The Effect Of Post-operative KT-1000 Score On Long-term Outcome In Anterior Cruciate Ligament Reconstruction.

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Objectives: Many long-term outcome studies have looked at risk factors for developing osteoarthritis after anterior cruciate ligament reconstruction (ACL). The purpose of this study was to evaluate the effect of post-operative graft laxity as measured by KT-1000 arthrometry on long-term clinical knee scores as well as the subsequent risk of additional knee surgery in transtibial ACL reconstructed patients.

Methods: Between 1992 and 1998, a cohort study of 171 consecutive patients undergoing transtibial bone-patellar tendon-bone ACL reconstruction was performed. Any patient with a history of prior ipsilateral or contralateral ACL reconstruction, menisectomy or cartilage restoration was excluded from this study. At 6, 12 and 24 months postoperatively, patients were evaluated by clinical examination, subjective and objective scoring systems, and KT-1000 arthrometry. Patients with a side to side difference of less than 3mm as measured by KT-1000 were considered ‘tight grafts’ and patients with a side to side difference of greater than 5mm were considered ‘loose’. At long-term follow-up patients completed subjective outcomes scores as well as questionnaires regarding their knee function. Differences within and between groups were analyzed.

Results: The study cohort comprised of eighty-five patients who met inclusion criteria; sixty-five ‘tight’ patients, and twenty ‘loose’ patients. 46 of 65 ‘tight’ patients (71%) and 15 of 20 ‘loose’ patients (75%) were available at long-term follow up (average 17 years; range 14.25 to 19.2). Lysholm scores improved significantly from pre-operative levels in both ‘tight’ and ‘loose’ reconstructions at both 2-year and long-term follow up; ‘tight’ grafts improved from 65.8 + 20.0 to 93.8 + 7.7, p<0.0001 and 90.4 + 10.4, p<0.0001 at 2-year and long-term follow up respectively, whereas ‘loose’ grafts improved from 74.2 + 13.4 to 94.4 + 6.7, p=0.0003 and 90.0 + 13.5, p=0.01 respectively. In addition, Lysholm scores at 17-years did not differ significantly from 2-year post-operative scores in either group (‘tight’, p=0.10; ‘loose’, p=0.18). Moreover, at long-term follow-up, there was no significant difference between ‘tight’ or ‘loose’ reconstructions in any outcome measure; Lysholm p=0.85, Tegner p=0.77, KOOS p=0.96, and IKDC (subjective) p=0.42. Tegner activity scores did, however, deteriorate significantly within each group at 17-years when compared with 2-years’ scores (‘tight’, p=0.003; ‘loose’, p<0.01). With respect to number of additional surgical procedures required on the ACL reconstructed knee at 17 years, there was no difference between groups (24% ‘tight’, 7% loose; p=0.15).

Conclusion: A side to side difference of greater than 5mm as measured by KT-1000 arthrometry has historically been considered a failure of ACL reconstruction. Our study suggests that a clinically loose post-operative result may not correlate with clinical failure at 17-year follow-up, and that transtibial ACL reconstruction still can provide excellent clinical results at long-term follow up.
Incidence of Second Anterior Cruciate Ligament (ACL) Injury 2 Years after Primary ACL Reconstruction and Return to Sport

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**Objectives:** The incidence of second anterior cruciate ligament (ACL) injury in the first 12 months after ACL reconstruction (ACLR) and return to sport in a young, active population has been reported to be 15 times greater than a previously uninjured cohort. It is unknown if this high relative rate of injury continues beyond the first year after return to sport following ACLR. The tested hypothesis was that the incidence rate of a subsequent ACL injury in the 2 years following ACLR and return to sports would be less than the incidence rate reported within the first 12 months after return to sport, but greater than the ACL injury incidence rate in an uninjured cohort of young athletes.

**Methods:** Seventy-eight subjects who underwent ACLR and were ready to return to a pivoting/cutting sport (RTS) and 47 controls were prospectively enrolled. Each subject was followed for injury and athletic exposure (AE) data for a 24-month period after return to sport. Twenty-three subjects after ACLR and 4 control subjects suffered an ACL injury during this time. Incidence rate ratios (IRR) were calculated to compare the rates (per 1000 athletic exposures \([\text{AEs}]\)) of ACL injury in athletes in the ACLR group and control group. For the ACLR group, similar comparisons were conducted for side of injury by sex.

**Results:** The overall incidence rate of a second ACL injury within 24 months after ACLR and RTS (1.39/1000 AE) was nearly 6 times greater (IRR=5.71, 95% CI: 2.0, 22.7, p=0.0003) than healthy control subjects (0.24/1,000 AE). Female ACLR athletes demonstrated 4 times greater rate of injury within 24 months of RTS (IRR=4.51; 95% CI: 1.5-18.2, p=0.0004) than female controls. Within the ACLR group, there was a trend for female subjects to be over two (RR=2.43, 95% CI: 0.8, 8.6) times more likely to suffer a contralateral injury (1.13/1000 AEs) than an ipsilateral injury (0.47/1000 AEs). Overall, 29.5% of athletes suffered a second ACL injury within 24 months of RTS with 20.5% sustaining a contralateral injury and 9.0% incurring an ipsilateral graft re-tear injury. A higher proportion of females (23.7%) suffered a contralateral injury compared to males (10.5%). Conversely, for ipsilateral injuries, the incidence proportion between females (8.5%) and males (10.5%) were found to be similar.

**Conclusion:** These data support the hypothesis that in the 24 months following ACLR and RTS, patients are at greater risk (nearly 6 times) to suffer a subsequent ACL injury compared to young athletes without a history of ACL injury. Additionally, the contralateral limb of female patients appears to be at greatest risk. These 24 month outcome data, analyzed in conjunction with recent 12 month outcome data which noted a 15 times greater risk of ACL injury compared to healthy control subject, indicate that the greatest risk of second ACL injury after ACLR occurs during the initial 12 months after ACLR and RTS than the second year after RTS.
Table 1: Summary of the incidence rate of ACL injury.

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Total</th>
<th>Females</th>
<th>Rate*</th>
<th>Males</th>
<th>Rate*</th>
<th>Rate Ratio</th>
<th>95% CI</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>AEs</td>
<td>No.</td>
<td>AEs</td>
<td>Rate*</td>
<td></td>
<td></td>
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<tr>
<td>ACLR</td>
<td>23</td>
<td>16537</td>
<td>19</td>
<td>12553</td>
<td>1.51</td>
<td>4</td>
<td>3984</td>
</tr>
<tr>
<td>2nd ACL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>1.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.5-6.1)</td>
</tr>
<tr>
<td>Control</td>
<td>4</td>
<td>16431</td>
<td>4</td>
<td>11923</td>
<td>0.36</td>
<td>0</td>
<td>4508</td>
</tr>
<tr>
<td>Initial ACL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>ACLR/CTRL Rate</td>
<td>5.71</td>
<td>4.51</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>95% CI</td>
<td>(2.0-22.7)</td>
<td>(1.5-18.2)</td>
<td>NA</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

AE, athletic exposures: each time an athlete took part in a practice or competition without limitation of anterior cruciate ligament (ACL) injury, thus being exposed to the risk of ACL injury; CI, confidence interval; ACLR, Anterior cruciate ligament reconstruction group; CTRL, control group.

*Rate, ACL injury rate per 1000 AEs.
†Rate Ratio Total 2nd ACL/Initial ACL (p=0.0003).
‡Rate Ratio Females: 2nd ACL/Initial ACL (p=0.0004).
Return to Sports and Subsequent ACL Injury Rates after Revision ACL reconstruction with Patellar Tendon Autograft

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Objectives: We sought to determine the rate at which competitive and recreational athletes of different age groups returned to the same sport at the same level after revision ACL reconstruction with a patella tendon autograft, as well as define the subsequent ACL injury rate to either knee.

Methods: We prospectively studied patients after revision ACL reconstruction with patellar tendon autograft. Patients who were involved in jumping/pivoting sports when they injured the ACL reconstructed knee and had the desire to return to the same sport at the same competitive level were included in the study. All patients underwent a perioperative rehabilitation program that emphasized limiting postoperative hemarthrosis, obtaining full range of motion, and achieving quadriceps muscle control before participating in an aggressive strengthening and functional progression program. Patients were grouped by age and competitive sport levels of high school (age < 17.5 years, mean 16.6 ± 0.9 years; N=84), college (ages 18 to 21.9 years, mean 19.6 ± 1.2 years; N=58) or recreational (22 to 35 years, mean age 27.6 ± 4.1 years; N=117). A subjective activity survey was used to determine what specific sport and sport level patients participated in before and after surgery. The International Knee Documentation Committee (IKDC) and modified Noyes knee surveys were also obtained.

Results: Of 84 high school athletes, 62 (74%) returned to play the same sport in high school. Of 58 college athletes, 43 (74%) returned to play the same sport at the college level. Of 117 recreational athletes, 73 (62%) returned to the same sport at a recreational level. The number of patients who had a subsequent ACL graft tear rate after revision surgery was 2 of 84 (2.3%) in the high school group, 3 of 58 (5.1%) in the college group, and 4 of 117 (3.4%) in the recreational group. The number of patients who had a subsequent ACL tear in the contralateral knee was 1 of 84 (1.1%) in the high school group, 1 of 58 (1.7%) in the college group, and 2 of 117 (1.7%) in the recreational group. Long-term subjective follow-up was obtained for 210 patients at 7.2 ± 5.3 years after surgery. The mean IKDC subjective total score was 86.1 ± 11.7 points at 2 years after surgery and 76.7 ± 18.3 at long-term follow-up. The mean modified Noyes total score was 89.7 ± 11.1 points at 2 years after surgery and 83.7 ± 16.2 points at long-term follow-up.

Conclusion: Revision ACL reconstruction with a patellar tendon autograft combined with perioperative rehabilitation allows patients to return to the same sport at the same level at a high rate, which is higher than what is reported for revision surgery with hamstring grafts or allografts. Subsequent ACL injury rates to either knee is low and appears lower than after primary surgery, which may indicate that although patients report they return to the same level of sport, they may be doing so at a lower intensity.

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Objectives: Multiligament knee injuries (MLI) are usually associated with high energy mechanisms such as motor vehicle accidents or sports injuries. However, obese patients are at risk of MLI from simple falls. Termed “ultra-low velocity” (ULV) dislocations, these may be associated with higher associated risks and complications due to the patient’s inherent size.

The objectives of this study are to characterize the epidemiology, risk factors, associated neurovascular injuries, and perioperative complications of ULV dislocations to allow surgeons to make informed decisions regarding their care.

Methods: Study Design: Retrospective cohort study. 215 consecutive patients with MLI were identified over a 12 year period. Their charts were reviewed to identify a cohort of patients with mechanisms consistent with ULV dislocation (n=23). This cohort was compared to all MLI. Additionally, ULV patients with neurovascular injury were compared to those without neurovascular injury.

Analysis: Means and ranges were calculated for continuous variables (age, BMI) and compared between cohorts using Student’s t test. Frequencies for categorical variables were compared using chi square tests.

Results: Compared to all patients with MLI, the ULV cohort had significantly higher BMI, greater prevalence of female gender, and higher rates of both peroneal nerve and popliteal artery injury (Table I). Within the ULV cohort, patients with neurovascular injury demonstrated significantly greater post-operative complications (Table II). There was a trend for higher BMI to be predictive of neurovascular injury in ULV dislocations, but patient numbers limited any additional statistical analysis.

Conclusion: ULV knee injuries occur in patients with greater BMI, more frequently in females, and with higher rates of concomitant neurovascular injury compared to other MLI. Additionally, a greater incidence of post-operative complications can be expected after ligament reconstruction in this population.

Table I. MLI and ULV cohort characteristics and univariate analysis

<table>
<thead>
<tr>
<th></th>
<th>MLI</th>
<th>ULV</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>215</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>32.0 (12.6)</td>
<td>35.7 (14.6)</td>
<td>0.184</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>34.1 (10.7)</td>
<td>49.1 (11.2)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Gender female (%)</td>
<td>56 (24.3%)</td>
<td>16 (69.6%)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>MOI (sport) (%)</td>
<td>51 (23.7%)</td>
<td>0 (0%)</td>
<td>&lt;0.0001*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injury Classification</th>
<th>n</th>
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</thead>
<tbody>
<tr>
<td>KDI</td>
<td>131</td>
</tr>
<tr>
<td>KDI1</td>
<td>9 (6.2%)</td>
</tr>
<tr>
<td>KDI2</td>
<td>40 (18.6%)</td>
</tr>
<tr>
<td>KDI3</td>
<td>23 (10.7%)</td>
</tr>
<tr>
<td>KDVI</td>
<td>12 (5.6%)</td>
</tr>
<tr>
<td>Vascular injury (%)</td>
<td>10 (4.2%)</td>
</tr>
<tr>
<td>Nerve injury (%)</td>
<td>18 (8.4%)</td>
</tr>
<tr>
<td>PLCL injury (%)</td>
<td>163 (75.8%)</td>
</tr>
<tr>
<td>PLCI injury (%)</td>
<td>128 (58.8%)</td>
</tr>
</tbody>
</table>

Table II. Characteristics of the ultra-low velocity NV intact and NV injury cohorts.

<table>
<thead>
<tr>
<th></th>
<th>NV Intact</th>
<th>NV Injury</th>
<th>p</th>
<th>Nerve Alone</th>
<th>Artery Alone</th>
<th>NvA Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>32</td>
<td>11</td>
<td></td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>BMI</td>
<td>45.5</td>
<td>52.6</td>
<td>0.176</td>
<td>51.7</td>
<td>46.5</td>
<td>56.7</td>
</tr>
<tr>
<td>Age</td>
<td>38.2</td>
<td>33.1</td>
<td>0.417</td>
<td>33.1</td>
<td>39.3</td>
<td>30.0</td>
</tr>
<tr>
<td>Gender female (%)</td>
<td>7 (35.3%)</td>
<td>9 (81.8%)</td>
<td>0.221</td>
<td>4 (80.0%)</td>
<td>1 (56.0%)</td>
<td>3 (75.0%)</td>
</tr>
<tr>
<td>KDI</td>
<td>8 (66.7%)</td>
<td>8 (72.7%)</td>
<td>0.752</td>
<td>4 (80.0%)</td>
<td>2 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>KDI1</td>
<td>2 (16.7%)</td>
<td>4 (36.4%)</td>
<td>0.283</td>
<td>1 (20.0%)</td>
<td>0 (0%)</td>
<td>3 (75.0%)</td>
</tr>
<tr>
<td>KDI2</td>
<td>1 (8.3%)</td>
<td>1 (9.1%)</td>
<td>0.949</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (25.0%)</td>
</tr>
<tr>
<td>Complications</td>
<td>6 (50.0%)</td>
<td>12 (100%)</td>
<td>0.000*</td>
<td>5 (100%)</td>
<td>2 (100%)</td>
<td>4 (100%)</td>
</tr>
</tbody>
</table>
Posterolateral Knee Repair Versus Reconstruction

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Objectives: Our goal was to compare clinical, functional and radiographic outcomes of posterolateral knee injuries treated with repair versus reconstruction. In addition, we compared varus stress radiographs of these patients with controls.

Methods: A retrospective chart review was performed to identify patients that underwent posterolateral knee reconstruction or repair from January 1, 2000 to March 1, 2012. Patients were asked to return for a clinical exam and varus stress radiographs, as well as fill out IKDC and Lysholm knee scales. Patients that could not return to clinic were assessed via phone interviews. Chart reviews were performed on patients that could not be contacted. Further, we compared varus stress radiographs of 20 control knees, with no history of knee trauma, to both posterolateral knee repair and reconstruction groups.

Results: We identified 61 knees in 60 patients who underwent posterolateral knee reconstruction or repair. 26 knees in 25 patients (17 reconstructions and 9 repairs) were evaluated at mean of 41.86 months postoperatively (range: 6-108). Average IKDC scores for reconstruction and repair were 68.23 and 71.30, respectively. Average Lysholm scores for these groups were 83.11 for reconstructions and 83.30 for repairs. There were no statistically significant differences in IKDC or Lysholm scores between the repair and reconstruction groups. Average varus gapping with the knee at zero degrees was 8.21 and 8.84 millimeters (mm) for reconstructions and repairs, respectively. Average varus gapping at 20 degrees knee flexion was 11.25 mm for reconstructions and 10.34 mm for repairs. No statistically significant differences were observed in varus gapping between the two groups. Control knee measurements, 20 knees in 20 different controls, showed average varus gapping of 5.27 mm at zero degrees and 6.55 mm at 20 degrees knee flexion. There was a statistically significant difference in varus gapping when comparing the operatively treated knees to the control group. On review of all 61 knees, there were five failures: three failed reconstructions, two failed repairs. The other complication included one small wound dehiscence in the reconstruction group that resolved without intervention.

Conclusion: Unlike previous studies, we did not find statistical differences in our posterolateral knee patients treated with reconstruction versus repair. We did find statistically significant differences in varus gapping, at both 0 and 20 degrees of knee flexion, between control knees and the operatively treated groups. However, this did not correlate to poor clinical outcomes in either group.
Hip Arthroscopy for FAI: Predictors of Patient Satisfaction and Conversion to Total Hip Arthroplasty 5 to 7 years Following Arthroscopy

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**Objectives:** Hip arthroscopy is treatment method for patients with symptomatic femoroacetabular impingement (FAI). It is unclear what factors are associated with mid-term success. The purpose of this study is to report the clinical outcomes and the predictors of successful outcome at a minimum 5 years post-operatively.

