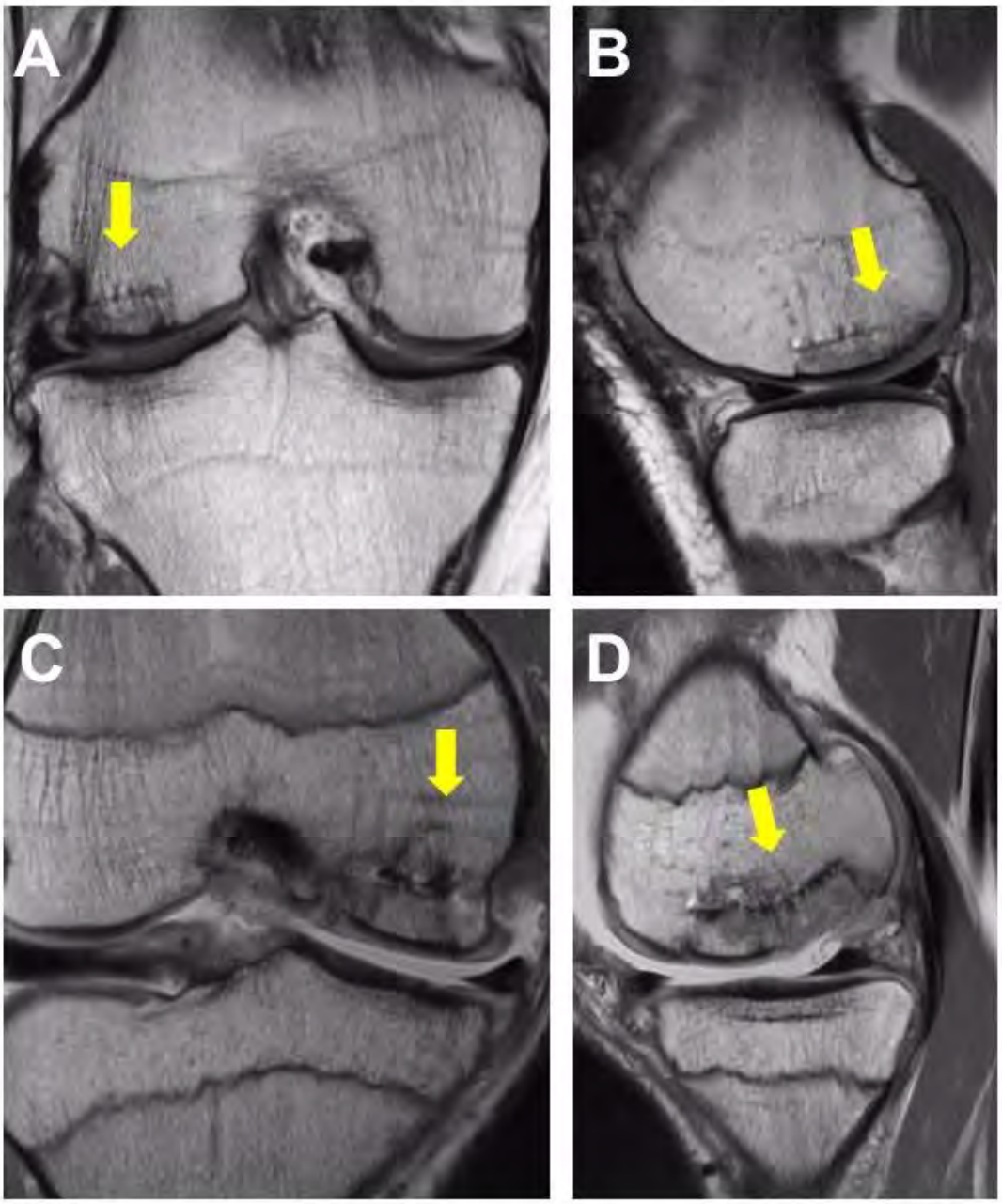

Figure 1. Representative 12-month coronal and sagittal MRI sections in a (A,B) 20-year-old male, demonstrating crossing trabeculae and minimal subchondral marrow edema, and (C,D) 16-year-old-male, demonstrating discernible clefts at the host-graft junction and significant subchondral marrow edema. Both were treated with BMAC+OCA.

Paper 137

Title:
Clinical Outcomes of Multiple Osteochondral Allograft Transplantation of the Knee: An Analysis of Snowman Technique and Multifocal Lesions

Authors:
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Objectives: To report the clinical outcomes of snowman technique osteochondral allograft transplantation (OCA) and clinical outcomes of multifocal OCA.

Methods: Consecutive patients who underwent either a primary snowman OCA or multifocal (i.e. bipolar patellofemoral, patellofemoral and a condyle or bicondylar) with a minimum 2-year follow-up by a single surgeon from 4/2003 to 4/2015 were isolated. Failure was defined as revision OCA, conversion to arthroplasty, or gross appearance of graft degeneration on 2nd look arthroscopy.

Results: Twenty-six patients (28 knees) were isolated with 22 patients (24 knees; 85.7%) having 2-year clinical follow-up. Nine of 11 patients (81.8%) who underwent isolated condylar snowman allografts met inclusion criteria at mean follow-up of 7.4±3.6 years, while 13 additional patients (15 knees; 88.2%) underwent multifocal OCA at mean follow-up of 6.4±3.9 years. All 9 patients who received isolated snowman OCA were to the medial femoral condyle. Reoperations were common with 44.4% (N=4) of the snowman group and 20% of multifocal OCA (N=3) undergoing at least 1 reoperation. There were 3 failures (33.3%) in the snowman technique group at a mean 7.7±5.5 years and 1 failure in the multifocal OCA group at 4.5 years. All 4 failures underwent TKA. Patients who underwent multifocal OCA demonstrated significant improvements in the International Knee Documentation Committee score, Knee Injury and Osteoarthritis subscores, Western Ontario and McMaster Universities Osteoarthritis Index subscores, and the Short-Form-12 physical component ($P < 0.05$ for all). Patients who underwent snowman OCA demonstrated significant improvement in KOOS pain subscore and WOMAC overall scores ($P<0.05$ for both) **Table 1**].

Conclusion: While in a small cohort, patients who underwent snowman OCA had a high rate of reoperation (44.4%) and a high rate of failure (33.3%). Comparatively, patients who underwent multifocal OCA had reoperation and graft survival rates comparable to published literature for focal OCA.

Table 1: Patient-reported clinical outcome measures for both snowman technique osteochondral allografts and multifocal grafts

	Preoperative		Postoperative		P Value
Multifocal Osteochondral Allograft Transplantation					
	Mean	SD	Mean	SD	
Marx	1.67	1.60	6.13	3.57	0.285
Lysholm	41.83	9.31	55.00	13.62	0.237
IKDC	32.71	5.02	52.92	12.55	**0.010**
KOOS-Pain	51.48	9.59	65.28	10.57	0.155
KOOS - Symptom	56.25	9.99	66.07	9.47	**0.025**
KOOS - ADL	58.70	9.47	77.21	10.18	**0.026**
KOOS - Sport	18.33	9.19	40.36	14.66	**0.026**
KOOS - QOL	11.98	5.41	41.07	16.16	**0.005**
WOMAC - Pain	8.82	1.81	6.07	1.81	0.212
WOMAC - Stiffness	4.00	0.89	2.93	0.89	**0.046**
WOMAC - Function	28.18	5.20	15.36	6.79	**0.037**
WOMAC - Overall	37.55	8.73	15.93	7.96	**0.047**
SF-12 Physical	33.62	4.07	44.65	5.25	**0.011**
SF-12 Mental	53.14	5.10	55.11	3.37	0.859
Snowman Technique Osteochondral Allograft Transplantation					
Marx	0.00	0.00	2.33	0.76	N/A
Lysholm	37.17	3.83	66.17	14.75	0.138
IKDC	29.34	2.54	54.14	13.29	0.285
KOOS-Pain	44.91	5.51	72.62	9.77	**0.043**
KOOS - Symptom	46.43	5.30	66.33	11.24	0.080
KOOS - ADL	56.86	13.25	82.35	11.09	0.345
KOOS - Sport	17.50	3.06	53.57	19.35	0.223
KOOS - QOL	19.79	7.24	49.11	14.71	0.104
WOMAC - Pain	9.17	1.93	6.00	2.47	0.109
WOMAC - Stiffness	4.83	0.86	2.71	0.75	0.068
WOMAC - Function	29.50	9.08	12.00	7.43	0.345
WOMAC -Overall	45.17	10.45	10.71	6.18	**0.043**
SF-12 Physical	45.01	3.03	41.45	5.40	0.686
SF-12 Mental	52.61	5.13	55.71	7.48	0.500

Paper 138

Title:
Radiographic Analysis of Glenoid Morphology after Arthroscopic Latarjet vs Distal Tibial Allograft in the Treatment of Anterior Shoulder Instability.

Authors:
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Objectives: The Latarjet procedure for autograft transposition of coracoid to the anterior rim of the glenoid remains the most common procedure for reconstruction of the glenoid after shoulder instability. The anatomic glenoid reconstruction using distal tibial allograft has gained popularity and is suggested to better match the normal glenoid size and shape. However, there is concern for decreased healing and increased resorption using an allograft bone. The purpose of this study was to evaluate the arthroscopic reconstruction of the glenoid with respect to the size, shape, healing, and resorption of autograft coracoid vs allograft distal tibia.

Methods: A retrospective review of 50 consecutive patients who had an arthroscopic boney reconstruction of the glenoid (13 coracoid; 37 distal tibial), diagnosed with anterior shoulder instability, and CT confirmed glenoid bone loss >20%. Pre-and post-operative CT scans were reviewed by two fellowship trained musculoskeletal radiologists for: graft position, glenoid concavity, cross sectional area, width, version, total area, osseous union, and graft resorption.

Results: Graft nonunion was seen in 3 (23.07%) of the coracoid patients, and in 2 (5.4%) of the tibial allograft patients (OR 5.25; 95% CI: 0.768-35.89). Odds ratios comparing allograft to coracoid for overall resorption was 5.00 (CI: 1.276-19.597). Graft resorption greater than 50% was seen in 3 (8.11%) of the allografts and was absent within the coracoid patients. Graft resorption lesser than 50% was greater in both groups with 27 (72.97%) allograft and 6 (46.15%) coracoid patients. However, no statistically significant difference was found between the two procedures regarding AP diameter of graft (p=0.818) or graft cross sectional area (p=0.797).

Conclusion: Arthroscopic anatomic glenoid reconstruction using distal tibial allograft showed greater boney union but higher resorption compared to coracoid autograft. Even so, there was no statistically significant difference between the two procedures regarding final graft surface area and size of grafts. These short-term results suggest distal tibial allograft as an alternative to coracoid autograft in the recreation of glenoid boney morphology.

Paper 140

Title:
Arthroscopic Bankart Repair with and without Arthroscopic Infraspinatus Remplissage in Anterior Shoulder Instability with Hill-Sachs Defect: Randomized Controlled Trial

Authors:
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Objectives: The purpose of this prospective randomized, double blinded controlled trial was to compare patient-reported outcomes and clinical results between arthroscopic Bankart repair with and without arthroscopic infraspinatus remplissage in patients with anterior shoulder instability with a Hill-Sachs lesion. Failure to recognize and address large Hill Sach's defects during arthroscopic stabilization surgery for glenohumeral instability is known to lead to high rates of recurrence. Arthroscopic remplissage has evolved in recent years as a reproducible technique with a proposed benefit of decreased dislocations. However, there are no high level clinical studies to conclusively support its efficacy in reducing redislocations.

Methods: One hundred and four patients, aged 14 years and older, with a confirmed Hill Sach's lesion on ultrasound, CT or MRI, were randomized intraoperatively after confirming an engaging Hill Sach's lesion to either undergo arthroscopic infraspinatus remplissage (REMP) or no remplissage during arthroscopic Bankart repair (NO REMP). Exclusion criteria included a glenoid defect >15% of the AP glenoid diameter, significant shoulder arthropathy, infection, or medical comorbidities. The primary outcome measure was the Western Ontario Shoulder Instability score (WOSI). Secondary outcomes included the Simple Shoulder Test (SST), the American Shoulder and Elbow Society standardized assessment of shoulder function (ASES), active range of motion, stability tests, and incidence of revision surgery. Study time points were pre-, 3-, 6-, 12-, and 24-months post-operative. Significance level was 0.05.

Results: A summary of demographics and outcomes are presented in Table 1. There were 53 patients (45 men, 8 women) randomized to REMP and 52 (46 men, 6 women) patients to NO REMP. The groups were comparable with regard to age, body mass index (BMI), and gender distribution). Both groups demonstrated a similar improvement in all subjective scores over time to 12-months post-operative with no difference between the groups (collection of data to 24-months post-operative is ongoing until 2019). The WOSI significantly improved from pre- to 12-months post-operative in both study groups. There were no differences between groups at any time point. ASES scores and SST scores followed a similar pattern. Additionally, there were no differences in range of motion between groups at any time point. There were 2/53 re-dislocations in REMP postoperatively compared to 6/52 in NO REMP; this difference was not significant (p=0.161). There were no differences between groups in reports of limitations in participation in sport attributed to the operated shoulder up to 12-months post-operative.

Conclusion: Based on this study, there is no difference in subjective outcome scores and redislocations rates between remplissage and no remplissage for an engaging Hill Sach's lesion while performing arthroscopic Bankart stabilization. As data continues to be gathered to 24-months post-operative including MRI, longer term benefits or drawbacks may become evident.

Table 1. Subjective outcomes by group - Mean (SD).

	NO REMP	REMP	p-value
WOSI (%): Pre	43 (21.7)	43.1 (17.5)	0.904
WOSI (%): 12 mo	79.1 (19.8)	81.1 (14.9)	0.645
ASES (%): Pre	69.2 (22.3)	74.1 (18.2)	0.239
ASES (%): 12 mo	89.1 (11.5)	89.1 (14.3)	0.990
SST (/12): Pre	9.1 (2.4)	8.9 (2.8)	0.675
SST (/12): 12 mo	11.4 (1.3)	11.5 (1.0)	0.631
Limited by shoulder in return to sport (0-100): 12 mo	27.4 (31.3)	20.9 (24.3)	0.351

Paper 141

Title:
Prospective Evaluation of Glenoid Bone Loss After First-Time and Recurrent Anterior Glenohumeral Instability Events

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Objectives: Determining the amount of glenoid bone loss in patients following anterior glenohumeral instability events is critical to guiding appropriate treatment. One of the challenges in managing shoulder instability in young athletes is the absence of clear data showing the impact of each event. The purpose of this study was to prospectively determine the amount of bone loss associated with a single instability event, in the setting of both first-time and recurrent instability.

Methods: We conducted a prospective cohort study of 714 athletes followed for four years. Baseline assessment included a subjective history of shoulder instability. Bilateral shoulder MRIs were obtained in all participants with and without a history of previous shoulder instability. The cohort was prospectively followed during the study period and those who sustained an anterior glenohumeral instability event were identified. A post-injury MRI was obtained and compared to the screening MRI. Glenoid width was measured for each patient's pre- and post-injury MRI. The projected total glenoid bone loss was calculated and compared for patients with a prior history of shoulder instability.

Results: Of the 714 athletes that were prospectively followed during the four-year period, 23 shoulders in 22 subjects sustained a first-time anterior instability event (5 dislocations, 18 subluxations), and six subjects with a previous history of instability sustained a recurrent anterior instability event (1 dislocation, 5 subluxations). On average, there was statistically significant glenoid bone loss (1.84 ± 1.47 mm) following a single instability event ($p<0.001$), equivalent to 6.8% (95% CI: 4.46%, 9.04%, range 0.71%-17.6%) of the glenoid width. Twelve shoulders (52%) demonstrated glenoid bone loss ≥ 5%, 4 shoulders demonstrated glenoid bone loss ≥13.5% and no shoulders had ≥20% glenoid bone loss after a first-time instability event. Pre-existing glenoid bone loss in subjects with a history of instability was 10.2% (95% CI: 1.96%, 18.35%, range 0.6% - 21.0%). This bone loss increased to 22.8% (95% CI: 20.53%, 25.15%, range 21.2% to 26.0%) following an additional instability event (P=0.0117). All six shoulders with recurrent instability had >20% glenoid bone loss.

Conclusion: Glenoid bone loss of 6.8% was observed after a first-time anterior instability event. In the setting of recurrent instability, the total calculated glenoid bone loss was 22.8% with a high prevalence of bony Bankart lesions (5/6). The findings of this study support early stabilization of young, active subjects following a first-time anterior glenohumeral instability event.

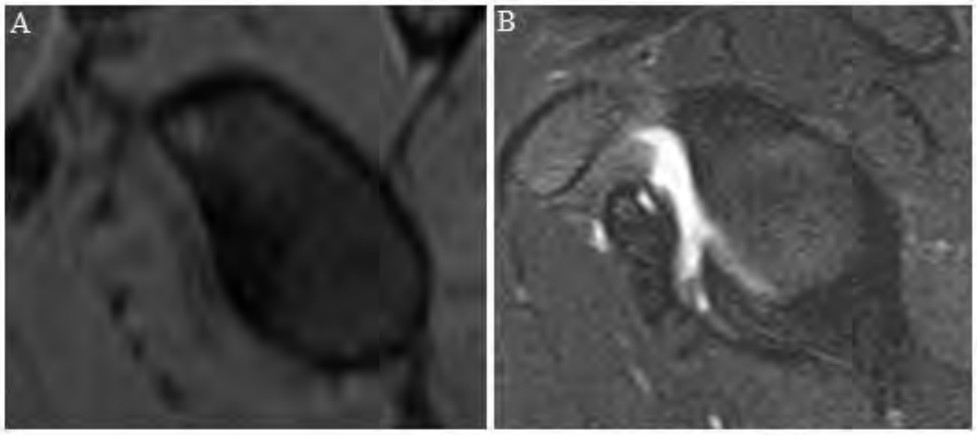

Figure 2. Clinical demonstration of a sagital *en face* MRI obtained prior to any instability event (A) and following a single subluxation event (B) with 14% bone loss and a bony Bankart.

Table 2: Glenoid Bone Loss in First-time and Recurrent Instability Cohorts

Instability Type	No. Shoulders	Δ Glenoid Width (mm)	ΔGlenoid Width (%)	Total Glenoid Bone Loss* (%)	P value
First-time	23	1.85 ± 1.49	6.8%	6.8%	< .0001
Recurrent	6	3.75± 2.37	13.6%	22.8%	.0117

Paper 142

Title:
Distal Tibial Allograft Glenoid Reconstruction for Recurrent Shoulder Instability: Clinical Outcomes and Complications

Authors:
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Objectives: Treatment options for recurrent shoulder instability, in the setting of significant glenoid bone loss, consists of several iterations of bone stabilization procedures. However, advanced arthritic changes with the Laterjet procedure and rapid resorption changes with the iliac crest bone graft reconstruction has led into the search for more optimal surgical reconstruction options. The purpose of this study is to evaluate the clinical and functional outcomes of patients with recurrent shoulder instability, with significant glenoid bone loss, treated with fresh distal tibial allograft reconstruction with regards to recurrence, revision surgery, and complications.

