PAPERS

PAPER NO. 226

Post-operative Pain Control in Supracondylar Humerus Fracture Fixation
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INTRODUCTION: Post-operative pain control in pediatric patients has become a priority for all institutions. There is a paucity of literature on pain control following orthopedic procedures in the pediatric population. The purpose of this study is to compare the efficacy of acetaminophen to narcotic analgesics, specifically, acetaminophen/codeine and morphine, for pain management after closed reduction and percutaneous pinning (CRPP) of displaced supracondylar humerus fractures in children. METHODS: We retrospectively evaluated 217 patients who received CRPP of Gartland Type II or III supracondylar humerus fractures at our institution from 2003-2009. Hospital charts were reviewed to obtain demographic data. Patients were divided into a narcotic and non-narcotic group. The Oucher and FLACC scales were used to quantify the effectiveness of the pain control that was delivered. Statistical significance was obtained using un-paired T-tests. In addition, complications as well as time to discharge were recorded for all patients. RESULTS: One hundred seventy-four patients were treated with non-narcotic pain medications and 43 patients received narcotics. The average age of these patients was 5.45 years. The mean post-operative pain score for the non-narcotic group was 1.9, while the mean post-operative pain score for the narcotic group was 2.2. This difference was not statistically significant. To account for the difference of age in patients and severity of fracture type we created an age matched cohort of patients with only Type III supracondylar fractures. The average age of this group was 6.22 years. The mean pain score for the acetaminophen subgroup was 2.1 compared to a mean pain score of 2.4 for the narcotic subgroup. This difference was not statistically significant. Severe nausea or vomiting attributed to either class of medication was not observed. In addition no patients developed a compartment syndrome. DISCUSSION AND CONCLUSION: Acetaminophen is as effective as narcotic analgesics for providing pain control after supracondylar fracture surgery in children, and are generally associated with fewer side effects. It is our recommendation to use acetaminophen alone for post-operative pain control in these patients.

PAPER NO. 227

Closed Reduction of Displaced Lateral Humeral Condyle Fractures in Children
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INTRODUCTION: The recommended treatment for displaced lateral humeral condyle fractures in children is open reduction internal fixation (ORIF). There have been few previous reports of closed reduction and percutaneous pinning (CRPP), and further research has been recommended. The purpose of this study was to study the outcome (clinically and radiographically) of CRPP, and compare it to ORIF. METHODS: We retrospectively analyzed the clinical and radiographic data on 90 lateral humeral condyle fractures in children. This data was collected prospectively over a four-year period (2007-2011), as part of an Institutional Review Board-approved study on pediatric elbow fractures. For inclusion, all patients required a minimum follow up of 12 weeks. We compared the results of CRPP with arthrography-confirmed reduction (n=25) to ORIF (n=65) by measuring operative time, recovery of range of motion (ROM), lateral spur formation and complications. RESULTS: The mean follow up for patients treated with CRPP and ORIF was 33 and 42 weeks, respectively. The CRPP group had a significantly less initial fracture displacement (3.2 mm) as compared to the ORIF group (6.0 mm) (p=0.0008). The mean was significantly shorter for patients treated with CRPP (30.4 min) as compared to those treated with ORIF (50.8 min) (p=0.00001). There was a trend towards less lateral spur formation for patients treated with CRPP as compared to those treated with ORIF (71.4% vs. 86.9%, p=0.1). The rate of recovery of ROM was similar in both groups; also, the relative ROM at the latest follow up was similar (94% of the normal, contralateral elbow in the CRPP group vs. 96% in the ORIF group, p=0.2). The overall rate of complications was 4.1% in the CRPP group and 10.8% in the ORIF group (p=0.3). In the CRPP group, one patient developed a superficial infection. In the ORIF group, one patient developed a deep infection with an associated avascular necrosis of the lateral condyle, two patients developed superficial infections and one patient developed a non-union of the lateral condyle. DISCUSSION AND CONCLUSION: CRPP is a viable alternative for moderately displaced lateral condyle fractures of the humerus in children. The potential benefits include less scarring (no incision) and decreased operative time. While it appears that CRPP does not significantly accelerate the recovery of ROM, it seems to have a lower incidence of complications. CRPP for moderately displaced lateral condyle fractures of the humerus is a safe alternative, and should be considered in the therapeutic armamentarium.

PAPER NO. 228

Lower Extremity Long Bone Fractures in Obese vs. Non-obese Pediatric Trauma Patients
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INTRODUCTION: Obesity may impact the musculoskeletal system through mechanical effects or indirectly via endocrine or inflammatory effects. We examined whether differences in fracture patterns occurred in obese vs. non-obese children who sustained blunt trauma. METHODS: The trauma registries of two pediatric hospitals were queried for patients with lower extremity long bone fractures resulting from blunt trauma. Weight was recorded from the charts and weight for age percentile >95th was defined as obese. Radiographs were reviewed and fractures were classified according to the method of treatment. RESULTS: A total of 245 patients were included in the study, of whom 94 were defined as obese. The obese patients were younger, shorter, and heavier than the non-obese patients. The rate of upper extremity fractures was higher in the non-obese group, while the rate of pelvic fractures was higher in the obese group. The mean follow-up for patients treated with closed reduction and percutaneous pinning (CRPP) was 24 weeks, while the mean follow-up for those treated with open reduction internal fixation (ORIF) was 36 weeks. CONCLUSION: Obese children are at risk for different fracture patterns compared to non-obese children. Further research is needed to determine the optimal treatment for these patients.

For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
the AO/OTA pediatric fracture classification system. We also recorded the mode of treatment (operative vs. non-operative) and occurrence of musculoskeletal complications (compartment syndrome, infection, loss of reduction, non-union, skin ulceration). Results were compared using Chi-square test or Fisher’s exact test.

RESULTS: A total of 356 patients met inclusion criteria. Some 78 (22%) were obese. The major finding was that obese patients were more likely to have fractures involving the physis and less likely to have fractures involving the metaphysis compared to non-obese patients. Multivariate analysis showed an age adjusted odds ratio of physeal fracture in obese patients of 5.63 (95% confidence interval 1.89-16.8, p 0.002). Obese patients were also more likely to receive operative treatment (74.7% vs 59.9% p<0.01). The overall rate of musculoskeletal complications was 5.1% in the obese patients and 2.9% in the non-obese patients. This finding was not statistically significant (p=0.30).

DISCUSSION AND CONCLUSION: Obese patients are more likely to sustain fractures involving the physis as a result of blunt trauma compared to non-obese patients. This could be related to intrinsic changes to the physis related to obesity or altered biomechanical stresses. This observation is consistent with the observed relationships between obesity and other conditions affecting the physis including Blounts and Slipped Capital Femoral Epiphysis.

PAPER NO. 229
Outcomes of Reduction More Than Seven Days After Injury in Type II Supracondylar Humeral Fractures (SCHF) in Children
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INTRODUCTION: Extended Type II fractures initially treated with closed reduction and casting can displace during the first two weeks of follow up. While closed reduction and percutaneous pinning (CRPP) is desirable for displaced supracondylar humeral fractures (SCHF) treated acutely, there is little or no available information regarding the possibility to obtain a satisfactory reduction when such a procedure is performed more than seven days after the original injury, or the clinical outcome of it.

METHODS: We reviewed the information on 143 type II pediatric SCHF that were treated by CRPP. To determine the effect of late treatment, we compared a group of fractures that was treated within the first seven days (Group 1, n=101) with a group that was treated more than seven days after the injury (Group 2, n=42).

RESULTS: Mean time from presentation to surgery was 2.1 days (range, 0-5) and 9.8 days (range, 7-15) for fractures in Groups 1 and 2, respectively (p<0.0001). There was no need for an open reduction in either group. An anatomic reduction was obtained in all fractures. There were no iatrogenic nerve injuries, vascular complications or compartment syndromes in either group. Length of surgery was similar in both groups (p=0.3). There were no significant differences in final carrying angle (p=0.2) or range of motion of the treated elbow (p=0.21). Avascular necrosis (AVN) of the humeral trochlea was identified in two fractures that were treated surgically eight days after the original injury (Group 2).

DISCUSSION AND CONCLUSION: It is possible to obtain an anatomic reduction of a Type II pediatric SCHF up to 15 days from the injury. Such a delay in surgery does not appear to lead to longer surgeries, higher incidence of open reduction or to alter the final alignment or range of motion of the elbow. The risk of developing AVN of the humeral trochlea must be considered.
Pediatric Supracondylar Humerus Fractures: A Technique to Aid in Closed Reduction
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INTRODUCTION: Pediatric supracondylar humerus fractures (PSCHFs) are the most common fracture of the pediatric elbow. Meticulous reduction and anatomic alignment of the fracture are essential to restore normal elbow function and to prevent future complications from malreduction and resultant abnormal joint kinematics. Anatomic reduction of displaced PSCHFs may not be possible via closed manipulation in unstable fracture patterns, necessitating formal open reduction. Open reduction has been associated with increased risks of elbow stiffness, myositis ossificans, scarring and iatrogenic neurovascular injury. METHODS: From March 2002 through December 2010, 145 displaced (Gartland type II or III) PSCHFs were treated operatively at a level-1 trauma center by a single fellowship-trained orthopaedic trauma surgeon and retrospectively identified. In Group 1, (March 2002 through September 2007) fractures failing successful reduction via closed manipulation underwent formal open reduction. In Group 2, (October 2007 through December 2010) fractures irreducible via simple closed reduction underwent a new technique involving percutaneous Shantz pin placement in the humeral shaft to assist in fracture reduction. This involved using a 2.4E18 terminal threaded Shantz pin placed in the posterior distal humeral diaphysis. The use of this pin as a joystick assisted in reduction of anterior/posterior translation as well as the reduction of varus/va1gus malalignment, but was instrumental in de-reotation of the humeral shaft which is often the impediment to a successful closed reduction. Following fracture stabilization, the Shantz pin was removed. Demographic data, fracture type, operative technique, complications and radiographic reduction were analyzed for all fractures. Operative time for all type III fractures in Group 2 was also recorded. RESULTS: A total of 145 PSCHFs were retrospectively identified. Group 1 had 91 fractures (33 type II and 58 type III), and Group 2 had 54 fractures (15 type II and 39 type III). There were two open fractures, one in each group. Significantly less type III fractures in Group 2 compared to Group 1 required open reduction (p=0.031). With 11 of 58 (19.0%) type III fractures in Group 1 and one of 39 (2.6%) type III fractures in Group 2. Ten of the 39 (25.6%) type III fractures in Group 2 utilized the Shantz pin technique, and all of these achieved anatomic reduction. No fracture treated with the Shantz pin reduction technique required open reduction. The average operative time for Group 1 fractures treated with open reduction was 32.7 minutes; whereas the average operative time for Group 2 fractures treated with the Shantz pin technique was 22.0 minutes (t=2.417, p=0.029). There were two superficial pin infections, both in Group 1. No significant difference was found between Group 1 and 2 for fracture reduction (as determined on AP and lateral radiographs) or complications. No radial nerve palsies occurred with the use of the Shantz pin technique. DISCUSSION AND CONCLUSION: The use of a posteriorly placed Shantz pin aids in timely anatomic reduction and decreases the need for open treatment of displaced PSCHFs, without compromising final reduction or complication rates.

Functional Outcomes after Adolescent Clavicle Fractures Based on Fracture Displacement and Age
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INTRODUCTION: Up until 2007, most displaced clavicle fractures in adolescents were treated non-operatively. There has been sparse research looking at the functional outcome of non-operative treatment. We hypothesized that adolescents with increased clavicle fracture shortening and increased age at injury would correlate with worse functional outcomes. METHODS: Initial radiographs of 91 adolescent patients between the ages of 10 and 18 who received non-operative treatment for a clavicle fracture over a three-year period were measured for angulation and shortening by two independent raters. Shortening was divided into four categories: non-displaced, < 1 cm of displacement, 1-2 cm shortened, or > 2 cm of shortening. Each patient completed a Pediatric Outcomes Data Collection Instrument (PODCI) and the Quick DASH (Disabilities of the Arm, Shoulder, and Hand) at a minimum of two years after treatment. RESULTS: Out of the 91 clavicle fractures included in the study, 45 were non-displaced, 14 were less than 1 cm displaced, 20 had 1-2 cm of displacement and 12 had greater than 2 cm of displacement. The average displacement was 0.7 cm (±0.08 cm), ranging from 0 - 3.6 cm. Angulation averaged 28 degrees (±11.33 cm), ranging from 0 - 50 degrees. Follow up averaged 3.5 years (ranging 2-7 years). Patients with clavicle fractures did not differ from healthy adolescents on any of the PODCI scales, except for having greater happiness (one sample t-test, p=0.017). Functional outcomes did not differ between the four displacement groups (Kruskal-Wallis test, p=0.05). However, greater shortening was significantly associated with better sports and physical function in the injured group (Spearman’s correlation, r=0.21, p=0.049). Older age was significantly correlated with worse upper extremity function as measured by the QuickDASH (Spearman’s correlation, r=0.21, p=0.042). Upper extremity, mobility, pain and global function, as measured by the PODCI, did not depend on age, displacement or angulation (Figures 1a-b, p>0.05, power of 0.80 to detect a correlation of 0.08). DISCUSSION AND CONCLUSION: Based on our findings, we believe that non-operative treatment of clavicle fractures is a safe and effective treatment even in fractures that are up to 50 degrees angulated or more than 2 cm shortened, especially in younger children. These findings differ from results reported in adult displaced clavicle fracture studies.