**Methods:** Between March 2005 and September 2006, 646 consecutive hip arthroscopies were performed. This study was IRB approved. Patients were included who underwent arthroscopic treatment of symptomatic FAI and chondrolabral dysfunction with radiographic and physical examination findings consistent with FAI. Exclusion criteria included patients < 18 years of age, professional athletes, labral reconstruction, Legg-Calve-Perthes disease, and those with underlying hip disease such as pigmented villonodular synovitis or synovial chondromatosis. All data were prospectively collected and retrospectively reviewed, including physical exam findings, radiographic measurements (alpha angle, the presence of a crossover sign or acetabular dysplasia, and joint space), re-operations or complications, and conversion to THA. Patients were evaluated pre- and post-operatively with a prospective subjective questionnaire. Primary outcome measure included the modified Harris Hip Score (MHHS), and secondary outcome measures included the Western Ontario and McMaster Universities Arthritis Index (WOMAC), Tegner activity scale, patient satisfaction, and conversion to THA.

**Results:** Twenty-four patients were deceased or refused to participate at follow-up, and 284 patients (293 hips) met the inclusion criteria. The average age was 42 years (range, 18 to 77) and there were 140 females and 144 males. Sixty-eight hips (68 patients) required a total hip arthroplasty (THA) (24%). The average age of the THA group was 52 years (range, 32 to 77), with 60 patients (88%) over 40 years of age at the time of arthroscopy. There were 22 females (32%) and 46 males (68%). The average time to THA was 34.6 months post-operatively (range, 7 months to 5 years) and the average pre-operative MHHS was 58 (range, 24 to 100). Of the remaining 216 patients (225 hips), 171 patients (79%, or 178 hips) were available for follow up at a minimum of 5 years. The average follow-up was 6.6 years (range, 5 to 7.2). The MHHS improved from 61 to 80 (p<0.001). The average WOMAC at follow-up was 9.0 and the median Tegner activity scale was 4.0. The median patient satisfaction with outcome was 9 (range, 1 to 10). There was no difference in the MHHS between patients who underwent labral debridement or labral repair (p=0.1). The significant multivariate predictors of increased post-operative patient satisfaction at follow-up were higher modified Harris Hip Scores (p=0.003) and not having a microfracture performed (p=0.015) ($r^2=0.2$). Logistic regression modeling identified 2mm or less of joint space (P<0.0001, odds ratio=11.7, 95% CI: 3.6 to 38.1), hip requiring microfracture (o<0.0001, odds ratio=8.6, 95% CI: 3.0 to 26.6) and age at surgery (p<0.0001) as significant independent, multivariate risk factors for conversion to THA.

**Conclusion:** Hip arthroscopy for FAI and chondrolabral dysfunction results in a significant improvement
in outcome measures with high patient satisfaction. Predictors of conversion to THA were age, 2mm or less of joint space, and having a microfracture. These results are from early generation hip arthroscopies and these predictors may be managed differently in current practice.

Paper 7

Identifying Cam Lesions on the False Profile View

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Objectives: Recently the AP, Dunn and Frog Leg Lateral radiographic views have been verified to accurately reflect the findings of three dimensional imaging while assessing for cam lesions. The false profile radiographic view is traditionally used to measure acetabular coverage in the setting of femoroacetabular impingement. We believe it should also be used to assess the femoral head neck junction. Our objective is to verify the accuracy of this view with respect to 3D CT scan findings.

Methods: We retrospectively reviewed 37 consecutive surgical patients between May 2012 and September 2012 with preoperative radial oblique reformatted CT scans and plain radiographs. Alpha angles were measured on plain radiographs (AP, Dunn, False Profile) and CT reformats. Abnormal alpha angles were considered greater than 55 degrees and the CT scans were considered gold standard. Post-operative radiographs were also measured. Two physicians independently measured the images and the results were compared.

Results: The false profile view was 70.6% sensitive and 95.0% specific for diagnosing a cam lesion. It was noted that the false profile view was 1.31 times better than other views at visualizing the anterior head-neck junction at a 3 o’clock position (See image 1). The false profile view pre-operative mean alpha angle was 53.4° versus its post-operative mean alpha angle was 41.9°, Δ = 11.5° (t = 0.001). The interclass correlation coefficient (ICC) was found to be 0.81.

Conclusion: This is the first study to suggest using the false profile view to assess the femoral head neck junction. For diagnostic and treatment purposes, the false profile view effectively characterizes cam lesions, particularly anterior 3 o’clock lesions. Further, it shows promising results as a peri-operative assessment tool to verify adequate osteoplasty. Measuring the alpha angle on this view also appears to be a reproducible with a significant ICC. We believe this view should be used for both acetabular
coverage measurements as well as for femoral head neck junction measurements.

Paper 8

The Effect of Capsulectomy On Hip Joint Biomechanics.

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Objectives: Hip arthroscopy is performed in young adult patients with hip pain. During arthroscopy, capsulectomy is performed to improve intraoperative visualization. The stability of the hip joint after capsulectomy is relatively unknown. Our study evaluated anterior hip stability in capsular sectioned states with labral injury. We theorized the load required for anterior translation would decrease with greater capsular injury.

Methods: Ten human cadaveric pelvises (20 hips, mean 54.25 years) without radiographic evidence of degeneration or dysplasia were harvested. The hips were prepared and mounted onto a custom built testing fixture. Two pelvises were excluded due to fixation issues for one or both hips. The 16 hips were tested in five states (table 1). Each hip was tested in neutral position with a 20N compressive force. The capsular incision was made in-line with the femoral neck. The labrectomy was made at 2:30 position. The sutured
capsule was created using #2 Ethibond suture 1cm apart along the incision. The partial capsulectomy was made by resecting the iliofemoral ligament, leaving the pubofemoral and ischiofemoral ligaments intact. Total capsulectomy state was created by removing the remaining capsule. The load at 12mm of anterior translation was recorded for each state after two preconditioning trials.

**Results:** A repeated measures ANOVA with a Bonferroni adjustment showed no difference between all-intact vs. sutured-intact. It also demonstrated no significant difference between the sutured-intact and the sutured labrectomy states.

A repeated measures ANOVA with a Bonferroni adjustment was run to compare the capsular states with a 1cm partial labrectomy (table 2). There was a significant difference between the sutured-labrectomy and the partial capsulectomy (p=0.0146) and between the sutured-labrectomy and the total capsulectomy (p=0.0005). There was also a significant difference when comparing the partial capsulectomy and the total capsulectomy (p=0.0377).

**Conclusion:** The findings demonstrate that both the capsule and labrum play a role in providing anterior hip stability. These results indicate that the iliofemoral ligament is crucial for preventing anterior translation in labral injured states. Intraoperative capsulectomy should be avoided in patients with large irreparable labral tears to prevent postoperative anterior hip instability.
**Capsulolabral States**

- Intact capsule, intact labrum (all-intact)
- Sutured capsule, intact labrum (sutured-intact)
- Sutured capsule, 1cm partial labrectomy (sutured-labrectomy)
- Resected iliofemoral ligament, 1cm partial labrectomy (partial capsulectomy)
- Total capsulectomy, 1cm partial labrectomy (total capsulectomy)

Table 1. The five conditions tested for each hip specimen.

<table>
<thead>
<tr>
<th>Capsular States</th>
<th>Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All - intact</td>
<td>160.8</td>
</tr>
<tr>
<td>Sutured - intact</td>
<td>160.2</td>
</tr>
<tr>
<td>Sutured - labrectomy</td>
<td>158.3</td>
</tr>
<tr>
<td>Partial capsulectomy</td>
<td>122.8</td>
</tr>
<tr>
<td>Total capsulectomy</td>
<td>99.3</td>
</tr>
</tbody>
</table>
Two-Year Outcome of Arthroscopic Capsular Repair of the Hip: A Prospective Matched-Pair Controlled Study

Benjamin G. Domb, MD1, Christine E. Stake, MA2, Zachary John Finley, BA3, Ryan A. Baise, BS3, Itamar Botser, MD4.
1Hinsdale Orthopaedics Associates, American Hip Institute, Westmont, IL, 2Hinsdale Orthopaedics Associates, Westmont, IL, 3Hinsdale Orthopaedic Associates, Westmont, IL, 4Stanford Orthopaedic Sports Medicine Fellowship Program, Redwood City, CA

Objectives: Capsulotomy and capsulectomy are common procedures to gain better joint access in hip arthroscopy. Based on biomechanical evidence and the principle of restoration of anatomy, it has been suggested that closure of the capsule following hip arthroscopy may be beneficial. However, outcomes have scarcely been reported regarding the routine use of this procedure. The purpose of this study was to compare the clinical results of two matched-pair groups - one undergoing capsular closure following hip arthroscopy and one in which the capsulotomy was left open – with a minimum follow-up of two years.

Methods: Data was prospectively collected for all patients undergoing hip arthroscopy between February 2008 and June 2010. Revision surgeries and previous hip conditions such as avascular necrosis and Legg-Calves-Perthes Disease were excluded. In the early part of the study period, the capsule was left open at the end of the surgery; in the later part, routine capsular closure was performed. Patients were matched according to gender and age within 3 years. The study group included patients who underwent closure of the capsule, whereas the control group included patients in which the capsule was left open. Surgical outcome was measured according to resolution of hip snapping, and improvement in four hip specific patient-reported outcome (PRO) tools: the modified Harris Hip Score (mHHS), Non-Arthritic Hip Score (NAHS), Hip Outcome Score Activity of Daily Living (HOS-ADL) and Sport-Specific Subscales (HOS-SSS). Pain was estimated on the visual analog scale (VAS) and satisfaction was measured on a scale from 0-10.

Results: Each group consisted of 46 patients. The mean age of the study group was 28.9 years (range, 14 to 62 years), whereas the average of the control group was 33.8 years (range, 14 to 52) (p=0.03). There were no reported complications with the procedure. The average follow-up was 27.8 months (range, 16 to 41) with no significant difference between the two groups. The patients who received closure of the capsule showed score improvement from preoperative to two-year follow-up of 62 to 88 for mHHS, 60 to 84 for NAHS, 67 to 88 for HOS-ADL, and 43 to 71 for HOS-SSS. The control group showed score improvement of 61 to 87 for mHHS, 54 to 85 for NAHS, 61 to 86 for HOS-ADL, and 35 to 76 for HOS-SSS. All score improvements in both groups were statistically significant (p<0.05). Pain scores decreased from 6.4 to 2.4 in the closed capsule group and 6.3 to 2.2 in the control group. Patient satisfaction was 8.3 for the closed capsule group compared to 8.5 for the control group. In comparing the two groups, there were no differences in magnitudes of score improvement for PRO measures, VAS, or satisfaction. Range of motion at last follow-up was comparable.

Figure 1(A-D): PRO Measures pre and postoperatively1A
Conclusion: Both repairing the capsule of leaving it open at the end of hip arthroscopy yielded excellent results at minimum two year follow-up, with similar score improvements between the groups. Additionally, repair of the capsule resulted in no related complications and no limitation in range of motion. Cadaveric studies have shown capsulotomy changes the biomechanics of the hip joint, suggesting that routine capsular repair may be advantageous. While this pilot study did not show any difference in clinical outcome between groups, it establishes the feasibility and safety of capsular closure in hip arthroscopy, and may open the door for further refinement of its indications.
Risk Factors for Anterior Glenohumeral Instability

**Brett D. Owens, MD**, Scot Campbell, MD, Kenneth L. Cameron, PhD, MPH, ATC.

1Keller Army Hospital, West Point, NY, 2Wilford Hall Medical Center, San Antonio, TX

**Objectives**: While anterior glenohumeral instability has been shown to be common in young athletes, the risk factors for injury are poorly understood. The elucidation of risk factors is critical to help develop prevention strategies. We hypothesized that specific modifiable and non-modifiable factors at baseline would be associated with the subsequent risk of injury in a cohort of young athletes.

**Methods**: We conducted a prospective cohort study in which 714 young athletes were followed from June 2006 through May 2010. Baseline assessments included a subjective history of instability, physical examination by a sports-trained orthopaedic surgeon, range-of-motion, strength with a hand-held dynamometer, and bilateral noncontrast shoulder MRI. A musculoskeletal radiologist measured glenoid version, glenoid height, glenoid width, glenoid index (height-to-width ratio), glenoid depth, rotator interval (RI) height, RI width, RI area, RI index, and the coracohumeral interval. Subjects were followed to document all acute anterior shoulder instability events during the 4 year follow-up period. The time to shoulder instability event during the follow-up period was the primary outcome of interest. Univariate and multivariable Cox proportional hazards regression models were used to analyze the data.

**Results**: We obtained complete data on 714 subjects. During our 4 year surveillance period, there were 38 anterior instability events documented. While controlling for covariates, significant risk factors of physical exam were: apprehension sign HR=2.96 (1.48, 5.90, p=0.002) and relocation sign HR=4.83 (1.75, 13.33, p=0.002). Baseline range-of-motion and strength measures were not associated with subsequent injury. Significant anatomic risk factors on MRI measurement were glenoid index HR=8.12 (1.07, 61.72, p=0.043) and the coracohumeral interval HR=1.20 (1.08, 1.34, p=0.001).

**Conclusion**: This prospective cohort study revealed significant risk factors for shoulder instability in this high-risk population. While modifiable risk factors such as strength and range-of-motion were not associated with subsequent instability, some non-modifiable risk factors were. That the exam findings of apprehension and relocation were significant while controlling for prior history of injury suggests that patients may be unaware of prior instability episodes. The anatomic variables of significance are also not surprising - tall and thin glenoids were at higher risk compared to short and wide glenoids; and the risk of instability increased by 20% for every 1mm increase in coracohumeral distance.

The Effect of Glenoid Version and Width on Outcomes of Arthroscopic Posterior Shoulder Stabilization
Objective: Posterior shoulder instability has become more widely recognized and recent studies have demonstrated improved outcomes with arthroscopic treatment. Chondrolabral version has been postulated to be an important contributor to posterior shoulder stability. Further, while glenoid bone loss has been shown to be an important predictor of the outcomes of anterior shoulder stabilizations, the effect of glenoid shape and size is less clear in the setting of posterior instability. We hypothesized that anatomical variations of the glenoid, specifically in its size and version, affect the patient outcomes following arthroscopic posterior shoulder stabilization.

Methods: Two-hundred athletes were prospectively followed after undergoing an arthroscopic repair of unidirectional posterior instability by a single surgeon. They were followed for a mean of 24 months post-operatively, and outcome measures included the ASES and standardized pain, function, and stability scores. MRI arthrogram measurements of the glenoid were performed on an axial image at the inferior one-third level. They included measurements of labral, chondral, and glenoid bone version and glenoid and labral width. Simple linear regressions were performed to determine relationships between MRI measurements and outcome scores.

Results: One-hundred eighteen MRI arthrograms were performed at our institution and were available for review. Glenoid bone width and bone version both predicted pre-operative pain and ASES scores, with patients with wider (slope 1.3, p<.05) and more retroverted glenoids (slope .94, p<.05) having better average pre-operative pain and ASES scores than subjects with smaller and more anteverted glenoids. At final post-operative follow-up, no significant differences in outcome scores were detected among subjects with regard to glenoid bone version. However, patients with wider glenoids continued to have better pain and ASES scores (slope 1.0, p<.05). There was no correlation between chondral and labral version and any outcome measure pre-operatively or post-operatively.

Conclusion: Glenoid anatomy may play an important role in the outcomes of patients undergoing arthroscopic stabilization of posterior capsulolabral injuries. While decreased glenoid retroversion and bony width both portended lower shoulder function pre-operatively, only decreased bony width was predictive of poorer outcomes postoperatively. Patients with posterior shoulder instability and a smaller glenoid width identified on MRI may warrant further investigation of glenoid bone morphology by CT scan. Further investigation of the effect of glenoid, chondral, and labral version and glenoid width on posterior shoulder stability and outcomes following posterior shoulder stabilization is warranted.

Paper 12

Conjoined Tendon Transfer vs Modified Bristow in a Glenoid Bone Loss Model: A Biomechanical Study

Anand P. Panchal, DO¹, Daryl C. Osbahr, MD², Wiemi Douoguih, MD³, Brent G. Parks, MSC⁴.
¹Triangle Orthopaedic Associates, PA, Durham, NC, ²MedStar Union Memorial Hospital, Baltimore, MD, ³Washington Hospital Center, Washington, DC, ⁴Union Memorial Hospital, Baltimore, MD
Objectives: Over the last ten years there has been a resurgent interest in the use of coracoid transfer procedures for the treatment of traumatic, anterior glenohumeral instability of the shoulder. Bankart repair, whether arthroscopic or open, is the gold standard for treatment of the majority of anterior glenohumeral instability cases. Coracoid transfer procedures, on the other hand, are effective for patients with significant bony defects, those with poor quality anterior capsulolabral tissues, and in collision athletes with higher risk of instability after simple soft-tissue repair. Despite high rates of success in most studies involving the Bristow and other coracoid transfer procedures, complications have been reported. Screw breakage, nerve injury, non-union of the coracoid fragment, and arthritis related to improper placement of the bone block have all been documented. Eliminating the bone block would help to decrease the number of potential complications associated with the procedure. For this reason, we sought to evaluate whether the Bristow procedure or the conjoined tendon transfer (CTT) would be more effective in restoring kinematics of the glenohumeral joint in a glenoid bone loss model for anterior shoulder instability. This is the first study to our knowledge comparing a bone block with its attached musculotendinous sling to a sling alone in a glenoid bone loss model.