Methods: At a single institution, all consecutive patients with recurrent shoulder instability and at least 15% anterior glenoid bone loss, undergoing distal tibial allograft reconstruction, between 2011 to 2016, were identified by diagnostic and procedural codes. All clinical notes, diagnostic imaging, and operative reports were reviewed in detail. From these sources, demographics, operative techniques, and radiographic parameters were collected and measured. Functional outcome scores were prospectively collected from patients. The primary outcome of the study was the Disability of Arm, Shoulder, Hand (DASH) score. The secondary outcomes of the study were the Visual Analog Scale (VAS) pain score, Single Assessment Numeric Evaluation (SANE) score, recurrent instability, revision surgery, and complications.

Results: At 6 years, there were a total of 36 distal tibial allograft reconstructions performed in patients with recurrent shoulder instability in the setting of significant glenoid bone loss. Amongst this cohort, average age was 35 years old with 72% of patients being male. The dominant extremity was involved in 20 (56%) of patients and 24 (67%) of patients had previous surgery to address episodes of shoulder instability. Follow-up, for the entire cohort was on average 15.5 months. In comparison to preoperative range of motion, after surgery there was significantly less abduction (P=0.01). At final follow-up, patients undergoing distial tibial allograft reconstruction showed trend towards significant improvement in the DASH score (preoperative DASH=50.7, postoperative DASH=37.1, P=0.09). In like manner, there was significant improvement in both the VAS score (P=0.001) and the SANE score (P=0.002). There was no significant difference in functional outcome scores between those patients who had failed a previous surgery for instability. Recurrent instability, after distal tibial allograft reconstruction, occurred in 4 (11%) of patients and 8 (22%) of patients underwent an additional surgical procedure. Complications occurred in 31% of patients, with the most common complication being rupture of the subscapularis.

Conclusion: This study provides functional outcomes in one of the largest consecutive cohort of patients undergoing distal tibial allograft reconstruction for recurrent shoulder instability due to significant glenoid bone loss. The study suggests that distal tibial allograft reconstruction may provide improved

functional outcomes in patients with recurrent shoulder instability. After this procedure, 89% of patients did not experience any additional episodes of shoulder instability. Despite these encouraging results, complications are common after this procedure, with 31% of patients experiencing a complication.

TABLE 2. Range of Motion & Physical Examination in patients with Tibial Plafond Allograft Reconstruction

	Tibial Plafond Allograft (n=36)		
	Preoperative	**Postoperative**	**P-Value**
Range of Motion (Active)			
Abduction	102.2 ± 26.8	82.6 ± 14.8	0.01
Forward Flexion	125.8 ± 31.3	137.9 ± 32.9	0.25
External Rotation	46.1 ± 9.8	43.2 ± 10.1	0.52
Internal Rotation	47.8 ± 9.3	52.3 ± 12.5	0.46

Continuous data are reported as mean ± standard deviation. Categorical data are reported as number (%).

TABLE 3. Functional Outcomes at Final Follow-Up of Tibial Plafond Allograft Reconstruction

	Tibial Plafond Allograft (n=36)		
	Preoperative	Postoperative	P-Value
Primary Outcome			
DASH	50.7 ± 27.8	37.1 ± 27.4	0.09
Secondary Outcome			
VAS	5.62 ± 2.7	1.38 ± 2.1	0.001
SANE	32.5 ± 18.9	75.8 ± 21.9	0.002

Continuous data are reported as mean ± standard deviation

Paper 143

Title:
Non-operative Management of Posterior Shoulder Instability: An Assessment of Survival and Predictors for Conversion to Surgery at 1 to 13 Years After Diagnosis

Authors:
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Objectives: Among patients treated non-operatively for 1 year following a diagnosis of posterior shoulder instability (PSI), little is known about the the incidence of surgery between 1-13 years after injury. The purpose of this study is to define the frequency and evaluate the factors predictive for late surgical intervention of symptomatic PSI.

Methods: This study included a population-based cohort of 115 patients (14 females, 101 males) diagnosed with PSI between January 1994 and July 2012 with a minimum 5-years follow-up (mean:13.9 years; range: 5-23 years). Landmark survival analysis was performed to evaluate incidence of surgery after 1 year. Survival was estimated using Kaplan Meier method and predictors of late surgical intervention were analyzed using Cox proportional hazards regression.

Results: A total of 61/115 (53%) patients were treated non-operatively for 1 year following diagnosis of PSI. Of these, 24/61 (39%) converted to surgery for symptomatic PSI. The overall survival free of surgery at 1 and 5 years was 53.0% (95% CI 434.7-63.0) and 37.1% (95% CI 29.1-47.1), respectively. BMI >35 (p=0.04, HR 3.3) was predictive for late conversion to surgery. Age, gender, occupation, or history of glenohumeral dislocation were not significant. Assessing surgery as a time dependent covariate, a patient undergoing surgery was at an increased risk for radiographic progression of osteoarthritis (p=0.02, HR=4.0, 95% CI 1.2-13.2).

Conclusion: Conservative management was performed for at least one year in over half of patients diagnosed with PSI. However, long-term follow-up demonstrates that nearly 40% of these patients eventually require surgery. Increased BMI was predictive for late failure of while age, gender, history of dislocation and occupation did not show an effect. Patients who underwent surgery were at an increased risk of radiographic progression of arthritis.

Paper 144

Title:
Failed Dermal Allograft Procedures in Irreparable Rotator Cuff Tears Can Still Improve Pain and Function. The "Biologic Tuberoplasty Effect"

Authors:
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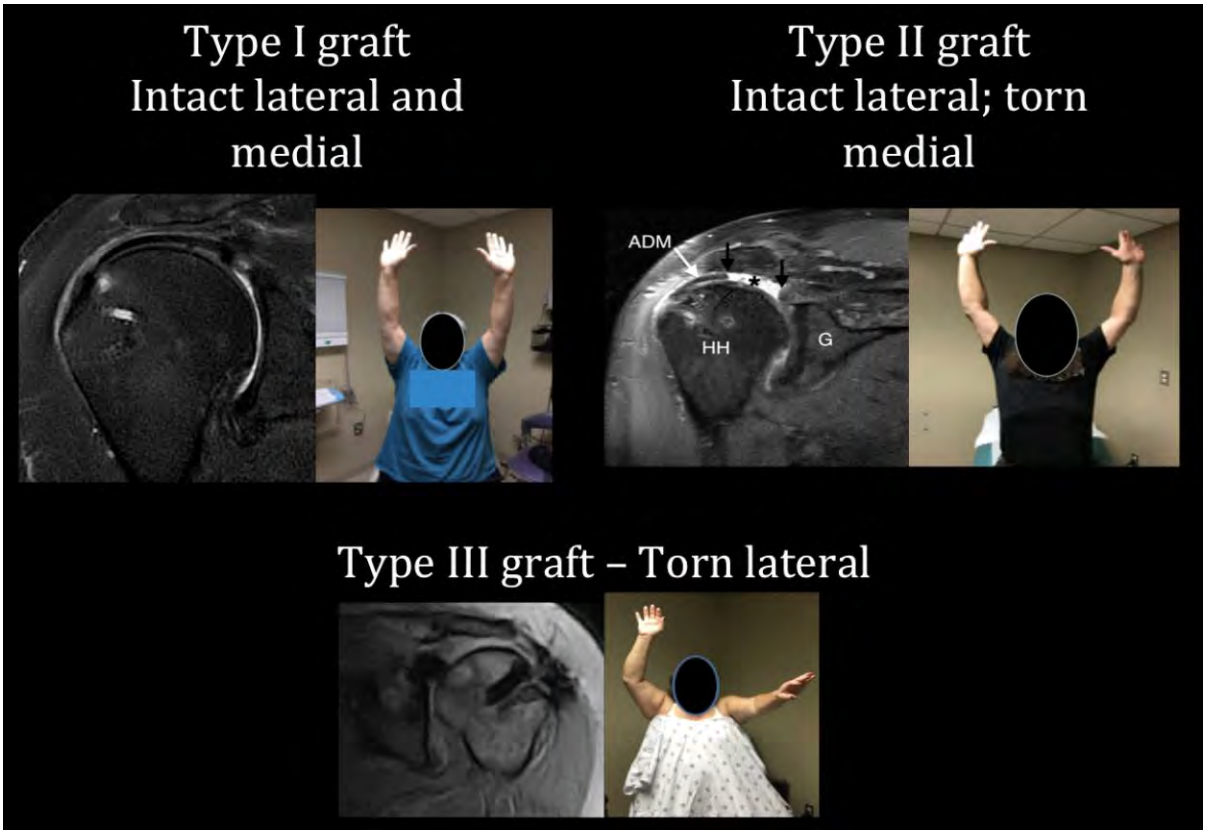
Objectives: Massive rotator cuff tears (MRCT) are a challenging problem. Dermal allografts have been used in "bridging" procedures and superior capsule reconstruction (SCR). Both have led to clinical improvement, but without correlation with post-operative imaging. The purpose of this study is to examine graft integrity on MRI in patients who underwent an SCR or bridging procedure to determine if graft integrity correlates with functional outcome. We also propose a new classification of dermal allograft re-tear on MRI.

Methods: This study was approved by our IRB. Between 2006 and 2016, 11 patients (12 shoulders) underwent a bridging procedure and 10 patients underwent an SCR for MRCT with a dermal allograft by a single surgeon. The grafts were secured to the tuberosity in a double-row, trans-osseous equivalent (DR-TOE) fashion. Pre- and post-operative VAS, acromiohumeral distance (AHD), and ASES scores, and pre-operative Hamada grade and Goutallier classification were prospectively collected and retrospectively reviewed. An MRI was obtained on all patients post-operatively to assess graft integrity. The status of the graft was divided into three types based on MRI findings: **Type 1**- Graft intact medially (rim of cuff or glenoid) AND laterally (greater tuberosity); **Type 2**- Graft intact laterally but torn medially; **Type 3**- Graft torn laterally. The shoulders were then grouped based on these types for further analysis.

Results: The average age was 61 (range: 49-73). Average follow-up was 21.6 months (range: 8-80). Average length from surgery to MRI was 13.9 months (range: 6-80). There was a significant improvement in VAS (pre-8.1 to post-1.3) and ASES (pre-26.3 to post-84.6) in **Type 1** (P<0.01) and in VAS (pre-7.0 to post-0.7) and ASES (pre-32.6 to post-91.2) in **Type 2** (P<0.01). There was no difference in post-operative VAS (1.3 vs 0.7) and ASES (84.6 vs 91.2) between **Type 1** and **Type 2** (P=0.8). There was no improvement in VAS (pre-7.3 vs post-5.7) and ASES (pre-30.6 vs post-37.2) in **Type 3**. There was a significant difference in post-operative VAS (5.7 vs 1) and ASES (37.2 vs 88.1) between **Type 3** versus **Types 1+2**, respectively (P<0.01). The AHD decreased in type 3 (pre-7.8 mm to post-3.2 mm, P=0.02) but did not change in **Types 1+2** (pre-7.8mm to post-8.0mm, P=0.7).

Conclusion: In patients who have SCR or "bridging" procedures for MRCT with a dermal allograft, there is significant improvement in VAS and ASES scores if the graft heals to the tuberosity, regardless if it is still intact to the glenoid (in SCR) or the rim of rotator cuff tendon ("bridging"). Individuals whose graft is torn from the tuberosity did not have improvement in VAS or ASES scores versus baseline. There was no significant difference in AHD in all groups. We believe that the dermal graft acts as a "biologic

(interpositional) tuberoplasty," preventing bone-to-bone contact between the tuberosity and the acromion, thus eliminating pain and improving function. We still recommend performing an SCR when indicated because it has been shown to restore the normal kinematics of the shoulder in a laboratory setting. However, careful attention should be paid to the repair of the graft to the tuberosity, so that in case the primary procedure fails medially, the graft can still improve pain and function.



Paper 145

Title:
Latissimus Dorsi Tendon Transfer With or Without Superior Capsular Reconstruction for Treatment of Irrepairable Rotator Cuff Tears

Authors:
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Objectives: Treatment options for massive irreparable rotator cuff tears, in middle aged adults, consists of tendon transfer or superior capsular reconstruction (SCR). The purpose of this study was to evaluate if transfer of the latissimus dorsi tendon transfer is enhanced with combination of superior capsular reconstruction for treatment of massive irreparable rotator cuff tears.

Methods: At a single institution, all consecutive patients undergoing transfer of the latissimus dorsi tendon with or without superior capsular reconstruction, between 2013 and 2016, for treatment of irreparable rotator cuff tears were evaluated. SCR, was indicated, in addition to latissimus transfer, for patients with impaired preoperative active abduction. All clinical notes, diagnostic imaging, and operative reports were reviewed in detail. Demographics, operative techniques, and radiographic parameters were collected and measured. Functional outcome scores were prospectively collected from patients. The primary outcome of the study was the Disability of Arm, Shoulder, Hand (DASH) score. The secondary outcomes of the study were the Visual Analog Scale (VAS) pain score, Single Assessment Numeric Evaluation (SANE) score, and the American Shoulder and Elbow Society (ASES) score.

Results: At 3 years, there were a total of 26 latissimus dorsi tendon transfers performed in patients with irreparable rotator cuff tears. Of these, 8 patients underwent only latissimus dorsi tendon transfer and 18 patients underwent latissimus dorsi tendon transfer combined with a superior capsular reconstruction. Average age was 53 years old with the majority of patients being male (88%). The dominant extremity was involved in 22 (85%) of latissimus transfers and 14 (53%) of patients had previous surgery to address a rotator cuff tear. Follow-up, for the entire cohort, was on average 29 months. At final follow-up, there was no significant difference in physical examination or radiographic measurements between patients with latissimus transfer alone and those with latissimus transfer with SCR. All patients, undergoing either technique, showed significant improvement in both the DASH score (preoperative DASH=59.6, postoperative DASH=39.9, P=0.049) and VAS score (preoperative VAS=6.6, postoperative VAS=3.3, P=0.0006). However, those patients undergoing revision surgery, regardless of technique, showed significantly less improvement in the DASH score (P=0.005), VAS score (P=0.002), SANE score (P=0.005), and the ASES score (P=0.001). Transfer of the Latissimus tendon with SCR, in comparison to only tendon transfer, did not show any significant difference in the final DASH score (p-value=0.72). At the same time, there was no significant difference between latissimus transfer, with or without SCR, in the secondary outcomes of the VAS score(P=0.97), the SANE score(P=0.63), or the ASES score (P=0.74).

Conclusion: This is the first study to report the outcomes of latissimus dorsi tendon transfer with superior capsular reconstruction in comparison to only latissimus dorsi tendon transfer for treatment of

irreparable rotator cuff tears. The study suggests that transfer of the latissimus dorsi tendon in combination with superior capsular reconstruction, at short term follow-up of 2 years, may not significantly influence functional outcome. Rather, patients undergoing revision surgery, regardless of technique, may demonstrate smaller improvements in functional outcomes.

TABLE 2. Range of Motion & Physical Examination in Latissimus Dorsi Tendon Transfer with/without SCR

	Lat Only (n=8)			Lat + SCR (n=18)		
	Preoperative	Postoperative	P-Value	Preoperative	Postoperative	P-Value
Range of Motion (Active)						
Abduction	135 ± 21.2	76.4 ± 18	0.04	75.4 ± 26.0	71.5 ± 22	0.80
Forward Flexion	106.9 ± 36.7	135.7 ± 32.2	0.15	103.5 ± 32.2	110.6 ± 45.4	0.35
External Rotation	36 ± 11.4	42.9 ± 15	0.80	25.3 ± 18.6	38.5 ± 16.3	0.04
Internal Rotation	65 ± 22.9	59.3 ± 12.4	0.55	54.4 ± 13.3	63.1 ± 13.0	0.08
Hornblower Sign	2 (25%)	2 (25%)	0.98	14 (78%)	2 (11%)	0.07
External Rotation Lag	6 (75%)	2 (25%)	0.34	17 (94%)	3 (17%)	0.01

Continuous data are reported as mean ± standard deviation. Categorical data are reported as number (%).

TABLE 4. Functional Outcomes at Final Follow-Up of Latissimus Dorsi Tendon Transfer With/Without SCR

	Lat Only (n=8)	Lat +SCR (n=18)	
	Mean (Std Dev)	Mean (Std Dev)	P-Value
Primary Outcome			
DASH	47.0 ± 39.8	42.5 ± 27.5	0.72
Secondary Outcome			
VAS	3.14 ± 3.5	3.4 ± 3.5	0.97
SANE	54.7 ± 38.5	60.9 ± 22.1	0.63
ASES	65.8 ± 36.3	60.6 ± 30.9	0.74
Constance	63.8 ± 31.0	50.3 ± 23.3	0.34

Paper 146

Title:
Arthroscopic Superior Capsular Reconstruction in Males Provides Superior Outcomes to Reverse Total Shoulder or Debridement for Irreparable Rotator Cuff Tears

Authors:
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[1]Mayo Clinic Arizona, Phoenix, AZ, USA, [2]Steadman Hawkins Clinic of the Carolinas; Greenville Health System, Greenville, SC, USA, [3]ATI Physical Therapy, Greenville, SC, USA, [4]Hawkins Foundation, Greenville, SC, USA, [5]Center for Effectiveness Research in Orthopedics, Greenville, SC, USA.

Objectives: Early results following arthroscopic superior capsular reconstruction(SCR) in patients with massive, irreparable rotator cuff tears are promising. However, no studies have compared patient reported outcomes between SCR or reverse total shoulder(rTSA) and rotator cuff debridement for these patients. Therefore, the purpose of this study was to compare 1 year outcomes between patients with massive irreparable rotator cuff tears who underwent a SCR, rTSA, or rotator cuff debridement with a concurrent biceps tenotomy or tenodesis.

Methods: Patients(n=63) who underwent either SCR(n=21), rTSA(21), or cuff debridement(n=21) and biceps tenotomy or tenodesis for a massive, irreparable rotator cuff tear treated with a minimum 1-year follow up were retrospectively reviewed. Age, sex, BMI, smoking status, Charlson Index, Hamada classification, and ASES scores were recorded and compared using a multivariate ANOVA were used to compare between surgical approaches. A Chi Square analyses were used to compare sex distribution and the Charlson Deyo Index between groups (α=0.05).

Results: Overall, patients across the 3 groups were not statistically different in age or follow up ASES score at minimum 14 month follow up (*P*> 0.05). There was a significant interaction effect between surgery group and sex (P=0.02) on ASES score but not age (*P*=0.08). Univariate F tests revealed that male patients who received an SCR displayed a 10-14% better outcome at follow up compared to other groups (Table 1) which exceeds the reported ASES score MCID.

Conclusion: Our results show comparable results across surgical options for massive irreparable cuff tears with good patient reported outcomes. Male patients displayed clinically important greater ASES scores at 1 year follow up. Future studies should evaluate these preliminary results to assess if these preliminary results hold up at longer follow up times.