Determining Displacement in Medial Epicondyle Humerus Fractures
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INTRODUCTION: Up until 2007, most displaced clavicle fractures in adolescents were treated non-operatively. There has been sparse research looking at the functional outcome of non-operative treatment. We hypothesized that adolescents with increased clavicle fracture shortening and increased age at injury would correlate with worse functional outcomes. METHODS: Initial radiographs of 91 adolescent patients between the ages of 10 and 18 who received non-operative treatment for a clavicle fracture over a three-year period were measured for angulation and shortening by two independent raters. Shortening was divided into four categories: non-displaced, < 1 cm of displacement, 1-2 cm shortened, or > 2 cm of shortening. Each patient completed a Pediatric Outcomes Data Collection Instrument (PODCI) and the Quick DASH (Disabilities of the Arm, Shoulder, and Hand) at a minimum of two years after treatment. RESULTS: Out of the 91 clavicle fractures included in the study, 45 were non-displaced, 14 were less than 1 cm displaced, 20 had 1-2 cm of displacement and 12 had greater than 2 cm of displacement. The average displacement was 0.7 cm (±0.08 cm), ranging from 0 - 3.6 cm. Angulation averaged 28 degrees (±11.33 cm), ranging from 0 - 50 degrees. Follow up averaged 3.5 years (ranging 2-7 years). Patients with clavicle fractures did not differ from healthy adolescents on any of the PODCI scales, except for having greater happiness (one sample t-test, p=0.017). Functional outcomes did not differ between the four displacement groups (Kruskal-Wallis test, p=0.05). However, greater shortening was significantly associated with better sports and physical function in the injured group (Spearman’s correlation, r=0.21, p=0.049). Older age was significantly correlated with worse upper extremity function as measured by the QuickDASH (Spearman’s correlation, r=0.21, p=0.042). Upper extremity, mobility, pain and global function, as measured by the PODCI, did not depend on age, displacement or angulation (Figures 1a-b, p>0.05, power of 0.80 to detect a correlation of 0.08). DISCUSSION AND CONCLUSION: Based on our findings, we believe that non-operative treatment of clavicle fractures is a safe and effective treatment even in fractures that are up to 50 degrees angulated or more than 2 cm shortened, especially in younger children. These findings differ from results reported in adult displaced clavicle fracture studies.
inconsistent and inaccurate. CT scan has been used to achieve an exact measurement, but remains expensive and increases the radiation exposure to these children. Previous work has demonstrated that internal oblique radiographs of the elbow can approximate the true anterior displacement. The purpose of this study was 1) to devise a reproducible method of determining true displacement of medial epicondyle fractures using internal oblique radiographs, and 2) to assess both intra-observer and inter-observer agreement in the measurements of displacement of these fractures on specified internal oblique radiographs.

METHODS: A cadaveric arm was used as our model and a medial epicondyle fracture created. The fragment was displaced at 5mm intervals in an anterodistal (relative to the humerus) direction (to simulate the pull of the flexor pronator mass) up to 15mm of displacement, creating three displacement groups. A fourth displacement group was created by displacing the fragment in a pure anterior direction, set at 10mm. For each group, digital internal oblique radiographs were taken starting at a straight AP and increasing at 15º intervals of internal rotation until a straight lateral radiograph was taken, with the arm maintained at 45º of flexion. Finally, results were repeated with radio-opaque wires placed on the fragment and fracture bed, and an additional group at 45º internal rotation was created by extending the forearm from 15º to 75º at 15º intervals. The 45º and 60º internal oblique radiographs were then presented to five separate reviewers with different levels of orthopedic training, including one nurse practitioner, one junior resident, one fellow, one junior attending surgeon and one senior attending surgeon. Each reviewer recorded the amount of perceived displacement in millimeters. A difference of >2mm between measurements represented clinical disagreement between reviewers. Intra-observer and inter-observer agreement was assessed by calculating both the intra-class correlation coefficient and the percentage of clinical disagreement between ratings. We devised a mathematical model to predict the true displacement by multiplying the measured displacement of the 45º oblique by 1.4 and the 60º oblique by 2.

RESULTS: The first three groups of x-rays had apparent anteromedial displacement of the 45º oblique by 1.4 and the 60º oblique by 2. RESULTS: The third group of x-rays had apparent anteromedial displacement. The fourth group (pure anterior) appeared non-displaced on AP and lacked the medialized appearance of the other groups. On the wired films, there was no significant change in displacement based on forearm position (p = 0.82). Our intra-observer reliability was excellent (ICC range = 0.979 - 0.988) and our inter-observer agreement was 0.953. Overall, the observers were 60% accurate in predicting the true displacement for the 45º oblique as compared to 35% using the 60º oblique.

DISCUSSION AND CONCLUSION: Standard radiographs for the assessment of humeral medial epicondyle fractures should include: AP, lateral and internal oblique views. Most hospitals have 45º wedge blocks in the radiology suites. By standardizing to a 45º internal oblique radiograph of the elbow (regardless of forearm flexion), then true displacement can be approximated by measuring the maximum fracture separation on this view multiplied by a factor of 1.4. The addition of a 45º internal oblique radiograph in children with a medial humeral epicondyle fracture has good intra- and inter-observer reliability to accurately assess the true displacement of these fractures.

PAPER NO. 234
Prospective Evaluation of Post Traumatic Stress and Parent Stress in Pediatric Orthopaedic Trauma Patients
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INTRODUCTION: Trauma has more than just physical effects on pediatric patient and their families. The purpose of this study was to evaluate pediatric orthopaedic trauma patients, and pediatric patients with isolated non-operative upper extremity fractures along with their parents for emotional/psychological symptoms associated with post-traumatic stress disorder (PTSD). We hypothesized pediatric orthopaedic trauma patients with high energy injuries would have significant rates of PTSD compared to the patients with isolated low energy upper extremity fractures.

METHODS: An Institutional Review Board-approved prospective study of pediatric patients age 8-18 who sustained a traumatic injury or an isolated upper extremity fracture at least three months prior to being seen in clinic. Data was collected from October 2009 to May. Exclusion criteria included a traumatic brain injury with Glasgow Coma Score <15. Demographic data, injury details and information on the child’s school and extracurricular activities were obtained. The Child PTSD Symptom Scale (CPSS) was utilized to evaluate the patients for PTSD. The Parent Stress Index (PSI) was utilized to evaluate the stress of the parents/guardian. For 80% power, we needed to recruit 32 children per group. P value was set at <0.05.

RESULTS: A total of 76 children and their parent/guardian participated in the study. The mean age was 12.6 years (range, 8-17 years). There were 56 males (74%) and 20 females (26%). The average time since injury was 12 months (range, 3-89 months). Thirty-two children in the trauma group had surgery with 10 having more than one surgery. No patients in the isolated upper extremity group had surgery. The data was evaluated based on four groups; trauma patients with PTSD, trauma patients without PTSD, upper extremity patients with PTSD and upper extremity patients without PTSD. Overall 33% of our total patients had PTSD; 24% of the trauma group and 9% of the upper extremity group. We found pediatric patients who experience high or low energy trauma can have PTSD. Involvement in music was found to be protective against PTSD (p=0.037). In our population, the stress of the parent was not associated with PTSD in the child.

DISCUSSION AND CONCLUSION: Post-traumatic stress disorder commonly affects pediatric patients who sustain injuries as a result of a traumatic event, whether low or high-energy mechanisms. We found no factors significantly associated with or predictive of PTSD in our four patient groups. Awareness of PTSD is important and we need to have a high index of suspicion in all pediatric trauma patients regardless of the energy associated with the traumatic event. Patients who exhibit signs of PTSD should be provided with resources so that an intervention can be done in a timely manner.
Combined Salter Harris II Fractures with Tibial Tuberosity Fractures: A Marker for Potential Complications
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INTRODUCTION: Tibial tuberosity fractures have been reported as a relatively uncommon injury. Due to the low numbers of cases reported in the literature, little is known regarding risks of refracture and more severe injuries associated with this fracture type. At our institution, we have noted a percentage of our patients with Salter-Harris IV fractures of the posterior proximal tibia associated with anterior tibial tuberosity fractures, previously classified as a Watson/Ryu type IVB injury. The purpose of this study is to examine the injury patterns and outcomes associated with this combination.

METHODS: All patients undergoing open reduction and internal fixation (ORIF) for a tibial tuberosity fracture presenting to a regional pediatric hospital from January 2003 through December 2010 were identified. All radiographs were reviewed to find those patients who had a tibial tuberosity fracture as well as a Salter Harris II fracture of the posterior tibia. Clinical findings and images were retrospectively reviewed to determine outcomes of this injury.

RESULTS: A total of 56 patients presented in this time period with the diagnosis of a tibial tuberosity fracture requiring ORIF, of whom 48 (85.7%) had radiographs available for review. All patients were male. Ten patients (20.8%) had a posterior Salter Harris IV fracture also identified by either radiograph or CT scan. Five patients (10%) with the combination injury had an adverse event: one patient (10%) had compartment syndrome affecting all four compartments, one patient (10%) suffered bilateral injuries and later refractured the non-SH IV side, two patients (20%) had a refracture of the SH IV side, and one (10%) patient suffered a contralateral injury one year later. The 38 (79.2%) patients who presented with a tibial tuberosity fracture without a posterior Salter Harris IV injury did not have any episodes of compartment syndrome, contralateral injury or refracture. All patients went on to uneventful healing and return to activities at last follow up.

DISCUSSION AND CONCLUSION: Salter Harris IV fractures associated with a tibial tuberosity fracture are a marker for potential complications. Ten patients who presented for ORIF of a tibial tuberosity fracture had this combination of injuries. Forty percent of these patients had a complication involving a refracture or contralateral injury, possibly indicating a more severe physeal injury or intrinsic physeal weakness. One patient also suffered compartment syndrome involving all four compartments of the leg, possibly due to the injury involving the entire proximal tibia. We recommend that this fracture combination be reclassified in the Ogden/Ryu classification system as a type VI injury because of the high rate of complications and frequency of occurrence.
**Immediate Intramedullary Flexible Nailing of Open Pediatric Tibial Shaft Fractures**

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Eric W. Edmonds, MD, San Diego, CA

**INTRODUCTION:** Flexible nailing has become the preferred implant for pediatric patients with tibial shaft fractures that require operative fixation. Immediate definitive fixation with flexible nails in patients with high-energy open fractures has not been examined. The purpose of our study was to determine if immediate flexible nailing of open pediatric tibial shaft fractures is safe and efficacious from a bone healing, wound and infectious standpoint.

**METHODS:** A retrospective review of 26 tibial shaft fractures consecutively treated with flexible nailing at our institution from 2003 to 2010 was performed. Age, mechanism of injury, associated injuries, presence of compartment syndrome, antibiotic administration, systemic insults, time to union as well as bone healing (nonunion, delayed union, malunion, leg length discrepancy, growth arrest), wound and infectious complications were collected. Comparisons were made between patients with open fractures and those with closed fractures.

**RESULTS:** We identified 14 patients with open fractures and a control group of 12 patients with closed injuries who underwent flexible nailing. Patients with open fractures were more likely to have polytraumatic injuries (71.0% vs. 25.0%, p = 0.04). There was no difference (p = 1.0) in the rates of compartment syndrome (open = 14.0% closed = 17.0%) between the two groups. Systemic complications (pulmonary compromise and increased intracranial pressure) were noted in two patients who underwent immediate nailing of their open fractures; both of whom had closed head injuries. There was no difference (p = 1.0) in the rates of wound / infectious complications between the open (7.0%) and closed (4.0%) fractures groups, with no cases of wound breakdown or osteomyelitis. There was an increased rate (p = 0.02) of bone healing complications in the open fracture group (21.0% versus 4.0%); all in patients with Gustilo type 2 or 3 injuries. All patients achieved radiographic union at final follow up.