Methods: Utilizing fresh frozen cadavers, biomechanical testing was undertaken comparing anterior glenohumeral translation in two groups of ten specimens each with a 25% anterior glenoid bone defect. Group 1 consisted of a tensioned conjoined tendon transfer (CTT) into the defect. Group 2 consisted of a Modified Bristow bone block (BB) transfer. Cyclic testing was performed with the shoulder at 90 degrees of external rotation in both 60 and 90 degrees of abduction.

Results: At 60 degrees of abduction, the conjoined tendon transfer showed a 43% reduction in anterior humeral head translation from the unstable or deficient state, while the bone block transfer showed a 12% reduction. This difference was statistically significant. At 90 degrees of abduction, the conjoined tendon transfer showed a 59% reduction in anterior humeral head translation from the unstable or deficient state, while the bone block transfer showed a 38% reduction. This difference trended towards significance. (Please see table 1. for full details/data)

Conclusion: A tensioned conjoined tendon transfer in the setting of 25% anterior glenoid bone loss exhibited a statistically significant reduction in anterior glenohumeral translation at 60 degrees of abduction and a nonsignificant reduction at 90 degrees of abduction versus a Modified Bristow bone block transfer. Biomechanically, we feel the musculotendinous sling of the conjoined tendon functions in place of the anterior and anterior/inferior capsulolabral structures, including the anterior band of the IGHL, which are typically deficient in the setting of recurrent anterior instability. This represents the initial step in determining if this procedure could be a viable alternative to a bone block transfer in the
setting of anterior glenohumeral instability with glenoid bone loss.

<table>
<thead>
<tr>
<th>Table 1. Anterior Glenohumeral Translation (mm, w/ Std dev)</th>
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<tbody>
<tr>
<td><em>Specimen</em></td>
</tr>
<tr>
<td>60° Abduction</td>
</tr>
<tr>
<td><strong>Intact</strong></td>
</tr>
<tr>
<td><strong>Destabilized</strong></td>
</tr>
<tr>
<td><strong>Repaired</strong></td>
</tr>
</tbody>
</table>

Paper 13

Shoulder Dislocation In Ontario, Canada From 1994 To 2011: The Incidence, Rate And Risk Factors For Recurrence.

Timothy Leroux, MD¹, David Wasserstein, MD², Tim Dwyer, MD³, Christian Veillette³, Amir Khoshbin, MD⁴, Rajiv Gandhi, MD, FRCSC¹, Peter Austin, PhD⁵, Nizar Mahomed, MD¹, Darrell Ogilvie-Harris, MD, FRCSC⁶.

¹University of Toronto, Toronto, ON, Canada, ²University of Toronto Sports Medicine Program - Mount Sinai Hospital, Toronto, ON, Canada, ³Toronto, ON, Canada, ⁴University of Toronto, ⁵Institute for Clinical Evaluative Sciences, Toronto, ON, Canada, ⁶Toronto Western Hospital, Toronto, ON, Canada.

Objectives: Recurrent shoulder dislocation is influenced by age, activity level and bone loss. Original estimates of recurrence risk approached 90% among persons under the age of 20, but declined with increasing age. Recent literature, however, suggests that the rate of recurrent dislocation is lower. The goals of this study were to: (1) define the incidence of primary shoulder dislocation in Ontario, Canada,
and (2) identify the rate of and risk factors for recurrent dislocation among demographic variables. 

**Methods:** Administrative databases (OHIP) were used to build the cohort of patients aged 15 to 70 that underwent a primary closed shoulder reduction by a physician in Ontario between July 1994 and October 2009. Exclusions included: associated humeral neck fracture, posterior dislocation, previous shoulder dislocation, prior shoulder arthroplasty, and non-Ontario residents. After cohort entry, subsequent shoulder relocations by a physician were sought. The yearly incidence (per 100,000 person-years) was calculated among all eligible Ontario residents. Kaplan-Meier survival curves to subsequent dislocation were generated. A Prentice, Williams and Peterson conditional proportional hazards survivorship model of time-to-recurrence was applied examining the influence of age, gender, income quintile, physician specialty and concurrent tuberosity fracture at index dislocation on the risk of recurrence (alpha set at 0.05). Hazard Ratios (HR) with confidence intervals were calculated.

**Results:** The primary dislocation cohort consisted of 37,356 patients. Median age was 34 years (IQR 22-50) and 74% were male. The average yearly incidence of primary shoulder dislocation was 23.1/100,000 person-years overall, but 45.2/100,000 person-years for patients younger than 20. Recurrent dislocation events were identified in 23% of the cohort (8573 patients), most of whom were younger (median age 24 years) and male (80%). In fact, patients younger than 20 had a 37.8% rate of recurrence (HR 1.9 (1.7-2.1), p<0.0001; compared to patient aged 36-40). Kaplan-Meier survival curves showed most recurrent dislocations took place in the first year: 93.4% at 6-months, 89.4% at 1-year, 85.2% at 2-years and 79.4% at 5-years. Protective factors against recurrence included primary relocation performed by an Orthopaedic Surgeon (HR 0.87 (0.79-0.94), p=0.001), age over 50 years (5.5% rate; HR 0.70 (0.61-0.80, p<0.0001) and an associated tuberosity fracture (HR 0.51 (0.42-0.63), p<0.0001), while lowest income quintile was a risk factor for recurrence (HR 1.1 (1.04-1.16), p=0.0007). Interestingly, at 2.5 years from the primary dislocation, only 14.7% of the cohort had undergone surgical shoulder stabilization.

**Conclusion:** Patients under 20 had twice the incidence of primary dislocation and twice the risk of recurrent shoulder dislocation compared to the median cohort age. A recurrence rate of 38% in patients under 20 is high, but less than previous reports.

**Paper 14**

The Cost-Effectiveness Of Arthroscopic Bankart Repair Versus Non-Operative Treatment For First-time, Traumatic, Anterior Shoulder Dislocations

**Ryan Patrick Donegan, MD**, Garrett Davis, MD, James Genuario, MD, John Bell, MD.  
1Dartmouth-Hitchcock Medical Center, Lebanon, NH, 2Steadman Hawkins Clinic-Denver, Denver, CO

**Objectives:** Prior studies have demonstrated excellent results after acute arthroscopic stabilization of first-time, traumatic, anterior shoulder dislocations in young patients. However, this treatment has not been widely accepted as first line management of this injury. Surgeons may point to the initial direct costs of surgical management as one rationale for conservative management of these injuries. The purpose of this study is to determine whether surgical stabilization of first time traumatic anterior
shoulder dislocation represents a cost effective treatment alternative when compared to non-operative treatment with physical therapy.

**Methods:** A decision-analytic model was constructed to assess the cost-effectiveness of arthroscopic bankart repair compared with non-operative treatment with physical therapy based on the incremental cost-effectiveness ratio (ICER). A threshold ICER of less than $100,000/quality adjusted life year gained was set to define a cost-effective treatment modality. Health state utilities for treatment outcomes of a recurrently dislocating shoulder and a stable shoulder were collected prospectively by surveying fifty patient volunteers using a time trade-off method. The probabilities of the various treatment outcomes and the costs associated with treatment were derived from the orthopaedic literature and adjusted Medicare reimbursement rates.

**Results:** The incremental cost-effectiveness ratio (ICER) for arthroscopic bankart versus non-operative treatment was $43,500. The estimated cost of surgical treatment must increase from approximately $11,000 to over $24,000 for surgery to no longer be cost-effective. The one-year probability of dislocation after bankart repair must increase from approximately 4% to 7%, or the probability of dislocation after non-operative treatment must decrease from 17% to approximately 11% for surgery to no longer be cost-effective.

**Conclusion:** Using currently available probabilities, estimated costs, and prospectively collected health state utilities, arthroscopic bankart repair represents a cost-effective treatment alternative for first-time, traumatic anterior shoulder dislocations in young patients. These results are robust when the costs, probabilities, and utilities are widely varied. Further studies should focus on identifying patient populations who fall within the threshold values identified in this analysis.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Cost</th>
<th>Increased Cost</th>
<th>Effectiveness (Quality Adjusted Life Years; QALYs)</th>
<th>Increased Effectiveness (QALYs)</th>
<th>Average Cost-Effectiveness ($/QALY)</th>
<th>Incremental Cost Effectiveness Ratio (ICER; $/QALY gained)</th>
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</thead>
<tbody>
<tr>
<td>Non-operative Treatment</td>
<td>$6,079</td>
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<td>8.81</td>
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<td>$689</td>
<td></td>
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<tr>
<td>Arthroscopic Bankart Repair</td>
<td>$17,349</td>
<td>$11,270</td>
<td>9.07</td>
<td>0.26</td>
<td>$1912</td>
<td>$43,582</td>
</tr>
</tbody>
</table>
One-way sensitivity analysis of Incremental Cost Effectiveness Ratio ($/QALY) against the cost of Bankart Repair
(Dashed Line=Threshold ICER Value- $100,000; Solid Line= current estimate value)
Paper 15

What are the Risk Factors for Failure after Conservative Treatment of Ulnar Collateral Ligament Injuries of the Elbow in Baseball Players?

Kozo Furushima, MD, PhD, Yoshiyasu Itoh, MD, PhD, Shohei Iwabu, MD, PhD.
Keiyu Orthopedic Hospital, Tatebayashi, Gunma, Japan.

**Objectives:** Recovery from ulnar collateral ligament (UCL) injury of the elbow was previously thought to be beyond hope for baseball players. In recent years, however, surgical treatment of UCL injury in baseball players has resulted in a high return-to-play rate. Meanwhile, the effectiveness of rehabilitation as conservative treatment has been re-evaluated; many players can return to play by improving bodily functions and pitching forms without surgery. The factors that are cause adverse effect on conservative treatment and that bring them to surgery remain yet unclear.

To identify the factors that affect to the results of conservative treatment, we prospectively compared the patients who were able to return to play with the patients who failed.

**Methods:** From November 2009 to June 2012 (31 months), 295 baseball players were diagnosed with UCL injury at our facility. Of these, players with pain other than that due to UCL injury, those undergone rehabilitation less than 3 months, and those playing for recreation were excluded. 166 patients who have completed rehabilitation (>3 months) and who could be followed up at a competitive sport level were evaluated in this study. Eighty-two players (age, 16.0 ± 2.0 years) returned to competitive play with...
conservative treatment (succeeded group) and 84 (age, 18.9 ± 3.8 years) underwent to surgical treatment or could not return to competitive play (failed group). Factors for comparison included existence of ossicle in ligament, presence of symptoms of ulnar nerve disturbance during or after pitching, the extent of UCL injury (partial or complete) on magnetic resonance imaging (MRI), malunion of the medial epicondyle avulsed fragment, DASH sports, etc. They were compared using the statistical software SPSS 20.0.

**Results:** There was an increased risk of negative results in patients with a residual ossicle (relative risk [RR] = 2.6, p<0.01), symptomatic ulnar nerve disorders (RR=2.2, p<0.01), complete UCL injury on MRI findings (RR 4.5, p<0.01) (Tables 1-3), period of pain and DASH score (p<0.01). Complete injury was the most significant factor. Though pitching was stopped for three months, it was a poor return rate of about 33%. (Table 3) Players with these factors showed a significantly high probability of requiring UCL reconstruction surgery. On the other hand, 82% in players with partial injury could return to play with competitive level. (Table 3)

**Conclusion:** We identified several baseline injuries that may increase the risk of adverse results of conservative treatment in patients with UCL injury in high level baseball players. In UCL injury with a residual ossicle of the ligament-bone junction, repeating sharp pain and remission readily leads to tear of the medial support structure and poor performance. Secondary ulnar nerve symptoms can result from medial instability by UCL injury during extended periods. Thus, these factors were considered to be refractory to conservative treatment. We believe that the results may help in evaluating candidates for surgery for UCL reconstruction.

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<tr>
<td>Without ossicle</td>
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<tr>
<td>Succeeded Group</td>
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<td>Failed Group</td>
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<table>
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<th>Table 2. Ulnar nerve symptoms</th>
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<td></td>
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<tr>
<td>Without symptoms</td>
</tr>
<tr>
<td>Succeeded Group</td>
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<tr>
<td>Failed Group</td>
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Table 3. MRI finding

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<th>Complete injury</th>
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<tr>
<td>Succeeded Group</td>
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<td>37</td>
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<tr>
<td>Failed Group</td>
<td>10</td>
<td>74</td>
</tr>
</tbody>
</table>

Relative Risk 4.5

Paper 16

Sequential Sectioning of the Ulnar Collateral Ligament of the Elbow in Cadaveric Arms with Ulnohumeral Laxity Assessed by Dynamic Ultrasonography

Christopher C. Dodson, MD, Levon Nazarian, MD, Michael G. Ciccotti, MD, Steven B. Cohen, MD, Sommer Hammoud, MD, Michael C. Ciccotti, BA.

1Rothman Institute at Thomas Jefferson University, Philadelphia, PA, 2Thomas Jefferson University Hospital, Philadelphia, PA, 3Jefferson Medical College, Philadelphia, PA

Objectives: Injury of the ulnar collateral ligament (UCL), whether acute or chronic, is potentially career-threatening for elite overhead throwing athletes. Dynamic ultrasound (DUS) allows for rapid, cost-effective, non-invasive, and non-radiating evaluation of the UCL and elbow joint both at rest and with applied stress. The purpose of this study was to determine the amount of cadaveric elbow valgus laxity with sequential UCL sectioning using DUS. Our objective was to quantify which portions of the UCL must be injured to cause the varying levels of laxity seen clinically on DUS testing. No prior study has used DUS to quantify valgus joint laxity with sequential cadaveric UCL sectioning. It was hypothesized that the change in laxity due to release of the anterior band of the UCL would be greater than that seen when the posterior and transverse bands were cut.

Methods: Twelve cadaveric elbows were dissected free of skin and subcutaneous tissue by an experienced orthopaedic surgeon. Baseline DUS at rest and with applied valgus stress was then performed by an experienced ultrasonographer. Sequential sectioning of the medial elbow soft-tissue stabilizing structures was then carried out with valgus stress applied to the joint at each sectioning interval utilizing a standardized device (Telos, Marburg, Germany). First the transverse band of the UCL was released, followed by the posterior band, then the anterior bundle of the anterior band, the remaining posterior bundle of the anterior band, and finally the complete flexor pronator mass.

Results: Mean ulnohumeral laxity in millimeters with 95% CIs was calculated for each step of the sequence. The deltas between each step of the dissection were also calculated with means and 95% CIs.
Mean baseline laxity of the unstressed ulnohumeral joint at rest was 3.2 mm (CI, 2.2-4.2); with the addition of valgus stress, mean laxity was 4.7 mm (CI, 3.5-6.0). When the transverse band was cut, ulnohumeral laxity increased to a mean of 5.5 mm (CI, 4.0-7.0). With release of the posterior band, mean laxity was 6.4 mm (CI, 4.3-8.5). When the anterior bundle of the anterior band of the UCL was cut, mean ulnohumeral laxity was 8.4 mm (CI, 5.7-11.0) and when the entire anterior band was released, mean laxity was 10.9 mm (CI, 7.8-14.0). Complete release of the flexor pronator muscle mass resulted in mean ulnohumeral laxity of 15.5 mm (CI, 12.9-18.1). The largest deltas were observed with release of the anterior bundle of the anterior band (2.0 mm; CI, 1.0-3.0), the entire anterior band (2.6 mm; CI, 1.3-3.8), and flexor pronator mass (4.6 mm; CI, 1.3-3.8). Release of the transverse and posterior bands of the UCL resulted in deltas of 0.74 mm (CI, 0.1-1.3) and 0.9 mm (CI, 0.3-1.5) respectively.

**Conclusion:** DUS allows for rapid, cost-effective, non-invasive, non-radiating evaluation of the elbow joint and UCL both at rest and with applied valgus stress. Previous studies have indicated that DUS can identify abnormalities of the UCL associated with chronic degeneration and ligamentous injury including thickening of the anterior band of the UCL as well as hypoechoic foci/calcifications. The results of the current cadaveric study suggest that different changes in clinical laxity are seen on DUS with injury of particular bands of the UCL. Early identification and localization of injury to a particular band of the UCL may allow more appropriate selection of patients who will benefit from operative treatment.

**Paper 17**

Glenohumeral Passive Range Of Motion And The Correlation To Elbow Injuries In Professional Baseball Pitchers

**Kevin E. Wilk, PT, DPT**, Leonard Macrina¹, Glenn S. Fleisig, PhD², Kyle Aune, MPH², Ron Porterfield³, Paul Harker⁴, James R. Andrews, MD⁵.

¹Champion Sports Medicine, Birmingham, AL, ²American Sports Medicine Institute, Birmingham, AL, ³Tampa Bay Rays, St. Petersburg, FL, ⁴Tampa Bay Rays, ⁵The Andrews Institute, Gulf Breeze, FL

**Objectives:** The purpose of this study was to determine whether GIRD and/or bilateral difference in total rotational motion (TRM) of the glenohumeral joint (external rotation + internal rotation) correlated with elbow injuries in professional baseball pitchers.

**Methods:** This study was conducted over eight competitive seasons (2005-2012). Each year during spring training, the same examiners assessed passive range of motion (PROM) of both the dominant and non-dominant shoulders of professional pitchers using a bubble goniometer. In total, 505 examinations were conducted on 296 pitchers. Glenohumeral joint motion was assessed in supine with the arm at 90 degrees of abduction and in the plane of the scapula for ER and IR. During ER and IR ROM assessment, the scapula was stabilized per methods previously established. Elbow injuries and days missed due to injury were assessed and recorded by the medical staff of the team.