Paper 147

Title:
Correlation of Patient Reported Outcome Measurement Information System Computer Adaptive Test (PROMIS-CAT) and Knee Injury and Osteoarthritis Outcome Score (KOOS) in Knee Osteotomy and Cartilage Procedures

Authors:
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Objectives: PROMIS-CAT is a novel and efficient method for obtaining patient reported outcomes. Since its inception in 2007, PROMIS has been validated for several body joints, but correlations between PROMIS and orthopaedic legacy measures (i.e., KOOS) have not been evaluated for many knee procedures. The purpose of this study was to determine whether the PROMIS-CAT tool demonstrates correlation with KOOS for patients undergoing either osteotomy or cartilage procedures of the knee.

Methods: After obtaining IRB approval, patients were identified who had undergone elective osteotomy (Tibial Tubercle Osteotomy [TTO], High Tibial Osteotomy [HTO], Distal Femoral Osteotomy [DFO]) and/or cartilage restoration (microfracture, DeNovo NT, Osteochondral Allograft Implantation [OCA], Autologous Chondrocyte Implantation [ACI], and meniscal transplant) procedures performed by a single surgeon. Eligible patients completed a series of outcome questionnaires including same day PROMIS-CAT for pain, mobility, physical function and KOOS domains for daily living, pain and sports and recreation. The scores were collected prospectively. Statistical analysis was performed using Spearman's rank correlations.

Results: A total of 212 data points (97 osteotomy, 53 cartilage, 62 combined) were identified to be used in the statistical analysis. Spearman's rank correlations of all patient scores collected between PROMIS Pain and KOOS Pain (for Pain), PROMIS Mobility and KOOS Daily Living (for Mobility and Living), and PROMIS Physical Function and KOOS Sports and Recreation (for Activity) produced rho values of -0.841, 0.816 and 0.715, respectively. Among osteotomy only patients, Pain scores, Mobility and Living scores and Activity scores correlated with a rho value of -0.828, 0.776, and 0.701, respectively. In patients undergoing cartilage procedures who did not have an osteotomy procedure performed, Pain scores, Mobility and Living scores and Activity scores correlated with a rho value of -0.784, 0.860, and 0.651, respectively. Patients undergoing both osteotomy and cartilage procedures had Pain scores, Mobility and Living scores and Activity scores correlate with rho values of -0.826, 0.830, and 0.732, respectively.

Conclusion: The PROMIS-CAT tool was found to correlate well with KOOS domains for patients undergoing osteotomy and/or cartilage procedures of the knee. PROMIS-CAT can be considered as an efficient and reliable method of collecting patient outcomes in this patient population. Advantages include reduced collection time and less of a ceiling effect than legacy outcome scores.

Paper 148

Title:
Demonstrating the Value of an ACL Registry

Authors:
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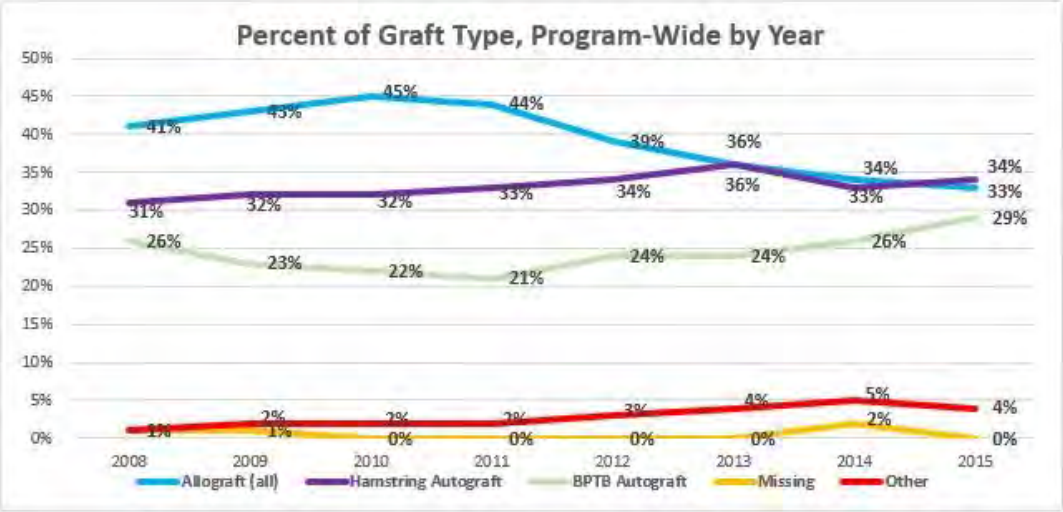
[1]Kaiser Permanente Hospital, Baldwin Park, CA, USA, [2]Kaiser Permanente, Irvine, CA, USA, [3]Kaiser Permanente, San Diego, CA, USA, [4]Kaiser Permanente, Walnut Creek, CA, USA, [5]Kaiser PermanenteDepartment of Orthopedics, El Cajon, CA, USA.

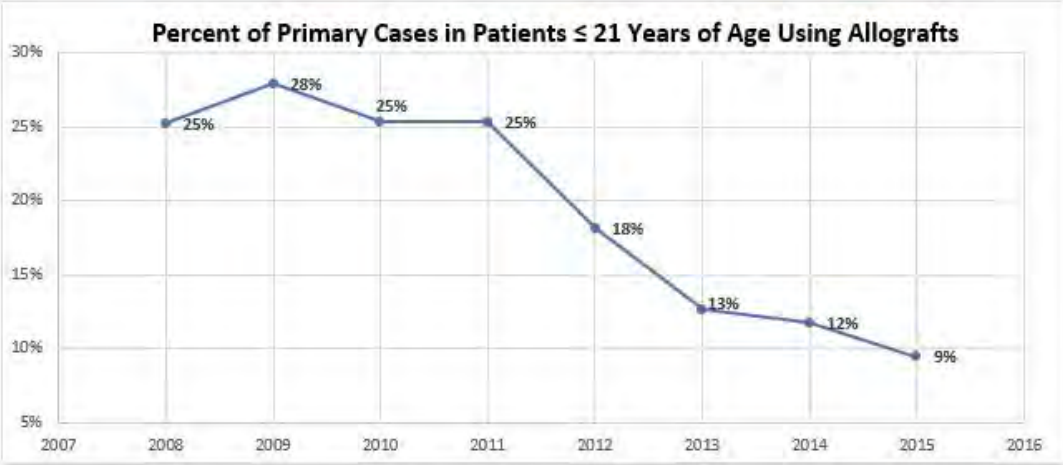
Objectives: One purpose of a registry is to identify procedures or devices that have either good or poor outcomes and improve treatment outcomes through feedback to surgeons. In 2010 we initially reported the influence of graft choice on the risk of early revision after ACL Reconstruction (ACLR). In 2012 we reported a three times higher risk of revision if allograft was used rather than bone-patellar tendon-bone (BPTB) autograft. In subsequent studies of allografts, we have identified poorer results with BPTB allografts compared to soft tissue allografts and with soft tissue allografts irradiated with > 1.8 Mrads or processed with chemical methods. Patients ≤ 21 years of age were also identified to be at particularly high-risk for revision if allograft tissue was employed. These registry findings were disseminated to surgeons within and outside our integrated healthcare system. The purpose of this study was to evaluate the impact of registry feedback on surgeon graft type selection.

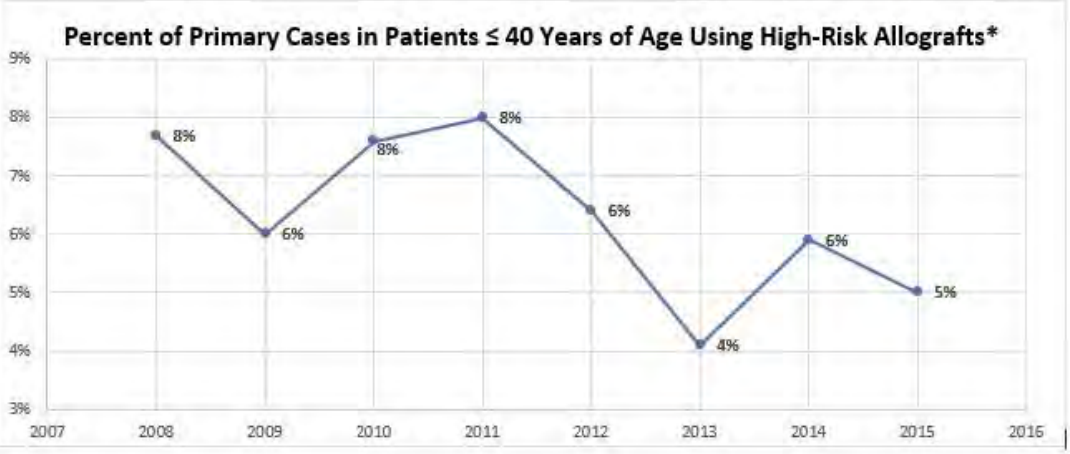
Methods: Feedback to surgeons on graft performance was presented through a variety of mechanisms including (1) peer-reviewed publications, (2) internal and external meetings and conferences (3) newsletters of study findings, (4) Risk calculators and (5) confidential individualized reports of surgeon's outcomes. In addition, surgeon champions set a quality improvement goal to reduce allograft usage overall and specifically to decrease the use of high risk grafts and usage in high-risk patient groups. Allograft usage was monitored on a quarterly basis to determine if the target was achieved. Annual graft utilization from 2008-2015 is reported here as proportions, for the overall cohort and for high-risk subgroups.

Results: Our integrated healthcare system's ACLR registry currently includes over 35,000 patients. Beginning in 2008, the annual proportion of ACLR cases using an allograft increased with a peak of 45% in 2010. Allograft use has decreased in the ensuing years and was 33% in 2015, a decrease of 27%. High-risk graft usage decreased from 8% in 2011 to 5% in 2015 which is a 38% decrease. Allograft use in patients ≤ 21 years of age decreased 68% from a high of 28% in 2009 to 9% in 2015. (see Figure)

Conclusion: Translating registry findings into evidence-based clinical practice is the goal of a registry. In this study, we found that information derived from an ACL Registry and disseminated to the participants can directly influence the use of specific procedures or implants that are associated with poor outcomes. Registries can provide useful information that may ultimately be used to improve patient care.


Percent of Graft Type, Program-Wide by Year
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
41%
43%
45%
44%
39%
36%
34%
33%
31%
32%
32%
33%
34%
36%
34%
33%
26%
23%
22%
21%
24%
24%
26%
29%
1%
2%
2%
2%
3%
4%
5%
4%
1%
0%
0%
0%
0%
2%
0%
2008
2009
2010
2011
2012
2013
2014
2015
Allograft (all)
Hamstring Autograft
BPTB Autograft
Missing
Other


Percent of Primary Cases in Patients ≤ 21 Years of Age Using Allografts
30%
25%
20%
15%
10%
5%
25%
28%
25%
25%
18%
13%
12%
9%
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


Percent of Primary Cases in Patients ≤ 40 Years of Age Using High-Risk Allografts*
9%
8%
7%
6%
5%
4%
3%
8%
6%
8%
8%
6%
4%
6%
5%
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

Paper 149

Title:
Socioeconomic Status Impacts Outcomes Following Anterior Cruciate Ligament Reconstruction Status

Authors:
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Children's Hospital Los Angeles, Los Angeles, CA, USA.

Objectives: Delays in pediatric and adolescent anterior cruciate ligament reconstruction (ACLR) are associated with increased prevalence of concomitant knee injuries and worse post-operative outcomes. However, few studies have described the factors that may contribute to these delays and adverse events. This study seeks to determine the impact socioeconomic status has on outcomes following ACLR.

Methods: Patients who underwent primary ACLR at a pediatric hospital between 2009 and 2015 were retrospectively reviewed. Variables included clinical outcomes and post-operative complications, as well as chronologic, demographic, and socioeconomic factors. Post-operative complication variables included graft failure, return to operating room, stiffness, and infection. Socioeconomic status was measured using health insurance type (commercial vs. government) and city block group level median household income levels derived from 2009-2015 U.S. Census Bureau data. Patients were excluded if they had multiligamentous knee injuries, prior ACLR, presented more than 365 days after injury, or had missing medical record data.

Results: Overall, 127 patients (69 male, 58 female) were included in data analysis. The mean age at time of surgery was 15.0 ± 2.3 years (range = 9 to 21 years). There were 68 patients in the commercial insurance group and 59 patients in the government insurance group. Patients in the commercial insurance group had an average household median income of $87,767 (SD = $38,325) compared to $51,366 (SD = $25,330) in the government insurance group, p = < 0.0001. Patients in the government insurance group demonstrated greater delays in time from injury to first appointment (p = 0.0003), injury to MRI (p = 0.021), injury to surgery (p = < 0.0001), first appointment to surgery (p = 0.0036), and injury to return to play, p = 0.044 **(Table 1)**. At time of surgery, 81% (48/59) of patients in the government insurance group presented with concomitant meniscal injuries compared 65% (44/68) of patients in the commercial insurance group, p = 0.034 (Odds Ratio = 2.38). Post-operatively, 22% (13/58) of patients in the government insurance group experienced decreased knee range of motion (“stiffness”) compared to 9% (6/68) in the commercial insurance group, p = 0.033 (Odds Ratio = 2.99). No significant differences were found between insurance types for rates of concomitant chondral injuries, graft failure, re-operation, or post-operative infection.

Conclusion: Pediatric patients with government health insurance may experience delays in receiving definitive knee injury management and be at risk for complications and diminished outcomes. These delays are likely multifactorial, and may be attributed to decreased access to care, familial resources, and social support. Of note, our findings suggest a significant discrepancy in time to treatment as well as rates of concomitant knee injuries and post-operative complications between government and commercial insurance types.

Table 1. Comparison of insurance types by chronologic variables			
	Commercial	**Government**	**P**
Injury to First Appointment (days)	48.9 ± 57.1	96.5 ± 85.4	0.0003
Injury to MRI (days)	44.2 ± 83.3	85.9 ± 80.8	0.021
Injury to Surgery (days)	90.4 ± 83.7	174.6 ± 122.2	< 0.0001
First Appointment to Surgery (days)	41.9 ± 65.2	78.1 ± 71.8	0.0036
Injury to Return to Play (days)	336.2 ± 130.4	394.7 ± 153.6	0.044
Surgery to Return to Play (days)	255.7 ± 116.8	238.9 ± 98.5	0.445

Paper 150

Title:
Prospective Validation of Patient-Reported Outcomes Measurement Information Systems (PROMIS) CAT Scores in a Hip Preservation Population

Authors:
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Objectives: Objectives: Current Hip Patient Reported Outcome Scores (PROs) are not universally obtained, centers use different forms to try to interpret treatment outcomes, and are limited by floor and ceiling effects. Legacy scores of Modified Harris Hip Score (mHHS), International Hip Outcome Tool (iHOT), and Hip Outcomes Score (HOS) are common place and used in the literature. Patient compliance for legacy PROs have been shown to limit proper data collection. PROMIS measures were developed through NIH funding, vetted against a population norm and PROMIS Computer Adaptive Testing (CAT) has been shown in recent literature to compare well with knee and shoulder legacy scores, and are completed in a quicker amount of time. We hypothesize that in a hip preservation population, the CAT PROMIS Profile V2.0 and PROMIS physical function (PF) would show high correlation with legacy scores of (mHHS, iHOT, and HOS).

Methods: *Methods:* After obtaining IRB approval, power analysis revealed 86 patients were needed to detect a significant difference. 100 patients were prospectively enrolled. Patients were asked to complete the iHOT-12, mHHS, HOS and then complete the CAT PROMIS Profile v 2.0. Inclusion criteria for the current study included all Initial encounter and single follow-up patients that have completed the CAT portion and started the legacy scores before opting out. Exclusion criteria will be any patient with a repeat encounter, patients under the age of 18 or a patient that did not complete the legacy or CAT scores. Repeat encounters were excluded due to statistical analysis assuming independence among observers. Correlation between instruments was defined as excellent (>0.7), excellent-good (0.7-0.61), good (0.6-0.4), and poor (0.3-0.2).

Results: *Results:* Demographics of 75 females and 25 males, mean BMI 26.3, and mean age 36.1 (range 18-67). The PROMIS Physical function, Pain Intensity, and Ability to Participate in Social Roles showed excellent correlation with the iHOT-12 ($r=0.71$ $P<0.001$), mHHS ($r=0.8$ $P<0.001$) and HOS ($r=0.82$ $P<0.001$). Patients averaged 21.6 questions to complete all seven arms of the PROMIS Profile. No patient experienced a ceiling effect utilizing the PROMIS Profile CAT.

Conclusion: Conclusion: The PROMIS Profile allows for an in-depth look at patients' dysfunction, not asked in current legacy scores. The PROMIS Physical function and Pain Intensity show excellent correlation with iHOT-12, mHHS and HOS. The CAT PROMIS Profile, shows no observed ceiling effect and can be considered to replace current legacy measures in hip preservation.

Paper 151

Title:
Management of Failed Proximal Biceps Surgery: Clinical Outcomes after Revision to Subpectoral Biceps Tenodesis

Authors:
David Savin, MD[1], Brian Robert Waterman, MD[2], Catherine Richardson[3], Shelby Sumner[4], Anthony A. Romeo, MD[5].
[1]Desert Orthopedic Center, Rancho Mirage, CA, USA, [2]Wake Forest University School of Medicine, Winston Salem, NC, USA, [3]Rush University, Chicago, IL, USA, [4]Rush University Medical Center - Chicago, IL, Chicago, IL, USA, [5]Midwest Orthopaedics at Rush, Chicago, IL, USA.

Objectives: The preferred technique for management of biceps-superior labral pathology is often debated, and rates of revision and persistence pain vary widely accordingly to surgical technique and patient demographics. The purpose of this study was to evaluate the clinical and functional outcomes of patients undergoing revision subpectoral biceps tenodesis after failed primary tenodesis or tenotomy.

Methods: A retrospective review was completed to identify of all patients undergoing revision biceps tenodesis by the senior surgeon with minimum 24-month follow-up. Demographic variables including age, sex, insurance status, and tobacco use were recorded, Patient reported outcomes including the functional score, Single Assessment Mumeric Evaluation (SANE) rating, Visual Analog Scale (VAS) pain scale, Simple Shoulder Test (SST), and American Shoulder and Elbow Score (ASES) were obtained, and range of motion (ROM), strength, and complications were quantified

Results: In total, 36 patients with revision biceps tenodesis were identified, with a mean age of 46 ± 12 years and mean follow up of 60 ± 29 months. The indication for revision surgery was failure of index suprapectoral biceps tenodesis (56%), subpectoral biceps tenodesis (36%), and failure of tenotomy (8%). Concomitant procedures including rotator cuff repair and capsular release were performed in 25% and 8% of index surgeries respectively. There was a significant improvement in VAS score ($P < 0.001$), SST ($P < 0.009$), functional score ($P < 0.001$) and forward elevation ($P < 0.001$). Postoperative shoulder strength ($P = 0.082$), SANE ($P = 0.074$), abduction ($P = 0.096$) and external rotation ($P = 0.8$) improved, but failed to achieve statistical significance. were not significantly improved following revision surgery. There was no difference in post-operative outcome measures between surgical indication, concomitant procedures and sex. 86% of patients reported high satisfaction and stated they would have this revision surgery again. Overall complication rate was 33% with the majority of these being either acute or chronic pain, with 8% of patients requiring additional surgeries to manage stiffness, chronic pain or rotator cuff deficiency.