**DISCUSSION AND CONCLUSION:** Immediate flexible nailing of open pediatric tibial shaft fractures can be safely performed with minimal risk of wound or infectious complications. Clinicians should understand that prolonged bone healing (particularly in Gustilo type 2 or 3 injuries) should be expected in patients who undergo immediate flexible nailing of their open fractures. Open tibial shaft fractures are high-energy injuries, and should be seen as surrogate markers of polytrauma in the pediatric population. The risk of compartment syndrome is high regardless of whether a patient has a closed or open tibia fracture, and caution should be utilized in performing flexible nailing in patients who may have closed head injury due to a risk of systemic complications.

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**Distal Femoral Valgus Overgrowth following Plate Fixation of Pediatric Femoral Shaft Fractures**

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Daniel J. Hedequist, MD, Boston, MA

**INTRODUCTION:** Treatment of pediatric femoral shaft fractures remains an area of evolving controversy, particularly for patients in the middle age group of childhood, from five to 12 years old. While increasing reports have led to narrowed indications for the use of flexible titanium intramedullary nails, evidence has emerged in parallel supporting the safe and effective application of submuscular plating, leading to an increase in use of plate fixation. This study investigated the frequency and risk factors associated with the development of distal femoral valgus overgrowth following plate fixation of diaphyseal femur fractures in children, a previously unreported phenomenon that can lead to deformity and other complications.

**METHODS:** Medical records of 85 patients, ages six to 15 years, who underwent plate fixation of a femoral diaphysis fracture at a single tertiary pediatric trauma center between 01/2003 and 12/2010 were reviewed. Demographic and clinical patient information, features of the fracture (pattern, location, pathologic vs. non-pathologic) and technical aspects related to surgery (open vs. closed reduction, type of plate, number/type of screws, bending of plate) were analyzed.

**RESULTS** Over an eight-year period, 15 surgeons performed plate fixation of pediatric diaphyseal femur fractures on 85 skeletally immature patients (17% female; mean age 10.2 y/o, range 6-15). Fracture site and pattern, and type of plating are summarized in Table 1. Plate length ranged from six holes to 18 holes. The plate was bent, either proximally or distally, in 72% of cases. Overall, 10 cases (12%) demonstrated distal femoral valgus overgrowth of ≥5°, eight (9%) of which occurred in patients with distal fractures, giving an incidence of 29% in the 28 distal fractures. According to the multivariate logistic regression model, patients who developed valgus overgrowth were significantly more likely to have a distal fracture type (p<0.001). Patients with distal plate placement ≥20mm were more likely to develop valgus overgrowth than those with greater distances (p=0.03). Risk of valgus deformity does not depend on site if the hardware is removed early; however it does depend on site if the hardware is removed after nine months from surgery or not at all (p<0.001).

**DISCUSSION AND CONCLUSION:** Progression towards distal femoral valgus deformity was detected in 12% of pediatric patients who underwent plate fixation at over an eight-year period and in 29% of the subset of patients with a distal fracture. We advocate removal of hardware within nine months in all cases that involve distal plate placement near the distal femoral physis (<2cm), particularly cases in which loss to follow up may be possible. Consideration should be given towards contacting patients with risk factors that may have been lost to follow up, as prevention or treatment of progressive deformity may be warranted.

## Table 1. Fracture and Plate characteristics

<table>
<thead>
<tr>
<th>Fracture Site n, (%)</th>
<th>Proximal</th>
<th>Midshaft</th>
<th>Distal</th>
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</thead>
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<tr>
<td>Distal</td>
<td>20, (23)</td>
<td>38, (45)</td>
<td>27, (32)</td>
</tr>
<tr>
<td>Fracture Pattern n, (%)</td>
<td>Oblique/Spiral</td>
<td>38, (46)</td>
<td>Transverse</td>
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<td>Comminuted</td>
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<tr>
<td></td>
<td>DCP</td>
<td>22, (26)</td>
<td>LISS</td>
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</tbody>
</table>

| Plate Type n, (%) | Recon Plating | 1, (1) |

*The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e. the drug or medical device is being discussed for an off label use). For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
INTRODUCTION: Increasing obesity among children is a major health care concern. The purpose of this study is to examine children with fractures, comparing those who are normal weight against those who are obese/overweight.

METHODS: A total of 224 consecutive pediatric fracture patients were enrolled into an Institutional Review Board-approved registry. Information collected at the time of injury included: sex, age, height, weight, fracture location and pattern. Patients two-16 years old were divided into two groups for comparison: (1) normal weight and (2) obese/overweight (defined as > 85th BMI for age). Statistical analysis was performed using Chi2 or Mann Whitney tests.

RESULTS: The total population of 224 patients consisted of < 2 years of age (18), normal weight (121) and obese/overweight (85). Obese patients made up 11.7% of the entire population; obese/overweight combined were 41.3% of the study group. There was no difference between the mean ages in the normal weight group (9.2 yrs) compared with the overweight/obese group (8.7 yrs). There was a slight increase in percentage of girls in the overweight/obese group (27/85, 31.8%), compared with the normal weight children (30/121, 24.8%), but this was not statistically significant. The distribution of upper and lower extremity fractures was also comparable between groups (64.5% normal vs. 65.9% overweight/obese). The normal weight group had higher rate of operative interventions compared to the overweight/obese group (8.7 yrs). There was a slight increase in percentage of girls in the overweight/obese group (27/85, 31.8%), compared with the normal weight children (30/121, 24.8%), but this was not statistically significant. The distribution of upper and lower extremity fractures was also comparable between groups (64.5% normal vs. 65.9% overweight/obese). The normal weight group had higher rate of operative interventions compared to the overweight/obese group, but this was not statistically significant (40.5% vs. 35.3%, p=0.54). However, the overweight/obese group had a significantly higher rate of growth plate injuries (40.0% vs. 23.1%, p=0.015).

DISCUSSION AND CONCLUSION: Eleven percent of children with fractures were obese which is lower than the expected prevalence of obesity in the general population. In contrast to the study by Rana, we report no statistical difference in the number of operative cases in the heavier children(1). While Rana studied children from trauma registries, our patient population included both low and high energy mechanisms of injury. The growth plate is the weakest part of the bone, so the finding that obese/overweight children had a greater number of growth plate injuries is not surprising. Future studies include continued expansion of this database with the hope that understanding fracture patterns based on weight will lead to better injury protection strategies for obese children in the future.

<table>
<thead>
<tr>
<th>UE Fracture</th>
<th>Operative</th>
<th>Growth</th>
<th>Plate Injury</th>
</tr>
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<tbody>
<tr>
<td>Normal Weight</td>
<td>70.0%</td>
<td>60.0%</td>
<td>50.0%</td>
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<tr>
<td>Overweight/Obese</td>
<td>70.0%</td>
<td>60.0%</td>
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Radiation Risk Associated with Diagnostic Studies for Spondylolysis in Children and Adolescents
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Winnie Zhu, MS, Philadelphia, PA
Norma Rendon, Philadelphia, PA
Jack M. Flynn, MD, Philadelphia, PA
Denis S. Drummond, MD, Philadelphia, PA

INTRODUCTION: Back pain is common in the pediatric population; spondylolysis is the most common radiographically identifiable cause with a prevalence of 5%. Diagnosis may be subtle, sometimes requiring one or more imaging studies. Radiation from these studies is directed at the pelvic bone marrow and intrapelvic organs. We sought to quantify the radiation risk and cost from imaging studies and apply it to all patients diagnosed with spondylolysis at our institution.

METHODS: We retrospectively reviewed records of patients aged 10-19 years diagnosed with spondylolysis at our institution from 1/1/2000 - 1/1/2008. Patients without imaging studies at our institution were excluded. With PCXMC software and ICRP103 risk models we calculated age-specific radiation effective doses, cancer “risk of exposure induced death” (REID) and loss of life expectancy for males and females 0-15 years, 16-18 years and >18 years for plain films, fine cut 2-level L-spine CT scans (CTs) and bone scans. REIDs were summed for all imaging studies that patients received at our institution up to 4/1/2010.

RESULTS: A total of 172 patients (mean age 12.03 years) had a total of 507 studies for the workup of spondylolysis. Costs and gender-averaged cancer REIDs are shown in table 1. Bone scans exposed patients to much more radiation than CTs, MRIs and plain film studies. When applied to our patients, the REID per individual patient was an average of 318 deaths/million studies (range 0 - 2,303) and the average cost per patient was $2,900 (range $350 - $18,450). The summed REID is shown in figure 1. Most patients (78%) had a summed REID of less than 500 (per million). Ten patients (6%) received enough radiation for a summed cancer REID of over 1000 (per million).

DISCUSSION AND CONCLUSION: The radiation exposure and REID of a four-view x-ray study is comparable to a limited CT study. The bone scan exposes patients to the highest dose and risk of all diagnostic exams using ionizing radiation. All but one patient in our study with a cancer REID >1000 (per million) had a bone scan. Clinicians must weigh these quantified risks with the benefits of each diagnostic study in the diagnosis and management of spondylolysis.

Costs and Age-Specific Radiation Effective Doses for Diagnostic Studies.

<table>
<thead>
<tr>
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<th>Cost</th>
<th>Cancer Risk of Exposure Induced Death (per million)</th>
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<tr>
<td>all ages</td>
<td></td>
<td>0-15 y/o 16-18 y/o &gt;18 y/o</td>
</tr>
<tr>
<td>2-view</td>
<td>$350</td>
<td>49 44 27</td>
</tr>
<tr>
<td>4-view</td>
<td>$500</td>
<td>88 79 51</td>
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<td>CT</td>
<td>$2,000</td>
<td>106 94 63</td>
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<tr>
<td>BS</td>
<td>$1,650</td>
<td>472 386 228</td>
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<tr>
<td>MRI</td>
<td>$2,900</td>
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PAPERS, POSTERS & SCIENTIFIC EXHIBITS

PAPER NO. 332

Preliminary Experience with Clinical Use of a DNA Prognostic Test for Adolescent Idiopathic Scoliosis
Suken A. Shah, MD, Wilmington, DE
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INTRODUCTION: A commercially available saliva-based prognostic DNA test has been developed which utilizes a panel of 53 single nucleotide polymorphisms to predict the risk of progression in patients with mild adolescent idiopathic scoliosis (AIS) to a severe curve (>40°).

METHODS: Over the past two years, 196 patients with mild AIS who were skeletally immature underwent this test in a prospective, consecutive fashion in our practice. Scores were reported in a range of 1 to 200, with groups stratified as follows: Low risk (1-50), Intermediate risk (51-179) and High risk (180-200).

RESULTS: Ninety-five patients (48%) tested in the low risk (LR) group; 92 patients (47%) tested in the intermediate risk (IR) group; and nine patients (5%) tested in the high risk (HR) group. Mean age at testing was 11.8 yrs (range 9-14 yrs), and was similar among the three groups. The mean Cobb angle at testing was 16.6° (range 10-25°) and did differ significantly between group LR and the other two groups: the mean Cobb angle at time of testing was 13.3° in LR, 19.2° in IR and 24.1° in HR (p<0.001). Patients presenting with curves of less than 20° tested LR 63% of the time. Thus far, 101 patients have had at least one follow up (f/u) visit at a mean interval of 7.0 months and had a mean Cobb angle of 19.2°. The length of first f/u is significantly different: 3.4 months for HR, 6.7 months for IR and 8.5 months for LR (p<0.001). Forty-three patients have had a second f/u visit at a mean interval of 6.5 months after the first f/u visit with a mean Cobb angle of 21.2°. There was no difference among groups in the mean of the change in Cobb angles between visits. One patient in the HR group has progressed to 44° at the latest f/u. Thirty-six patients overall (23%) are being treated with a brace: 60% patients in HR, 33% in IR, and only 7% in LR (p<0.001). There has been a significant change in practice compared to historical controls.

DISCUSSION AND CONCLUSION: SA prospective series of patients who underwent prognostic AIS genetic testing is described. 48% tested low risk and had smaller curve magnitudes on the test date, a longer period between follow up visits and x-rays and a lower incidence of bracing. Follow up to at least skeletal maturity is required to make any statements about validation of the test for risk of children with mild AIS progressing to a severe curve. Significance: Proportions of AIS prognostic test results in our practice are different than those described by the developers.
of the test; it may be that our high acuity practice does not reflect a school screening population. This is important for clinicians in similar situations since it affects recommendations for anticipatory guidance.