**Results:** Significant differences were noted during side-to-side comparisons (p<0.0001) within subjects. Amongst this cohort, there were 50 shoulder injuries in 38 players accounting for a total of 2294 days
missed. GIRD did not correlate to elbow injuries (p= 0.5507). Pitchers with a deficit of more than 5 degrees in TRM between shoulders had a 2.3x higher risk of injury (p = 0.0214).

**Conclusion:** Based on these results, pitchers with bilateral differences in total rotational motion had a significant impact on the risk of elbow injuries. This information can help guide the clinician during the evaluation and progression of the professional baseball pitcher.

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**Paper 18**

The Accurate Diagnosis of Biceps-Labral Complex Lesions with MRI and “3-Pack” Physical Examination: A Retrospective Analysis with Prospective Validation

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**Objectives:** Effective treatment of Biceps-Labral (B-L) Complex lesions is predicated upon accurate diagnosis. Diagnostic algorithms include both physical examination and MRI. We sought to evaluate the contribution of MRI and physical examination to the accurate diagnosis of B-L Complex lesions.

**Methods:** A retrospective review of 273 surgical cases of lesions of the B-L Complex was performed comparing the preoperative documented clinical "Three Pack" examination to the preoperative Radiologist’s MRI reading in accurately predicting lesions of the B-L Complex seen at the time of surgery, and as documented by intraoperative photos and videos. After the completion of this retrospective review, an additional 145 patients(116 symptomatic, 29 matched controls) were enrolled in a prospective validation study of the "Three Pack" examination. All patients were examined independently and separately by three examiners without contamination: the senior surgeon, the sports medicine fellow, and the senior surgeon’s PA. Results were adjusted for order of examination. All B-L Complex Lesions were documented at surgery by digital photos and or video.

**Results:** In the retrospective review, the MRI accurately described the labral tears found at surgery in only 45% of the cases. Of the documented biceps lesions, only 28% of the time was the biceps read on MRI as abnormal. When the preop ACT was positive, a positive"arthroscopic"ACT (where the biceps incarcerates between the humeral head and glenoid) or labral tear was noted in 88% of the cases. There were no cases where the preop ACT was negative and the "arthroscopic" ACT was positive. However, when the "arthroscopic"ACT was positive, 46% of the time there was no tear of the labrum. The average age of the patients with a positive "arthroscopic" ACT was 34 yo. In the subsequent prospective validation of the "Three Pack", The interobserver reliability for the "three pack" evaluation was quite strong with Kappa values between .700 to .850 for all tests, indicating substantial (.61-.80) to almost perfect (.81-1.00) agreement categories. This was in contrast to other “traditional” tests performed (Speed’s, Yergason’s, full and empty can tests), where only moderate agreement at best (.41-.60) was noted. Tenderness to BGP had a high sensitivity and specificity of .978 and .703 respectively for groove
lesions; a positive throwing test had a moderate sensitivity of .694 and higher specificity of .745; the ACT (O'Brien Sign) had a very high sensitivity for labral tears and biceps incarceration, .897 and .914 respectively, with moderate specificities of .562 and .602 respectively. Seventy percent of patients had more than 1 site of pain and pathology confirmed at surgery. 88% of patients had a positive ACT in the symptomatic shoulder vs 11% in the unaffected shoulder (and 18% of controls) for a p value<.001; 87% of patients had a positive BGP test versus 18% in the unaffected shoulder (and 11% of controls) for a p value of <.001 as well. Seventy six percent of unaffected shoulders had all three tests negative.

**Conclusion:** The "Three Pack" Examination is a highly reliable approach for evaluating painful lesions of the B-L Complex, with strong interobserver reliability. This more comprehensive approach to the B-L complex is also important as many patients have more than one site of pain and pathology. A positive Active Compression Test appears to be a normal finding as well, seen in 18% of patients who have never had shoulder pain, and had never felt that pain before.

**Paper 19**

**Biomechanical Risk Factors for Lower Extremity Stress Fracture**

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**Objectives:** Stress fracture injuries disproportionately affect athletes and military service members and little is known about the modifiable biomechanical risk factors associated with these injuries. The purpose of this study was to prospectively examine the association between neuromuscular and biomechanical factors upon entry to military service and the subsequent incidence of lower-extremity stress fracture injury during four years of follow-up.

**Methods:** We analyzed data from the JUMP-ACL cohort, an existing prospective cohort study of military cadets. JUMP-ACL conducted detailed motion analysis during a jump landing task at the initiation of each subject’s military career. We limited our analyses to the class years 2009-2013 (i.e., subjects who completed baseline testing in 2005-2008). There were 1895 subjects available for analysis. Fifty-two subjects reported a history of stress fracture at baseline and were excluded from further analysis leaving 1843 subjects. Incident lower extremity-stress fracture cases were identified through the Defense Medical Surveillance System and the Cadet Injury and Illness Tracking System during the follow-up period. The electronic medical records of each potential incident case were reviewed and each case was confirmed by an adjudication committee consisting of two sports medicine fellowship trained orthopaedic surgeons. The primary outcome of interest was the incidence rate of lower-extremity stress fracture during the follow-up period. The association between incident stress fracture and sagittal,
frONTAL, and transverse plane hip and knee kinematics during the jump-landing task were examined at initial contact (IC), 15%(T15), 50%(T50), 85%(T85) and 100%(T100) of stance phase. Descriptive plots of all biomechanical variables along with 95% confidence intervals (CI) were generated during the stance phase of the jump landing task. Univariate and multivariable Poisson regression models were used to estimate the association between baseline biomechanical factors and the incidence rate of lower-extremity stress fracture during follow-up.

**Results:** Overall, 94 (5.1%, 95%CI: 4.14, 6.21) subjects sustained an incident stress fracture during the follow-up period. The incidence rate for stress fracture injuries among females was nearly three times greater when compared to males (IRR=2.86, 95%CI: 1.88, 4.34, p<0.001). Compared to those with greater than 5° of knee valgus, subjects with neutral or varus knee alignment experienced incidence rates for stress fracture that were 43%-53% lower at IC (IRR=0.57, 95%CI: 0.29, 1.11, p=0.10), T50 (IRR=0.47, 95%CI=0.23, 1.00, p=0.05), and T85 (IRR=0.53, 95%CI: 0.29, 0.98, p=0.04). Subjects with greater than 5° of internal knee rotation exhibited rates for stress fracture that were 2-4 times higher at T15 (IRR=2.31, 95%CI: 1.01, 5.27, p=0.05), T50 (IRR=3.98, 95%CI: 0.99, 16.00, p=0.05), and T85 (IRR=2.31, 95%CI: 0.86, 6.23, p=0.10), when compared to those with neutral or external knee rotation alignment.

**Conclusion:** Several potentially modifiable biomechanical factors at the time of entry into military service appear to be associated with the subsequent rate of stress fracture. It is possible that injury prevention programs targeted to address these biomechanical movement patterns may reduce the risk of stress fracture injury in athletes and military service members.

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**Paper 20**

The Elite Football Players with a Fifth Metatarsal Fracture

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**Objectives:** Fractures of the proximal fifth metatarsal can be a difficult clinical problem, especially in the athlete who wishes to return to competition. Clinical and radiographic evaluation cannot always be relied upon to assess complete healing. Refracture, after operative and nonoperative treatment, of a fifth metatarsal is a known phenomenon. The purpose of the study was to characterize and describe the prevalence of fifth metatarsal fractures in athletes at the NFL Scouting Combine and test the hypothesis that radiographic healing and symptom free return to play in college predict length of career and risk of re-injury.

**Methods:** A retrospective review was performed of the database of players presenting to the annual NFL National Invitational Camp from 2005 to 2010 to identify athletes in whom fifth metatarsal fractures occurred. Each of these players underwent anteroposterior (AP), oblique, and lateral foot radiographs that were analyzed for indicators of hindfoot malalignment in addition to the presence or absence of a residual fracture gap. The date of the injury, the date of surgery (if applicable), and the number of
games missed after the injury were also obtained from history. An internet search and NFL.com was used to determine the effect of their prior fifth metatarsal injury on the player’s career (games played, career length, and re-injury).

Results: 87 feet (81 players; 4.4% of all players) were identified. 52.9% of these injuries occurred in the left foot. Among all NFL Scouting Combine participants, fifth metatarsal fractures most commonly occurred in offensive linemen (20.7%), wide out receivers (20.7%), defensive linemen (17.2%), and defensive backs (11.5%). 78.2% of players were treated with an intramedullary screw. A persistent fracture gap was noted in 18.4% of players. 17.2% of players had a re-injury during their career. No radiographic measurements differed between players that had a residual fracture gap or re-injury.

Players that played at least one full collegiate season after injury were less likely to have re-injury during professional play (5.6% vs. 46.7%; p < 0.001) or a residual fracture gap (9.7% vs. 60%; p < 0.001). Players without a residual gap were also less likely to have a re-injury (7% vs. 37.5%; p < 0.001). Players treated with surgery were less likely to have re-injury (10.3% vs. 21.1%) but more likely to have gap formation (20.6% vs. 10.5%).

Conclusion: Players who are able to complete at least one full year of collegiate football after a fifth metatarsal fracture are less likely to have re-injury or a residual fracture gap. No radiographic measurements are predictive of re-injury or residual fracture gap.

Paper 21

Treatment Of Chronic Lateral Ankle Instability With ATLF And CFL Fibular Advancement: Surgical Technique And Clinical Outcome

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Objectives: To report the 2 to 5 year outcome of ATFL and CFL fibular advancement for the treatment of lateral ligament instability of the ankle.

Methods: Fifty-five patients presenting with chronic lateral ankle instability who had failed non-operative management (bracing, taping, physiotherapy) underwent a lateral ligament fibular advancement between 2005 and 2008. In each case the ATLF and CFL were released from the fibula and advanced using two double loaded metallic suture anchors (3.5mm). The senior author DJOH performed all the cases. Patients were allowed to full weight bear in a walking boot for 6 weeks after surgery. Patients were assessed pre-operatively and post-operatively using the Foot and Ankle Outcome Score (FAOS). Data were prospectively collected and retrospectively reviewed by an independent author.

Results: Six patients (11%) were lost at follow-up, leaving a study group of 49 patients (23 male and 26 female). The mean patient age at the time of surgery was 25 years old (range, 18-37 years old), with a mean duration of symptoms of 1.8 years (range, 6 months - 5 years). The mean follow-up was 42
months (range, 24 - 60 months). Significant improvement was seen in the FAOS score from a mean value of 36 pre-op to 75.4 post-op (p<0.001). Pain subscale improved from 35 to 75 (p<0.001); symptoms from 29 to 77 (p=0.01); function from 45 to 77 (p<0.001); function in sports and recreation from 38 to 70 (p<0.001); foot and ankle related quality of life from 35 to 78 (p<0.001). The failure rate was 6%, with three patients complaining of residual instability secondary to re-tear. Two cases of superficial infections were seen. One patient complained of temporary nerve irritation and numbness.

Conclusion: This study demonstrates that ATFL and CFL advancement with suture anchor fixation and early, protected weight bearing is an effective procedure for the treatment of chronic lateral ankle instability.

Paper 22

Diclofenac Sodium Topical Gel (DSG) 1% Reduces Swelling and Tenderness and Improves Ankle Joint Function in Subjects with Acute Ankle Sprain: a Randomized, Double-Blind, Placebo-Controlled Trial

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Objectives: Ankle sprains are among the most common sports-related injuries and are often self-treated. Over-the-counter treatment options known to reduce pain and inflammation, such as oral non-steroidal anti-inflammatory drugs (NSAIDs), may be associated with systemic side effects (e.g. gastrointestinal), while topically applied rubefacients are frequently ineffective, despite their popularity. DSG 1%, which has been clinically proven to be effective and well-tolerated for the treatment of osteoarthritis, could be a new option for the treatment of acute injuries, such as ankle sprains. This study evaluated the efficacy and safety of DSG 1% applied q.i.d in subjects with acute ankle sprain.

Methods: In a double-blind, multicenter study, 205 subjects with acute sprain of the lateral ankle (Grade I-II) were randomized in a 1:1 ratio to DSG 1% (n=102) or placebo (n=103) applied q.i.d for 7 days. The primary efficacy outcome was pain-on-movement (POM) at 72 hours, assessed on a 100 mm visual analog scale (VAS). Secondary efficacy outcomes included ankle swelling assessed by circumference measurement compared with the non-affected ankle, tenderness measured by pressure algometry compared with the non-affected ankle, and ankle joint function assessed by the Karlsson scoring scale. Efficacy assessments were conducted at clinic visits at 12, 24, and 72 hours after treatment initiation. All adverse events were recorded and blood samples were collected for laboratory safety analysis.

Results: DSG 1% treatment resulted in a significant decrease of POM mean scores when compared with placebo (57 mm vs. 21 mm respectively; p<0.0001). DSG 1% treatment also resulted in significantly greater reductions in ankle swelling than placebo. The difference in circumference between the injured and non-affected ankles for subjects treated with DSG 1% vs. placebo was 1.9 cm vs. 2.4 cm at 12 hours, 1.4 cm vs. 2.0 cm at 24 hours, 0.8 cm vs. 1.5 cm at 72 hours, and 0.2 cm vs. 0.8 cm at 7 days (p<0.0001 at all time points). In subjects treated with DSG 1%, the mean difference in tenderness between the
injured and non-affected ankles decreased more rapidly than in subjects in the placebo group at 12 hours (-24.7 N/cm² vs. -28.5 N/cm²), 24 hours (-17.8 N/cm² vs. -25.3 N/cm²), 72 hours (-9.7 N/cm² vs. -19.8 N/cm²), and 7 days (-2.6 N/cm² vs. -12.1 N/cm²) ($p<0.0001$ at all time points). In subjects treated with DSG 1%, the mean total ankle joint function score was 24.5 at baseline vs. 25.3 for the placebo group. At 72 hours and Day 7, mean ankle joint function scores were 56.3 and 79.7, respectively, for the DSG 1% group vs. 35.6 and 47.0, respectively, for the placebo group. The differences between treatment groups were significant at all time points ($p<0.0001$). The safety profile of DSG 1% was similar to that of placebo.

**Conclusion:** DSG 1% applied 4 times daily was significantly superior to placebo in reducing pain, swelling and tenderness and improving ankle joint function in subjects with acute ankle sprain. Overall, DSG 1% was well tolerated both systemically and locally.

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**Paper 23**

Corticosteroid Injections Hasten Return to Play of National Football League Players Following Stable Ankle Syndesmosis Sprains

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**Objectives:** Injuries to the ankle syndesmosis are common in contact athletes and may result in significant time lost from sport. Syndesmosis sprains require more treatment and time off for recovery as compared to lateral ankle sprains. A previous study of collegiate football players described an average of 31 days lost from these injuries treated with standard conservative measures and rehabilitation protocols. Treatment methods for stable syndesmosis sprains are not well documented in the literature. The purpose of this study was to compare our series of stable ankle syndesmosis sprains treated with or without corticosteroid injections.

**Methods:** A retrospective review of ankle syndesmosis sprains from two National Football League (NFL) teams over an eight-year period (2003-2011) was performed. All players were evaluated with standard radiographs as well as magnetic resonance imaging (MRI) to confirm their diagnosis. All players were subsequently treated with (Group 1) or without (Group 2) a corticosteroid injection into the syndesmosis within 72 hours of injury and progressed through a nonoperative rehabilitation program based on the treatment practices of the team. Time lost was calculated as total days from date of onset before returning to unrestricted activity including practice and games.

**Results:** A total of 31 stable ankle syndesmosis sprains were identified. All injuries confirmed with MRI were reviewed. Thirteen players received a corticosteroid injection (Group 1) within the syndesmosis
and had an average return of 15 days (5-26). Eighteen players did not receive a corticosteroid injection (Group 2) within the syndesmosis and had an average return of 25 days (1-43). This difference in return was statistically significant (p=0.0097). All players in both groups returned to play. There was one recurrence in Group 1 and two recurrences in Group 2.

**Conclusion:** Ankle syndesmosis sprains are debilitating injuries for NFL players and result in significant time lost from sport. Compared to our control group, the use of corticosteroid injection coupled with standard rehabilitation for acute stable ankle syndesmosis sprains hastened return to play by an average of 40% (10 days). In a highly competitive athlete, this may represent a significant clinical difference.

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**Paper 24**

The Demographics And Epidemiology Of Osteochondritis Dissecans Of The Ankle, Elbow, Foot, And Shoulder In Children

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**Objectives:** To assess the demographics and epidemiology of osteochondritis dissecans (OCD) of the ankle, elbow, foot, and shoulder in patients age 2-19.

**Methods:** A retrospective chart review was done on OCD between 2007 and 2011. Inclusion criteria included OCD of the ankle, elbow, foot, or shoulder, and patients aged 2-19. Exclusion criteria included the co-existence of any other intra-articular lesions. Joint involvement, laterality, and all patient demographics were recorded. The incidence of OCD in 2010 was determined for the ankle, elbow, and foot.

**Results:** 125 patients with a total of 128 OCD lesions fit the inclusion criteria. 60.2% of lesions were right sided and 39.8% left sided. Males had 53.9% and females 46.1% of all lesions. Lesions of the ankle, elbow, foot, and shoulder represented 66.4%, 31.3%, 0.8%, and 1.6% of all joints, respectively. No OCD lesions were found in the 2-5 year-olds. The incidence of ankle OCD for patients aged 6-19 was 4.7 per 100,000 for all patients, and 3.5, and 6.0 per 100,000 for males and females, respectively. The incidence of elbow OCD was 2.2 per 100,000 for all patients, and 3.8 and 0.6 per 100,000 for males and females, respectively. The incidence of OCD in the foot was 0.15 per 100,000 for all patients. The male/female ratio for elbow OCD was 6.4/1, and 1/1.6 for ankle OCD.