Conclusion: The current study demonstrates high patient satisfaction (86%) and significant improvement in functional outcomes with revision biceps tenodesis after previous failed tenodesis or tenotomy. Revision biceps tenodesis using a mini-open, subpectoral technique may be an effective strategy to address failed prior surgery, although the potential for persistent pain must be emphasized.

Paper 152

Title:
Arthroscopic SLAP IIb Repair Using Knot-tying Versus Knotless Suture Anchors: Is There a Difference?

Authors:
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Objectives: SLAP IIb surgical outcomes have traditionally been less predictable when compared to other shoulder injuries. Traditional knotted anchors may partially be to blame by abrading the rotator cuff leading to tearing and pain.

Methods: Seventy-four athletes who underwent arthroscopic SLAP IIb repair with traditional (n=42) and knotless anchors (n=32) at minimum 2-year follow-up were evaluated. Demographic, surgical data, return to play (RTP), KJOC, ASES, stability, ROM, strength, and pain scores were compared.

Results: Knotless anchors had slightly higher RTP (93.5%, 58.1% same level) vs. traditional (90.2%, 53.7% same level), but was not statistically significant. Knotless anchors were less likely to require revision surgery (9%) compared to traditional anchors (17%), but was not statistically significant. There was no difference in KJOC, ASES, stability, ROM, strength, and pain between the two anchor types (Table 1). Pain was the only variable linked to decreased RTP ($p < 0.0001$). Younger patients had significantly poorer KJOC ($p = 0.02$) and ASES scores ($p = 0.02$) but no difference in RTP. No difference in outcome measures or RTP was found with gender, age, overhead athletes, number of anchors, or sport type (Table 2). Average follow-up was 6.5 years.

Conclusion: Knotless anchors required less revision surgery, had higher RTP, ASES, and KJOC scores; however, statistical significance was not achieved in this relatively small cohort. Further evaluation, such as case matching and assessment of a larger sample size should be done. Possible other advantages such as tensioning and surgical time may also be important when considering lower profile knotless fixation.

Paper 153

Title:
Suprapectoral vs. Intra Articular Biceps Tenodesis: A Comparison of Clinical Outcomes

Authors:
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Objectives: The long head of the biceps tendon is a frequent pain generator within the shoulder. It is subjected to trauma and wear within the glenohumeral joint and within the intertubercular groove. Tenodesis of this tendon is a common treatment option for patients experiencing biceps tendon related pain. There are several different techniques to perform this procedure. Proximal intra-articular tenodesis can be performed but leaves the tendon within the intertubercular groove. Alternatively, suprapectoral tenodesis can be performed removing the tendon from the bicipital groove and sheath while avoiding conversion to an open procedure. Further, suprapectoral tenodesis limits complications associated with an open distally based incision. Several studies have compared these techniques to tenotomy or open-subpectoral tenodesis. This is the first study to directly compare patient outcomes between intra-articular and suprapectoral bicep tenodeses.

Methods: Retrospective review of patients undergoing intra-articular or suprapectoral arthroscopic biceps tenodesis from 2010 - 2015. Clinical outcomes were measured at set intervals post-operatively (3 months, 6 months, and 12 months) and compared to pre-operative scores. Outcome measures included short form-12, both physical (PSF) and mental (MSF) component scores, and the American Shoulder and Elbow Surgeons score (ASES).

Results: A total of 96 patients were available for this study, 43 had intra-articular tenodesis and 56 had suprapectoral tenodesis. There was no difference in functional outcomes between intra and extra articular biceps tenodesis at 1-year post-operative. The intra-articular group had a quicker improvement in scores with the greatest increase at 3 months post-operatively, specifically in PSF group ($p=0.016$): however, this difference leveled off at 1-year follow up ($p=0.238$). The intra-articular group had greater absolute scores at all measured time points, but not significantly. Both groups showed improvement in all outcome measures and there was found to be no difference in changes for ASES, PSF, or MSF ($p=0.262$, $p=0.489$, and $p=0.907$ respectively).

Conclusion: This study demonstrates that both intra-articular and surpapectoral techniques are acceptable options for biceps tenodesis. Despite leaving the biceps tendon within the glenohumeral joint and intertubercular groove, the intra-articular technique offers similar improvement in outcome measures to the suprapectoral technique.

Paper 154

Title:
The Borderline Dysplastic Hip: Arthroscopy or PAO?

Authors:
George Grammatopoulos, MD[1], **Cecilia Pascual-Garrido, MD**[2], Jeffrey Nepple, MD[2], Christopher M. Larson, MD[3], Asheesh Bedi, MD[4], ANCHOR Group[2], Paul Beaule, MD[5], John C. Clohisy, MD[2].
[1]University of Oxford, Oxford, United Kingdom, [2]Washington University, Saint Louis, MO, USA, [3]Minnesota Orthopaedic Sports Medicine Institute at Twin Cities Orthopedics, Edina, MN, USA, [4]University of Michigan, Ann Arbor, MI, USA, [5]The Ottawa Hospital, Ottawa, ON, Canada.

Objectives: The borderline dysplastic hip (characterized by a lateral centre-edge angle (LCEA): 20 - 25° and an acetabular index (AI): 10 - 15°) can pose a significant challenge as symptoms may be due to insufficient acetabular coverage, the presence of femoro-acetabular impingement (FAI) or both. Accordingly, different treatment options have been described, including peri-acetabular osteotomy (PAO), hip arthroscopy, open arthrotomy or a combination of procedures.
This study aims to determine patient and deformity-specific characteristics that direct treatment decision-making in the borderline dysplastic hip. Furthermore, we describe the early-term results of both the PAO and hip arthroscopy in treating this challenging patient population.

Methods: A prospective, multicenter, longitudinal surgical cohort of young adult hips was searched. From 2060 hips, 291 hips satisfied the inclusion criteria of idiopathic borderline dysplasia, adequate follow-up (> 1-year) and functional outcome. Demographic and radiographic features are included in Table 1. Fifty-five hips (19%) had a previous hip operation (most commonly a hip arthroscopy).
A number of different procedure types were performed which were broadly divided into 3 groups; PAO-only (n=42), hip arthroscopy-only (n=127) or PAO and intra-articular treatment (either arthroscopically or open, addressing the cam morphology and/or labral pathology) (n=122). Outcome measures included complications-, re-operations- rates and clinical outcomes using the Harris Hip (HHS) and HOOS scores; pre-operatively and at follow-up; the difference was defined as Δ. Patient characteristics, radiographic morphology and clinical outcome measures were compared between the 3 groups.

Results: Patients that underwent a PAO were younger and more likely to be female. The PAO groups had a greater number of previous hip procedures (26%, 24%), most of which were hip arthroscopies. The patients that underwent hip arthroscopy had greater incidence of high alpha angles (66%) compared to the PAO groups (35%, 38%) (p<0.001). The PAO groups having slightly more dysplastic features (LCEA, AI, ACEA) (Table 1).
At a mean follow-up of 2.5 years, there were no differences in the complication (7-10%, p=0.8) or re-operation rates (13%). Pre-operatively, the PAO groups had inferior HOOS and WOMAC scores compared to the arthroscopy group (p=0.02-7). No differences in the post-op scores were seen (Table 1).
The groups that addressed the intra-articular pathology (arthroscopy and PAO-articular treatment) had significantly greater ΔHHS (23) compared to PAO-only (13) (p=0.02).

Conclusion: Younger patients, those with a failed previous arthroscopy, without evidence of intra-articular wear and with worse pre-operative function were more likely to receive a PAO (with or without articular adjunct treatment). Addressing the intra-articular and impingement-related pathology (in addition to a when a PAO is considered necessary) was associated with better improvement in PROMs and should be strongly considered in the borderline hip.

Parameter		**Cohort** (n=291)	**Groups**			**p-value**
			PAO (n=42)	*Arthroscopy (n=127)*	*PAO & Intra-articular (n=122)*	
Age (years old)		27 ± 11	22 ± 7	31 ± 12	24 ± 8	**<0.001***
Gender (%female)		77%	95%	64%	84%	**<0.001***
BMI		24 ± 4	24 ± 4	24 ± 4	24 ± 4	0.5
Chronicity of pain	<1 –year	32%	24%	35%	31%	**0.04***
	1 – 3 years	45%	52%	35%	52%	
	>3 years	13%	24%	30%	17%	
Previous hip surgery (%)		19%	26%	12%	24%	**0.02***
Previous arthroscopy (%)		17%	26%	9%	21%	0.1
Acetabular Index/°		9 ± 3	11 ± 3	9 ± 3	10 ± 3	**<0.001***
LCEA/°		22 ± 2	22 ± 2	23 ± 2	22 ± 2	**<0.001***
ACEA/°		25 ± 8	23 ± 10	28 ± 6	22 ± 8	**<0.001***
Cross Over Sign (%)		44%	31%	49%	43%	0.1
Congruity	Excellent	31%	59%%	24%	28%	**<0.001***
	Good	65%	36%	71%	69%	
	Fair	4%	5%	5%	3%	
Tönnis Grade	0	61%	76%	41%	76%	**<0.001***
	1	38%	22%	58%	24%	
High α Angle (AP or lateral) (%)		50%	36%	66%	38%	**<0.001***
Complication		8%	10%	7%	9%	0.8
Re-operation		18%	19%	16%	20%	0.8
THA by follow-up		2%	-	3%	-	0.07
HHS_pre-op		60 ± 16	63 ± 19	61 ± 15	58 ± 16	0.07
HOOS_pre-op		54 ± 22	52 ± 21	58 ± 22	50 ± 21	**0.02***
WOMAC_pre-op		64 ± 22	64 ± 22	67 ± 22	61 ± 22	0.06
SF12_pre-op		37 ± 10	40 ± 10	38 ± 10	35 ± 10	**0.03***
HHS_post-op		78 ± 19	75 ± 20	80 ± 18	78 ± 19	0.4
HOOS_post-op		77 ± 22	73 ± 23	81 ± 20	75 ± 23	0.07
SF12_post-op		45 ± 12	43 ± 12	47 ± 11	46 ± 12	0.6
ΔHHS		21 ± 25	13 ± 13	23 ± 26	22 ± 20	0.08
ΔHOOS		27 ± 31	20 ± 35	28 ± 31	27 ± 29	0.5
ΔSF12		10 ± 15	4 ± 19	10 ± 16	12 ± 15	**0.02***

Table 1: Patient demographics, radiographic parameters, complication-, re-operation rates and patient reported outcome measures for the whole cohort and the three treatment subgroups.

Paper 155

Title:
Does Time from Injury to Surgery Affect Outcomes Following Surgical Repair of Partial and Complete Proximal Hamstring Ruptures?

Authors:
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Objectives: The purpose of this study was to determine if time from injury to surgery affected postoperative outcomes after primary repair of partial and complete proximal hamstring ruptures. The secondary aim of the study was to assess patients' experiences from initial evaluation to finding a treating surgeon to help increase awareness of the injury.

Methods: Office records from 2008 to 2016 were reviewed from one orthopedic surgeon's practice. A total of 124 partial and complete proximal hamstring repairs in 121 patients were identified. Ninety-two patients completed questionnaires including a custom survey in addition to validated outcome measures: Lower Extremity Outcome Score (LEFS), custom LEFS, Marx Activity Scale, custom Marx scale, and University of California at Los Angeles (UCLA) Activity Score. A chart review was performed to collect demographic, encounter, and operative information. Results were analyzed and compared for both partial and complete proximal hamstring repairs performed ≤ 3 weeks, ≤ 6 weeks, and > 6 weeks following injury.

Results: Mean follow-up of study respondents was 43 months (range, 6-116 months). Of the 93 proximal hamstring repairs reviewed, 50.5% (9/28 partial, 38/65 complete), 78.5% (16/28 partial, 57/65 complete) and 21.5% (12/28 partial, 8/65 complete) were performed ≤ 3 weeks, ≤ 6 weeks, and > 6 weeks, respectively. At various injury-to-surgery time intervals, no statistical difference was found in the LEFS, custom LEFS, Marx Activity Scale, custom Marx Scale, and UCLA Activity Scores. Overall, partial proximal hamstring repairs had better outcome scores compared to complete tears although this was not statistically significant with the exception of leg pain at rest, which was higher after repair of complete tears (P = 0.021). Additionally, female gender and age were negative predictors of outcome scores. Increasing time from injury-to-surgery was associated with lower perceived strength of operative side compared to contralateral leg, most notable with surgery > 6 weeks after injury (% patients with perceived near or full strength of the contralateral limb: partial tears ≤ 6 weeks 93.8% versus > 6 weeks 75%; complete tears ≤ 6 weeks 75.4% versus > 6 weeks 50%). Patients who underwent repair > 6 weeks following injury for both partial and complete tears exhibited a greater sitting intolerance after one hour compared to those repaired ≤ 6 weeks (0% partial, 7.1% complete ≤ 6 weeks; 12.5% partial, 25% complete > 6 weeks). The majority of patients with complete ruptures (42%) were initially evaluated at a local emergency room while most partial tears were evaluated by their primary care physician (35.7%). Patients with repairs performed > 6 weeks following injury visited, on average, 2.6 practitioners prior to evaluation by the treating surgeon compared to 1.6 for those surgically treated ≤ 6 weeks following injury.

Conclusion: Proximal hamstring ruptures performed in both the acute and chronic setting can expect overall successful outcomes but may experience lower perceived strength and difficulty with prolonged sitting with repair > 6 weeks following injury. Patients also faced challenges in correct diagnosis of the injury and referral to an appropriate treating surgeon. These findings emphasize the need for increased awareness of the injury not only within the orthopedic community, but also the emergency room and primary care settings.

Paper 156

Title:
Endoscopic Repair of Partial Thickness Under-Surface Tears of the Abductor Tendon (pusta): Clinical Outcomes with Minimum Two-year Follow-up

Authors:
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[1]Mayo Clinic Arizona, Phoenix, AZ, USA, [2]Hinsdale Orthopaedics and American Hip Institute, Westmont, IL, USA, [3]University of Chicago, Chicago, IL, USA, [4]American Hip Institute, Westmont, IL, USA.

Objectives: To report the minimum two-year outcomes of trans-tendinous repairs of Partial thickness UnderSurface Tears of the Abductor (PUSTA) tendon using patient reported outcomes (PROs), visual analog scale (VAS), and patient satisfaction scores.

Methods: All patients who underwent endoscopic trans-tendinous gluteus medius repair between October 2009 and May 2013 at one institution were prospectively evaluated. Exclusion criteria consisted of less than two-year follow-up, previous hip surgery, inflammatory arthritis, open surgery, full thickness abductor tear, and worker's compensation patients. All patients had a documented pre-operative physical exam with strength testing (0-5) and observation of their gait. Patient satisfaction and PRO scores were recorded preoperatively, at 3 months postoperatively, and annually thereafter. The PRO scores collected were mHHS, HOS-ADL, HOS-SSS, NAHS, and VAS. Preoperative strength and gait were compared to latest follow-up.

Results: There were 25 patients that fit our criteria. Significant improvement in PRO scores were demonstrated for mHHS, HOS-ADL, HOS-SSS, NAHS, and VAS from 54.9-76.2, 50.2-80.6, 30.1-67.3, 51.9-82.4, and 7.1-2.7 respectively ($p<0.001$). There were 11 patients with objective weakness prior to surgery; seven of these patients moved up at least one strength grade by final follow-up. There were 14 patients who had a Trendelenbrug gait pre-operatively, 12 of them had a normal gait at latest follow-up (p-<0.001). Average patient satisfaction was 7.5. There were no revision surgeries, and no complications noted.

Conclusion: PUSTA lesions can be treated successfully with endoscopic trans-tendinous repair preserving the intact attachment of superficial fibers of the gluteus medius. We recommend this treatment for partial undersurface tears recalcitrant to non-operative treatment, as patients demonstrated clinical benefit at greater than 2 years follow up that exceeds substantial clinical benefit and minimally clinical important difference.

Paper 157

Title:
Outcomes After Arthroscopic Management of Subspinous Impingement in Borderline Hip Dysplasia

Authors:
Daniel Feghhi, MD, Srino Bharam, MD, Jonathan Shearin.
Lenox Hill Hospital, New York, NY, USA.

Objectives: Arthroscopic management of femoroacetabular impingement in the setting of borderline hip dysplasia is controversial. There is concern for iatrogenic hip instability with rim-resection in an already structurally compromised acetabulum. Recently, there has been increased awareness of a prominent anterior inferior iliac spine (AIIS) resulting in subspinous impingement. The purpose of this study was to report on the outcomes of arthroscopic subspinous decompression in patients with symptomatic hip impingement and borderline hip dysplasia.

Methods: An IRB approved retrospective study of patients with symptomatic hip impingement, borderline dysplasia (LCEA 18-24°) and prominent AIIS who failed conservative management and subsequently underwent arthroscopic subspinous decompression was conducted. Eighteen patients, 19 hips (4 male and 14 female, average age 28) were identified from 2012 to 2015. 3D-CT imaging was used to categorize AIIS morphology into Type 1, 2 or 3 (Hetsroni classification). Alpha angle and femoral version were determined as well. Patient-reported outcome scores (PROs) consisting of the modified Harris Hip Score (mHHS), Hip Outcome Score-Activities of Daily Living (HOS-ADL) and Sport-Specific Subscale (HOS-SSS) were obtained preoperatively and at an average of 44 months postoperative (range, 23-61 months).

Results: There were no postoperative complications or symptoms of instability. Fourteen hips were of Type 2 AIIS morphology and 6 were categorized as type 1. Femoral osteoplasty was performed in 17 hips (average alpha angle 66°). Repeated measures ANOVA revealed a significant improvement in all PROs from preop to latest follow-up; (mHHS 64.7, 93.4, $p< .001$; HOS-ADL 62.1, 94.6, $p< .001$; HOS-SSS 26.5, 93.4 $p< .001$). An ANCOVA revealed patients with type 2 AIIS had a significantly higher post-op mHHS than those with a type 1 morphology; (88.3, 95.6, $p< .01$).
Conclusion: Arthroscopic AIIS decompression in patients with co-existing borderline dysplasia and subspinous impingement leads to favorable outcomes without compromising hip stability.