PAPER NO. 333

Pitx1 Haploinsufficiency Causes Clubfoot in Humans and a Clubfoot-like Phenotype in Mice

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Matthew B. Dobbs, MD, Saint Louis, MO
Christina A. Gurnett, MD, PhD, Webster Groves, MO

INTRODUCTION: Clubfoot affects one in 1,000 live births, though little is known about its genetic or developmental basis. We recently identified a missense mutation in the PITX1 bicoid homeodomain transcription factor in a family with a spectrum of lower extremity abnormalities, including clubfoot. Because the E130K mutation reduced PITX1 activity, we hypothesized that PITX1 haploinsufficiency could also cause clubfoot.

METHODS: We identified 40 isolated idiopathic clubfoot probands with at least one affected first-degree relative. DNA was extracted from all affected individuals following the manufacturer’s protocol. To identify the genes responsible for isolated clubfoot, 40 probands with at least one affected first-degree relative were screened for genomic copy-number variants (CNVs).

Pitx1 +/- mice were bred and genotyped in our laboratory. Magnetic resonance imaging (MRI)/magnetic resonance angiography (MRA) of the hind limbs of the clubfoot mice were performed using a 4.7 small-animal MR scanner. The arterial patterns were subjectively compared between limbs, using the contralateral normal limb as a control. Muscle, fat and total limb volume measurements were quantified using the semi-automated image software ImageJ 1.44. To evaluate skeletal structures, 3D micro-computed tomography scanning was performed (45kVp, 177uA, 0.031 mm isometric voxel resolution, 100 ms integration time). Hindlimb buds were collected from Pitx1 +/- mated mice at embryonic day E12.5 and genotypes were determined by PCR of DNA isolated from tails.

RESULTS: We identified a 241kb chromosome 5q31 microdeletion involving PITX1 in a patient with isolated familial clubfoot. The PITX1 deletion segregated with autosomal dominant clubfoot over three generations. To study the role of PITX1 haploinsufficiency in clubfoot pathogenesis, we began to breed Pitx1 knockout mice. Although Pitx1 +/- mice were previously reported to be normal, clubfoot was observed in 20 of 225 Pitx1 +/- mice, resulting in an 8.9% penetrance. Clubfoot was unilateral in 16 of the 20 affected Pitx1 +/- mice, with the right and left limbs equally affected, in contrast to right-sided predominant hindlimb abnormalities previously noted with complete loss of Pitx1. Peroneal artery hypoplasia occurred in the clubfoot limb and corresponded spatially with small lateral muscle compartments. Tibial and fibular bone volumes were also reduced. Skeletal muscle genes expression was significantly reduced in Pitx1 +/- E12.5 hindlimb buds compared to wild-type, suggesting that muscle hypoplasia was due to abnormal early muscle development and not disuse atrophy.

DISCUSSION AND CONCLUSION: Our morphological data suggest that PITX1 haploinsufficiency may cause a developmental field defect preferentially affecting the lateral lower leg, a theory that accounts for similar findings in human clubfoot.

PAPER NO. 334

Distraction Osteogenesis Utilizing a Longitudinal Corticotomy

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Sebastien Lustig, MD, Lyon, France
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Faisal A. Al-Saati, PhD, Riyadh, Saudi Arabia

INTRODUCTION: Distraction osteogenesis can be utilized to lengthen long bones that are abnormally short secondary to trauma, infection or congenital deformities. Traditionally described techniques involve the creation of a transverse corticotomy followed by gradual distraction until the desired lengthening is achieved. A consolidation phase follows, during which the newly formed bone ossifies and gains strength. This phase can often be prolonged, introducing a risk of fracture. We hypothesize that the use of a longitudinal corticotomy (S-Z osteotomy) results in more rapid

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consolidation following distraction osteogenesis of shortened tibiae.

METHODS: Sixty-seven lengthening procedures were performed in 51 patients ranging in age from nine to 38 years (mean 25 years). Diagnoses included short stature (32 tibiae), post-polio limb deformity (22 tibiae), osteomyelitis (three tibiae), trauma (two tibiae) and other diagnoses (eight tibiae). Forty-five lengthenings were performed via a longitudinal corticotomy in the shape of an S (left tibia) or a Z (right tibia) (S-Z osteotomy) and 22 were performed via a transverse corticotomy. Patients were followed until consolidation of the regenerated bone was noted radiographically. The healing index (consolidation time per centimeter of lengthening) was calculated for each patient and any complications were noted. The mean healing index was compared between the two groups.

RESULTS: The healing index was significantly lower in the S-Z group (30.8 ± 9.6 days/cm) than in the transverse corticotomy group (46.8 ± 20.2 days/cm) (p < 0.0001). The mean lengthening was 6.6 cm (range: 2.5 to 12.5 cm) in the S-Z group and 5.8 cm (range: 2.0 to 12.0 cm) in the transverse group (p = 0.28). The mean consolidation time was 6.3 ± 2.8 months (range: three to 16 months) in the S-Z group and 8.1 ± 3.8 months (range: three to 13.5 months) in the transverse group (p = 0.03). One fracture of the regenerate bone occurred in the transverse group and none occurred in the S-Z group.

DISCUSSION AND CONCLUSION: The S-Z osteotomy safely reduces consolidation time of regenerative bone in the tibia when used during distraction osteogenesis.

PAPER NO. 335
Predicting the Need for Tibialis Anterior Tendon Transfer in Patients with Idiopathic Clubfoot
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Alice Chu, MD, Livingston, NJ
Debra A. Sala, PT, New York, NY
Wallace B. Lehman, MD, New York, NY

INTRODUCTION: The purpose of this study was to determine if there are early factors associated with the need for tibialis anterior tendon transfers in patients with idiopathic clubfoot who have been treated with the Ponseti method.

METHODS: All patients treated with idiopathic clubfoot at our institution since 2000 were evaluated. Patients who underwent surgical procedures other than tibialis anterior tendon transfer were excluded. Charts were queried and data was collected for each patient. Age at presentation, history of previous treatment, number of casts used, need for percutaneous heel cord tenotomy, age of initiation of foot abduction orthosis (FAO), compliance with FAO, need for additional casts were recorded and need for tibialis. Dimeglieo and Catterall scores were recorded at initial presentation and at initiation of FAO.

RESULTS: Since 2000, 227 patients with idiopathic clubfoot have been followed. Of these, 186 had the possibility of at least three years of follow up. Sixty-one patients (43 percent), had complete records with greater than three years of follow up from the time of initial presentation (mean=62.7 +20.4 months). Of the total 89 feet, 38 feet had undergone tibialis anterior tendon transfers at the time of data collection (42 percent). Patients who underwent tendon transfers did not differ from those who did not require surgical intervention in terms of sex, involved side, the age at initial presentation, history of previous treatment or the need for a percutaneous heel cord release. Patients who eventually required tibialis anterior tendon transfer had significantly higher Dimeglieo (15.00 compared to 12.77, p<0.0001) and Catterall scores (4.80 compared to 3.80, p=0.007) at initial presentation as well as significantly higher Dimeglieo scores at initiation of the bar (3.42 compared to 2.17, p=0.002). The transfer group patients needed more casts for correction (5.84 compared to 5.14, p=0.017), were less compliant with FAO (p=0.003) and were more likely to need additional casting after initiation of the FAO (p=0.04).

DISCUSSION AND CONCLUSION: In our cohort of idiopathic clubfoot patients treated with the Ponseti technique, those requiring tibialis anterior tendon transfer tend to present with worse Dimeglieo anterior tendon transfer and Catterall scores, require more casts to achieve correction and are less frequently compliant with use of the Denis-Browne Bar.

PAPER NO. 336
Treatment of Adduction Deformity in Relapsed Clubfoot: A New Mini Invasive Technique
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Luca Labianca, MD, Rome, Italy
Francesco Turturro, MD, Rome, Italy
Russalka Hoedemaeker, MD
Cosma Calderaro, Rome, Italy
Vincenzo Di Sanzo, MD, Rome, Italy
Andrea Ferretti, Rome, Italy

INTRODUCTION: Adduction of the forefoot is the most common deformity in relapsed clubfoot. It may cause functional disability. Adduction is caused by a length inequality between the medial and the lateral column of the foot. Several techniques have been described to correct this inequality. Known complications of these, often difficult, surgical procedures are overcorrection, stiffness and arthritis. Therefore we developed a new technique using an eight plate and performing a temporary arthrodosis of the calcaneus-cuboid joint to compensate with growth the length difference between the medial and lateral column.

METHODS: We selected 10 patients with relapsed clubfoot presenting mild adduction deformity; all patients underwent temporary arthrodosis of the calcaneus-cuboid joint by a guided-growth treatment with the eight-plate device. Radiological controls were planned before surgery and then at first, third and every four months until correction was satisfying. Talus-I metatarsus angle and calcaneus-IV metatarsus angle were evaluated. RESULTS: In all cases full correction was obtained, with a significant improvement (p<0.05) of both measured angles.The eight-plate was then removed. At three-year follow up, none of the patients presented overcorrection or relapse of the deformity. All patients had good function.

DISCUSSION AND CONCLUSION: This is a minimally invasive technique that does not require casting and allows immediate post-operative weight bearing. An eight plate device was used to perform a temporary arthrodosis of the calcaneus-cuboid joint to manage the length difference between medial and lateral column. This avoids the need to perform subsequent surgeries to correct a deformity over time. Our preliminary results suggest that this new technique can be a valid alternative in selected cases.
**Long-term Follow Up of Van Nes Rotationplasty for Proximal Focal Femoral Deficiency**

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**Jeffrey D. Ackman, MD, Chicago, IL**
**Ann Flanagan, PT, PCS, Chicago, IL**
**Mary Peer, PT, Chicago, IL**
**Adam Graf, MS, Chicago, IL**
**Joseph Krzak, MD, Brookfield, WI**
**Sahar Hassani, MS, Chicago, IL**
**Gerald Harris, MD, Brookfield, WI**

**INTRODUCTION:** Proximal focal femoral deficiency (PFFD) is a congenital anomaly that presents challenges for orthopaedic and prosthetic management. The Van Nes rotationplasty is one treatment in which the extremity is surgically rotated to utilize the ankle and foot as a functional knee joint in a prosthesis. The purpose of this study is to determine the long-term functional and quality of life (QOL) outcomes for individuals who have undergone rotationplasty surgery for congenital PFFD compared to age and gender matched controls.

**METHODS:** This prospective study had 12 prosthetic participants (PFFD Group: 8 M, 4F, age range 16-57 years) average 31.6±13.5 years and 12 control participants (Control Group: 8M, 4F) with an average age 32.6±14.1 years. Participants completed the following outcome questionnaires: SF-36, Revised-Faces Pain Scale, Harris Hip Score, Oswestry back pain score; and the Prosthetic Evaluation Questionnaire© (PEQ). The Wilcoxon Signed rank test was used to statistically compare each PFFD Group participant to the matched Control Group participant with values statistically significant at p<0.0123.

**RESULTS:** Participants had rotationplasty performed at an average age of 6.5±3.9 years with follow up testing done 25.1±11.2 years later. All adult subjects were working full time in a variety of manual and office/desk jobs. No significant issues were seen for body image. Pain: The PFFD and Control Groups both reported similar low back pain with 6.8±9.7% and 7.0±13.0% disability respectively on the Oswestry back pain questionnaire. On the day of testing, only one PFFD participant reported mild low back pain on the Revised-Faces Pain Scale. The average Harris Hip Score for the PFFD Group was 92.7±9.2 out of 100, indicating excellent outcome. Two participants reported pain on their non-prosthetic hip. ROM: The PFFD Group showed significantly decreased hip flexion and ankle dorsiflexion, and increased ankle plantarflexion strength on the prosthetic side compared to the Control Group. The PFFD Group had significantly greater ankle abduction strength on their non-prosthetic side compared to the Control Group. Strength: The PFFD Group demonstrated significantly weaker hip flexion, hip abduction and ankle plantarflexion on the prosthetic side compared to the Control Group. TUG: The PFFD Group scored an average of 8.5±1.6 seconds on the TUG, demonstrating a low fall risk. The Control Group scored significantly lower with an average of 6.5±1.0 seconds. SF-36: There were no significant differences between the groups in overall health and well-being. PEQ©: The PFFD Group scored lower in areas of satisfaction, appearance, and sounds of the prosthesis. However, participants reported that others perceived them well and they did not see themselves as a social burden. Gait Analysis: Temporal-spatial gait parameters for the PFFD Group demonstrated significant decrease in cadence, stride time, opposite foot off, single support and walking speed compared to Control Group. Posturography: The PFFD Group showed significant decrease in symmetry in stance, as well as a decrease in end point and maximum excursion in limits of stability testing compared to the Control Group.