In the ankle joint, the vast majority involved the medial talus (71.8%), with most of the rest involving the lateral talus (22.4%). Females had 28.8% of lesions in the lateral talus while males had only 12.1%. Almost all elbow lesions (97.5%) involved the capitellum. In the shoulder, both lesions involved the glenoid, and in the foot, the single lesion involved the metatarsal head.

**Conclusion:** In this population-based cohort study of pediatric OCD in nearly 1 million children, males had a greater incidence of OCD and most were right sided. Females had nearly twice the incidence of ankle OCD, while males had over 6 times the incidence of elbow OCD. To our knowledge, this is the
largest epidemiologic/demographic study of pediatric OCD of the ankle, elbow, foot, and shoulder reported.

Paper 25

Physeal-Specific MRI Analysis of Growth Plate Disturbance Following All-Inside Anterior Cruciate Ligament Reconstruction in Skeletally Immature Patients: Does a Physeal-Sparing Technique Offer any Advantage?

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Objectives: The decision to perform anterior cruciate ligament (ACL) reconstruction in skeletally immature patients carries a risk of growth disturbance due to iatrogenic physeal injury. Multiple physeal-sparing techniques have been described but none, to our knowledge combine the benefits of an anatomic reconstruction and socket fixation, without violation of either the femoral or tibial physis at any stage of the procedure. The purpose of this study was to compare the incidence and calculate the area of post-operative physeal disturbances, using a physeal-sensitive magnetic resonance imaging (MRI) sequence*, between all-epiphyseal (AE) and partial transphyseal (PTP) ACL reconstructions in a cohort of skeletally-immature patients.

Methods: Twenty-one skeletally immature patients with a mean chronologic age of 12.7 years (range 10 to 16) undergoing all-inside ACL reconstruction were prospectively followed. Fourteen patients had an all-epiphyseal (AE) ACL reconstruction and 7 patients had a partial transphyseal (PTP) ACL reconstruction, which spared the femoral physis but crossed the tibial physis. Hamstring autograft was used in all cases. At a mean of 11.6 months follow-up, all patients were assessed for focal physeal disturbance and graft survival using a three-dimensional (3D) fat suppressed spoiled gradient-recalled echo (SPGR) MRI sequence. Angular deformity and leg length discrepancy were evaluated on full-length standing radiographs. The International Knee Documentation Committee (IKDC) subjective score and Lysholm knee score were also documented.

Results: The tibial physis was violated in 13/14 patients in the AE group and all patients in the PTP group. The mean area of post-operative tibial physeal disturbance (± SD) was 42.4 ± 38.6 mm² (mean 1.7% of total physeal area) in the AE group compared to 216.7 ± 129.1 mm² (mean 7.3% of total physeal area) in the PTP group (p = 0.003). The femoral physis was violated in one case in both groups resulting in a mean physeal disturbance of 1.5% of the total distal femoral physeal area. No cases of fracture, articular surface violation or avascular necrosis were noted on MRI in either group. Short-term graft survival was 100% amongst the entire cohort. There were no cases of angular deformity in either group with a mean side-side difference in the lateral distal femoral angle of 1.11° ± 1.02° in the AE group and 0.72° ± 0.65° in the PTP group (p = 0.23). No significant leg-length discrepancies were measured in either group. The mean IKDC and Lysholm scores (± SD) were 93.3 ± 5.9 and 97.8 ± 3.8 respectively in the AE
group and $87.7 \pm 3.5$ and $96 \pm 5.2$ respectively in the PTP group.

**Conclusion:** All-epiphyseal ACL reconstruction caused significantly less focal physeal disturbance than PTP ACL reconstruction, as determined by a 3D physeal-sensitive MRI sequence. Neither technique however resulted in angular deformity or leg-length discrepancy at early follow-up. Both all-inside ACL reconstruction techniques used in this study are safe and effective at early follow-up in skeletally immature patients. Further longitudinal study of this cohort is required to determine any potential advantages of a purely physeal-sparing technique.


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**A. Sagittal MRI Scan using SPGR sequencing of an AE ACLR, B. Physeal model of tibial physis from MRI (A) showing a 1.8% physeal area disruption., C. Sagittal MRI Scan of a PTP ACLR, D. Physeal model of tibial physis from MRI (C) showing a 4.1% physeal area disruption.**

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Paper 26

Micheli ACL Reconstruction in Prepubescent Youths: A Retrospective Outcomes Study

S. Clifton Willimon, MD¹, Christopher Robert Jones, MD², Keith May, DPT³, Mackenzie Herzog, BA³, Melissa Leake, ATC³, Michael T. Busch, MD⁴.
Objectives: Management of anterior cruciate ligament (ACL) tears in the skeletally immature patient remains controversial. In patients with significant growth remaining, physeal injury from conventional surgical reconstruction risks creating a limb length inequality or angular deformity; however, continued instability poses significant long-term morbidity from subsequent chondral and meniscal injuries. Done with appropriate precautions, transphyseal reconstructions are reasonably safe in older adolescents; however, little evidence of safety in the prepubescent athlete exists. Micheli has described a physeal sparing technique using the iliotibial band for a combined intra-articular and extra-articular ACL reconstruction. The purpose of this study is to analyze another surgeon’s experience with this procedure.

Methods: This study was IRB approved. Between 2005 and 2011, all patients who underwent Micheli ACL reconstruction, performed by a single surgeon, were identified. Three or more years of growth remaining was a prerequisite for Micheli reconstruction. Patients were excluded if postoperative follow-up was less than one year. Patients with associated knee injuries and/or concomitant knee procedures were not excluded. Functional outcome, graft survival, radiographic outcome, growth disturbance and additional procedures were evaluated.

Results: Twenty-one patients (22 knees) met the inclusion criteria for this study. Mean chronological age at time of surgery of 11.8 years (range: 9.9-14.3 years). All patients were male with a minimum of three years of growth remaining. There were four concomitant meniscal repairs and five concomitant partial meniscectomies performed at the index procedure. Of the included patients, 19 patients (20 knees)(90%) completed follow-up at mean postoperative duration of 3.1 years (range: 1.0-6.9 years). Two knees (9%) underwent revision ACL reconstruction for graft failure at 2.8 and 4.0 years postoperatively. Of the remaining 18 knees, the median patient satisfaction was 10 (range: 9 to 10). Mean pedi-IKDC knee score was 96.3± 2.9 points. Mean Lysholm score was 94.7 ± 6.2 points. Mean pre-injury Tegner activity level was 8 (range: 6-10) and mean postoperative Tegner activity level was 8 (range: 6-10). All patients had a normal Lachman examination with firm endpoint and a normal pivot-shift examination. At time of follow-up, 50% of patients had closed physes. There were no radiographic angular deformities or leg length discrepancies appreciated. Four of 18 knees (22%) underwent subsequent procedures including 1 graft shrinkage, 2 partial meniscectomies and 1 meniscal repair.

Conclusion: At mean follow-up of 3.1 years, our findings confirm excellent functional outcomes, a low revision rate and no growth disturbances associated with the Micheli ACL reconstruction. Patients are able to return to the preoperative activity level following reconstruction. This procedure offers a safe and effective alternative to trans-physeal reconstruction in prepubescent children with several years of growth ahead.
The Association of the Type of Football Helmet and Mouth Guard With the Incidence of Sport Related Concussion in High School Football Players.

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Objectives: Approximately 40,000 Sport Related Concussions (SRC) occur annually in high school football in the US. Football helmet and mouth guard manufacturers cite laboratory research to claim that their models will absorb and lessen impact forces associated with SRC greater than their competitors’ models. Therefore, players who utilize their equipment may reduce the likelihood they will sustain a SRC. However, there are limited prospective data detailing how specific types of football helmets and mouth guards affect the incidence and severity of SRC in players actually participating in high school football. The objective of this study is to determine which types of football helmets and mouth guards are associated with the incidence and severity of SRC in high school football players.

Methods: This prospective study collected data at 36 public and private high schools in Wisconsin during the 2012 high school football season. A convenience sample of N = 1,332 football players (grades 9 - 12, age: 15.9 ± 1.8 yrs) enrolled in the study. During the pre-season, subjects completed a demographic questionnaire. Athletic Trainers (ATCs) at each high school recorded the incidence and severity (days lost) of SRC throughout the season. Chi-square tests were used to compare the incidence of SRC in players with their non-injured peers. SRC severity (median days lost, IQR) was analyzed by the Kruskal-Wallis test. Relative risks [RR, 95% CI] were calculated for variables with significant tests (p < .05).

Results: Two hundred fifty-one (19%) reported at least one SRC within the last 6 years while 171 (13%) reported SRC within the previous 12 months. The helmets worn by the players were manufactured by Riddell (52%), Schutt (35%) and Xenith (13%) and were purchased in 2011-2012 (39%), 2009-2010 (33%), 2002-2008 (28%). Mouth guards worn by players included generic models provided by the school (61%) and specialized mouth guards (39%) custom fitted by a dental professional or specifically marketed to reduce the risk of SRC. A total of 115 (8.6%) players sustained 116 SRCs. There was no difference in the rate of SRC [%, 95% CI] by the type of helmet worn [p = 0.454], (Riddell {9.5, 7.4 - 12.0}, Schutt {8.1, 5.9 - 11.1} and Xenith {6.7, 3.7 - 11.8}), as well as the year the helmet was purchased [p = 0.745], (2011-2012 {9.3, 7.0 -12.3}, 2009-2010 {7.9, 5.7 -11.0} and 2002-2008 {8.8, 6.2 -12.3}. The severity (days lost) of SRC was not different (p = 0.883) for players wearing Riddell (13.5: 8.8, 19.0), Schutt (13.0: 10, 21.5) and Xenith (13.5: 10.8, 21.3) helmets. The SRC rate for players who wore a specialized or custom-fitted mouth guard (12.5, 9.8 - 15.8) was higher [RR = 1.9, 1.36 - 2.70], than for players who wore a generic mouth guard provided by their school (6.4, 4.8, 8.3), [p <.001].

Conclusion: Contrary to equipment manufacturers’ claims, lower risks of sustaining a SRC or the severity of a SRC were not associated with a specific helmet brand. In addition, the rates of SRC were similar for players wearing newer helmets as compared to players wearing older helmets. Notably, players who wore a generic mouth guard provided by the school had a lower rate of SRC compared to players who wore more expensive mouth guards marketed to reduce the incidence of SRC. Sports medicine providers need to carefully assess equipment manufacturer’s claims that their products will reduce the likelihood of high school football players sustaining a SRC.
Baseline Neurocognitive Test Results In Non-concussed Athletes: Does Sleep Matter?

D. Jake McClure, BS1, Scott L. Zuckerman, MD2, Scott J. Kutscher3, Andrew Gregory, MD4, Gary S. Solomon, MD4.

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Objectives: When managing sport-related concussions (SRC), sports medicine physicians utilize serial neurocognitive assessments and self-reported symptom inventories when evaluating athlete recovery and safety for returning to play (RTP). Since post-concussive RTP goals include symptom resolution and return to neurocognitive baseline, clinical decisions rest on an understanding of modifiers of baseline performance. Several studies have reported the influence of age, gender and sport on baseline neurocognitive performance, but few have assessed the potential effect of sleep. We hypothesized that: 1) athletes receiving less sleep prior to baseline testing would perform worse on neurocognitive metrics; and 2) decreased sleep would have no association with the quantity of reported symptoms.

Methods: We retrospectively reviewed 3,704 non-concussed athletes, 2,385 male, 3,321 high school and 383 college-aged, with baseline symptom and neurocognitive scores on Immediate Post-concussion Assessment and Cognitive Testing (ImPACT). Subjects were stratified into three groups based on self-reported sleep duration the night prior to testing; 1) short < 7 hrs, 2) intermediate 7−9 hrs; and 3) long ≥ 9 hrs). Multivariate analysis assessed the influence of categorical sleep duration on the baseline number of reported symptoms and ImPACT performance, with alpha level of 0.05.

Results: When controlling for age, gender and sport as covariates, the multivariate analysis of covariances showed a significant association between shorter sleep duration and poorer verbal memory scores (p=0.019), visual memory scores (p=0.035), and reaction time scores (p=0.044), but not for visual-motor scores. Significance was found between shorter sleep duration and increased number of reported symptoms (P < 0.0001). Subsequent pairwise comparisons revealed these associations to be most significant when specifically comparing the short and intermediate sleep groups.

Conclusion: Our results indicate that athletes sleeping less than 7 hours prior to testing perform worse on 3 out of 4 neurocognitive ImPACT scores and endorse more symptoms. Because concussion management and RTP decisions hinge on the comparison to a reliable baseline evaluation, sports medicine physicians should strongly consider amount of sleep prior to neurocognitive testing in the assessment of athletes’ recovery.
SUMMIT Prospective, Randomized, Controlled Trial: Response Rates To Matrix-induced Autologous Chondrocyte Implant (MACI) Versus Microfracture (MFX) By Lesion Characteristics

Daniel Saris, MD, PhD1, Andrew Price, MD2, Jon Olav Drogset, MD, PhD3, Ales Podškubka, MD4, Anika Tsuchida, MD1, Mauritz Bezuidenhoudt, MSc5, Sven Kili, MD5, David W. Levine, MD, MPH6, Mats Brittberg, MD, PhD7.

1University Medical Center Utrecht, Utrecht, Netherlands, 2NDORMS, University of Oxford, Oxford, United Kingdom, 3Department of Orthopaedics, Trondheim University Hospital, Trondheim, Norway, 41st Faculty of Medicine, Charles University in Prague, Bulovka Hospital, Dept of Orthopaedics, Prague, Czech Republic, 5Sanofi Europe (formerly Genzyme), Naarden, Netherlands, 6Sanofi Biosurgery (formerly Genzyme Biosurgery), Cambridge, MA, 7Region Halland Orthopaedics, Kungsbacka Hospital, Kungsbacka, Sweden.

Objectives: To compare the response rates of patients treated with the MACI implant with those treated with MFX for the repair of symptomatic articular cartilage defects of the knee, based on lesion characteristics, in the phase 3 SUMMIT (Superiority of Matrix-induced autologous chondrocyte implant versus Microfracture for Treatment of symptomatic articular cartilage defects) trial (sponsored by Sanofi/Genzyme Biosurgery).

Methods: Patients with ≥1 symptomatic focal articular cartilage defect of the femoral condyles (MFC/LFC) and/or trochlea and baseline Knee Injury and Osteoarthritis Outcome Score (KOOS) pain score ≤55 participated in this prospective, randomized, controlled trial (NCT00719576). The co-primary endpoint was improvement in KOOS pain and function (sports/recreational activities) at 2-year follow up. A patient was considered a responder if they had at least a 10-point improvement over baseline in KOOS pain and function scores. The Cochran-Mantel-Haenszel χ² (α=0.05) was used to analyze differences in response rates between groups by lesion size (>4 cm², >5 cm²), lesion location (MFC/LFC/trochlea), and osteochondritis dissecans (OCD) etiology (yes/no).

Results: Patients (N=144) had a mean age of 33.8 years and 51% were male. The mean lesion size was 4.8 cm², and most lesions were on the MFC (74%). The KOOS pain and function (sports/recreational activities) co-primary endpoint improvement was clinically and statistically significantly better in patients treated with the MACI implant versus MFX (P=0.001) at 2-year follow up. Significantly better improvements were also observed for KOOS activities of daily living (P<0.001), quality of life (P=0.029) and symptoms (P<0.001) with the MACI implant compared with MFX. Response rates for the overall and subgroup analyses are shown in the Table. The incidence of adverse events was similar between the treatment groups and no unexpected safety findings were reported. Based on the small patient numbers in the subgroups, further research on response predictors is warranted.
Conclusion:
Clinically and statistically significantly better results in KOOS pain and function co-primary scores were observed with the MACI implant versus MFX for treating cartilage defects of the knee 2 years following surgery. More patients responded with the MACI implant compared with MFX when their lesions were >4 cm², on the MFC, and not of OCD origin.

Paper 30
Magnetic Resonance Imaging and Clinical Evaluation of Chondral lesions treated with Allografts Juvenile Cells

Cecilia Pascual-Garrido, MD¹, Stephanie L. Gold, MS¹, Jaclyn Snikeris, BS¹, Alissa Burge, MD¹, Joseph Nguyen, MPH², Hollis G. Potter, MD³, Russell F. Warren, MD¹, Riley J. Williams, MD¹, Scott A. Rodeo, MD¹.
¹Hospital for Special Surgery, New York, NY, ²Hospital for Speical Surgery, New York, NY, ³Hospital for Special Surgery

Objective: The De Novo NT graft (°)(natural tissue) (Zimmer, Warsaw, IN) is a new technique that consists of a scaffold free allogeneic juvenile cartilage. The purpose of this study is to describe the first cases performed in our institution with De Novo NT (°) assessing both clinical outcomes and magnetic resonance imaging.

Methods: 17 patients with focal patella femoral cartilage lesions treated with De Novo NT (°) were prospectively followed. The mean age at the time of surgery was 30 years. Clinical assessment was performed with the International Knee Documentation Committee (IKDC), KOOS and MARX at baseline and most recent follow up. Magnetic resonance imaging, including T2 relaxation time maps and T1 rho in six patients, was used to evaluate the cartilage repair morphologic characteristics in 12 patients.