Paper 158

Title:
Influence of Naproxen, Age and Body Mass Index on the Biological Composition of Leukocyte Rich Platelet-Rich Plasma: A Prospective, Therapeutic, Cohort Study

Authors:
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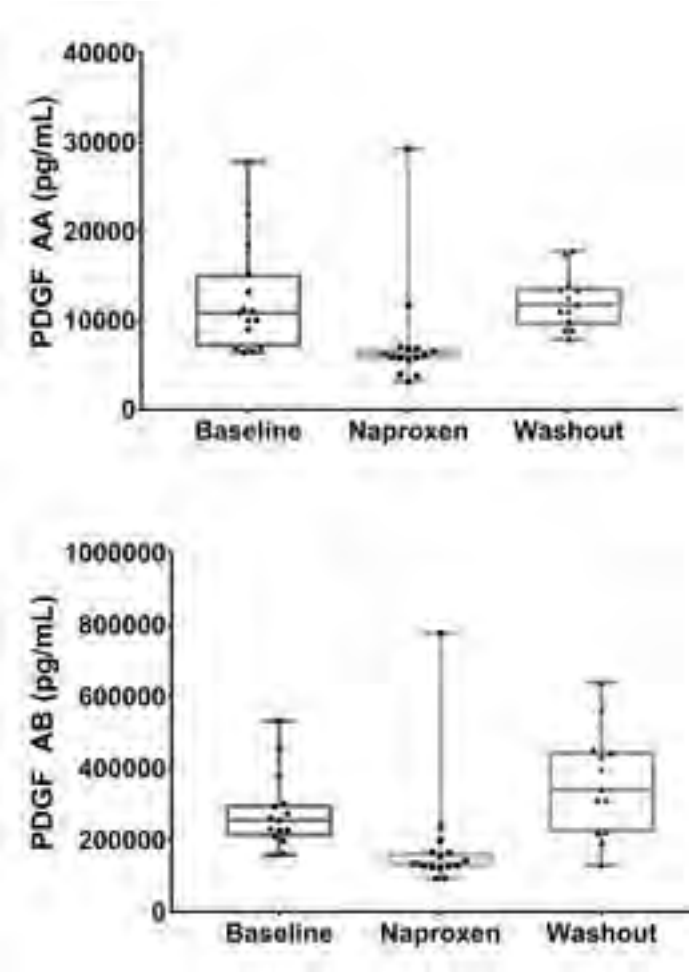
[1]University of Rochester Medical Center Program, Rochester, NY, USA, [2]Steadman Philippon Research Institute, Vail, CO, USA, [3]Santa Monica Orthopaedic & Sports Medicine Group Program, Santa Monica, CA, USA, [4]University of Texas Health Science Center at Houston Medical School, Houston, TX, USA, [5]The Steadman Clinic, Vail, CO, USA.

Objectives: Platelet-rich plasma (PRP) is comprised of several biologically active factors that can stimulate musculoskeletal healing processes. Non-steroidal anti-inflammatory drugs (NSAIDs) are used to treat many musculoskeletal conditions and influence platelet function. The influence of NSAIDs on the biological composition of PRP is not well known. The purpose of this study was to quantify and compare growth factors and other chemokines and cytokines in leukocyte-rich PRP (LR-PRP) between baseline, following one-week of NSAID (Naproxen) use, and after a one-week washout period. We hypothesized that Naproxen would alter both the catabolic and anabolic factors in LR-PRP. Our secondary hypothesis was that discontinuing Naproxen use for one-week would be sufficient to return LR-PRP's molecular constituents back to baseline. **Study Design:** Non-randomized, prospective cohort study; Level of evidence: 2.

Methods: Sixteen healthy volunteers (n=8 male and n=8 females) were enrolled in this IRB approved study. Peripheral blood was drawn at three-time points: baseline, one-week after Naproxen intake, and after a one-week washout period. Donors were instructed after the first blood-draw to ingest oral Naproxen tablets twice a day (440 mg bid) for one-week. Fifty-two anabolic and catabolic factors in LR-PRP were measured at all time points. Donor demographics were collected at the time of the initial blood-draw. To address the primary hypothesis of this study, Friedman's test was used to identify significant differences between the baseline, Naproxen and washout time points while accounting for the repeated measures design of this study. When Friedman's test was significant, pairwise comparisons were made using Holm's method to control the family-wise type 1 error rate.

Results: Three anabolic growth factors, platelet derived growth factor-AA (PDGF-AA, Figure 1), platelet derived growth factor-AB (PDGF-AB, Figure 1), and transforming growth factor-β1 (TGF-β1), had a significant decline from baseline ($p<0.05$) after one-week of Naproxen use. There was a significant recovery ($p<0.05$) of PDGF-AA and PDGF-AB levels after the one-week washout of NSAIDs, with a return to baseline levels. TGF-β1 did not recover to baseline levels after a one-week washout period. Catabolic factors tumor necrosis factor-β (TNF-β) and interleukin-6 (IL-6) had a significant decline from baseline ($p<0.05$) after NSAID use for one-week and returned to levels similar to baseline ($p<0.05$) after a one-week washout period.

Conclusion: Naproxen use diminished several biological factors in LR-PRP; however, a one-week washout period was sufficient for the recovery of PDGF-AA, PDGF-AB, TNF-β, and IL-6 to return to baseline levels. Our results suggest that patients undergoing PRP treatment should discontinue Naproxen, and other NSAID use, at least one-week prior to harvest and injection of PRP.



Paper 159

Title:
Anti-Inflammatory Effects of Bone Marrow Aspirate Concentrate on Joint Tissues In Patients Undergoing ACL Reconstruction

Authors:
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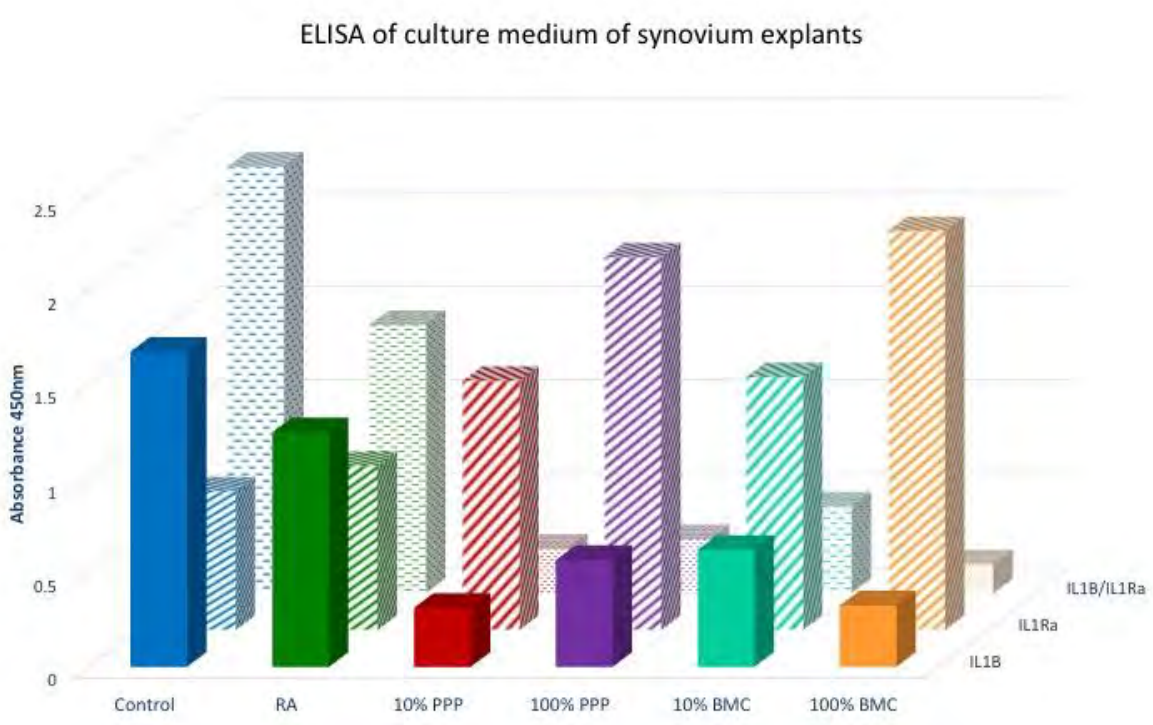
Objectives: Studies have shown that up to 50% of ACL injuries progress to post traumatic osteoarthritis (PTOA). This may be due to a cascade of molecular and mechanical changes occurring following injury and subsequent to reconstruction. A mechanobiological intervention may be best to target molecular pathways in combination with correcting the biomechanical ligament deficiency. Bone marrow aspirate concentrate (BMC) is a source of mesenchymal stromal cells (MSCs), platelets and other cytokines and growth factors that represents an inexpensive, readily available biological intervention that may have a therapeutic effect on PTOA progression. BMC increases the concentration of Interleukin 1 receptor antagonist protein, which may provide anti-inflammatory and immunomodulatory effects. We hypothesize that BMC will reduce synovial inflammation and cartilage degradation. Furthermore, it will modulate injury responses via its paracrine effect on resident cells of articular cartilage and synovium.

Methods: This is a controlled laboratory study nested within a randomized controlled clinical trial. Following preoperative quantitative MRI, 12 subjects undergoing ACL reconstruction within 3 months of injury were randomized to either intra-articular injection of BMC or placebo. Urine, blood, synovial fluid, synovium, cartilage, BMC, platelet poor plasma (PPP) were collected at the time of surgery. Post-operatively urine, synovial fluid and blood were taken at 2 and 6 weeks, 6, 12 and 24 months. MRIs were repeated at 6 and 12 months post-op. BMC was sent for cell differential and flow cytometry for MSCs. Tissue samples were cultured in transwell culture plates with either 10% or 100% BMC, 10% or 100% PPP, 5% retanoic acid, or culture medium control. Samples were cultured for 72hrs and then tissue and the media were collected. qPCR and ELISA was done for inflammatory and growth markers on all samples. Tissue samples were also processed, embedded, sectioned and stained. Student's t-tests and ANOVAs were done.

Results: Baseline demographics were the same between groups. Pre-op MRI T1Rho images had significantly higher relaxation time in the posterolateral tibial plateau in the ACL tear knees compared to the contralateral side. We were able to corroborate previous studies demonstrating MSC content and cell differential in the BMC. Synovium had significantly lower inflammatory cells in the BMC treated cultures ($p<0.05$), and synovial medium produced lower levels of IL-1B and higher levels of IL-1Ra when treated with BMC.



There were no differences in cartilage degeneration scores between treatment groups.

Conclusion: We were able to corroborate previous studies demonstrating MSC content in BMC and demonstrated that BMC increases anti-inflammatory mediators *in vitro* and decreases inflammatory cell content in synovial tissue in patients undergoing ACL reconstruction. There was no early effect on the cartilage morphology. This preliminary data shows some promise that BMC therapy in conjunction with ligament reconstruction may reduce the inflammatory cascade post injury/surgery and thereby modulate PTOA progression.

Paper 160

Title:
Incidence of Heterotopic Ossification Among NFL Athletes Following Platelet-Rich Plasma (PRP) for Treatment of Core Muscle Injuries (CMI)

Authors:
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Objectives: Platelet-rich plasma (PRP) therapy is an increasingly-popular treatment to promote healing in damaged tendons, ligaments, cartilage and muscles. Few studies analyze long-term effects of PRP. The authors have a busy practice treating core muscle injuries (CMI) and, in the last several years, have noticed an unusually high incidence of HO among patients with previous PRP injections for these injuries. The purpose of this study is to investigate PRP and heterotopic ossification in core muscle injuries.

Methods: NFL players with core muscle injuries treated at a single institution during the 2015 season filled out questionnaires and were included in retrospective analysis. Heterotopic ossification was observed on MRI and intraoperatively and confirmed pathologically.

Results: Five NFL players had previous PRP injections for core muscle injuries and 4/5 (80%)had HO. These were 2 linebackers and 2 cornerbacks. The fifth, a kicker, had no ossification but extensive fibrosis around the distal rectus abdominis and proximal adductors. These results are similar for all athletes with previous PRP injections treated around the same time period, 87% (13/15). The incidence of HO among all athletes without a previous PRP injection was 2/1088 (0.18%).

Conclusion: Retrospective analysis may be overestimating the true incidence and we have yet to identify patterns related to the variations in PRP technique. But these preliminary results suggest the need for further research and a cautious approach to using PRP in the treatment of CMI.

Paper 161

Title:
Direction of Capsular Strain Implies Surgical Repair Following Recurrent Anterior Shoulder Dislocation

Authors:
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Objectives: Capsular plication is often performed in addition to arthroscopic Bankart repair. However, little is known regarding the direction of capsular injury making the direction of plication fairly arbitrary. This study aimed to determine the optimal direction for capsular plication within four sub-regions of the inferior glenohumeral capsule following multiple dislocations.

Methods: Seven fresh-frozen cadaveric shoulders (age range 48-66 yrs) were dissected free of all soft tissue except the glenohumeral capsule. A grid of strain markers was affixed to the anterior and posterior band (A/PB) of the inferior glenohumeral ligament (IGHL), and the axillary pouch. The position of the markers while the capsule was inflated with minimal pressure served as the reference state. The humerus and scapula were then mounted in a 6 degree-of-freedom robotic testing system. At 60 degrees of abduction and 60 degrees of external rotation of the glenohumeral joint, an anterior load was applied to reach an anterior translation of one half the maximum AP width of the glenoid plus 10 mm. This definition of dislocation resulted in non-recoverable strain and a reproducible Bankart lesion. Following 1, 2, 3, 4, 5 and 10 dislocations, the positions of the strain markers were again recorded with the capsule inflated. The difference in these positions compared to the reference state defined the non-recoverable strain. The strain map was split into four sub-regions, the anterior band of IGHL (AB), anterior axillary pouch (AA), posterior axillary pouch (PA), and the posterior band of IGHL (PB) (Fig. 1). The angle of deviation between each of the maximum principle strain vectors and the AB-IGHL or PB-IGHL for the anterior and posterior regions of the capsule were determined using ImageJ. Circular statistics were employed to calculate mean direction of each sub-region and a Watson-Williams test was performed to compare mean direction among each dislocation with significance set at $p < 0.05$. The mean direction of all strain vectors in each sub-region was categorized as parallel or perpendicular to the AB-IGHL or PB-IGHL serving as the clinical reference. Direction ranging from 0 to 45 or 135 to 180 degrees was categorized as parallel. Direction ranging between 45 and 135 degrees was categorized as perpendicular.

Results: The direction of 81.8% of the AB sub-regions was categorized as parallel and 18.2% categorized as perpendicular to the AB-IGHL. Direction of 61.3% of the AA sub-region was categorized as parallel (Table 1) and 38.7% categorized as perpendicular to AB-IGHL. The direction of 33.3% of the PA sub-region was categorized as parallel and 66.7% categorized as perpendicular to the PB-IGHL. The direction of 21.4% of PB sub-region was categorized as parallel and 78.6% categorized as perpendicular to PB-IGHL. A Watson-Williams test demonstrated that the direction of 81.3% of the sub-regions were not

significantly different ($p > 0.05$) among dislocations for each specimen (Table 1).

Conclusion: The non-recoverable strain in most of the AB and AP sub-regions were categorized as parallel to the AB-IGHL while for the PA and PB sub-regions mostly perpendicular to the PB-IGHL. These findings imply that it may be more optimal to plicate the anteroinferior capsule parallel to the AB-IGHL while posteroinferior capsular plication, which is often not classically considered for plication in the setting of anterior instability, may also be necessary and best performed perpendicular to the PB-IGHL.

Figure 1. Fringe plot of non-recoverable strain for anterior half of inferior capsule in a typical shoulder following 5th dislocation. The borderline of AA and posterior axillary pouch sub-regions was the column of markers placed at the 6 o'clock position of the glenoid. AB-IGHL, anterior band of inferior glenohumeral ligament; AA, anterior axillary pouch sub-region; AB, anterior band of IGHL sub-region.

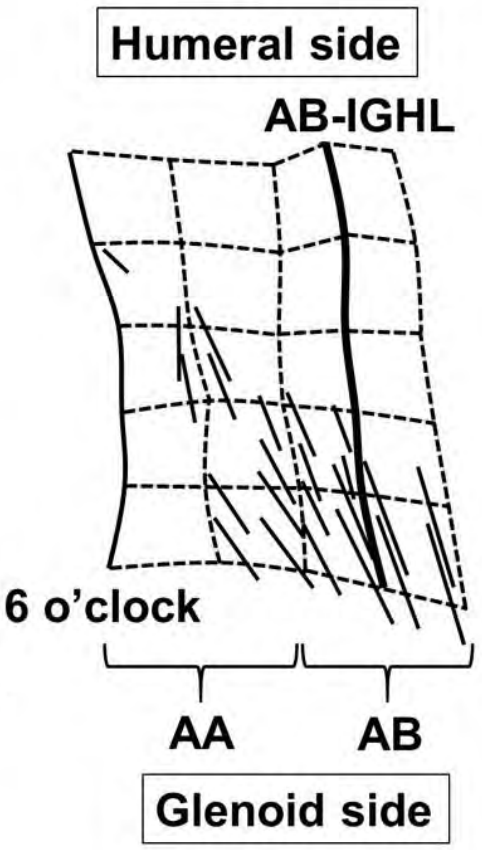

Table 1. Direction of non-recoverable strain in the anterior axillary pouch sub-region following 1st to 10th dislocations for a typical shoulder (mean ± SD)

Anterior Axillary Pouch sub-region	Direction of non-recoverable strain	Categorization
Dislocation 1	168±5	Parallel to AB-IGHL
Dislocation 2	168±8	Parallel to AB-IGHL
Dislocation 3	166±5	Parallel to AB-IGHL
Dislocation 4	165±5	Parallel to AB-IGHL
Dislocation 5	175±13	Parallel to AB-IGHL
Dislocation 10	158±20	Parallel to AB-IGHL

Watson-Williams test showed directions were not significantly different among dislocations ($p=0.33$). Directions through 6 dislocation states were categorized as parallel (between 135 to 180 degrees) to anterior-band (AB) of IGHL.

Paper 162

Title:
Risk Factors for Recurrent Shoulder Instability after Arthroscopic Revision Anterior Stabilization

Authors:
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Objectives: Individuals that fail arthroscopic anterior stabilization of the shoulder represent a unique and challenging patient population. To date, there have been few large studies that have investigated failure rates following arthroscopic revision anterior stabilization (ARAS) for failed primary arthroscopic stabilization. This study aims to determine the risk factors for recurrence of shoulder instability following ARAS. We hypothesized that male gender, younger age, participation in contact sports, significant glenoid and/or humeral bone loss, ligamentous laxity, and worker's compensation would increase the risk of revision failure.

Methods: Patients who underwent ARAS after a failed arthroscopic primary Bankart repair and had a minimum of 2-year follow-up were included in this study. Glenoid and humeral bone loss were quantitatively assessed using pre-operative T1-weighted magnetic resonance arthrograms to determine if the lesions were on- or off-track. Failure was defined as a recurrent dislocation or subluxation. Chi-square test and t-test were used to compare demographical and surgical parameters between failure and non-failure groups. The significance level was set to 0.05.

Results: Sixty-five patients [age at revision = 26 years (range, 15 - 57), 44 (68%) male] met the inclusion criteria. The mean follow-up time was 4.7 years (range, 2 - 10.8). Twenty-seven patients (42%) had a failed revision at a mean time of 2.3 years (range, 0.2 - 6.1). Age less than 22 years old, ligamentous laxity, the presence of an off-track lesion, and a concomitant superior labral anterior to posterior were significantly associated with revision failure ($p < 0.05$) (Table 1). No difference was observed in the size of glenoid defect between failure and non-failure groups (14.1% ± 4.4% vs. 13.7% ± 3.9%, $p = 0.762$). The width and depth of the Hill-Sachs lesions were not significantly different between groups (width: 15.3 ± 5.1 mm vs. 14.2 ± 4.8 mm, $p = 0.432$; depth: 4.2 ± 2.3 mm vs. 3.5 ± 1.8 mm, $p = 0.244$). On multivariate analysis, only the presence of an off-track lesion, age less than 22 years, and ligamentous laxity were independent predictors for recurrent instability (OR = 8.9, $p = 0.022$; OR = 5.4, $p = 0.028$; OR = 7.8, $p = 0.031$, respectively).