**DISCUSSION AND CONCLUSION:** Overall, long-term follow up of teens and adults who underwent Van Nes rotationplasty showed that they maintained a high level of function, participation and QOL. They did present with significant differences in temporal spatial and posturography parameters compared to the Control Group.

**Implant Costs, Fixation Points, and Patient Outcomes: Implications for the Surgical Treatment of AIS**

**Suneel B. Bhat, MD, Philadelphia, PA**
**Jeffrey A. Rihn, MD, Media, PA**
**Kristen E. Radcliff, MD, Margate City, NJ**
**Todd J. Albert, MD, Philadelphia, PA**
**Alexander Vaccaro, MD, PhD, Gladwyne, PA**
**Alan S. Hilibrand, MD, Philadelphia, PA**
**D. Greg G. Anderson, MD, Moorestown, NJ**
**Timothy T. Ward, MD, Pittsburgh, PA**

**INTRODUCTION:** Surgical correction is indicated in patients with progressive adolescent idiopathic scoliosis (AIS). There has been an ongoing trend towards the use of pedicle screws and increasing implant fixation points to achieve correction. However, in the context of unclear clinical benefit of more complicated, costly surgical constructs, implant costs with associated scoliosis surgery are of increasing concern to hospitals and surgeons. This study aimed to identify whether the number of fixation points or the cost of implants used in corrective scoliosis surgery is predictive of percent Cobb angle correction, SRS-22 outcome scores or reoperation.

**METHODS:** We retrospectively reviewed a cohort of patients who underwent surgical correction of AIS by a single surgeon at a single institution between March 1986 and March 2010. Patients were excluded if implants used were unknown. Demographic data, complication/reoperation, curve description, surgical plan, pre- and post-operative Cobb angle measured by standard technique, implants used and SRS-22 scores were collected. Standardized
itemized hospital implant costs were obtained by averaging the unit cost per implant across the three highest volume suppliers to a tertiary level pediatrics hospital, adjusted to 2009 dollars. Multiple regression analysis for continuous outcome variables and logistic regression analysis for dichotomous outcomes were used to analyze the relationship between the number of fixation points and total cost of implanted hardware with outcomes. RESULTS: A total of 270 patients were identified for inclusion in the analysis, with a mean age of 14.7. Mean percent Cobb angle correction for structural PT, structural MT, and structural TL/L curves respectively was 24.0%, 48.5% and 44.4%, and mean total SRS-22 score was 82.98. The re-operation rate for the cohort was 15.6%. The mean number of fixation points used was 13.53, and the mean implant cost for the cohort was $11,316.43 with a range of $3,406.28 to $22,701.20. None of the factors in multiple regression models of age, sex and either number of fixation points or total implant cost were significantly predictive of percent Cobb correction of the structural curve or total SRS score. Logistic regression of age, sex and total implant cost was not significant for reoperation, however in a logistic regression model of age, sex and number of fixation points, the latter factor was significantly associated with reoperation at $p=0.32$.

**DISCUSSION AND CONCLUSION:** Increased use of hardware, either with greater number of fixation points, or with more expensive implant modalities, or both, does not significantly improve Cobb correction or SRS outcome scores. However, increasing the number of fixation points does increase the risk of reoperation. In the context of the tremendous economic implications of implant costs in surgical correction of scoliosis, where possible, surgical constructs that minimize implant usage - for example alternating levels for pedicle screws or favor less expensive hardware - for example hybrid constructs, would result in cost savings, reduce reoperation rates and not result in significant change of clinical outcomes.

**PAPER NO. 339**

**Use of Bipolar Sealer Device Reduces Blood Loss and Transfusions in Posterior Spinal Fusion**

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Jochen P. Son-Hing, MD, Cleveland, OH  
George H. Thompson, MD, Cleveland, OH

**INTRODUCTION:** Use of a bipolar sealer device in posterior spinal fusion for idiopathic scoliosis significantly reduced blood loss and transfusion rate when compared to a control group in this retrospective review. Reducing perioperative blood loss and the need for transfusions in patients undergoing spinal surgery is important to orthopedic surgeons. Since 2001 at our institution all pediatric patients undergoing posterior spinal fusion for idiopathic scoliosis receive epsilon aminocaproic acid during surgery, which we have shown in previous studies to significantly reduce perioperative blood utilization. As an effort to further reduce blood loss and transfusions, we began using a bipolar sealer device as an adjunct to electrocautery. We present the results of our first 25 months of experience with this device.

**METHODS:** Using a prospectively maintained database we reviewed the operative time, estimated blood loss, cell saver use and intraoperative and postoperative transfusion rate in patients who underwent posterior-only spinal fusion for idiopathic scoliosis. Fifty patients were identified who fit these criteria since the use of the bipolar sealer device was instituted. We compared these patients to a control group of the preceding 50 patients in whom this device was not used for hemostasis. All patients, including those in the study group, received aminocaproic acid (infusion of 100 mg/kg over 15 to 20 minutes, then 10 mg/kg per hour throughout the remainder of the procedure). The surgical technique did not differ between the two groups.

**RESULTS:** Baseline characteristics between the two groups were similar except for the number of levels fused, which was larger in the investigational group (12.5 versus 11.8, $p=0.027$). There was no difference in operative time or hospital length of stay. Intraoperative blood loss in the investigational group and control group was 597mL and 1085mL respectively ($p<0.0001$). Total perioperative blood loss, including postoperative drain output, was 1266mL in the study group and 1600mL in the control group ($p=0.01$). Intraoperative cell saver transfusion was lower in the study group, 127mL versus 200mL ($p=0.001$). Eleven patients in the study group and 26 patients in the control group required additional intraoperative or postoperative transfusions ($p=0.004$). The number of packed red cell units transfused per patient was 0.26 in the study group and 0.58 in the control group ($p=0.034$), reducing the transfusion rate by over 50%. Total blood volume transfused, including cell saver and any other additional transfusions, was also significantly lower in the study group, 212mL versus 388mL ($p<0.001$).

**DISCUSSION AND CONCLUSION:** Use of a bipolar sealer device significantly reduces total perioperative blood loss and transfusion requirements in posterior spinal surgery for idiopathic scoliosis.

**PAPER NO. 340**

**Are Oblique Views Valuable in the Diagnosis of Spondylolysis in Children?**

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Winnie Zhu, MS, Philadelphia, PA  
David A. Spiegel, MD, Philadelphia, PA  
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Wuddhan V. Sankar, MD, Wynnewood, PA  
Jack M. Flynn, MD, Philadelphia, PA

**INTRODUCTION:** Obtaining anteroposterior (AP), lateral (LAT) and right and left oblique radiographs are standard practice in children with a clinical suspicion of spondylolysis. Recent concerns regarding radiation exposure and costs have brought into question the value of obtaining oblique views.

**METHODS:** Radiographs of 50 patients with L5 spondylolysis without a lisshtesis and 50 controls were retrospectively reviewed. A power analysis confirmed the sample size was sufficient.

**RESULTS:** There was no significant difference in test characteristics between four-view and two-view plain films in the diagnosis of spondylolysis (See table). Sensitivity, specificity, inter- and intra-rater ICC and agreement with GS ICC had no statistical difference. Overall agreement for inter- and intra-rater agreement was assessed with percent overall agreement and intraclass correlation coefficients (ICC). PCXMC software generated effective radiation doses. Study charges are from radiology billing data.

**RESULTS:** There was no significant difference in test characteristics between four-view and two-view plain films in the diagnosis of spondylolysis (See table). Sensitivity, specificity, inter- and intra-rater ICC and agreement with GS ICC had no statistical difference. Overall agreement for inter- and intra-rater reliability was moderate for both. Percent overall agreement was 79.8% for four-view and 79.7% for two-view. Test characteristics are shown in table 1. Radiation effective dose was 1.26 mSv for four-view studies and 0.72 mSv for two-view (Δ=0.54 mSv).
mean sagittal tibial condylar inclination of the medial tibial plateau group and four degrees medial in the control group (p=0.62). The coronal were noted in the lateral compartment. The mean coronal tibial cartilage morphology between the Blount and the control groups averaged 6.7 mm in the Blount and 2.3 mm in the control group (p=0.33). The thickness of the unossified cartilage of the proximal medial tibial epiphyses was eight degrees posterior in the Blount group and four degrees posterior in the control group (p=0.11). The sagittal bimemiscal inclination averaged four degrees posteriorly in the Blount group and three degrees posterior in the control group (p=0.53).

RESULTS: The medial meniscal mid-coronal height was 7.6 mm with GS ICC 0.96 and intra-rater ICC 0.89. The mean height of the anterior and posterior horn of the meniscus was noted in 11 limbs (33%) in the Blount group and 4.8 mm (p<0.0001) and 5.3 mm (p<0.0002) respectively in the control group. Abnormal signal changes were noted in the unossified proximal medial tibial epiphyses, tibial condylar and meniscal inclination as well as increased height and width of the medial meniscus, especially posteriorly, as well as greater frequency of abnormal signals and tears of the medial meniscus. The morphologic changes of the medial compartment appear to compensate for the diminished height of the ossified portion of the medial tibial epiphyses. These findings may be related to abnormal mechanical stresses of the growing proximal tibia in these typically obese children.

INTRODUCTION: The clinical and radiographic abnormalities of the lower limb in children with Blount disease are well known. However, there is controversy regarding the nature of intra-articular morphologic changes in the involved knee joint. The purpose of our study was to evaluate the meniscal and articular surface morphology in children with Blount disease using MRI and compare these findings with similar measurements in a control group. METHODS: Using a single surgeon's database, 26 children with 33 affected knees with Blount disease (16 early onset, 17 late onset), mean age 10.5 years (range 3.1 -18.1), who had undergone a pre-operative MRI of the involved knee were identified. Twenty children without Blount disease, mean age 9.6 years (range 5.4-15.9), who had an MRI of the knee to evaluate juxta-articular pathology were used as control subjects. The coronal and sagittal morphometric parameters including the height and width of the medial and lateral meniscus, thickness of the unossified proximal tibial epiphyses, tibial condylar and meniscal inclination as well as presence of signal changes/ tears of the menisci were documented in both groups using standardized measurement technique. RESULTS: The medial meniscal mid-coronal height was 7.6 mm in the Blount and 4.6 mm in control group (p<0.0001). Meniscal width was 10.5 mm in the Blount and 7.0 mm in the control group (p<0.0001). The mean height of the anterior and posterior horn of the medial meniscus was 6.7 mm and 7.3 mm in the Blount group and 4.8 mm (p<0.0001) and 5.3 mm (p<0.0002) respectively in the control group. Abnormal signal changes were noted in the medial meniscus in 12 limbs (36%) in the Blount group and one limb (5%) in the control group (p=0.008). A hypertrophic medial meniscus was noted in 11 limbs (33%) in the Blount group and no limb (0%) in the control group (p=0.004). The thickness of the unossified cartilage of the proximal medial tibial epiphyses averaged 6.7 mm in the Blount and 2.3 mm in the control group (p=0.0005). No such differences in meniscal or unossified cartilage morphology between the Blount and the control groups were noted in the lateral compartment. The mean coronal tibial condylar inclination was six degrees medial in the Blount and three degrees medial in the control group (p=0.10). The coronal bimemiscal inclination averaged four degrees medial in the Blount group and four degrees medial in the control group (p=0.62). The mean sagittal tibial condylar inclination of the medial tibial plateau was eight degrees posterior in the Blount group and four degrees posterior in the control group (p=0.11). The sagittal bimemiscal inclination averaged four degrees posteriorly in the Blount group and three degrees posterior in the control group (p=0.53).

Using multivariate regression analysis, body mass index (BMI) correlated with the height of the medial meniscus in the coronal (p= 0.0035) and sagittal plane (posterior horn) (p= 0.0037). DISCUSSION AND CONCLUSION: This is the largest study to date documenting MRI findings in patients with Blount disease. Compared to the control group, children with Blount disease have increased thickness of the unossified proximal medial tibial epiphyses, increased height and width of the medial meniscus, especially posteriorly, as well as greater frequency of abnormal signals and tears of the medial meniscus. The morphologic changes of the medial compartment appear to compensate for the diminished height of the ossified portion of the medial tibial epiphyses. These findings may be related to abnormal mechanical stresses of the growing proximal tibia in these typically obese children.