Results: Fifteen patients met the study criteria with a mean follow up of 12 months (±3). The mean
defect size was 217±100 mm. In 11 cases the lesion was in the patella, 3 in the trochlea and one in both patella and trochlea. Mean improvement in preoperative to postoperative score was significant for the IKDC objective score 45.8 (±28) to 73.3 (±24) (p=.009), IKDC pain score 49.1 (±20) to 69.8 (±23) (p=.003), KOOS 53.5 (±21) to 75.5 (±15) (p=.001), IKDC subjective 41.3 (±21.7) to 72.7 (±15) (p=.004). MRI demonstrated only two cases (16%) with graft hypertrophy. There was only one case with a detached graft. Mild and moderate subchondral edema was present in 90% (11 patients) of the cases. At the interface between the repaired tissue and the native cartilage, there were only two cases with a fissure of more than 2mm. Very good (66 to 100%) and good (between 33-66%) cartilage fill was present in 54% of the cases. Mild synovial reaction was present in 58% of the cases. From the 6 patients with T2 mapping, all repairs showed significantly different prolongation of quantitative T2 values in both the superficial and deep components of the repair tissue (47.18 for repair vs 28.3 for native (p=0.005) in the deep area and 58.6 for repair vs 37.4 for native in the superficial area (p=0.02). (Figure 1).

**Conclusion:** De Novo NT® appears to be an effective treatment for patello-femoral chondral lesions, with significant improvement in the short-term clinical follow up. The MRI indicated implant stability with peripheral integration in most cases. As the implanted cells are allogeneic, synovial reaction is a parameter that should be considered. Only 5 patients had moderate synovial reaction, which did not affect the graft. Quantitative T2 mapping showed stratification of T2 values suggesting maturation to hyaline cartilage.
Are Articular Cartilage Lesions and Meniscus Tears Predictive of IKDC, KOOS, and Marx Activity Level Outcomes after ACL Reconstruction? A 6-Year MOON Cohort Study

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**Objectives:** Identifying risk factors for inferior outcomes after ACL reconstruction (ACLR) is important for prognosis and future treatment. Study goal: analyze a sufficiently large enough cohort to evaluate whether articular cartilage and meniscal variables are predictive of three validated sports outcome instruments. We hypothesized that articular cartilage lesions and meniscus tears/treatment would be predictors of IKDC, KOOS (all 5 subscales), and Marx Activity Level at 6 years after ACLR.

**Methods:** From 2002-2004, 1411 ACLR subjects were prospectively enrolled and followed longitudinally with the IKDC, KOOS, and Marx completed at entry, 2 and 6 years. A logistic multivariable model consisted of patient demographics, surgical technique variables, and articular cartilage injuries and meniscal tears/treatment for determining predictors (risk factors) of IKDC, KOOS, and Marx at 6 years.

**Results:** We completed a minimum follow-up on 93% (1307/1411) of our cohort at 6 years. Baseline results: 56% male, median age 23 years, 75% with non-contact injury mechanism, articular cartilage pathology (MFC-25%, LFC-20%, MTP-6%, LTP-12%, patella-20%, and trochlear-9%), and meniscal pathology (medial-38%, lateral-46%).

Both articular cartilage lesions and meniscal tears significantly predicted 6 year outcomes on IKDC and KOOS (Table 1). Grade 3 or 4 articular cartilage lesions (excluding patella) significantly reduced IKDC and KOOS scores at 6 years. Figure 1 focuses on IKDC and demonstrates worse outcomes with chondral injuries on the MFC, MTP, and LFC. Likewise, KOOS was negatively affected by cartilage injury. The sole significant predictor of reduced Marx activity was the presence of a grade 4 lesion on the MFC. Lateral meniscus repairs did not correlate with inferior results, but medial meniscus repairs predicted worse IKDC and KOOS scores. Lateral meniscus tears left alone significantly improved prognosis. Small partial meniscectomies (<33%) on medial meniscus fared worse, but conversely, larger excisions on lateral meniscus (>50%) improved prognosis.

Analogous to previous studies, other significant predictors of worse outcome scores were lower baseline scores, higher BMI, lower education level, smoking, and revisions.

**Table 1. Significant Predictors of Each Outcome Scale at 6 Years (p values)**

<table>
<thead>
<tr>
<th>Structure</th>
<th>IKDC Symptoms</th>
<th>KOOS Pain</th>
<th>KOOS ADL</th>
<th>KOOS Spts/Rec</th>
<th>KOOS QOL</th>
<th>Marx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Medial 1</td>
<td>Medial 2</td>
<td>Medial 3</td>
<td>Lateral 1</td>
<td>Lateral 2</td>
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<tr>
<td>MENISCUS</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.004</td>
<td>0.025</td>
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</tr>
<tr>
<td>--Medial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>--Lateral</td>
<td>0.027</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
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<tr>
<td>ARTICULAR CARTILAGE</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>--MFC</td>
<td>0.012</td>
<td>0.017</td>
<td></td>
<td>0.002</td>
<td>0.05</td>
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</tr>
<tr>
<td>--LFC</td>
<td>0.002</td>
<td>0.029</td>
<td></td>
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<td></td>
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<tr>
<td>--MTP</td>
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<td>0.033</td>
<td>0.024</td>
<td>0.02</td>
<td>0.029</td>
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<tr>
<td>--LTP</td>
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<td>0.037</td>
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<tr>
<td>--Patella</td>
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<tr>
<td>--Trochlea</td>
<td>0.031</td>
<td>0.031</td>
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</tr>
</tbody>
</table>
Conclusion: Both articular cartilage injury and meniscal tears/treatment at the time of ACLR were significant predictors of both IKDC and KOOS scores at 6 year follow-up. Similarly, having a grade 4 MFC lesion significantly reduced a patient’s Marx activity level score at 6 years.
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demonstrates that while both the ACL and MCL resist knee valgus during landing, physiological magnitudes of the applied loads that lead to high ACL strain levels and injury were not sufficient to compromise MCL integrity. Further, these findings support multi-planar knee valgus collapse as a primary mechanism of non-contact ACL injury. This enhances our understanding of the non-contact ACL injury mechanism, and provides insight that can improve current risk screening and injury prevention strategies.

Figure 1: Relative ACL and MCL strain compare to the baseline (landing under no applied external loads) under different modes of loading (* p<0.003)

Paper 33

The Role of the Indirect Femoral Insertion of the Anterior Cruciate Ligament in Restraining Tibial Translation and Rotation: Implications for Anatomic Femoral Tunnel Placement.

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**Objectives:** Despite a trend toward lowering the femoral tunnel and thus positioning ACL grafts partially within the indirect insertion of the ACL attachment, the biomechanical role of the indirect insertion has not been described. The purpose of this study was to determine the effect of debridement of the indirect femoral ACL insertion on tibiofemoral translation and rotation. It was hypothesized that debridement would have a negligible affect on tibiofemoral kinematics.

**Methods:** Knee kinematics in six degrees of freedom were measured on a robotic device in nine cadaveric knees. Measurements were made with the ACL intact, following debridement of the indirect insertion, and following complete sectioning of the ACL. Three loading conditions were used: (1) a 134 N anterior tibial load, (2) a combined 10 Nm valgus and 5 Nm internal rotation torque, and (3) a simulated, robotic pivot shift. Debridement involved exposing 5-6 mm of bone from the central, inferior aspect of the direct ACL attachment to the inferior cartilage margin. Anterior tibial translation (ATT) was recorded in response to an anterior tibial load and combined rotatory loads at 0°, 15°, 30°, 45°, 60°, and 90° of knee flexion. Additionally, posterior tibial translation and external tibial rotation were recorded during a simulated, robotic pivot shift. Based on pilot data, it was estimated that 9 specimens would be required to detect a 1.4 mm difference in ATT between different experimental conditions with 80% power at an alpha level of 0.05. Data were analyzed using repeated measures ANOVA.

**Results:** For the anterior tibial loading condition, debridement of the indirect insertion increased tibial translation by 0.37±0.24 mm at 0° (P<.01) and by 0.16±0.19 mm at 15° (P<.05; increases were < 1 mm in all specimens). ACL deficiency increased ATT in response to an anterior tibial load (P<.0001) with maximum effect at 15° (11.26±1.15 mm vs. ACL intact; 11.04±1.08 mm vs. indirect insertion debridement). For the combined rotatory loading condition, debridement increased tibial translation by 0.17±0.11 mm at 0° (P<.01; increases were < 0.3 mm in all specimens) with no effect at other flexion angles. ACL deficiency increased ATT in response to a combined rotatory load (P<.01) with maximum effect at 15° (4.45±0.85 mm vs. ACL intact; 4.44±0.84 mm vs. indirect insertion debridement). The contribution of the indirect insertion to restraining ATT in response to an anterior tibial load or a combined rotatory load was ≤ 5.5% in all specimens, at all flexion angles. During the simulated pivot shift, posterior tibial translation (12.79±3.22 mm) and external tibial rotation (17.60±4.30°) were greater in the ACL deficient condition (P<.0001) compared with the ACL intact (1.29±1.34 mm and 1.54±1.61°) and indirect insertion debridement conditions (1.28±1.34 mm and 1.54±1.47°). Posterior translation and external tibial rotation were not significantly different between the ACL intact and debridement conditions (P=.68, P=.99).

**Conclusion:** Debridement of the indirect insertion resulted in a less than 1 mm increase in tibial translation and a less than 0.5° increase in tibial rotation in all specimens and testing conditions. Thus, the indirect femoral insertion of the ACL contributed minimally to restraint of tibial translation and rotation. These results support placement of the soft tissue aspect of a BPTB graft within the area of the direct insertion of the ACL and superior to the biomechanically insignificant indirect insertion.
Does Sex Matter? Analysis Of Results At 5 Years After Matrix-assisted Autologous Chondrocyte Transplantation In A Large Cohort Of Patients

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Objectives: The main purpose was to document and analyze the influence of sex on the clinical outcome in a large cohort of patients treated with a cartilage regenerative procedure for knee chondral lesions and prospectively followed at medium-term follow-up.

Methods: 250 knees have been treated with matrix-assisted autologous chondrocyte transplantation (MACT) and prospectively evaluated at 1, 2, and minimum 5-year follow-up. The patients were 182 men and 68 women affected by focal International Cartilage Repair Society (ICRS) grade III-IV chondral knee defects involving femoral condyles, trochleae and patellae. Two homogeneous groups of 56 patients each have been selected by a blinded independent statistician for a case-control comparative analysis. The clinical outcome was analysed using the Cartilage standard Evaluation Form as proposed by ICRS and the Tegner score.

Results: After the treatment, a statistically significant improvement in all the scores was observed in both groups. The IKDC subjective score showed better results for men at all follow-ups in the general population: 79.5±18.6 vs 64.3±20.2 for men and women respectively (p<0.0005) at 5 years; the same trend was confirmed by EQ-VAS and Tegner scores. The case control analysis with scores standardized according to the specific patient category didn’t confirm the sex related difference and did not show any statistically significant difference at all follow-ups between men and women. Etiology, lesion site and pre-injury activity level differ in women and men affected by cartilage lesions and are responsible for the difference in the final outcome of the general population.

Conclusion: Women have a different chondral lesion pattern; more frequently they present unfavorable conditions related to etiology, site and activity level; they also reach lower not normalized scores. However, a case-control analysis with normalized data for the specific patient's categories showed that on equal terms women have the same success possibilities than men after a surgical treatment for knee cartilage regeneration.

Joint Space Loss after Arthroscopic Partial Meniscectomy: Data from the Osteoarthritis Initiative

Alexander Rothy, MS1, Steven Cherney, MD2, Stephen D. Fening, PhD3, Jeffrey Duryea, PhD4, Carl S. Winalski, MD4, Morgan H. Jones, MD5, Anthony Miniaci, MD4.
Objectives: Knee osteoarthritis (OA) is a prevalent disease that causes substantial disability and use of medical resources, and knee arthroscopy is frequently performed in patients with OA or at risk of developing OA. While meniscectomy has been associated with progression of OA in multiple studies, none have assessed progression of joint space width (JSW) loss compared to matched controls. The Osteoarthritis Initiative (OAI) provides a unique cohort to enable this evaluation. We hypothesize that JSW significantly decreases in meniscectomy patients versus matched controls within a one-year period, and that joint space loss continues to be more rapid in subsequent years.

Methods: A prospective cohort study with matching was conducted using records from the OAI public use data sets. The cohort (n=4796) contains the incidence subcohort (normal radiographs with risk of developing OA) and the progression subcohort (radiographic evidence of OA). Subjects have fixed-flexion radiographs taken at yearly intervals and validated measurements of JSW are performed. Additional details about the OAI and study design are publicly accessible at http://oai.epi-ucsf.org/datarelease/About.asp. 141 meniscectomy knees were identified and 141 controls were randomly selected while matching for subcohort, gender, study site, age, knee side, and year. Paired t-test was used to evaluate change in JSW over the first year in the 141 matched pairs. Repeated measures MANOVA with adjustment for age, gender, race, and BMI was used to assess longitudinal changes in JSW in a subset of 33 matched pairs with 4 years of JSW measurements available.

Results: Meniscectomy and control groups were balanced with respect to age, gender, race, BMI, and baseline JSW. The JSW decrease over a 1-year period was 0.948 mm in meniscectomy knees and 0.137 mm in controls (p<0.0001). Table 1 shows similar results when stratifying by subcohort. In the crude and adjusted analyses of knees with 4 years of follow-up, the rate of JSW loss after the first year was not significantly different between meniscectomy knees and controls as shown in Figure 1.
Conclusion: Arthroscopic partial meniscectomy is associated with increased loss of JSW during the first year after surgery in knees with OA and knees at risk of developing OA; however, the rate of JSW loss is not accelerated over the next 3 years. Immediate JSW narrowing may occur due to loss of the interposed meniscus, due to morphologic changes such as flattening and extrusion, or due to rapid degeneration of articular cartilage in response to increased tibiofemoral contact stress. Significance among both subcohorts suggests that meniscectomy causes progression of osteoarthritis independent of disease stage. Future investigation of change in cartilage and meniscal volumes on MR imaging may further explain the cause of this joint space loss.
**Stephen Christopher Hamilton, MD**, Grant Whitby Bennett, MD, Curtis Anderson Bush, MD, Douglas J. Wyland, MD.

1Steadman Hawkins Clinic of the Carolinas Program, Greenville, SC, 2Conway Orthopaedic and Sports Medicine Clinic, Conway, AR, 3Orthopedic Specialty Associates, Fort Worth, TX, 4Steadman-Hawkins Clinic of the Carolinas, Spartanburg, SC

**Objectives:** High tibial osteotomies (HTO) are commonly performed to correct coronal malalignment in young, active patients who have concomitant cartilage lesions and/or cruciate ligament insufficiency. An unintended change of native tibial slope can negatively affect both the strain on reconstructed cruciate ligaments and the contact forces on cartilage. Therefore, one of the goals when performing an HTO is to minimize any change in posterior tibial slope. This study was designed to determine if there is a time zero difference in the maintenance of native tibial slope when performing valgus producing opening wedge HTOs using two distinct surgical techniques and fixation devices.

**Methods:** Controlled Laboratory Study

Experienced surgeons performed valgus producing opening wedge HTOs in 24 matched paired cadaveric specimens using free hand (FH, n=12) and biplanar cutting jig (Jig, n=12) techniques. Digital fluoroscopy was used to capture anteroposterior and lateral images in all specimens, and the angle of posterior tibial slope (TS) was measured using digital software (NIH image; Bethesda, MD) in a manner blinded for technique and fixation.

**Results:** There was good to excellent intra- and inter-observer reliability with the measurement technique using a Model 3,k, intra-class correlation coefficient (ICC). Both observers’ measurements passed tests for homogeneity (p=0.07, and p=0.12). There was no significant change in the maintenance of tibial slope between JIG and FH groups for observer 1 [JIG = 2.40° (SD = 1.3°) FH= 2.95° (SD=2.89°), p = 0.55] or observer 2 [JIG = 2.32° (SD = 2.5°) FH = 3.14° (SD=3.3°), p = 0.49].

**Conclusion:** When performing a valgus producing opening wedge HTO, neither the cutting jig nor the free hand technique maintained native posterior tibial slope. Both techniques increased posterior tibial slope by an average of 2-3° with no significant difference between the groups. This change in posterior tibial slope is consistent with previously reported values in the literature.

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**Locked Intramedullary Fixation Vs Anatomically Contoured Locked Plating Of Clavicle Shaft Fractures - A Prospective Randomised Controlled Trial**

**Reggie Paul King, MB,Ch.B.**

Tygerberg Academic Hospital, Cape Town, South Africa.
**Objectives:** The treatment of displaced clavicle shaft fractures has evolved due to complications experienced by conservatively treated patients. Numerous operative modalities are available with various positive and negative aspects associated with each technique. This prospective randomised controlled trial compares the outcome of patients treated operatively with a novel locked intramedullary device and patients treated by traditional anatomically contoured locked plating.

**Methods:** Patients with displaced and shortened clavicle shaft fractures were randomized according to presentation into 2 groups - intramedullary fixation and anatomically contoured locked plating. All patients were operated by the same surgeon with similar post-operative regimes for both groups. Outcomes accessed were DASH and Constant Shoulder scores at 6 weeks, 3 months and 6 months, scar size and quality, operative time, union rate and incidence of supraclavicular nerve injury at the time of surgery. Patients were assessed by the operative surgeon, a physiotherapist and an occupational therapist. Progression to union was assessed by a radiologist.