Conclusion: The failure rate of arthroscopic revision anterior stabilization was 42% with off-track lesions, age less than 22 years, and ligamentous laxity independent risk factors for recurrent instability. While ARAS may be a viable treatment option in the appropriate setting, our study suggests that considerable thought should be exercised before utilizing this approach given the significant number of patients who suffered recurrent instability at greater than 2-years follow-up. For young patients with off-track lesions and/or evidence of ligamentous laxity on physical exam, strong consideration should be given to either an open Bankart repair, a bony augmentation procedure such as a Bristow-Latarjet procedure, or an arthroscopic revision approach with additional augmentation such as a remplissage.

Table 1. Parameters Tested Against Arthroscopic Revision Anterior Stabilization Failure[a]

Parameter	Revision Failure	No Revision Failure	OR	p-value
Age at Revision < 22 y	16/27 (59%)	13/38 (34%)	2.80	**0.045**
Ligamentous Laxity	10/27 (37%)	5/38 (13%)	3.88	**0.024**
Off-Track Lesion	10/22 (45%)	4/36 (11%)	6.67	**0.003**
SLAP Tear	11/27 (41%)	6/38 (16%)	3.67	**0.024**
Male Gender	17/27 (63%)	27/38 (71%)	0.69	0.492
BMI > 30 kg/m^2	3/24 (13%)	3/27 (11%)	1.14	1.000
Dominant Side Injured	20/27 (74%)	23/38 (61%)	1.86	0.255
Bilateral Anterior Instability	3/27 (11%)	7/38 (18%)	0.55	0.503
Workers' Compensation	3/27 (11%)	9/38 (24%)	0.40	0.331
Athletes	12/27 (44%)	17/38 (45%)	0.99	0.981
Contact Sports	9/12 (75%)	12/17 (71%)	1.25	1.000
Competitive Level	3/12 (25%)	3/17 (18%)	1.56	0.669
Open Primary Bankart Repair	2/23 (9%)	4/35 (11%)	0.74	1.000
Traumatic Repair Failure	7/18 (39%)	16/35 (46%)	0.76	0.635
Time from Failure to Revision < 1 y	21/27 (78%)	31/38 (82%)	0.79	0.706
Total Number of Anchors ≤ 3	6/20 (30%)	10/30 (33%)	0.86	0.804
Number of Anteroinferior Anchors ≤ 3	14/20 (70%)	19/30 (63%)	1.35	0.626
Labral Tear ≥ 120°	13/20 (65%)	20/30 (67%)	0.93	0.903

[a]Data expressed as count/number of available cases (%). Competitive level is defined as collegiate or higher. Bold denotes significance. SLAP, superior labrum anterior and posterior; BMI, body mass index; OR, odds ratio.

Paper 163

Title:
Arthroscopic Shoulder Stabilization in the High-Risk Young Athlete: Return to Sport and Second Surgery Rates

Authors:
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Objectives: Shoulder instability in the young athlete has become an increasingly significant clinical problem in recent years. This high-risk population of athletes less than 25 years of age is a difficult cohort to manage because they have high failure rates with non-operative treatment and they reportedly have the lowest return to sport (RTS) rates and highest second surgery rates following arthroscopic shoulder stabilization compared to older patients. The purpose of this retrospective study is to evaluate the two-year clinical outcomes of a cohort of high-risk athletes less than or equal to 22 years of age following arthroscopic shoulder stabilization with a focus on RTS and incidence of second surgery.

Methods:
The primary outcomes evaluated were RTS and revision surgery following arthroscopic shoulder stabilization performed by the senior author at minimum follow-up of 24 months. Athletes were excluded if they had > 5 pre-operative episodes of instability, significant bone loss or had primary posterior instability. Demographic data was recorded including age, sex, BMI, last recorded range of motion, # episodes of recurrent instability, and revision surgery. A brief survey was completed regarding their shoulder instability history, sports prior to surgery, sports returned to following surgery, satisfaction with and level of RTS, time at which return to sports was achieved, recurrent instability, revision operations, and single assessment numeric evaluation (SANE) score.

Results: A total of 67 athletes met inclusion criteria, with a mean age of 17.4 years (range, 13-22 years). There were 19 females (28%) and 48 males (72%). The mean number of instability events was 2 (range 0-5), 57% in the dominant arm and 43% in the non-dominant arm. Evaluation of RTS, demonstrated that 59 (88%) were able to RTS with 56 (84%) of those returning to the same level or higher, while 8 (12%) patients did not RTS for reasons other than recurrent instability or apprehension. Among the 59 patients who RTS, the average time to return was 7.3 months (range: 5-12 months) and baseball and football were the most common sports. There was a gender specific difference with respect to RTS and revision surgery. The male RTS rate was 94% compared to the female rate of 74%. Four of 67 (6%) patients underwent revision stabilization 11 to 36 months for recurrent instability, however all were male athletes 4/48 (8%). There were no female athletes who required revision surgery. Patient reported mean SANE score was 88 (SD, ±15).

Conclusion: Shoulder instability in the young high-risk athlete is a complex problem with a relatively high rate of recurrence and revision surgery in the literature. In our case series, we found a relatively low reoperation rate (6%) with a high rate of RTS (88%), at an average time of 7.3 months. There was a

gender specific difference with respect to RTS and revision surgery. The male RTS rate was 94% and revision surgery rate was 8% (4/48) while the female RTS rate was 74% and revision surgery rate was 0%. The athletes reported a return to near full function with an average SANE score of 88. We believe the improved outcomes in this cohort of high risk young athletes are related to the pre-operative selection criteria excluding those athletes with a greater number of pre-operative episodes of instability and those with significant bone loss and bipolar lesions as open stabilization and bone augmentation (Latarjet) are more predictable operations in athletes with these risk factors.

Paper 164

Title:
Prospective, Randomized, Double Blind Evaluation of the Efficacy of a Single Dose Hyaluronic Acid for the Treatment of Patellofemoral Chondromalacia.

Authors:
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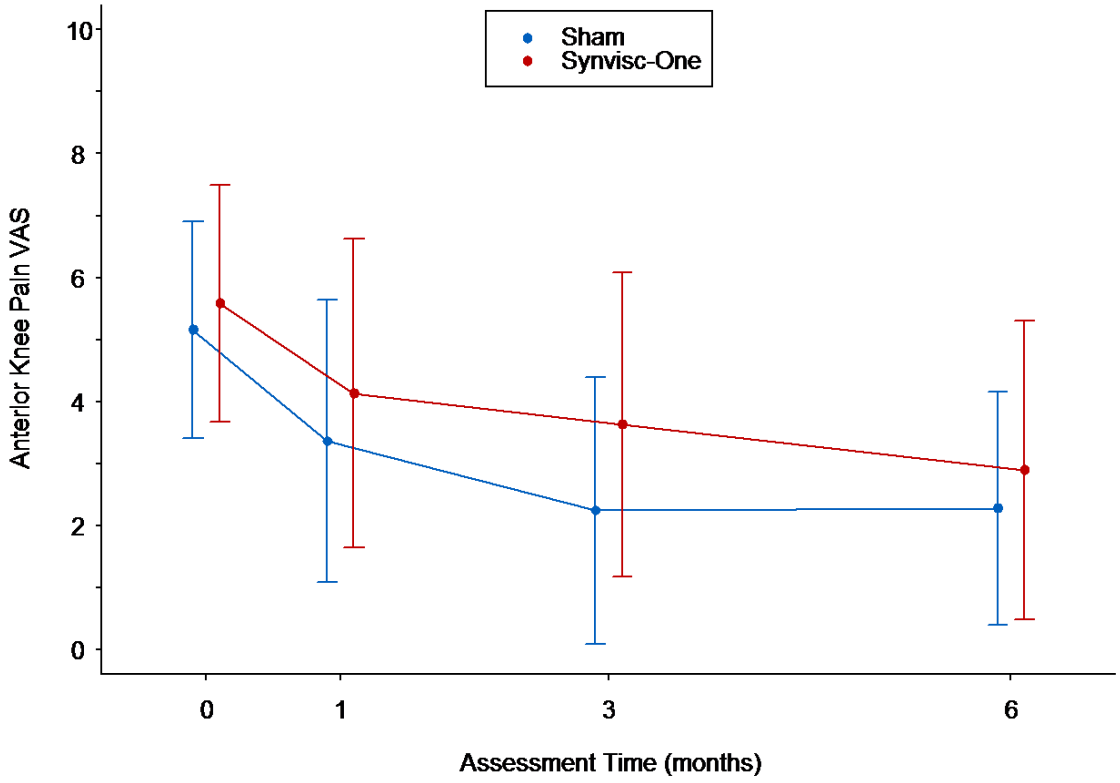
Objectives: Introduction: Patellofemoral pain is common and is often diagnosed as chondromalacia patella in the absence of radiographic evidence of osteoarthritis. Chondromalacia patella is often painful and debilitating, affecting patients' function, activity level and quality of life. Non-operative management is limited and focuses on physical therapy and modalities. Hyaluronic acid (HA) is an injectable device that has been used for the treatment of knee osteoarthritis. We hypothesize that a single injection of HA will reduce pain, improve function and improve muscle strength in patients who have previously failed conservative management.

Methods: Methods: This was a prospective, randomized, double-blind, sham-controlled, parallel group clinical trial to compare outcomes for 6-months after a single injection of HA (Synvisc One) in the knees of patients with a diagnosis of chondromalacia patella. A total of 86 patients with a clinical diagnosis of chondromalacia (65F/21M, 27.0±7.7years, 168.6±8.9cm, 74.6±17.0kg, BMI 26.0±5.2) including no radiographic evidence of tibiofemoral or patellofemoral osteoarthritis were recruited and enrolled in this study. All patients failed at least 1 month of conservative management including a program of therapeutic quadriceps strengthening exercises under a physical therapist's direction. Patients were evaluated by blinded observers. Outcome assessments included patellofemoral pain assessment using a visual analog scale during a single leg squat, knee osteoarthritis outcome score (KOOS), Tegner activity rating and normalized isometric knee extension strength. After baseline measurements, patients were randomly allocated to either 6cc of HA or a sham injection (needle stick) and visually shielded during injection for blinding. All patients were prescribed an additional home exercise program including lower extremity strengthening and flexibility exercises and followed at 1, 3 and 6 months. Group assignment was revealed to the patients after the 6-month outcome assessment and crossover treatment offered to patients receiving the sham injection who were still symptomatic. Repeated measures ANOVA was used to compare outcomes between groups and across time.

Results: Results: 45 patients were randomized to HA injection, 41 to sham, and 5 patients were lost to follow up (93% follow up rate). Patients in both groups experienced a significant reduction in visual analog pain ratings and significant increases in all domains of the KOOS at the 6 months compared to baseline measurement ($P<0.05$); however, there was no significant difference between groups. There were no differences observed over time or between groups for normalized knee extension strength or Tegner activity rating ($P<0.05$).

Conclusion: Conclusion: We observed improvements in patient reported pain and function with no change in quadriceps strength or activity rating. HA injections did not have an effect at 6 months after

injection. HA injection had no effect on pain or functional outcomes in patients with a clinical diagnosis of chondromalacia patella.



Paper 165

Title:
Unloader Knee Brace Increases Medial Compartment Joint Space During Gait In Knee Osteoarthritis Patients

Authors:
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Objectives: Clinical outcome measures suggest the unloader brace provides small-to-moderate improvements in pain and function in varus knee osteoarthritis (OA) patients. However, controversy still exists as to whether the brace has the real effect of increasing tibiofemoral joint space in the medial compartment during functional activity. As a limitation, the previous studies did not report ground reaction forces (GRF) with and without the brace, which could be a confounding factor affecting joint space. Therefore, the purpose of the present study was to investigate the effect of an unloader brace on dynamic joint space in medial compartment in OA patients while simultaneously recording GRF during gait. The hypotheses were (1) dynamic joint space in the medial compartment would be greater with the unloader brace than without the brace during gait, and (2) GRF during gait would be smaller with the brace than without the brace.

Methods: Ten varus knee OA patients were enrolled (Age: 52±8 years). After minimum 2-week daily use of the unloader brace, subjects walked (1.0 m/s) on an instrumented treadmill while biplane radiographs of the OA knees were acquired at 100 Hz. Tibiofemoral motion was determined from the biplane radiographs from initial contact to terminal stance phase (gait cycle: 0-40%) using a previously validated model-based tracking process. Dynamic joint space measurement in the medial compartment was performed using previously reported method. Briefly, the medial tibial plateau was divided into 9 sub-regions (Figure 1A) and the average minimum distance between femur and tibia subchondral bone was calculated in each region. The region with the smallest joint space over the three walking trials was selected for the analysis. GRF during gait were collected at 1000Hz and normalized by each subject's body weight. Output parameters were averaged over 10% intervals of the gait cycle. Two-way repeated measures ANOVA (gait cycle x brace condition) was used to explore differences in medial compartment dynamic joint space and GRF between the 2 conditions (unbraced and braced). Post-hoc paired t-tests identified the differences between the 2 conditions during the same gait cycle period. Significance level was set as $P < 0.05$. A subjective questionnaire for the brace usage was collected at the time of the test.

Results: The dynamic joint space in the medial compartment was significantly greater with the unloader brace than without the brace during gait ($P = 0.004$) (Table 1, Figure 1B). The average difference between the 2 conditions was 0.27 mm (95% confidential interval: 0.12-0.43). No significant difference was observed in terms of GRF between unbraced and braced conditions. The questionnaire showed participants felt reduced pain (4.1±0.7 out of 5 scale) and were comfortable (3.8±0.8 out of 5) when wearing the brace.

Conclusion: The unloader knee brace induced a small but significant increase in medial dynamic joint space during gait. Furthermore, no differences in GRF during gait were found between unbraced and

braced conditions, indicating that the increase of medial joint space with bracing was not due to decreased limb-loading during gait, but instead due to the brace use itself. These results suggest that the OA unloader brace may reduce medial compartment joint loading during dynamic loading activities.

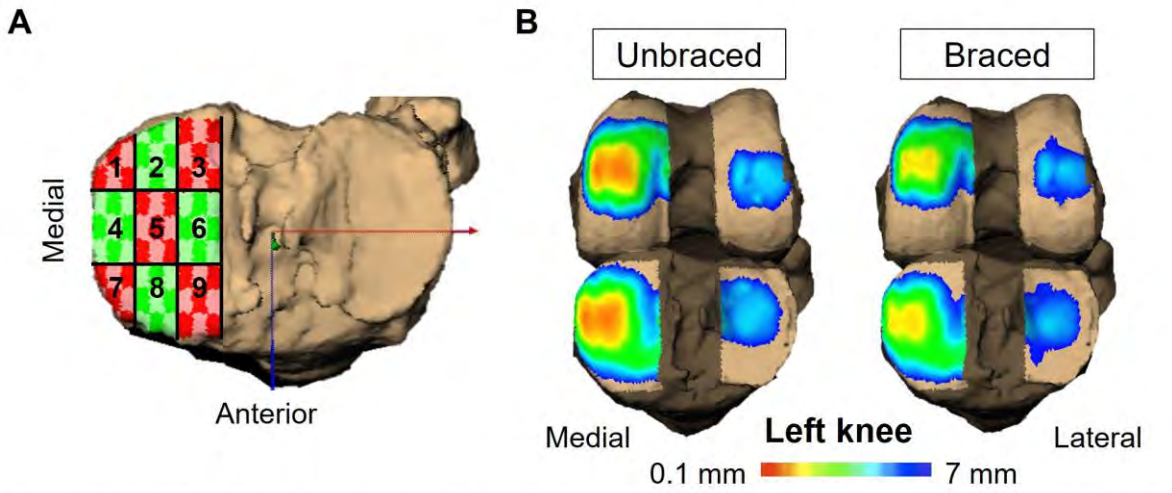

Figure 1. (A) Medial compartment regions used to calculate dynamic joint space. The medial tibial plateau was divided into 9 sub-regions, and the average joint space in each region was obtained over every 10% of gait cycle. The regions with the smallest joint space (region 5 in 9/10 subjects) was selected for the analysis. **(B)** The instantaneous dynamic joint space during gait at 15% of the gait cycle for one subject, demonstrating increased medial compartment joint space in the braced condition.

Table 1. Results of medial compartment dynamic joint space and ground reaction forces during gait. *Statistically significant difference (vs unbraced condition)

Gait cycle	Medial compartment dynamic joint space (mm)			Ground reaction forces / Body weight		
	Unbraced	Braced	P-value	Unbraced	Braced	P-value
0-10%	2.8 ± 0.9	3.2 ± 1.0*	0.007	0.55 ± 0.11	0.56 ± 0.12	N/A
10-20%	2.4 ± 0.8	2.6 ± 0.8*	0.001	0.94 ± 0.11	0.94 ± 0.08	
20-30%	2.4 ± 0.8	2.6 ± 0.7*	0.028	0.87 ± 0.09	0.92 ± 0.08	
30-40%	2.3 ± 0.7	2.6 ± 0.6*	0.017	0.90 ± 0.08	0.91 ± 0.09	
Overall	2.5 ± 0.8	2.8 ± 0.7*	0.004	0.81 ± 0.04	0.83 ± 0.04	0.15

Paper 166

Title:
Posterior Translation of the Fibula is a Critical Factor in the Stability of the Syndesmosis After Injury and Repair

Authors:
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Objectives: Anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL), and interosseous membrane (IOM) disruption is a predictive measure of residual symptoms after an ankle injury. Unstable syndesmotic injuries are typically treated surgically with cortical screw or suture button fixation. Previous studies have shown contradicting findings regarding the effects of partial syndesmotic injuries and different surgical fixation methods on tibiofibular kinematics. Thus, the objective of this study was to quantify tibiofibular joint motion with sequential disruption of the syndesmosis and with syndesmotic screw and suture button fixation compared to the intact ankle.

Methods: Nine fresh-frozen human cadaveric specimens (mean age 60 yrs.; range 38-73 yrs.) were tested using a six degree-of-freedom robotic testing system. The subtalar joint was fused and the tibia and calcaneus were rigidly fixed to a robotic manipulator, while complete fibular length was maintained and fibular motion was unconstrained. A 5Nm external rotation moment and 5Nm inversion moment were independently applied to the ankle at 0°, 15°, and 30° plantarflexion and 10° dorsiflexion. Fibular motion with respect to the tibia was tracked by a 3D optical tracking system. Outcome variables included fibular medial-lateral (ML) translation, anterior-posterior (AP) translation, and external rotation (ER) in the following states: 1) intact ankle, 2) AITFL transected, 3) AITFL, PITFL, and IOM transected (complete injury), 4) 3.5mm cannulated tricortical screw fixation, 5) suture button fixation. An ANOVA with a post-hoc Tukey analysis was performed for statistical analysis (*$p < 0.05$).