INTRODUCTION: The goal of this study was to compare the results of two different protocols (Ponseti and Kite) for the treatment of idiopathic clubfoot. METHOD: Ponseti’s and Kite’s methods of conservative management in idiopathic congenital clubfoot were compared in a prospective randomized study consisting of 100 infants (150 feet) younger than three months. There were 76 and 74 feet that underwent treatment by Ponseti’s and Kite’s methods, respectively. RESULTS: After an average follow up of 36.2 months in the Ponseti group, correction was achieved in 73 feet (96%), with only three patients requiring surgical management. There were 10 relapses (13.2%), all of which were corrected conservatively. However, two of these required surgical intervention on showing a relapse again in the second year. In the Kite group, we achieved correction in 55 feet (74.3%) after an average follow up of 35.1 months, with 19 patients requiring surgical intervention. There were 10 relapses of which only five could be corrected conservatively. Both groups were reviewed by blinded reviewers and rated according to Pirani score. DISCUSSION AND CONCLUSION: We think that Ponseti’s method is superior to Kite’s method in achieving correction in idiopathic clubfeet in a relatively shorter time.

INTRODUCTION: Insertion of pedicle screws is not without potential risks, especially in the thoracic spine. The use of O-arm is increasing (203 in the United States; 91 outside of the United States) as it has been shown that pedicle screw placement in posterior spinal surgery is more accurate when performed under CT guidance. Our hypotheses are that both free hand and navigation techniques are associated with more accurate screw placement, but the time for imaging and the amount of radiation is greater using the navigation/real time technique. METHODS: A retrospective review of operative and radiographic

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PAPER NO. 343

Accuracy and Safety of Insertion of Pedicle Screws Using the O-arm in Pediatric Spinal Deformity Surgery

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INTRODUCTION: Insertion of pedicle screws is not without potential risks, especially in the thoracic spine. The use of O-arm is increasing (203 in the United States; 91 outside of the United States) as it has been shown that pedicle screw placement in posterior spinal surgery is more accurate when performed under CT guidance. Our hypotheses are that both free hand and navigation techniques are associated with more accurate screw placement, but the time for imaging and the amount of radiation is greater using the navigation/real time technique. METHODS: A retrospective review of operative and radiographic
records of patients on whom the O-arm was used from 2007-2011 for posterior spinal surgery using thoracic and lumbar screws was performed. Patients were divided into two groups: the non real time group (NRTG) freehand technique in which the pedicle screws were placed using the O-arm at the end of screw placement and the real time group (RTG) navigation technique in which the screws were placed using navigation technology. Categorical variables and group comparisons were analyzed by the chi-square test and the Fischer’s exact test. Student t-test was used for continuous variables. A p value ≤ 0.05 was considered statistically significant for all analyses. RESULTS: Eighty-four patients were included in this study. The average age was 14.13 years (4.5 - 21.9 years). Adolescent idiopathic scoliosis was the most common underlying diagnosis (61%). There were 42 patients in the NRTG and 42 patients in the RTG. A total of 1,367 pedicle screws were placed in both groups (average of 16.3 screws per patient). Both groups were homogeneous in age, number of screws and pedicle levels (p < 0.05). There were no neurological deficits in either group. In the NRTG, 16.7% required one screw change, and 40.5% required two-plus changes. There was one case in which a signal decrease resolved after repositioning of a pedicle screw. In the RTG, 11.9% required one screw change, and 4.8% required two-plus changes. Less screws required replacement in the RTG (nine vs. 57; p < 0.0001), but the O-arm was used more frequently within the RTG (1.8 vs. one, p < 0.0001). Surgical time was longer within the RTG (334.90 vs. 287.79 min, p=0.025). The total number of CT spins within the RTG per patient was higher than the number within the NRTG (3.32 vs. 1.77, p<0.0001). The total amount of radiation received per patient was higher in the RTG (57.08 vs. 35.30 mGy, p<0.0001).

DISCUSSION AND CONCLUSION: The use of the O-arm allows for more accurate and safer placement of pedicle screws. The NRTG is faster, with less exposure to radiation. The RTG required fewer screw changes, but increased surgical time, and O-arm radiation exposure. Both techniques are valuable in that they serve as an excellent learning and teaching tool in pedicle screw placement.

PAPER NO. 344

◆Pediatric Pedicle Screw Placement Using Intraoperative CT and 3D Image-Guided Navigation

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INTRODUCTION: Pedicle screws are widely used in children for the correction of spinal deformity. Intraoperative CT-guided navigation systems are available as an adjunct to fluoroscopy and anatomic techniques for pedicle screw placement. This study reports the accuracy of open pedicle screw placement in pediatric patients using intraoperative CT-guided navigation. Results are compared to the same technique in adults and to previous literature reports.

METHODS: Between 2007-2010, 984 pedicle screws were placed in a consecutive series cohort of 50 pediatric patients for spinal deformity correction. Intraoperative CT (O-arm) was performed to establish reference points for the computerized navigation system. Screws were placed under real-time navigation guidance and then imaged. Need for redirection or removal of screw based on the intraoperative CT is the primary outcome measure for this study. During the study period, 1,511 screws were placed in adult patients using the same image guidance system and surgical team.

RESULTS: Mean patient age was 14.4 years (range, seven to 18). Underlying diagnoses included idiopathic or neuromuscular scoliosis (43), Scheuermann’s kyphosis (three), congenital hemivertebra (two), acquired kyphotic deformity (one), thoracic instability after tumor resection (one). A total of 984 pedicle screws were placed using real-time navigation, with a mean of 20 screws per patient (range, two to 34). Based on intraoperative CT, 35 screws (3.6%) were revised (27 redirected, and eight removed) representing a 96.4% accuracy rate. Thoracic spine screw malposition was most common (see Figure). No patients returned to the OR due to screw malposition. Of the 1,511 screws placed in adult patients, 28 (1.8%) were revised intraoperatively for malposition on CT imaging, for an overall 98.2% accuracy rate. Screw revision thus was more common in the pediatric population (chi-square, p=0.008). However, the pediatric screw revision rate is significantly less than the findings from a recent meta-analysis of predominantly non-navigated screws in children, which reports a 94.9% accuracy rate (p=0.03). Further, Kosmopoulos et al. report comparable results in a cohort of adult patients (93.7% accuracy rate for navigated screws). They found an 86.6% accuracy rate in non-navigated screws, however, which is significantly poorer than our results (p<0.0001).

DISCUSSION AND CONCLUSION: We report 96.4% accuracy in pedicle screw placement using a CT-guided navigation system. This is similar to other reports in children, and better accuracy than a recent meta-analysis of non-navigated screws. Pedicle screw placement in children using CT navigation resulted in no identified complications and is a promising technique for improving the safety of pedicle screw placement.

PAPER NO. 345

High-Grade Spondylolisthesis in Children: Is it Safe to Pursue an Anatomic Reduction?

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INTRODUCTION: The optimal surgical treatment for high-grade spondylolisthesis in children remains unclear. The purpose of this study is to compare the outcomes of three different surgical techniques for the treatment of high-grade spondylolisthesis. METHODS: We retrospectively reviewed 28 cases of high-grade spondylolisthesis treated surgically over a 20-year period. Patients were divided into three groups: (1) in situ arthrodesis (n = 8); (2) arthrodesis with intraoperative reduction and posterior instrumentation (n = 7); and (3) arthrodesis with intraoperative reduction, wide nerve root...
DISCUSSION AND CONCLUSION: As expected, the intracapsular difference between diastolic blood pressure and hip pressure are a percentage of the mean arterial pressure as well as the similar trends when comparing the intracapsular hip pressure in the normal group was 21.8 mmHg. There was no the unstable SCFE group was 48.2 mmHg and the average SCFE group was 27.0 mmHg, while the average pressure in the stable SCFE group was 21.8 mmHg. This may explain why the risk of AVN in stable SCFE is significantly lower than that of unstable SCFE. It also supports the idea that capsulotomy is indicated for unstable slips to decrease the elevated hip pressure but not in stable SCFE.

PAPER NO. 362
Prevalence of Cam-Type Femoroacetabular Impingement in Asymptomatic Children and Adolescents
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INTRODUCTION: Femoroacetabular impingement (FAI) is an important cause of hip pain in the young adult, and may have an important role in the development of primary hip arthritis. The etiology of the anatomic deformity at the femoral head-neck junction in Cam-type FAI is at present unknown, and little is known about the role of skeletal development. Our study was designed to assess and compare the radiological morphology of the femoral head-neck junction in asymptomatic children with open physes versus adolescents with closed physes.

METHODS: A prospective cross-sectional study design was utilized. Healthy children without any history of lower extremity disease or symptomatology were recruited. Males were 10-12 years (pre-closure) or 15-18 years (post-closure); females were 8-10 years or 14-18 years. MRI and physical examination of the hips including impingement tests were carried out on both hips. Radiological assessment was blinded and alpha angles were measured at both the 3:00 (anterior head-neck junction) and 1:30 (antero-superior head-neck junction) radial image positions.

RESULTS: Fifty-two volunteers were recruited (32 boys, 20 girls; 28 open-physes, 24 closed-physes), of whom 44 had bilateral hips imaged (23 open-physes, 21 closed physes, total 88 hips imaged). Radiographic analysis showed 0/23 (0%) Cam-type morphology in pre-closure hips and 3/21 (14.3%) cam-type FAI deformities in the open-physes vs. closed-physes groups strongly suggests the importance of the period of physeal closure to the development of Cam-type FAI. Additionally, the difference between 3:00 and 1:30 radial image positions was significant; open-physes group means were 38.1° at 3:00 versus 45.2° at 1:30, while closed-physes group means were 42.0° at 3:00 versus 50.1° at the 1:30 position.

DISCUSSION AND CONCLUSION: The difference between alpha angle measurements at the 3:00 and 1:30 radial positions was significant; open-physes group means were 38.1° at 3:00 versus 45.2° at 1:30, while closed-physes group means were 42.0° at 3:00 versus 50.1° at the 1:30 position. The difference between alpha angle measurements at the 3:00 and 1:30 radial positions was significant; open-physes group means were 38.1° at 3:00 versus 45.2° at 1:30, while closed-physes group means were 42.0° at 3:00 versus 50.1° at the 1:30 position. The difference between findings of Cam-type FAI deformities in the open-physes vs. closed-physes groups strongly suggests the importance of the period of physeal closure to the development of Cam-type FAI. Additionally, the difference between 3:00 and 1:30 alpha angle measurements closely matched the published difference in adults, showing the importance of standardized alpha angle measurement in all populations.

PAPER NO. 361
Intracapsular Hip Pressure after Stable Slipped Capital Femoral Epiphysis
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Kelly L. Vanderhave, MD, Ann Arbor, MI
Jose A. Herrera Soto, MD, Orlando, FL

INTRODUCTION: Stable slipped capital femoral epiphysis (SCFE) has been shown to have a lower rate of avascular necrosis (AVN) than unstable SCFE. A recent study found increased intracapsular hip pressures in the setting of unstable SCFE, thus increasing the risk of AVN. The purpose of this study was to measure the intracapsular pressure in stable SCFE and compare it to the intracapsular pressure in normal hips and in unstable SCFE.

METHODS: Thirteen hips with stable SCFE and 15 hips with unstable SCFE were identified. Using a side-bored needle, intracapsular hip pressures were measured at the time of surgery. Within these two study groups, 11 unaffected (normal) hips were also measured. Diastolic blood pressure and mean arterial pressure at the time of measurement were recorded.

RESULTS: The average intracapsular hip pressure in the stable SCFE group was 27.0 mmHg, while the average pressure in the unstable SCFE group was 48.2 mmHg and the average pressure in the normal group was 21.8 mmHg. There was no significant difference between the normal and stable SCFE groups. There was a statistically significant difference between the stable SCFE and unstable SCFE groups (p < 0.0001). We found similar trends when comparing the intracapsular hip pressure are a percentage of the mean arterial pressure as well as the difference between diastolic blood pressure and hip pressure.

DISCUSSION AND CONCLUSION: As expected, the intracapsular pressure in the setting of stable SCFE approaches that of normal hips. This may explain why the risk of AVN in stable SCFE is significantly lower than that of unstable SCFE. It also supports the idea that capsulotomy is indicated for unstable slips to decrease the elevated hip pressure but not in stable SCFE.