**Results:** 40 patients with 6 months follow-up were available for review - 20 in each group. No statistically significant difference in average DASH and Constant Shoulder scores at 6 weeks, 3 months and 6 months for the two groups were found. The surgical scars were smaller and the cosmetic result better in the intramedullary group. Operative time was significantly shorter in the intramedullary group. Both groups achieved a 100% union rate at 6 months post-op. The rate of supraclavicular nerve injury in the plating group was higher and most patients complained of prominent hardware.

**Conclusion:** Locked intramedullary fixation of clavicle shaft fractures using the Sonoma CrX system was found to be a reliable method of achieving fracture reduction and fracture union. Shoulder function was restored and union achieved with a good cosmetic result. Supraclavicular nerve injury is rare and a second operation to remove prominent hardware is not necessary. Patient outcomes were found to be similar to that achieved by anatomically contoured locked plating - the current accepted gold standard method of treatment.

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**Paper 38**

**Intra- And Inter- Observer Agreement In The Classification And Treatment Of Midshaft Clavicle Fractures**

**Grant L. Jones, MD**¹, Julie Bishop, MD², Brian Lewis, MD³, Angela Pedroza⁴, Shoulder Group MOON, MD⁵.

¹Ohio State Univ - Sports Medicine Ctr, Columbus, OH, ²The Ohio State University, Columbus, OH, ³Ohio State, Columbus, OH, ⁴Department of Orthopaedics - Div of Sports Medicine, Columbus, OH, ⁵Vanderbilt University, Nashville, TN

**Objectives:** The purpose of this study was to determine the intraobserver and interobserver reliability in the classification of midshaft clavicle fractures via standard plain radiographs and to determine the intraobserver and interobserver agreement in the treatment of these fractures.

**Methods:** Charts of patients seen by the two senior authors from 2006 to 2011 were reviewed to identify patients treated for clavicle fractures (CPT 23500 and 23515). AP and 30 degree cephalad
radiographs were selected, representing midshaft clavicle fractures treated both operatively and non-operatively. Thirty pairs of radiographs were included in the investigation. The radiographs were standardized for size to allow accurate measurements within a non-PACS program. A PDF file was created with all representative radiographs. Clinical scenarios were created for each set of radiographs, and the evaluators were asked to perform the following tasks: 1) measure the degree of shortening in millimeters; 2) determine the percent displacement; 3) determine whether the fracture was comminuted; and 4) state whether they would treat the fracture operatively or non-operatively. The radiographs and clinical scenario handout, along with instructions on how to use the measuring tool with Adobe Reader, were distributed to 16 shoulder/sports medicine fellowship-trained orthopaedic surgeons who completed the evaluations. The radiographs and scenarios were then reordered and redistributed approximately three months later.

**Results:** Intra and interobserver results are summarized in table 1. The following variables statistically predicted whether surgery was recommended (p< 0.001): 1) odds of surgery are 2.26 if comminution was noted holding displacement and the interaction between displacement and shortening constant, and 2) the odds of surgery are 3.37 if there is displacement > 100% compared to displacement 0-49% holding comminution and shortening constant.

Table 1. Intra and Interobserver reliability results

<table>
<thead>
<tr>
<th>Intraobserver reliability</th>
<th>Interobserver reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa (p&lt;0.001)</td>
<td>Kappa (p&lt;0.001)</td>
</tr>
<tr>
<td>Operative (Y/N)</td>
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<tr>
<td>Comminution (Y/N)</td>
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<td>Displacement (Y/N)</td>
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</tr>
<tr>
<td>50-100%</td>
<td>0.38</td>
</tr>
<tr>
<td>&gt;100%</td>
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</tr>
<tr>
<td>Shortening</td>
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</tr>
<tr>
<td>0-5mm</td>
<td>0.38</td>
</tr>
<tr>
<td>5.1-10mm</td>
<td>0.38</td>
</tr>
<tr>
<td>10.1-15mm</td>
<td>0.38</td>
</tr>
</tbody>
</table>
Conclusion: Our study demonstrated that there was moderate to strong interobserver and intraobserver agreement for both displacement and comminution when utilizing standard plain radiographs. However, there was only weak to no interobserver agreement and minimal intraobserver agreement on the amount of shortening. Also, there was minimal interobserver and only moderate intraobserver agreement on whether operative treatment should be selected, most likely due to the poor reliability of plain radiographs in determining the degree of shortening. Therefore, other modalities including comparison radiographs of the contralateral clavicle should be considered to more reliably measure the degree of shortening and help determine the need for surgery.

Paper 39

Trends In The Volume Of Operatively Treated Mid-shaft Clavicle Fractures In Children And Adolescents

Benton E. Heyworth, MD, Catherine A. Suppan, BA, Mininder S. Kocher, MD, MPH, Donald S. Bae, MD.

Boston Children's Hospital, Boston, MA

Objectives: Clavicle fractures are common in children and adolescents and are traditionally treated nonoperatively. With youth sports participation increasing in popularity, including contact sports, the frequency of such injuries may be increasing. The purpose of this study was to examine institutional trends in the volume of operative plate fixation for mid-shaft clavicle fractures in children and adolescents.

Methods: Medical records, identified through a departmental database and cross-referenced for accuracy against billing records using ICD-9 codes, were retrospectively reviewed to identify otherwise healthy 10-18 years-olds who presented with a clavicle shaft fracture between 1999-2011 at a single tertiary-care pediatric hospital. Demographic data, fracture characteristics and treatment details were analyzed. Radiographic review of operative cases was used to confirm fracture location and surgical implant. Annual volumes were determined for the overall number of clavicle fractures, mid-shaft clavicle...
fractures, and mid-shaft fractures that underwent operative plate fixation. Additionally, the annual rate was determined for the number of operative cases among all mid-shaft fractures. Kendall’s Tau-b was used to assess the relationship between case volume and time.

**Results:** From 1999-2011, a total of 882 patients were seen at our institution with a diaphyseal clavicle fracture (mean age: 14.3), 644 (73%) of which were mid-shaft. Of these 644, 111 were treated with operative plate fixation (mean age: 15.9). There was a significant increase in the number of mid-shaft clavicle fractures seen annually over that period, from 20/yr to 85/yr (r=0.80, p<0.0001). The percent of mid-shaft clavicle fractures treated with plate fixation also increased significantly from 5% to 25% (r=0.84, p<0.0001) while the rate of mid-shaft fractures among all diaphyseal fractures remained more stable. Among the mid-shaft fracture cases that received operative plate fixation, 53.2% presented with fractures received during a competitive sporting event.

**Conclusion:** The volumes of clavicle fractures and of mid-shaft clavicle fractures treated operatively appear to be increasing. Additionally, despite a lack of evidence based support, the frequency of operative plate fixation of mid-shaft clavicle fractures appear to be increasing in the pediatric population. Many of these fractures are of a sports-based etiology.

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**Paper 40**

**Normal Parameters Of Skeletally Immature Knees: Developmental Changes On Magnetic Resonance Imaging**

Mary Bathen, MD¹, Tracey P. Bastrom, MA², Eric W. Edmonds, MD².

¹University of California, San Diego, San Diego, CA, ²Rady Children's Specialists San Diego, San Diego, CA

**Objectives:** A child’s knee undergoes significant morphologic changes during development. Age-specific normal parameters have not been previously described. The purpose of this study was to delineate the changes that occur with growth utilizing magnetic resonance imaging (MRI).

**Methods:** A retrospective review of a radiologic database of MRI knees, ages 4 to 18 years, was undertaken using “normal” diagnosis codes, including: knee pain, plicae, septic arthritis, jumper’s knee, growing pains, benign neoplasm, and osteomyelitis. 19 osseous parameters were measured, plus their cartilaginous counterparts, if different. Spearman’s rho correlations were calculated between age and MRI measures.

**Results:** 132 MR images were reviewed. Significant correlation with age was observed in all but MPFL insertion on the sagittal view for the osseous measurements (p<0.05). Similarly, the cartilage measures all demonstrated significant correlation with age except MPFL insertion on the sagittal view, but also the Notch-Width index, and trochlear morphology. The magnitude of correlation was significantly different between the osseous and cartilage measures for all but 3 of the variables: osseous and cartilage Insall-Salvati ratios, and insertion of MPFL on the femur. Osseous patella height stabilizes by age 10 with
values ranging from 0.9-1.2 until age 18. Cartilage patella height demonstrates a modest linear increase with age (rho=0.352). MPFL insertion on the sagittal view remains stable with age (rho=0.036, p>0.05) and the mean insertion remains below the growth plate (11.5 mm to 4.9 mm). On the coronal view, MPFL insertion modestly increases with age (rho=0.33, p<0.001) starting below the growth plate on average (4.3 mm to 2.6 mm), until age 7 when the mean insertion appears to be at or above the growth plate.

**Conclusion:** Most of the studied parameters follow a clear trend of growth and change in size that correlates with maturity. However, the normal Insall-Salvati ratio that delineates patella alta does not appear to be within the normal range until age 10. Furthermore, the discrepancy in the literature concerning the location of the MPFL insertion on the femur in relation to the physis may be attributed to migration of the insertion site during maturation, with the MPFL insertion being below the physis until age 7 when it migrates to insert at or above the physis.

**Paper 41**

**Does One Size Fit All: Variation In Tibial Tubercle Trochlear Groove (TTTG) Measurements As A Function Of Age, Size, And Patellar Instability**

**Andrew T. Pennock, MD¹, Milad Alam, BS², Tracey P. Bastrom, MA¹.**

¹Rady Children's Hospital, San Diego, CA, ²University of California, San Diego, La Jolla, CA

**Objectives:** The tibial tubercle trochlear groove (TTTG) measurement was developed to quantify rotational abnormalities about the knee associated with patella instability and to help guide surgical decision making. The purpose of this study was to assess variations in TTTG as a function of patient age and size in a population of patients with patella instability compared to those with no instability.

**Methods:** This IRB approved retrospective study assessed all patients under the age of 21 undergoing a surgical procedure for patella instability from 2010 to 2012. A cohort of 180 patients with no history of patella instability or patellofemoral complaints was used as a control group. TTTG was measured in all patients on MR axial images using the centers of the tibial tubercle and the trochlear groove. Data was then normalized based on patient height, weight, BMI, and femur width. Statistical analysis was performed with an alpha set at p<0.05 to declare significance.

**Results:** The average age of the 45 patella instability patients was 15.4 years (range 10 - 18), their mean TTTG was 16.3 mm (range 6.5 - 26), and 51% were male. By comparison, the mean age of the control was 16 years (range 10-19), the mean TTTG was 11.7 mm (range 3 - 22), and 58% were male. The TTTG and the normalized TTTG for height, weight, BMI, and femur width were all greater in the patella instability group compared to those with no instability (p≤0.001). 31% of patients had a TTTG greater than 20 mm in the instability group compared to 2.7% in the control group (p<0.05, Specificity 97%, Sensitivity 31%). TTTG was found to increase as a function of height in both groups (r =0.14, p=0.04) and decreased with age only in the instability group (r = -0.3, p=0.04). There was no correlation between TTTG and age in the non-instability group (r= -0.04, p=0.5). TTTG was not associated with patient gender, weight, or
BMI (p>0.05).

**Conclusion:** Much like adult patients, an elevated TTTG is associated with patella instability both in pediatric and adolescent patients. However, this measurement varies as a function of patient age and height. Normalization of TTTG to patient height may control for size variations and should be undertaken in the work-up and management of patients with patella instability. Given the dependence of TTTG on patient age and height, care should be taken when using absolute values or a singular critical cutoff in the adolescent or pediatric population in the surgical decision process.

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**Paper 42**

**CT And MRI Measurements Of Tibial Tubercle To Trochlear Groove Distances (TT-TG) Are Not Equivalent.**

Christopher L. Camp, BS¹, Jeffrey R. Bond, MD², Mark S. Collins, MD¹, Michael J. Stuart, MD¹, Aaron John Krych, MD³, Bruce A. Levy, MD³, Diane Lynn Dahm, MD¹.

¹Mayo Clinic, Rochester, MN, ²Mayo Clinic RochesterRadiology, Rochester, MN, ³Mayo Clinic of Rochester Minnesota, Rochester, MN

**Objectives:** TT-TG distance is a commonly used measurement for surgical decision-making in patients with patellofemoral malalignment and instability. This measurement has historically been performed utilizing axial CT scans. More recently, MRI has been proposed as an equivalent test for measurement of TT-TG distance. We sought to determine the reliability of TT-TG measurements on both MRI and CT, and to determine whether the measurements can be used interchangeably.

**Methods:** All patients diagnosed with patellar instability who had received both CT and MRI of the knee between 2003 and 2011 were included (n=59 knees in 54 patients). Two fellowship trained musculoskeletal radiologists measured the TT-TG distances for each patient by CT and MRI in a randomized, blinded fashion for a total of 236 measurements. Inter-observer reliability was calculated between radiologists for both imaging modalities and inter-methods reliability was calculated between the two imagining modalities. The results are reported using intraclass correlation coefficients (ICC) and Bland Altman analysis (BAA).

**Results:** The 59 knees had a mean TT-TG distance of 16.9 mm (range: 8.3-25.8) by CT and 14.7 mm (range: 1.5-25.1) by MRI. Eighteen patients (31%) had a TT-TG ≥ 20 mm by CT, and only 9 (15%) had a TT-TG ≥ 20 mm by MRI. Inter-observer reliability between the radiologists was considered excellent for both CT and MRI (ICC = 0.777 and 0.843 respectively). When comparing CT to MRI, however, the ICC was considered only fair for each of the two raters (0.532 and 0.539). A total of 11 patients (19%) had a TT-TG ≥ 20 mm on CT preoperatively and underwent distal realignment by tibial tubercle osteotomy (TTO). In this surgical subgroup, the mean TT-TG on CT was 22.5 mm (range 19.8-25.8) while the mean TT-TG on MRI was only 18.7 mm (range 14.4-22.8).

**Conclusion:** TT-TG distance can be measured with excellent inter-rater reliability on both MRI and CT scans; however, the values derived from these two tests may not be interchangeable. This observation
should be taken into consideration when MRI is used for surgical planning since MRI may underestimate TT-TG distance when compared to CT.

Paper 43

Conflict of Interest in Sports Medicine: Does it Affect Our Judgement?

**Fotios P. Tjoumakaris, MD¹, Bradford S. Tucker, MD², Matthew D. Pepe, MD³, Sommer Hammoud, MD⁴, Steven B. Cohen, MD⁵, Michael C. Ciccotti, BA³.**

¹The Rothman Institute, Egg Harbor Township, NJ, ²The Rothman Institute, Egg Harbor Twp, NJ, ³Rothman Institute, Philadelphia, PA, ⁴Rothman Institute at Jefferson, Philadelphia, PA, ⁵Rothman Institute, Media, PA

**Objectives:** The American Academy of Orthopaedic Surgeons (AAOS) and other orthopaedic societies require members who present original research to disclose conflicts so that audiences can make informed decisions when interpreting data. To what degree members use this information when interpreting studies has never been investigated. The purpose of our study was to evaluate how a reported conflict of interest by the primary research team can influence the perceived value of data presented in original research.

**Methods:** We devised a hypothetical prospective study (https://www.surveymonkey.com/s/MPCCLCX) and asked orthopaedic surgeons and non operative sports medicine specialists to rate the perceived clinical value of the data that was obtained based upon variations of study design, statistical significance of outcomes between treatment groups, and characteristics of the research setting (academic v. private institution). The research team in question was disclosed to have the following conflict of interest: the project was funded by a pharmaceutical company and that all authors received compensation for consulting services.

**Results:** 750 sports medicine physicians were sent a survey request to participate in this IRB approved study. 522 responses were obtained for an overall response rate of 70%. 99% of respondents were orthopaedic surgeons. The majority of respondents were from the Northeastern U.S. (32%) and male (96%). Most have been in practice for over 20 years (40%) and were from private practice single specialty groups (58%). 80% of respondents strongly agreed with the statement that conflict disclosure is important when interpreting study results. 62% of respondents reported always reading the disclosure slide during academy or other meeting presentations. 41% of respondents reported always using this information when deciding how to interpret scientific data. Using a case series design with significant positive results at an academic center, 24% reported that the study was likely trustworthy. When the setting of the study was changed to a community hospital, this number decreased to 5%. When no significant difference was found between the groups, 42% believed the study to be trustworthy. When the study design was Level I evidence (RCT trial) and at an academic center, 57% believed the study to be trustworthy. With the same criteria but at a community hospital, this number decreased to 39%. When the results of this design showed no difference among groups, the majority of respondents...
believed the study to be trustworthy (62%).

**Conclusion:** Although the majority of orthopaedic surgeons in our analysis believed that disclosure of conflict of interest is important, less than half used this information when interpreting studies. Changing the study design from a case series to a randomized controlled trial improved the perceived reliability of the data, but was not as important as the reporting of “negative” results.

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**Paper 44**

**Complications Following Arthroscopic Knee Surgery**

Matthew J. Salzler, MD¹, Chealon Dain Miller, MD², Albert Lin, MD³, Sara Herold, MS⁴, James J. Irrgang, PhD PT ATC¹, Christopher D. Harner, MD³.

¹University of Pittsburgh Medical Center, Pittsburgh, PA, ²University of Pittsburgh/UPMC Medical Education Program, Pittsburgh, PA, ³UPMC Center for Sports Medicine, Pittsburgh, PA, ⁴University of Pittsburgh, Pittsburgh, PA

**Objectives:** The purpose of the study was to examine the nature and frequency of complications following the most common arthroscopic knee procedures, with particular attention to fellowship training, geographic location of practice, and age and sex of the patient.