Results: All significant differences in fibular motion between ankle states occurred during the inversion moment. An isolated AITFL injury caused significant increases in fibular posterior translation at 15° and 30° plantarflexion compared to the intact ankle. A complete syndesmotic injury caused significant increases in fibular posterior translation in all 4 ankle positions and in fibular ER at 0° flexion and 15° plantarflexion compared to the intact ankle. No significant differences were detected in fibular motion between an isolated AITFL injury and complete injury at any ankle positions. No significant differences existed between the tricortical screw fixation and the intact ankle. Significantly higher fibular posterior translation was observed with the suture button compared to the intact ankle at 0° flexion, 30° and 15° plantarflexion. (Figure 1)

Conclusion: An isolated AITFL injury resulted in a significant increase in fibular posterior translation relative to the tibia, comparable to that a complete injury, especially in positions of plantarflexion. Current diagnostic protocols after injury focus on the evaluation of fibular ML translation. However, these findings show that it is important to also evaluate syndesmotic stability in the sagittal plane and at different ankle positions. Restoration of native tibiofibular kinematics is essential to prevent post-

traumatic arthritis. Tricortical screw fixation was able to restore tibiofibular kinematics in all planes. However, suture button fixation was not able to restore tibiofibular AP translation, which suggests that physicians should critically evaluate fibular AP translation and individualize treatment of unstable ankle injuries when reconstructing the syndesmosis with suture button fixation.

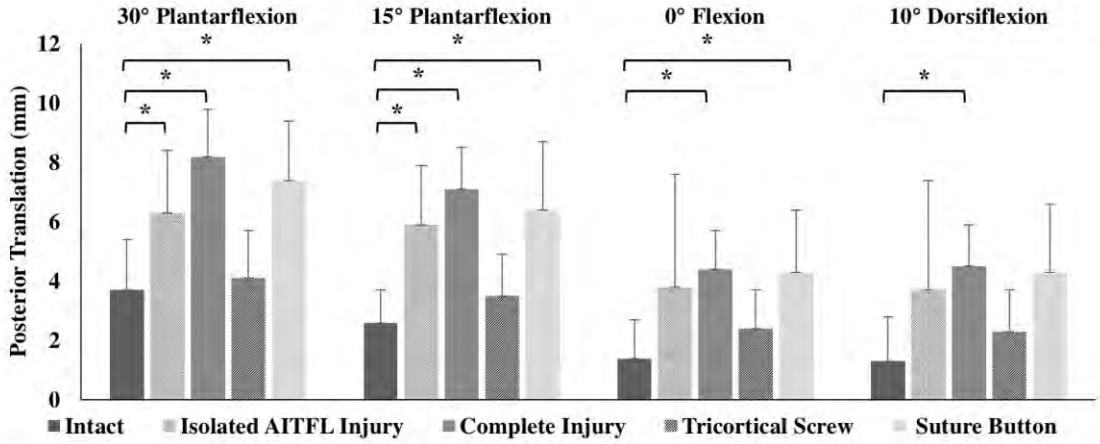

Figure 1. Posterior translation of the fibula relative to the tibia (mean ± standard deviation) during a 5Nm inversion moment at 0° flexion, 15° and 30° plantarflexion, and 10° dorsiflexion in different ankle states: intact ankle, isolated AITFL injury, complete injury, tricortical screw fixation using a 3.5mm screw, suture button fixation. *$p < 0.05$

Paper 167

Title:
Arthroscopic Assessment of Syndesmotic Instability in the Sagittal Plane. A Cadaveric Study

Authors:
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Objectives: Arthroscopic evaluation of the ankle syndesmosis joint is being increasingly used to treat syndesmotic instability. The aim of this study was to arthroscopically assess the degree of syndesmotic ligamentous injuries necessary to produce syndesmotic instability in the sagittal plane as well as to establish which cut-off value has the highest sensitivity and specificity for the diagnosis of instability in that plane.

Methods: Twenty-one above-knee cadaveric specimens were divided into three sequences of ligamentous transection. In group 1 (n=7), the anterior-inferior tibiofibular ligament (AITFL) was cut first, followed consecutively by the interosseous ligament (IOL), posterior-inferior tibiofibular ligament (PITFL), and superficial and deep deltoid ligament (DL). In group 2 (n=7), the sequence was DL, AITFL, IOL, and PITFL. In group 3 (n=7), the corresponding sequence was PITFL, IOL, AITFL, and DL. In the intact ligamentous state and at each stage of transection, a 100N posterior-anterior and 100N anterior-posterior hook tests were performed while anterior and posterior translations were measured, respectively. Measurements were performed using calibrated probes ranging from 0.1 to 6.0 mm. In each group, one-way repeated ANOVA and post-hoc Dunnett test were used to compare the sum of the anterior and posterior translation at each stage of transection with those of the intact state (reference value). An adjusted p value < 0.05 was considered statistically significant. Receiver operating characteristic (ROC) curve analysis was developed to determine the optimal cut-off value for the detection of instability in the sagittal plane. No ankle distraction was conducted in this study.

Results: There was no significant anteroposterior translation when 1 or 2 ligaments were transected regardless of the group analyzed. In contrast, a significant increment was noted in translation after combined disruption of AITFL, IOL, and PITFL in group 1 ($p = 0.013$); DL, AITFL, and IOL in group 2 ($p < 0.001$), and PITFL, IOL, and AITFL in group 3 ($p = 0.024$). In addition, a significant increase was observed in translation after disruption of all syndesmotic and deltoid ligaments in all groups (group 1, $p = 0.041$; group 2, $p < 0.001$; group 3, $p < 0.001$). ROC curve analysis revealed that the Area Under Curve (AUC) on predicting instability was 0.91 (95% confidence interval, 0.85 - 0.96). The highest sensitivity (77.50%) and specificity (88.89%) occurred when the sum of anterior and posterior translation was more or equal than 2mm.

Conclusion: Evaluating the syndesmosis arthroscopically, disruption of all syndesmotic ligaments or the disruption of DL, AITFL, and IOL produces significant translation in the sagittal plane. Based on our ROC

curve which showed an excellent predictive model, sagittal translation more or equal than 2mm appears to be the cut-off value for the detection of sagittal plane syndesmotic instability.

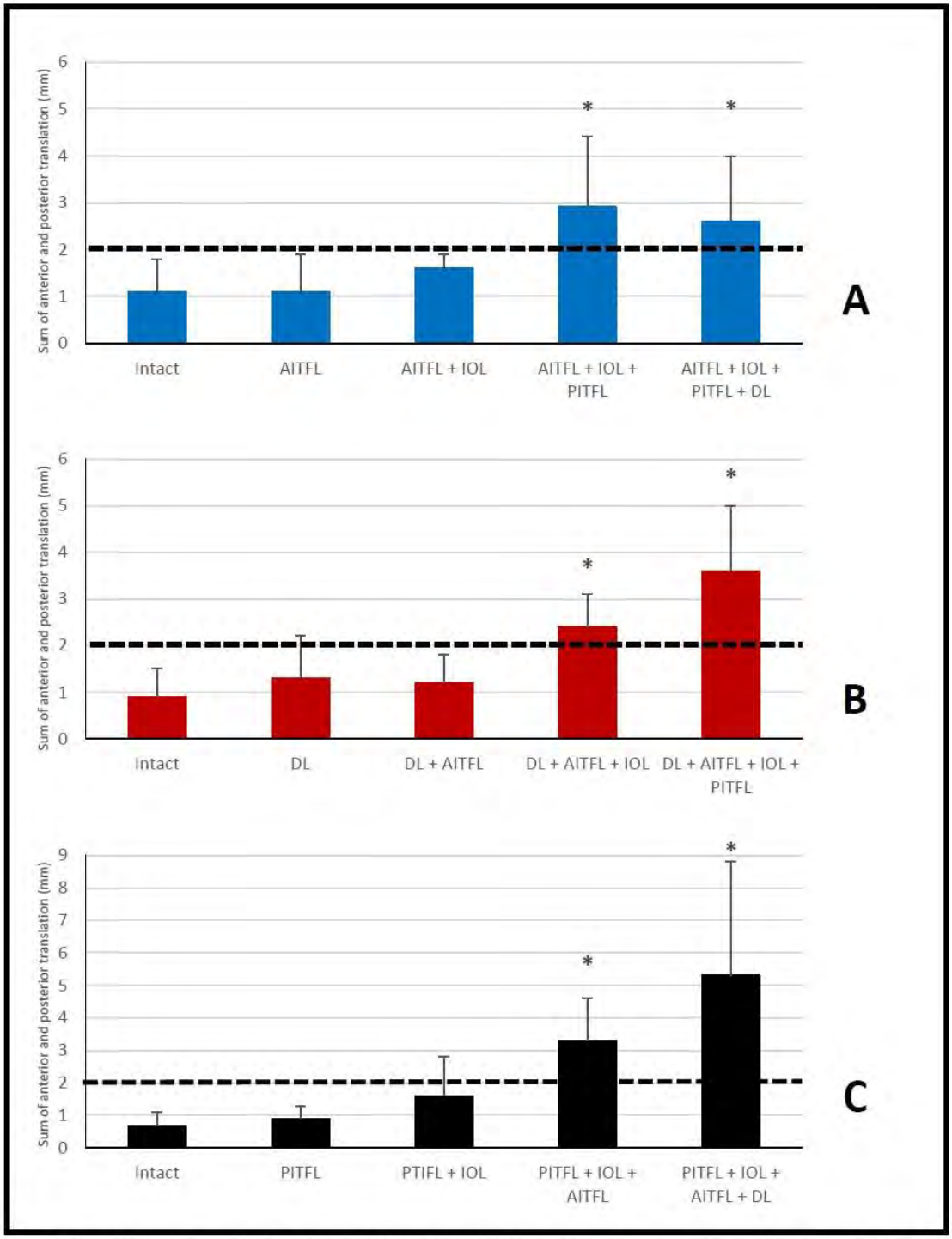

Figure 1. Sum of the anterior and posterior translation (mean in mm) for three different sequences of ligamentous transection. (A) Intact, AITFL, IOL, PITFL, and DL; (B) Intact, DL, AITFL, IOL, and PITFL; (C) Intact, PITFL, IOL, AITFL, and DL. Error bars represent standard deviations. * Asterisks denote *p-value* <0.05. Each stage of transection was compared with the intact state. Broken lines are representing the cut-off value which had the highest sensitivity and specificity for the detection of syndesmotic instability. Abbreviations: AITFL, anterior-inferior tibiofibular ligament; IOL, interosseous ligament; PITFL, posterior-inferior tibiofibular ligament; DL, deltoid ligament.

Paper 168

Title:
Early Return to Play After Intramedullary Screw Fixation of Jones Fractures in Collegiate Athletes: 23 Year Experience

Authors:
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Objectives: There is a general consensus that Jones fractures should be treated operatively with an intramedullary screw in high-level athletes. However, there is disagreement among team physicians, without conclusive evidence as to when the athlete should be allowed to return to play. The objective of this study is to report our experience of early return to sport in collegiate athletes after intramedullary screw fixation of Jones Fractures.

Methods: All skeletally mature collegiate athletes with a true Jones fracture of the base of the fifth metatarsal that was treated by one of two orthopaedic surgeons with operative intramedullary screw fixation over a 23-year period (1994-2016) were identified and records reviewed retrospectively. All return to play and complication data was obtained from the athletic trainer database at the two universities. Fixation consisted of a single intramedullary screw (10 partially threaded cannulated screws, 13 cannulated variable pitch screws, 3 solid screws). The athletes were allowed to weight bear as tolerated in a CAM boot immediately postoperatively, and return to play with a carbon fiber insert as soon as they could tolerate activity. In 2016, patients were contacted to complete patient reported outcome scores that included the Foot and Ankle Ability Measure (FAAM) score and a brief survey specific to our study, as well as follow-up radiographs if possible.

Results: 26 Jones Fractures were treated in 25 collegiate athletes. The average age was 20 years (18-23). Overall, athletes returned to play or training at an average of 3.5 weeks (1.5-6). All in-season athletes returned to play within 4.5 weeks (1.5-4.5). Off-season athletes returned to play within 4-6 weeks. There were no cases of nonunion (clinically or radiographically). Three screws were removed due to symptomatic skin irritation. There was one re-fracture following screw removal after documented radiographic and clinical fracture union. This patient was treated with repeat cannulated percutaneous screw fixation. The athlete returned to play in 2 weeks. One screw was noted to be broken on an ankle radiograph 1-year post-op, but the fracture was healed and the athlete was playing division 1 sports without symptoms, and continued professionally without symptoms. 18/25 athletes completed patient reported outcome scores at an average of 7.95 years (range 1.2-17) follow-up. The average estimated percent of normal for activities of daily living was 93.8% (70-100% , and for athletic participation was 90.3% (40-100%). Follow up radiographs were obtained on 13/26 fractures at an average of 6.48 years (range 1.2-16) with no nonunion, malunion, or additional hardware complications identified.

Conclusion: Athletes with Jones fractures can safely be allowed to return to play after intramedullary screw fixation as soon as their symptoms allow without significant complications. In our experience, this is usually within 4 weeks from injury.

Paper 169

Title:
Cost Comparison and Complication Rate of Lisfranc Injuries Treated with Open Reduction Internal Fixation versus Primary Arthrodesis

Authors:
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Objectives: Controversy exists regarding optimal primary management of Lisfranc injuries. Whether open reduction internal fixation or primary arthrodesis is superior remains unknown. Our retrospective study uses a private payer database to compare cost, complication rate, and hardware removal rate in Lisfranc injuries treated with primary open reduction internal fixation or primary arthrodesis.

Methods: Utilizing data mining software created by a private organization, a national insurance database of approximately 23.5 million orthopedic patients was retrospectively queried for subjects who were diagnosed with a Lisfranc injury from 2007-2016 based on international classification of diseases (ICD) codes for tarsometatarsal (TMT) dislocation (PearlDiver, Colorado Springs, CO). Patients with TMT dislocations then progressed on to either non-operative treatment, open reduction internal fixation, or primary arthrodesis. Associated treatment costs based on diagnosis codes were followed after initial diagnosis and t-tests were used to determine statistical significance. Subgroups were then created based on having at least one complication ICD or current procedural terminology (CPT) code after the beginning of treatment, which included: hemorrhage, infection, nonunion, malunion, thromboembolism, wound and hardware complications, or amputation. Additionally, patients undergoing implant removal were identified by CPT code for removal of hardware performed after the index procedure. Complication and hardware removal rates were compared with chi-square test.

Results: 2205 subjects with a diagnosis of Lisfranc injury were identified in the database. 1248 patients underwent non-operative management, 670 underwent open reduction internal fixation, and 212 underwent primary arthrodesis. The average cost of care associated with primary arthrodesis was greater ($5,005.82) than for open reduction internal fixation ($3,961.97, P=0.045). The overall complication rate was 23.1% (155/670) for open reduction internal fixation and 30.2% (64/212) for primary arthrodesis ($P=0.04$). Rates of hardware removal independent of complications were 43.6% (292/670) for open reduction internal fixation and 18.4% (39/212) for arthrodesis ($P<0.001$). Furthermore, 2.5% (17/670) patients in the open reduction internal fixation group progressed to arthrodesis at a mean of 308 days, average cost of care associated with this group of patients was $9,505.12.

Conclusion: Primary arthrodesis for the management of acute Lisfranc injuries is both significantly more expensive and has a higher complication rate than open reduction internal fixation. Open reduction internal fixation demonstrated a low rate of progression to arthrodesis, although there was a high rate

of hardware removal, which may represent a planned second procedure in the management of a substantial number of patients treated with open reduction internal fixation.

Paper 170

Title:
Complete Radiographic Healing and Related Factors in Juvenile Osteochondritis Dissecans of the Talus

Authors:
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Objectives: Rates of healing following treatment of juvenile osteochondritis dissecans (OCD) of the talus remain scarce. Additionally, there is a paucity of research into the outcomes associated with the treatment of these lesions. The purpose of this study was to evaluate radiographic healing of talar dome OCDs in adolescents.

Methods: This was a retrospective review of patients ≤18 years of age with talar OCD from a single pediatric institution within a 12-year period. Charts and radiographs were reviewed for demographics and clinical data, lesion's location and dimensions, and physeal status. The final radiologic healing was evaluated at 1-year follow-up. Complete and incomplete healing groups were compared using multivariable logistic regression models to examine the predictive effects for the independent variables. A nomogram was produced from the study sample to allow predictions to be made in individual patients.

Results: Ninety-two lesions in 74 patients with mean age of 13.1 years (range 7.1 to 18.0 years) were analyzed. 60.8% of the patients were female. Thirty-three (41.8%) lesions were treated conservatively, and 59 (58.2%) were treated surgically (drilling, debridement, microfracture, bone grafting, or loose body removal). Thirty-nine (42.4%) lesions demonstrated complete healing. Patients with complete healing were younger (p 0.032) and had lower BMIs (p 0.006) compared to those with incomplete healing. In a multivariate regression model, the factors that correlated significantly were the age, BMI, Berndt and Harty's stage at presentation and type of treatment (observation vs. surgical). Location and dimension of the lesion, physeal status (open vs. closed), presenting symptoms, and type of surgical procedure showed no association with likelihood of healing. A nomogram was developed using the independent variables that correlated significantly with the likelihood of complete radiographic healing (Figure 1).

Conclusion: Complete radiologic healing of juvenile OCDs was more likely in patients with younger age and lower BMI. Although the difference in outcome between various surgical treatment types was not statistically significant, initial management with surgery was more likely to result in a complete healing compared to observation alone. To our knowledge, this is the first time a nomogram predicting outcome in terms of complete radiographic healing has been developed for juvenile OCD lesions of the talus. Besides its potential role in treatment decision making process, this nomogram can be used to counsel patients and their families with regard to the prognosis for healing.