PAPERS, POSTERS & SCIENTIFIC EXHIBITS PEDIATRICS
The Role of Obesity in Bilateral Slipped Capital Femoral Epiphysis
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INTRODUCTION: As the epidemic of childhood obesity continues to amplify, an increasing number of children are presenting with slipped capital femoral epiphysis (SCFE). Evidence suggests SCFE is occurring in greater overall volume, at increasingly younger ages, and in the form of bilateral SCFE (BL-SCFE) greater than historically reported. In contrast to unilateral SCFE (UL-SCFE), little information has been published on risk factors for BL-SCFE, and there is considerable controversy surrounding the role of prophylactic pinning of the contralateral hip in UL-SCFE patients. The purpose of this study was to evaluate obesity and other clinical features as potential risk factors for BL-SCFE and to investigate changes in patient body mass index (BMI) in the post-operative period.

METHODS: Records of 502 patients surgically treated for SCFE between 1990 and 2009 at a tertiary-care children's hospital were reviewed to identify the subset of patients diagnosed with BL-SCFE and were compared to a control group of UL-SCFE patients treated in a similar fashion. Multivariate logistic regression was utilized to identify possible risk factors for BL-SCFE, including gender, age, slip stability, slip chronicity, slip grade and obesity (based on the Centers for Disease Control and Prevention (CDC) age-specific and gender-specific Body Mass Index definition of obesity). Inclusion criteria consisted of ≥3 month post-operative follow up, presence of BMI recordings in the medical record at time of surgery and post-operative follow-up visits, and surgical treatment with in-situ percutaneous fixation. Trends related to changes in BMI postoperatively were analyzed.

RESULTS: Of 179 patients who met the inclusion criteria, 65 underwent surgery for BL-SCFE, either concurrently or in staged fashion, yielding a 36.3% incidence of BL-SCFE within this cohort. Among BL-SCFE patients, 42 (64.6%) were males. Mean age was 12.4 years for males and 11.4 for females (range, 8-17). Gender, slip stability, slip chronicity and slip grade were not associated with a higher risk of BL-SCFE. Patients with post-operative obesity (OR=3.7, 95% CI: 1.5-9.5, p=0.003), and age ≤10 years at the time of the first SCFE surgery (OR=2.5, 95% CI: 1.3-5.7, p=0.023) had an increased risk of presenting with or developing BL-SCFE. Among those who developed BL-SCFE, 73.3% were ‘obese’ at the primary SCFE procedure, whereas 88.9% had become ‘obese’ at the time of their contralateral SCFE procedure. Obese patients who lost enough weight to become ‘non-obese’ had an associated risk of progression to BL-SCFE significantly less compared to those who reMed ‘obese’ (OR=0.16, 95% CI: 1.2-116.5, p=0.026).

DISCUSSION AND CONCLUSION: In this series, obesity and age 10 years or younger represented significant risk factors for BL-SCFE, while gender, slip chronicity, slip stability and slip grade were not risk factors. Weight gain or persistence of BMI ≥95th percentile was associated with increased risk of developing a contralateral SCFE, while weight reduction after SCFE surgery was associated with significantly lower risk of development of contralateral SCFE. The importance of supervised therapeutic weight management programs for patients treated for UL-SCFE should be emphasized.

Transplantation of Stem Cells in an Experimental Perthes' Model Resulted in Maintenance of Femoral Head Sphericity
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INTRODUCTION: The deformation of the femoral head in Legg-Calvé-Perthes' disease is thought to occur during the remodeling that follows the ischemic necrosis of an immature femoral head, even though the disease is self-limiting and the blood supply is restored. This deformity can lead to an increased predisposition to degenerative joint disease and functional limitations. Our question was whether stem cells can positively alter the post ischemic necrosis remodeling. In a surgically induced piglet femoral head avascular necrosis (AVN) model, revascularization occurs by two weeks post surgery, remodeling is seen and the femoral head collapses by six to eight weeks. Our hypothesis is that the cells remaining in the femoral head after AVN is induced are insufficient to restore or maintain the femoral head. The aim of this study is to assess whether autologous stem cells transplanted into the operated femoral head after revascularization can favorably alter the history of femoral head deformation in this experimental model.

METHODS: AVN was surgically induced in 11 four to six week old Yorkshire piglets by ligating the blood vessels supplying the femoral head. The blood supply to the epiphysis immediately after surgery and before injection was assessed by contrast enhanced MRI. In nine animals, the epiphysis with AVN was injected under fluoroscopic guidance with 5x10^7 autologous mesenchymal stem cells, isolated from the bone marrow, and cultured under conditions that caused their differentiation into osteoblasts. In two control animals, femoral epiphyses were injected with the hydrogel carrier only. Animals were then sacrificed at three to five weeks post injection, and both operated and contralateral non-operated femoral heads were harvested and volumetric CT scan performed ex vivo. The epiphyseal height and physeal diameter were determined and epiphyseal quotient calculated by dividing height by diameter. Histological analysis was performed on both operated and contralateral heads to assess bone formation and osteoblastic and osteoclastic activity.

RESULTS: Contrast enhanced MRI confirmed that the femoral head after revascularization can favorably alter the post ischemic necrosis remodeling. In a surgically induced piglet femoral head avascular necrosis (AVN) model, revascularization occurs by two weeks post surgery, remodeling is seen and the femoral head collapses by six to eight weeks. Our hypothesis is that the cells remaining in the femoral head after AVN is induced are insufficient to restore or maintain the femoral head. The aim of this study is to assess whether autologous stem cells transplanted into the operated femoral head after revascularization can favorably alter the history of femoral head deformation in this experimental model. In nine animals, the epiphysis with AVN was injected under fluoroscopic guidance with 5x10^7 autologous mesenchymal stem cells, isolated from the bone marrow, and cultured under conditions that caused their differentiation into osteoblasts. In two control animals, femoral epiphyses were injected with the hydrogel carrier only. Animals were then sacrificed at three to five weeks post injection, and both operated and contralateral non-operated femoral heads were harvested and volumetric CT scan performed ex vivo. The epiphyseal height and physeal diameter were determined and epiphyseal quotient calculated by dividing height by diameter. Histological analysis was performed on both operated and contralateral heads to assess bone formation and osteoblastic and osteoclastic activity. Results: Contrast enhanced MRI confirmed that the femoral heads were avascular after the surgery and demonstrated restoration of the blood supply two weeks post surgery. It also demonstrated that the epiphyseal height of the operated femoral head tended to be less than that of the contralateral head prior to the injection. On gross inspection of harvested femoral heads, seven of nine experimental femoral heads were not morphologically collapsed as they were in the two control femoral heads and in historical controls. Of these seven, four had maintained epiphyseal height (range 9 to 12 mm) within 1 mm of the height of the contralateral femoral head (range 10 to 13 mm). The epiphyseal quotients of the operated femoral heads of these four animals were also maintained (range 0.37 to 0.47) compared to the contralateral heads (range 0.41 to 0.45). Histological analysis of these four heads showed extensive new bone formation including osteoblastic and osteoclastic activities associated with and independent of vascular invasion, suggesting that the restoration of the femoral head height and quotient was due to increased bone formation.
Effects of Non-weight Bearing on Preserving the Femoral Head Following Ischemic Osteonecrosis

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INTRODUCTION: Non-weightbearing (NWB) as a part of treatment for Legg-Calve-Perthes disease (LCPD) remains controversial. A clear scientific basis for the treatment is lacking. The purpose of this study was to determine the effect of NWB on preventing the development of the femoral head deformity following ischemic osteonecrosis. A piglet model was used since it is a well described model which produces femoral head deformity similar to LCPD.

It was hypothesized that NWB will decrease the development of femoral head deformity following ischemic osteonecrosis in immature pigs. This study was approved by our local IACUC.

METHODS: Sixteen piglets were induced with right femoral head ischemia by placing a ligature tightly around the femoral neck and transecting the ligamentum teres. Eight animals received a below or above knee amputation at the time of ischemia surgery to prevent weight bearing on the ischemic head (NWB group). The remaining eight piglets did not receive an amputation surgery and were allowed to weight bear as tolerated (WB group). The contralateral, normal femoral heads of the WB group were used as normal controls. All animals were sacrificed at eight weeks post-ischemia.

RESULTS: Radiographic, CT, and micro-CT assessments were performed. Radiographic assessment showed significantly better preservation of the femoral head shape in the NWB group compared to the WB group. The epiphyseal quotient (a ratio of femoral head height to diameter) was significantly higher in the NWB group (0.41±0.06, p<0.001) compared to the WB group (0.27±0.07), indicating a greater deformity in the WB group. In comparison to the normal control group (0.48±0.01), NWB had significantly lower epiphyseal quotient (0.41±0.06), indicating that even the NWB group had some degree of deformity.

CT and micro-CT assessments of the femoral heads revealed large areas of bone resorption in the NWB and WB groups with greater collapse in the WB group. Micro-CT analysis of the epiphyseal bone parameters revealed a significant loss of the bone volume in the ischemic femoral heads compared to the normal femoral heads in both groups. No significant difference in the trabecular bone volume, thickness and number were observed between the WB and NWB groups.

CONCLUSION: The findings of this study demonstrate that non-weight bearing decreases the development of femoral head deformity following ischemic osteonecrosis. However, it does not completely prevent the deformity nor does it stimulate bone formation and healing. We postulate that in addition to non-weight bearing, therapeutic strategies to stimulate bone formation and inhibit bone resorption will be beneficial to optimize bone healing and to shorten the duration of the disease.
The Seeds of Flatback: Reciprocal Loss of Lumbar Lordosis Following Selective Thoracic Fusion
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INTRODUCTION: Segmental posterior spinal instrumentation and fusion (PSIF) has become the standard of care for surgical treatment of severe adolescent idiopathic scoliosis (AIS). A common outcome of these procedures is loss of physiological thoracic kyphosis (TK). Studies show that in adults, flattening of TK and lumbar lordosis (LL) can develop pain and dysfunction associated with “flatback syndrome.” Analysis of post-fusion sagittal alignment is lacking in the AIS population. The purpose of this study was to investigate the relationship between iatrogenic loss of TK after selective PSIF for AIS with straightening of LL and increase in pelvic tilt (PT).

This study tests the hypothesis that loss of TK will result in a compensatory and reciprocal loss of LL and an increase in PT.

METHODS: Query of a prospective multicenter database identified 123 AIS patients (Lenke curve types 1, 2, or 3) at least two years following selective thoracic PSIF with lowest instrumented vertebra equal or cephalad to T1. TK (T5-T12), LL (T12-S1), global sagittal alignment (GSA) and PT were measured from preoperative and two year postoperative visits. Health related quality of life measures (HRQOL) were also examined.

RESULTS: A total of 31% of patients undergoing a selective fusion had a net loss of TK at two years postoperatively (2-year TK - Preop TK <0). Patients who had decreased TK had a significantly higher rate of loss of LL than patients without loss of TK (68% vs. 32%, p<0.001). Change in LL was positively correlated to change in TK (p<0.001) and negatively correlated to both change in GSA (p=0.002) and change in weight (p=0.04). Change in PT was negatively correlated to both change in TK (p=0.03) and change in LL (p=0.001), and positively correlated to change in weight (p=0.01). Multiple regression analysis revealed that both TK and SB had significant predictive effect on LL (p<0.001, R2=0.31), and LL had significant predictive effect on PT (p=0.0045, R2=0.12). There were no significant associations between changes in TK or LL and HRQOL.

DISCUSSION AND CONCLUSION: Iatrogenic loss of TK occurs commonly in selective fusion for AIS. This loss of kyphosis is strongly associated with a compensatory and reciprocal loss of LL in the unfused segments, as well as an increase in PT. Although a significant difference in HRQOL at two years postoperatively was not appreciated in this study, the experience of adults with “flatback syndrome” suggests that loss of physiologic sagittal alignment in surgical correction of AIS may increase the risk for suboptimal clinical outcomes for these patients in the future. This way, spinal fusion can have unintentional effects on sagittal alignment which may have distant effects that remain to be fully elucidated.
of high Harris Hip scores and better functional outcomes and range of motion. Not only does post-operative CPM use appear to make a positive difference in clinical outcomes of adolescents; the improvement seems to be related to the duration of CPM. There were no cases of AVN hip in our series or trochanter healing problems.

INTRODUCTION: Children at high-risk for developmental dysplasia of the hips (DDH) are routinely screened for dysplasia at six months of age with an anterior-posterior (AP) pelvis x-ray. Plain radiography is the gold standard screening modality in this age group, but concerns arise over exposing asymptomatic children to ionizing radiation for the screening exams. Ultrasound is the modality of choice in newborns, and it is not associated with ionizing radiation. However, ultrasound has not been traditionally used in older children because of potential limitations secondary to the developing ossific nucleus. We hypothesized that the size of the ossific nucleus in six-month-old children would still permit assessment by substituting ultrasound for plain radiography as the DDH screening modality of choice in this age group.