**Methods:** Data were obtained from the ABOS database for orthopaedic surgeons who sat for the part II examination from 2003-2009. The database was queried to determine the type and frequency of complications for patients who underwent knee arthroscopy and for those who underwent sports medicine knee arthroscopy including arthroscopic partial meniscectomy, meniscal repair, chondroplasty, microfracture, anterior cruciate ligament reconstruction, or posterior cruciate ligament reconstruction. Factors affecting complication rates that were investigated included type of procedure, fellowship training status, geographic location of practice, and age and sex of the patient.

**Results:** Results: There were 4435 complications out of 92,565 knee arthroscopic procedures obtained from the ABOS database for an overall candidate-reported complication rate of 4.8%. The complication rate was highest for PCL reconstruction (20.1%) and ACL reconstruction (9.7%). The complication rates for meniscectomy, meniscal repair, and chondroplasty were 2.8%, 7.7%, and 3.5%, respectively. The complication rate for sports fellowship trained candidates was higher than for non-sports trained candidates (5.1%: sports, 4.1%: no sports) and for male patients (4.9% vs. 4.3%). The complication rate was highest for surgeons in the Northwest (4.9%) and lowest in the South (4.2%). Younger patients (60, 3.6%). The overall rate of pulmonary embolus was 0.11%. Surgical complications were more common than medical or anesthetic complications (Table 1), and infection was the most common complication overall (0.84%).

**Conclusion:** The overall self-reported complication rate for arthroscopic knee procedures was 4.7%, which may be even higher given that the data are self-reported. PCL and ACL reconstruction had the highest complication rate amongst arthroscopic procedures in this study. The increased risk of complications for sports fellowship trained surgeons may be explained by a higher percentage of
complex procedures being performed by fellowship trained surgeons. Knee arthroscopy is not a benign procedure and patients should be aware of the risk of complications. In order to reduce the number of complications, surgeons should be aware of the complexity of the procedure, patient factors, and regional differences in care. Limitations of the study include self-reporting of data, which may underestimate their actual complication rate, and that surgeons in their board collection period are more likely to be earlier in their career, which may overestimate the complication rate for more experienced surgeons.

<table>
<thead>
<tr>
<th>Categorized Complications</th>
<th>Complication Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical Complications</td>
<td>3.68%</td>
</tr>
<tr>
<td>Medical Complications</td>
<td>0.77%</td>
</tr>
<tr>
<td>Anesthetic Complications</td>
<td>0.22%</td>
</tr>
</tbody>
</table>

Paper 45

Complications after Hip Arthroscopy: A Prospective, Multicenter, Study Using a Validated Grading Classification

Christopher M. Larson, MD1, John C. Clohisy, MD2, Paul Beaule, MD3, Bryan T. Kelly, MD4, Russell Giveans, PhD5, Rebecca M. Stone, MS, ATC1, Kathryn M. Samuelson, BS1.
1Minnesota Orthopedic Sports Medicine Institute at Twin Cities Orthopedics, Edina, MN, 2Washington University School of Medicine, St Louis, MO, 3University of Ottawa, Ottawa, ON, Canada, 4Hospital for Special Surgery, New York, NY, 5Fairview/MOSMI Orthopedic Fellowship, Edina, MN

Objectives: There is very little published literature looking at comprehensive complication rates after hip arthroscopy with current techniques and indications.

Methods: Between 01/2011 and 11/2012, 1,026 consecutive hips (507 males, 519 females) with a mean age of 31.2 years (range 12 - 73) underwent hip arthroscopy at three institutions. The diagnosis, demographic information, and procedures were recorded, and a validated complications grading classification for hip joint surgery (Clavian classification) was utilized for all patients prospectively.

Results: There were 951 primary hip arthroscopies and 75 revision hip arthroscopies. Arthroscopy was performed for FAI in 936 hips (91.2%), and 760 hips (74.1%) had a labral repair and 229 hips (22.3%) had a labral debridement. The most common event (18.7% of hips) noted was post-operative sensory disturbance adjacent to the portals or involving the distal anterolateral thigh consistent with LFC nerve disturbance. This was typically not noticed by patients and found on physical examination and only
persisted beyond 6 months in 7 hips (0.7%). Iatrogenic chondral injury was noted for 20 hips (1.9%), iatrogenic labral puncture in 11 hips (1.1%), superficial portal infection in 6 hips (0.6%), sensory deficit about the foot in 9 hips (0.9%), deep venous thrombosis in 3 hips (0.3%), pulmonary embolism in 1 hip (0.1%), pulmonary edema in 1 hip (0.1%), wound hematoma in 2 hips (0.2%), perineal numbness ( pudendal nerve) in 9 hips (0.9%), heterotopic ossification in 4 hips (0.4%), reflex sympathetic dystrophy in 1 hip (0.1%) and wound/skin (traction) dehiscence in 1 hips (0.1%). There were no femoral neck fractures, iatrogenic instability, AVN, or extra-abdominal fluid extravasation in this cohort. The overall complication rate not including temporary periportal and thigh numbness (sequalae) was 6.9% (71 hips). Overall 88.7% had a grade 1, 5.6% Grade 2, 4.2% grade 3, and 1.4% grade 4 complication. There was no difference in the rate of complications between males and females (p=.221), primary vs revision cases (p=.159) or labral repair vs debridement (p=.173), and BMI had no effect on complication rate.

**Conclusion:** The overall complication rate after hip arthroscopy was 6.9% and higher than previously reported in the literature. This rate of complications is in line with complication rates after open surgical dislocation using the same classification system.

**Paper 46**

**Injury to the Suprascapular Nerve During SLAP repair: A Rotator Interval Portal is Not Safer Than an Anterosuperior Portal**

Ryan Morgan, MD, Ralph Frank Henn, MD, James C. Dreese, MD.

University of MD School of Medicine Dept of Orthopaedics, Baltimore, MD

**Objectives:** The suprascapular nerve is potentially at risk during superior labrum repair. We compared risk of injury to the suprascapular nerve during suture anchor placement through an anterosuperior versus a rotator interval portal. Our hypothesis was that the rotator interval portal provides a safer and more reproducible method for repair of Type-II SLAP tears.

**Methods:** Each pair of ten bilateral fresh human cadaveric shoulders was randomized to suture anchor placement through an anterosuperior portal on one shoulder and a rotator interval portal on the contralateral shoulder. Suture anchors were placed into the glenoid rim (one o’clock, eleven o’clock, and ten o’clock positions for right shoulder; eleven o’clock, one o’clock, and two o’clock for left shoulder). Standard 3 × 14 mm suture anchors were placed, and the suprascapular nerve was carefully dissected. When glenoid perforation occurred, the distance from the suture anchor tip to the suprascapular nerve was measured. The anchors were removed, and the distance from the glenoid rim to the suprascapular nerve and drill hole depth at each suture anchor entry site was recorded.

**Results:** All far posterior suture anchors (ten o’clock anchor for right shoulders, two o’clock anchor for left shoulders) perforated the glenoid rim using the anterosuperior or rotator interval portal. For the far posterior anchor, distance from anchor tip to suprascapular nerve averaged 8.02 mm (range, 3.4 to 14 mm) using the anterosuperior portal and 2.1 mm (range, 0 to 5.5 mm) using the rotator interval portal, a
statistically significant difference of 5.92 mm (95% confidence interval [CI]: −7.81 to −4.04; \( p \leq 0.001 \)).

**Conclusion:** Using an anterosuperior or rotator interval portal results in consistent penetration of one o’clock and two o’clock posterior suture anchors and may place the suprascapular nerve at risk of iatrogenic injury. Based on the high likelihood of glenoid perforation and closer proximity of the suture anchor tip to the suprascapular nerve, the risk of injury is significantly greater with a rotator interval portal for superior labrum anterior and posterior repair.

Clinical Relevance: It is important to recognize the high rate of glenoid perforation and risk of injury to the suprascapular nerve when placing anchors in the posterior glenoid from either portal.

<table>
<thead>
<tr>
<th>Anchor Tip to Nerve Distance by Different Portal</th>
<th>Anchor</th>
<th>Anterosuperior Portal (mm)</th>
<th>Rotator Interval Portal (mm)</th>
<th>Difference (mm)</th>
<th>95% CI</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>6.04</td>
<td>4.24</td>
<td>-1.8</td>
<td>-6.11 to 2.51</td>
<td>0.36</td>
<td></td>
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<tr>
<td>Far Posterior</td>
<td>8.02</td>
<td>2.1</td>
<td>-5.92</td>
<td>-7.81 to -4.04</td>
<td>&lt;0.001</td>
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</table>

**Paper 47**

Surgical Dislocation of the Hip Versus Arthroscopic Treatment of Femoro-acetabular Impingement: A Prospective Comparative Study with 2-Year Follow-Up

Timothy J. Jackson, MD\(^1\), Christine E. Stake, MA\(^2\), Youssef El Bitar, MD\(^3\), Dror Lindner, MD\(^4\), Itamar Botser, MD\(^5\), Benjamin G. Domb, MD\(^6\).

\(^1\)Congress Medical Associates Program, Pasadena, CA, \(^2\)Hinsdale Orthopaedics Associates, Westmont, IL, \(^3\)Beirut, Lebanon, \(^4\)Hindale Orthopaedics, Hinsdale, IL, \(^5\)Stanford Orthopaedic Sports Medicine Fellowship Program, Redwood City, CA, \(^6\)Hinsdale Orthopaedics Associates, American Hip Institute, Westmont, IL

**Objectives:** Femoroacetabular impingement (FAI) can be treated by arthroscopy or by surgical dislocation of the hip. Advocates of each have suggested advantages of each technique.

To date, there have been no studies that directly compare these two treatment modalities, using patient-reported outcomes (PRO), in a single surgeon design. The purpose of this study was to prospectively compare outcomes of patients receiving surgical hip dislocation to arthroscopic treatment for FAI, using a matched-pair analysis. Our hypothesis is the arthroscopic group will demonstrate improved clinical outcomes when compared to patients receiving open surgical dislocation.

**Methods:** During the study period between January 2008 and August 2011, data was prospectively...
collected on all patients <30 years of age treated for FAI. Patients were given the choice of open dislocation versus arthroscopic treatment. Patients with developmental dysplasia of the hip, Legg-Calve-Perthes disease, Tonnis grade >1, and previous hip surgery were excluded. The patients in the surgical dislocation cohort were pair-matched in a 1:2 ratio to patients treated arthroscopically, based on age within 2 years, gender, workers’ compensation status and diagnosis of FAI. PRO tools, including the modified Harris Hip Score (mHHS), Non-Arthritic Hip Score (NAHS), Hip Outcome Score – Sport Specific Subscale (HOS - SSS) and Hip Outcome Score - Activity of Daily Living (HOS - ADL), were obtained in all patients pre-operatively and post-operatively at 3 months, 1 year, and 2 years, and at latest follow up. Alpha angles were measured pre- and post- surgery for both groups. Revision surgery and complications were recorded for each group.

**Results:** Ten patients were included in the surgical dislocation group, and 20 pair-matched patients were included in the arthroscopic group. 100% patient follow-up was obtained at mean 24.8 months in the open group and 25.5 months in the arthroscopic group. Preoperative mHHS, NAHS, HOS-ADL and HOS-SSS were similar between the two groups. Both the arthroscopic group and the surgical dislocation group had significant postoperative improvement at 3 months, 1 year and final follow-up for all scores. In comparing the two groups, the ΔHOS-SSS was significantly higher in the arthroscopic group at final follow-up, improving 42.8 points versus 23.5 in the surgical dislocation (p=0.047). The arthroscopic group also had significantly better NAHS at 3 months (88.1 vs. 75.3, p=0.016) and at final follow-up. (94.2 vs. 85.7, p=0.01). Nine out of 10 patients in the dislocation group had good/excellent results, and 19 out of 20 patients in the arthroscopic group had good/excellent results. Patient satisfaction for the open group was 8.1, and 9.2 in the arthroscopic group (p=0.07). Both groups showed a significant decrease in the alpha angle postoperatively, from 58° to 40° in the dislocation group, and 57° to 40° in the arthroscopic group, with no difference between the groups (p=0.775). The dislocation group had 8 patients undergo hardware removal, and two required hip arthroscopy for continued pain.

**Conclusion:** This is the first study to directly compare surgical dislocation to arthroscopic management of FAI in single surgeon design. Favorable results were shown with both approaches, with significant improvement in all PRO measures and high patient satisfaction ratings. However, arthroscopic treatment of FAI showed greater improvement in the HOS-SSS and a higher absolute NAHS score at 2 year follow-up.
Two Year Follow-up Of Hip Arthroscopies: A Match-controlled Study Comparing Patients Over 50 Years To Under 30 Years

Dror Lindner, MD¹, Christine E. Stake, MA¹, Timothy J. Jackson, MD², Youssef El Bitar, MD³, Austin Chen³, Benjamin G. Domb, MD⁴.

¹Hinsdale Orthopaedics Associates, Westmont, IL, ²Congress Medical Associates Program, Pasadena, CA, ³American Hip Institute, Westmont, IL, ⁴Hinsdale Orthopaedics Associates, American Hip Institute, Westmont, IL

<table>
<thead>
<tr>
<th></th>
<th>Open Dislocation (n = 10)</th>
<th>Arthroscopic (n=20)</th>
<th>Significance</th>
</tr>
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<tbody>
<tr>
<td>mHHS</td>
<td>92 ± 12.6</td>
<td>92.4 ± 7.13</td>
<td>P=0.914</td>
</tr>
<tr>
<td>NAHS</td>
<td>85.7 ± 12.4</td>
<td>94.2 ± 4.5</td>
<td>P=0.01</td>
</tr>
<tr>
<td>HOS ADL</td>
<td>91.5 ± 7.7</td>
<td>95.3 ± 5.4</td>
<td>P=0.129</td>
</tr>
<tr>
<td>HOS SSS</td>
<td>77.3 ± 22.7</td>
<td>87.1 ± 12.1</td>
<td>P=0.131</td>
</tr>
<tr>
<td>VAS</td>
<td>2.8 ± 3.1</td>
<td>2.0 ± 1.2</td>
<td>P=0.328</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>8.1 ± 2.3</td>
<td>9.2 ± 0.8</td>
<td>P=0.07</td>
</tr>
<tr>
<td>Good/Excellent</td>
<td>9</td>
<td>19</td>
<td>P=0.605</td>
</tr>
</tbody>
</table>
Objectives: Few studies have addressed the issue of hip arthroscopy in the aging population, and none has compared it directly to a young cohort. The purpose of the study was to compare the outcomes and patient characteristics of hip arthroscopy procedures in patients 50 years and over with a matched control group of patients 30 years and younger, at a minimum post-operative follow-up of two years.

Methods: Between September 2008 and March 2010, data was prospectively collected on all patients 50 years and over undergoing primary hip arthroscopy. Sixty-four cases met our inclusion/exclusion criteria, of which 57 (89%) were available for follow-up at a minimum of two years. A gender-matched control group of 57 patients 30 years and younger was created. All patients were assessed pre- and post-operatively, using four patient-reported outcome (PRO) measures: the modified Harris Hip Score (mHHS), Non-Arthritic Hip Score (NAHS), Hip Outcome Score Activity of Daily Living (HOS-ADL) and Sport-Specific Subscales (HOS-SSS). Pain was estimated on the visual analog scale (VAS) and satisfaction was measured on a scale from 0-10. Pre-operative radiographic assessment was performed on all patients, and intra-operative findings were recorded.

Results: The mean age of our study group was 55.68 (50-76), and the control group was 21 (14-30). The groups were gender-matched, including 17 (30%) male and 40 (70%) females in each group, with an average follow-up of 32 months (range 24-54 months). The two-year survivorship for the study group was 82%. The mean time from arthroscopy to joint replacement was 18.4 months (range 3.5-38.5 months). At latest follow-up, survivorship was 6 of 12 (50%) for patients with Tonnis 2 arthritic grade, versus 32 of 45 (71%) for patients graded Tonnis 0 or 1. For patients 50 and over, the score improvement from preoperative to two-year follow-up was 64 to 89 for mHHS, 60 to 88 for NAHS, 67 to 90 for HOS-ADL, and 42 to 77 for HOS-SSS. For patients 30 and younger, the score improvement from preoperative to two-year follow-up was 55 to 84.5 for mHHS, 53 to 80 for NAHS, 58 to 83 for HOS-ADL, and 35 to 62 for HOS-SSS. All improvements in both groups were statistically significant (p<0.05). There were no significant differences seen between the groups in score improvements for mHHS, NAHS or HOS-ADL. However, the improvement in the HOS-SSS was greater in the control group (p=0.03). The post-operative VAS was similar between the groups: 3.1 for the 50 and over group and 2.5 for the 30 and younger group. Satisfaction was 8.27 for the 50 and over group and 8.41 for 30 and younger group, and was also similar between groups.

Figure 1A-D: PRO Measures pre and postoperatively. A
Conclusion: Overall, survivors 50 and over years of age experienced similar improvement to patients 30 and younger after hip arthroscopy regarding pain, functional scores, and patient satisfaction. Patients 50 and over with Tonnis grade 0 or 1 have higher survivorship than those with Tonnis grade 2. While a certain subset of patients in the older group may progress to hip replacement, the two-year survivorship of patients 50 and over was high (82%). These results present favorable two-year clinical outcomes for the older group when compared to a matched control group of younger patients. Therefore, we believe that hip arthroscopy should be considered a valid option when treating hip pain in patients 50 years and over with arthritic grade Tonnis 0 or 1.