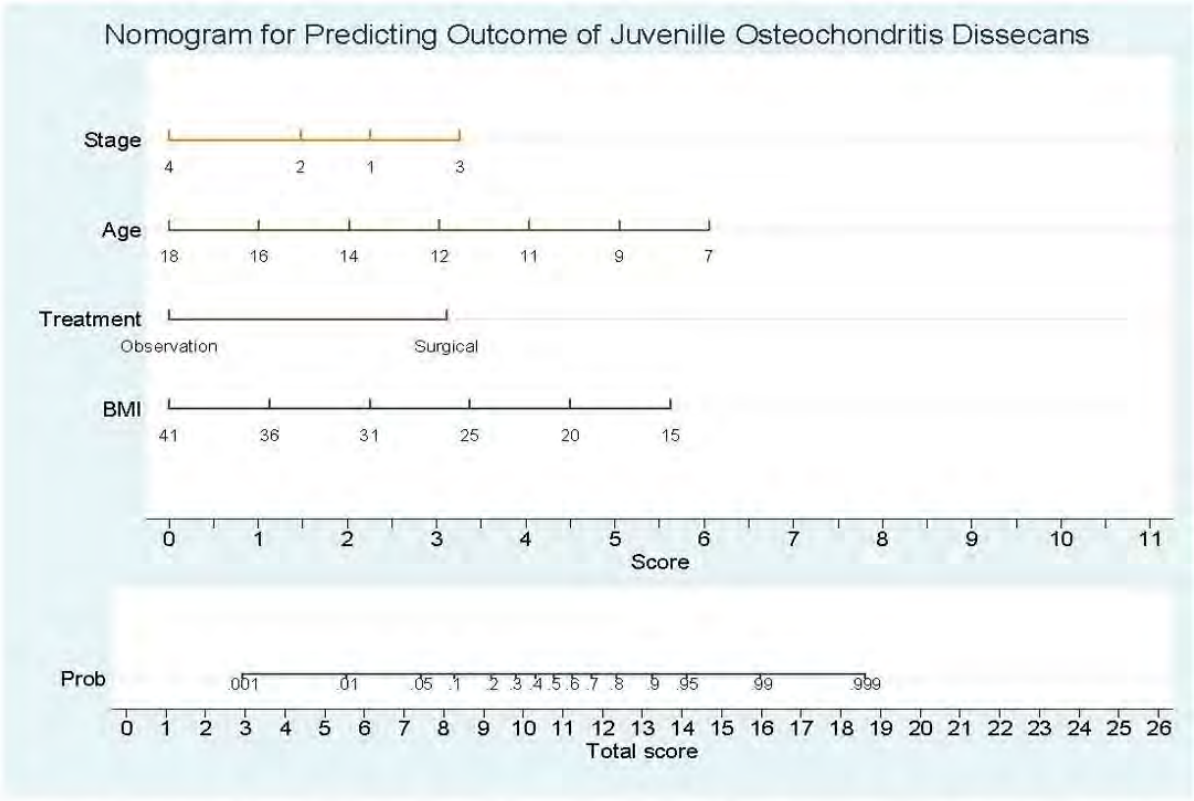

Figure 1. Nomogram for predicting outcome of juvenile osteochondritis dissecans (OCDs) lesion of the talus. To use the nomogram, one should place a straight edge vertically so that it touches the designated variable on the axis for each predictor and then should record the value that each of predictor provides on the ''Score''. All of the recorded ''points'' are then summed, and this value is located on the ''total score'' line with a straight edge. A vertical line drawn down from the ''total score'' line to the ''Prob'' line will identify the probability that the patient will demonstrate healing or progression toward healing after 12 months of treatment.

Paper 171

Title:
Operative and Non-Operative Management of Osteochondritis Dissecans in the Knee of Skeletally Immature Patients: Rates of Persistent Knee Pain, Osteoarthritis, and Arthroplasty at Mean 14-Years Follow-up

Authors:
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Objectives: The purpose of this study was to report long-term follow-up of skeletally immature OCD lesions treated operatively and non-operatively and determine risk factors for persistent knee pain at final follow-up.

Methods: A large, geographic database of over 500,000 patients was reviewed in this case series to identify and confirm patients with OCD of the knee. Presenting radiographs and MRI were reviewed. Clinical course including operative management, persistent knee pain, and conversion to TKA were obtained and analyzed through review of clinical and operative notes.

Results: 95 skeletally immature patients (70 males, 25 females) with OCD lesions diagnosed at a mean age of 13 years (range: 7-16) were followed for a mean of 14 years (range: 2-40). 53 patients (56%) were treated operatively and 42 patients (44%) were treated non-operatively. At final follow up, 13 patients with a mean age of 30 years noted persistent knee pain, 8 (15%) treated operatively versus 5 (12%) treated non-operatively. Risk factors for knee pain were female gender, patellar lesion location, and unstable lesions (Table 1). Four patients (8 %) treated operatively and two (5 %) treated non-operatively developed symptomatic osteoarthritis at a mean of 28.6 years following diagnosis. One patient treated operatively and two treated non-operatively converted to TKA at a mean of 37 years following diagnosis. Mean age at TKA was 52 years, significantly younger than that observed for primary TKA at our institution ($p = 0.004$).

Conclusion: Patients with skeletally immature OCD lesions have an estimated 14% rate of persistent knee pain, 6% risk of symptomatic osteoarthritis, and 3% risk of conversion to TKA at a mean of 14 years following time of diagnosis. Female patients, patellar lesions, and unstable lesions demonstrated increased risk of persistent knee pain at final follow-up. Patients with OCD of the knee convert to TKA at a significantly younger age than that of the general primary TKA population.

Table 1: Risk factors for persistent knee pain at the time of final follow-up

Variable	HR (95% Confidence Interval)	p-value
Treatment		
Non-Operative	Reference	
Operative	1.16 (0.35 – 3.83)	0.81
Age at diagnosis		
< 10	Reference	
≥ 10	10.3 (0.11 – 9.63)	0.98
Gender		
Female	Reference	
Male	0.24 (0.07 – 0.81)	**0.02**
Location		
MFC	Reference	
LFC	2.91 (0.57 – 14.97)	0.20
Patella	5.30 (1.37 – 20.48)	**0.02**
Trochlea	0.00 (0.00 – 0.00)[a]	**<0.01**[a]
AP Radiograph Lesion Width		
< 20 mm	Reference	
≥ 20 mm	1.74 (0.23 – 12.97)	0.59
AP Radiograph Lesion Depth		
< 5 mm	Reference	
≥ 5 mm	0.68 (0.08 – 6.00)	0.73
Lateral Radiograph Lesion Width		
< 20 mm	Reference	
≥ 20 mm	1.75 (0.31 – 10.01)	0.53
Lateral Radiograph Lesion Depth		
< 5 mm	Reference	
≥ 5 mm	2.14 (0.38 – 11.95)	0.38
Lesion Contour		
Concave	Reference	
Convex	0.45 (0.08 – 2.54)	0.37
Disruption of subchondral bone		
No	Reference	
Yes	0.73 (0.15 – 3.54)	0.70
Intra-articular displaced fragment		
No	Reference	
Yes	0.85 (0.10 – 7.48)	0.88
Adjacent Focal Articular Cartilage Defects		
No	Reference	
Yes	0.85 (0.10 – 7.48)	0.88
Stability		
Stable	Reference	
Unstable	10.58 (1.26 – 88.63)	**0.03**

[a]Of the n = 2 lesions present on the trochlea, none developed symptomatic knee pain

Paper 172

Title:
Long-term Follow Up of Arthroscopically Repaired Meniscal Tears in a Pediatric Population

Authors:
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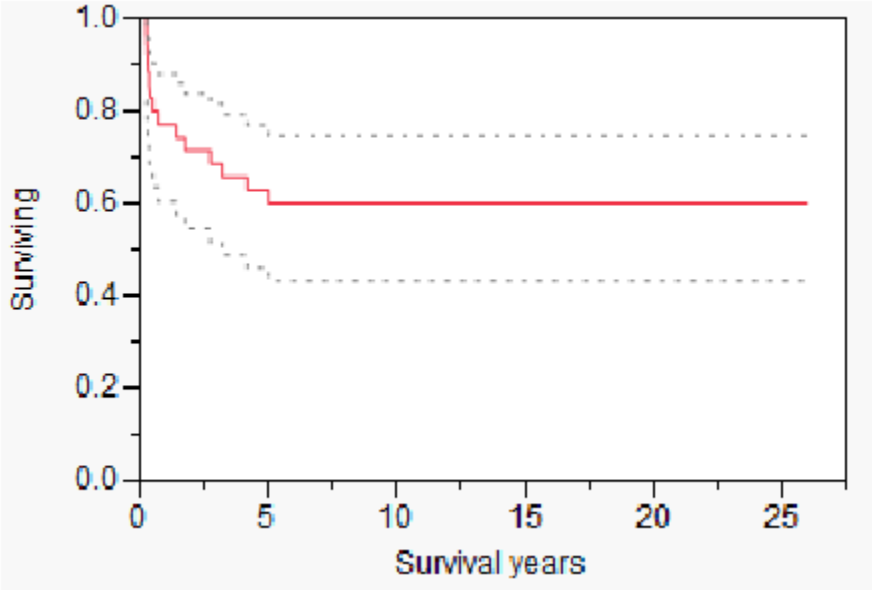
Objectives: Background: Meniscal repair is desirable over resection to prevent post-meniscectomy arthritis, especially in young and active patients. However, long-term data is currently lacking following meniscus repair, particularly in the pediatric population. **Purpose:** To report long-term follow-up of isolated meniscus tears treated by meniscal repair in a pediatric population, and to compare those results to previous mid-term follow-up data reported. We hypothesized that these patients would have satisfactory function and reoperation rates at long-term follow-up.

Methods: Patients less than 18 that had a meniscal repair procedure performed between 1990 and 2005 were included. Concomitant ACL reconstructions were excluded from the present study. At the time of final follow-up, recurrent meniscus tear, reoperation rates, and IKDC and Tegner scores were determined. Wilcoxin signed ranks tests were performed to calculate the differences in clinical outcome for the 3-time points (pre-operative, average 7 years post-op, and average 18 years post-op) and Spearman coefficients were calculated for Tegner and IKDC with different variables.

Results: At an average follow-up of 18 years (range 13.2 - 25.9 years), 34 patients with 35 isolated meniscus repairs (4F: 30M) with an average age of 16 (9.9 - 18.7) were included in this study. Of the 35 knees (34 patients), none had “failed” or re-injured their affected meniscus since mid-term follow-up in 2008. The average IKDC score was 92.1 which was found to be significantly increased when compared to both preoperative IKDC 64.7 (P<.0001) and mid-term IKDC scores, 89.8 (p=.02). However, the average Tegner score (6.5) was significantly lower than both pre-operative 8.28 (p<.0001) and the mid-term Tegner average 8.25 (p<.0001). Patients with a meniscus re-tear and subsequent partial meniscectomy had lower IKDC scores than clinically successful repairs (88.9 vs 94.0), but this did not reach statistical significance (p=.09). There was no correlation for Tegner or IKDC values with 1) rim width, 2) current age, 3) time elapsed since surgery, or 4) time from injury to surgery. There were also no differences in Tegner or IKDC scores when comparing; medial versus lateral, left versus right, tear types, surgical repair technique, or male vs female.

Conclusion: This study demonstrates very good clinical long-term outcomes following meniscal repair in a pediatric population.


1.0
0.8
0.6
0.4
0.2
0.0
Surviving
0
5
10
15
20
25
Survival years

Paper 173

Title:
Exceeding Pitch Count Recommendations in Youth Baseball Increases The Elbow Injuries

Authors:
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Objectives: With the incidence of Little League elbow increasing, pitch limit recommendations for preventing throwing injuries have been developed in the United States and Japan. In 1995, the Japanese Society of Clinical Sports Medicine announced limits of 50 pitches per day and 200 pitches per week to prevent throwing injuries in younger than 12 years old. However, the relationship between pitch limit recommendation and elbow injuries among pitchers has not been adequately studied. The aim of our study was to evaluate the association between pitch counts and elbow injuries in youth pitchers.

Methods: A total of 149 pitchers without prior elbow pain were observed prospectively for 1 season to study injury incidence in relation to specific risk factors. Average age was 10.1 years (range, 7-11 years). One year later, all pitchers were examined by questionnaire. Subjects were asked whether they had experienced any episodes of elbow pain during the season. The questionnaire was also used to gather data on pitch counts per day and per week, age, number of training days per week, and number of games per year. We investigated the following risk factors for elbow injury: pitch counts, age, position, number of training days per week, and number of games per year. Data were analyzed by multivariate logistic regression models and presented as odds ratio (OR) and profile likelihood 95% confidence interval (CI) values. The likelihood-ratio test was also performed. A two-tailed P value of less than .05 was considered significant. All analysis was done in the SAS software package (version 8.2).

Results: Of the 149 subjects, 66 (44.3%) reported episodes of pain in the throwing elbow during the season.

1. Analysis for pitch count per day

Univariate analysis showed that elbow pain was significantly associated with more than 50 pitches per day. Multivariate analysis showed that more than 50 pitches per day (OR, 2.44; 95% CI, 1.22-4.94), and more than 70 games per year (OR, 2.47; 95% CI, 1.24-5.02) were risk factors significantly associated with elbow pain. Age and number of training days per week were not significantly associated with elbow pain.

1. Analysis for pitch count per week

Univariate analysis showed that elbow pain was significantly associated with more than 200 pitches per week. Multivariate analysis showed that more than 200 pitches per week (OR, 2.04; 95% CI, 1.03-4.10), and more than 70 games per year (OR, 2.41; 95% CI, 1.22-4.87) were risk factors significantly associated

with elbow pain. Age was not significantly associated with elbow pain.

Conclusion: A total of 44.3% of youth baseball pitchers had elbow pain during the season. Multivariable logistic regression revealed that elbow pain was associated with more than 50 pitches per day, more than 200 pitches per week, and more than 70 games per year. Previous studies have revealed the risk factor with the strongest association to injury is pitcher. Our data suggest that compliance with pitch limit recommendations including limits of 50 pitches per day and 200 pitches per week may be protective against elbow injuries. Those who played more than 70 games per year had a notably increased risk of injury. With increasing demand on youth pitchers to play more, there is less time for repair of bony and soft tissues in the elbow. In conclusion, among youth pitchers, limits of 50 pitches per day, 200 pitches per week, and limits of 70 games per year may protect elbow injuries.

Paper 174

Title:
The Latarjet Procedure for Anterior Shoulder Instability in Pediatric and Adolescent Athletes

Authors:
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[1]Boston Children's Hospital, Boston, MA, USA, [2]Harvard Medical School, Boston, MA, USA, [3]Children's Hospital (Boston) Program, Boston, MA, USA.

Objectives: To investigate surgical outcomes of the Latarjet procedure in the pediatric and adolescent athletic population compared to alternative techniques used to treat anterior shoulder instability with glenoid bone loss.

Methods: This retrospective comparative cohort study involved a review of 40 patient records with a mean age of 16.7 years (range: 14.3 to 19.2) with anterior shoulder instability and glenoid bone loss (mean: 19%). Demographic and clinical features were recorded pre- and post-operatively, with mean follow up of 26.3 months (sd, 22.8). Advanced imaging and arthroscopic assessment were used to quantify concomitant pathology. Percent glenoid bone loss was calculated using the “glenoid rim distances” method. Glenoid track width and Hill-Sachs interval (HSI) were measured to determine if shoulders were on-track or off-track. Patients were contacted to obtain validated functional outcome questionnaires, including Quick-DASH, ASES, and Marx shoulder activity scale.

Results: Of the 40 patients, 18 underwent the Latarjet procedure and 22 underwent alternative stabilization procedures. At presentation, both groups were statistically similar with regard to presence of HS (overall 92%), and mechanism of initial dislocation. However, patients who underwent the Latarjet procedure were slightly older at surgery (p=0.045), had longer symptom duration (p=0.015), and had failed more arthroscopic Bankart repair procedures (p=0.002). Additionally, more patients had “off-track” glenohumeral bone loss in the Latarjet group (38%) compared to the control group (9%), (p=0.049). Post-operatively, the Latarjet and control groups had comparable minimal loss of external rotation (47% vs .45%, p=0.768) and high rates of return to sports (94% vs 100%) at a similar time (5.3 vs. 5.4 months, p=1.0). There was a 17% recurrent instability rate in the Latarjet cohort similar to 23% in the control cohort (p=0.709). There were no cases of post-operative nerve palsy or coracoid non-union in those who underwent the Latarjet, compared to one non-union following bony Bankart ORIF in the control group. Functional outcome scores were similarly high across both groups (Table 1).

Conclusion: Despite being a technically challenging, salvage-type, open reconstructive shoulder procedure, the Latarjet procedure yielded low complication rates and comparably good outcomes in an adolescent cohort with more risk factors for recurrence than a control group of adolescents undergoing other procedures. For young, athletic patients with multiple instability recurrences, previous surgeries, long symptom duration, and glenohumeral bone loss—including severe, ‘off track’ variations—the Latarjet procedure provides a high rate of return to sports, good/excellent functional outcome scores, and low rates of recurrent instability and complications.

Paper 175

Title:
Prevention of Elbow Injuries in Young Baseball Players: A 6-year Longitudinal Study.

Authors:
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[1]Kyoto Chubu Medical Center, Kyoto, Japan, [2]Kyoto Prefectural University of Medicine, Kyoto, Japan, [3]Kyoto Prefectural University of Medicine, Kamigyo-ku, Kyoto, Japan, [4]Doshisha University, Kyoto, Japan.

Objectives: Injuries in young baseball players are on the rise. However, there are few large-scale related to injury prevention activities. We have continued an injury prevention project in Kyoto, Japan since 2010. The aim of this study was to verify the preventive effect of our project.

Methods: We offered medical screening of elbow for elementary and junior high school players. We examined their elbow manually, performed ultrasonography and guided the players how to check their elbow themselves. Additionally, we instructed baseball coaches and parents regarding injury prevention annually. In this study, a cumulative total of 2624 baseball players (mean age 11.0±0.6) who participated in our injury prevention project (2010-2016) were enrolled. We asked them to answer the questionnaire to investigate the experience of elbow pain and evaluated the tenderness of humeral medial epicondyle and range of motion. Ultrasonography of humeral capitellum and medial epicondyle was examined. Subjects with abnormalities on ultrasonography were further examined through radiographic study and osteochondritis dissecans of the humeral capitellum (OCD) was diagnosed. Humeral medial epicondyle apophysitis was diagnosed with abnormalities of ultrasonography, and physical findings. The annual incidence were investigated and analyzed statistically. $P < 0.05$ was considered significant for all statistical analysis.

Results: The mean prevalence rate of OCD was 1.1% and flexion restriction was 12.3%. There were no significant differences in annual incidence. However, the experience rate of elbow pain was 14.4% in 2010 and 4.4% in 2016, tenderness of humeral epicondyle was 32.2% and 5.8%, extension restriction was 12.5% and 6.9%, and humeral medial epicondyle apophysitis was 22.1% and 5.3%, respectively, that significantly reduced year by year (Table 1).

Conclusion: There has been increasing recognition for the importance of preventing the overuse injuries among young baseball players. However, large-scale and longitudinal evaluation studies for preventing elbow injuries have not been reported. The prevalence rates of elbow injuries have generally reduced year by year, which indicates that annual medical screening and educational project for young baseball players, coaches and parents would be an effective approach for preventing elbow injury.

Annual incidence of elbow injuries

	2010	2011	2012	2013	2014	2015	2016	mean	p-Value
OCD(%)	1.4	0.7	2.2	1.1	1.1	0.6	0.8	1.1	0.43
Medial epicondyle apophysitis(%)	22.1	9.3	7.3	10.9	5.4	5.4	5.3	8.2	<0.001

Elbow pain(%)	14.4	10.3	7.0	5.9	6.2	4.6	4.4	6.7	<0.001
Tenderness(%)	32.2	11.3	7.0	16.8	9.4	5.8	8.1	11.1	<0.001
Extension restriction(%)	12.5	10.7	7.9	6.4	7.8	11.7	6.9	8.9	<0.05
Flexion restriction(%)	13.5	9.7	10.8	11.5	11.3	15.0	13.3	12.3	0.96