PAPER NO. 370

Hip Arthroplasty in Adolescents: Functional Outcomes and Risk of Revision Surgery

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INTRODUCTION: Hip arthroplasty is an important reconstruction option in adolescent patients. Few studies have evaluated hip arthroplasty in children. Bipolar hemiarthroplasty (BHA) has the theoretic advance of conserving the native acetabulum in young patients. To date, no comparisons of total hip arthroplasty (THA) versus hemiarthroplasty have been made in the pediatric population. A well-controlled study of BHA versus THA in adults with osteonecrosis found BHA outcomes equivalent or superior to THA outcomes and recommended the use of BHA. (1)

METHODS: We reviewed the clinical records for patients under age 21 years who underwent bipolar hemiarthroplasty (BHA) or total hip arthroplasty (THA) in the past 10 years at a single institution. The Hospital of Surgery Surgery (HSS) scoring system was used to assess hip functional outcomes. Variables of walking distance, hip flexion and pain level were determined for each variable by calculating the interclass correlation coefficient (ICC). The correlation coefficients were determined for AI versus alpha angle and AI versus BRP.

RESULTS: Forty hip procedures were evaluated in 37 patients. Eight patients were excluded for inadequate follow-up (<12 months). Twenty BHAs and 12 THAs were included. Median age at the time of surgery was 17 years (11-21). Patient diagnoses included avascular necrosis (41%), musculoskeletal tumor (28%), SCFE (16%) or musculoskeletal dysplasia or degenerative disease (16%). Average follow-up was 3.0 years with longer follow up in BHA group. Time to revision was on average two years. Three of four revisions were BHAs and revision surgery occurred in BHA group. Twenty BHAs and 12 THAs were included. Median age at the time of surgery was 17 years (11-21). Patient diagnoses included avascular necrosis (41%), musculoskeletal tumor (28%), SCFE (16%) or musculoskeletal dysplasia or degenerative disease (16%). Average follow-up was 3.0 years with longer follow up in BHA versus THA (4.8 versus 2.5 years). Revision surgery was necessary in 4/32 (12.5%) hips and 4/29 (13.7%) patients. Revision rate of THA (8.3%) versus BHA (15%) should not be directly compared secondary to possible confounding by greater length of follow up for the BHA group. Time to revision was on average two years. Three of the four revisions were BHAs and revision surgery occurred in BHA patients for painful acetabular (bipolar) components. HSS outcome scores for BHA versus THA, respectively were as follows: pain (7.8/8.2), ROM (7.8/8.0), walking distance (8.5/8.8) and function (7.7/8.8). Functional results were inferior and revision surgery was
more common (3/4) in the arthroplasty patients with an oncologic diagnosis. Some 75% of THA and 40% of BHA were pain free post-operatively. Poor results occurred in 15% of bipolar and 0% THA.

DISCUSSION AND CONCLUSION: Our data suggests lower rates of revision, a higher likelihood of being pain free, and better functional results after THA versus BHA. Our results are limited by a small sample size, disparate indications, short-term follow up and variable follow up between groups. All measures suggest THA is superior to BHA in the adolescent population and therefore, demonstrates an inconsistency between outcomes in the adult arthroplasty literature and the pediatric experience. Hip arthroplasty appears to be an acceptable procedure for adolescent patients.


PAPER NO. 371
Closed Reduction of DDH: Risk Factors for Development of Avascular Necrosis
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INTRODUCTION: Closed reduction, plus spica cast application, has been widely reported to be successful (success rates as high as 95%) in the treatment for developmental dysplasia of the hip (DDH), in particular in children up to 18-24 months of age. Complication rates however have been reported as high as 79%, and avascular necrosis (AVN) has proven to be particularly problematic. This major complication has a reported incidence of 0-73% following closed reduction and can result in multiple sequelae, including pain, joint incongruity, limb length discrepancy and persistent hip instability. The purpose of this study was to identify and evaluate the risk factors for AVN after closed treatment for DDH in a consecutive series of patients.

METHODS: A retrospective review of all children diagnosed with DDH at one tertiary-care children’s hospital between 1986 and 2009 was performed. Inclusion criteria were children with diagnosis of DDH who underwent closed reduction and spica cast application, followed by CT evaluation, and minimum one-year radiographic and clinical follow up. Exclusion criteria included teratologic and neuromuscular hips, and open reduction as initial treatment. The collected data included patient demographics, radiographic parameters, complications, subsequent treatments and outcome. Hips were assessed for the presence of AVN according to Salter’s classification system.

RESULTS: A total of 124 affected hips in 100 children (10 males and 90 females) with an average age of 9.5 months at initial closed reduction (range: 0.5 - 31 months) met inclusion criteria. Patients were followed for a mean of four years (range: 1-18 years). Forty-two of 100 patients (42%) in 44/124 of affected hips (35%) and 0/76 of unaffected hips (0%) developed AVN. AVN was more common in males (8/10, 80%) than females (34/90, 38%) (p = 0.03). The presence of an osseous nucleus (p = 0.58 and pre-operative Pavlik harness or brace trial (p = 0.28) did not affect the rate of AVN. Overall, the degree of abduction did not affect the rate of AVN (p = 0.19). However, in patients treated with closed reduction younger than six months of age, the rate of AVN was increased with abduction ≥ 50° (13/32, 41%) compared to abduction < 50° (0/11, 0%) (p = 0.03).

DISCUSSION AND CONCLUSION: The risk of AVN (42%) following closed reduction treatment for DDH is significant. The presence of an osseous nucleus and pre-operative bracing do not appear to increase the risk of AVN. The degree of abduction in spica cast, however, does appear to be a risk factor, in particular in patients younger than six months. The authors recommend that abduction in spica casts should be limited to less than 50° in children younger than six months of age.

PAPER NO. 372
Intra-articular Abnormalities Associated with Residual Perthes-like Hip Deformities
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INTRODUCTION: Residual Perthes-like hip deformities are complex and may encompass proximal femoral deformity, secondary acetabular dysplasia and associated intra-articular abnormalities (labral tears, articular cartilage and osteochondral lesions). These intra-articular abnormalities have not been well characterized. The purpose of this study was to determine the characteristics of intra-articular disease associated with residual Perthes-like hip deformities.

METHODS: Thirty-five consecutive patients (36 hips) with residual Perthes deformities and hip symptoms were treated with surgical dislocation. Twenty-four were male, 11 female and the average age at surgery was 18.5 years. Intraoperative findings were documented prospectively and comprehensive radiographic review performed. Radiographic findings were correlated with intraoperative findings.

RESULTS: Labral tears and acetabular cartilage lesions were present in 72% and 56% of hips, respectively. Combined acetabular chondral lesions and labral disease were observed in 42% of hips. Labral and articular lesions were primarily located at the anterior (96%; 65%) and superolateral (62%; 80%) labrochondral junctions. Femoral head chondromalacia was observed in 81% of hips. Male sex was associated with any severe chondromalacia (64% vs. 27%) femoral head chondromalacia (35% vs. 18%) and advanced radiographic arthritis (44% vs. 9%) (all p < 0.043). Stulberg classification of 3 or greater was associated with moderate to severe acetabular chondromalacia (71% vs. 30%; p = 0.017). LCEA < 20 degrees was protective of severe chondromalacia (38% vs. 73%; p = 0.037) and radiographic arthritis (19% vs. 53%; p = 0.031). This protective effect was also noted with acetabular inclination > 15 degrees for any severe chondromalacia (23% vs. 70%; p = 0.007). Center-trochanteric distance < 1.7 was associated with more labral tears (90% vs. 57%; p = 0.042).

DISCUSSION AND CONCLUSION: Chondral lesions of the acetabulum and femoral head, in additional to labral disease, are common in symptomatic residual Perthes deformities. Male sex is associated with more advanced intra-articular disease, while secondary acetabular dysplasia seems protective of the articular cartilage. These factors should be considered in preoperative surgical planning and when counseling patients regarding surgical outcomes.

PAPER NO. 373
Acetabular Morphology and its Changes During Maturation: MR Assessments of Asymptomatic Volunteers
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INTRODUCTION: Normative data is integral to advancing the understanding of the pathophysiology of disease, and therapy for...
Outcomes of Total Hip Arthroplasty (THA) Following Pediatric Hip Disease: What Can Patients Expect?

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INTRODUCTION: Developmental dysplasia of the hip (DDH) and slipped capital femoral epiphysis (SCFE) are two of the most common pediatric hip disorders, both of which may progress to degenerative hip arthritis requiring total hip arthroplasty (THA) despite the best orthopaedic management. It is important for pediatric patients and their parents to be aware of the characteristics and outcomes of future reconstructive procedures that may be required following the diagnosis and management of these hip disorders. In order to assist appropriate counselling of pediatric patients and their parents affected by these hip conditions, we performed a national joint registry review to examine the characteristics and outcomes of THA performed for DDH or SCFE, and compared these results with those of THA performed for primary osteoarthritis (OA).

METHODS: All patients with a history of DDH or SCFE who underwent primary THA over a 10-year period between 1 January 1999 and 31 December 2008 were identified from a national joint registry. A reference group was generated from registry records including all patients with OA undergoing primary THA during the study period. Baseline information, operative characteristics and postoperative outcomes (Oxford Hip Score (OHS) at six months, five years and 10 years postoperatively, revision rate and six-month mortality) were examined and compared between the study groups. Both univariate and multivariate analyses were employed for postoperative outcome comparisons in order to evenly match the study groups according to age, gender, surgical approach, cementation and operative duration.

RESULTS: We identified 1,205 patients with a history of DDH, 117 patients with a history of SCFE and 40,589 patients with a history of OA, who underwent primary THA during the study period. Patients with a history of DDH or SCFE undergoing THA were significantly younger (mean age 49.3 years (DDH) vs. 48.5 years (SCFE) vs. 67.6 years (OA), p<0.001), with DDH patients more often female (74% (DDH) vs. 52% (OA), p<0.001) and SCFE patients more often male (60.7% (SCFE) vs. 48% (OA), p<0.001), than patients with OA undergoing THA. There was no significant difference in six-month OHS (44.0 (DDH) vs. 45.7 (SCFE) vs 46.0 (OA), p=0.093) between the three patient groups. There was no significant difference in 10-year OHS (43.0 (DDH) vs. 41.6 (SCFE) vs. 42.6 (OA), p=0.083) or five year OHS (44.0 (DDH) vs. 46.0 (SCFE) vs. 42.6 (OA), p=0.093) between the three patient groups. There was no significant difference in 10-year OHS (43.0 (DDH) vs. 41.6 (SCFE) vs. 42.6 (OA), p=0.190) between the DDH and OA patient groups (no SCFE patients achieved 10-year OHS follow up during the study). There was no significant difference in revision rate (0.79 (DDH) vs. 1.16 (SCFE) vs. 0.61 (OA) revisions per 100 component years, p=0.083), or six-month mortality rate (0.5% (DDH) vs. 0.9% (SCFE) vs. 0.8% (OA), p=0.562) between the three patient groups. Multivariate analyses confirmed that there was no significant difference in revision rate in six month OHS (p=0.174), five year OHS (p=0.402), 10 year OHS (p=0.775), revision rate (p=0.771), or six month mortality rate (p=0.052), between the three patient groups.

DISCUSSION AND CONCLUSION: Pediatric patients and their parents can be counselled that those DDH or SCFE patients who progress to require THA can expect excellent functional outcomes, with comparable revision rates to THA performed for primary OA.
Medial Versus Anterior Open Reduction for Developmental Hip Dislocation in Age-matched Patients

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INTRODUCTION: Surgical management for developmental hip dysplasia can utilize a medial approach open reduction (MAOR) or anterior approach (AAOR). The relative risk of avascular necrosis (AVN) and further corrective surgery (FCS) such as femoral or acetabular osteotomy remains a point of controversy. This study compared age-matched cohorts of each approach in terms of radiographic evidence of AVN and persistent dysplasia requiring FCS. The prognostic impact of a prior failed closed reduction was also investigated.

METHODS: Following Institutional Review Board approval we searched hospital records and identified 19 hips (14 patients) managed by MAOR. We matched 19 hips (18 patients) managed by AAOR, based on age at operation (mean 6.0, range 1.4-14.9 months). Patients with neuromuscular conditions and known connective tissue disorders were excluded. Primary outcomes assessed were whether patients had radiographic evidence of AVN (Kalambisi and MacEwen system) or required FCS at two years and at their latest visit (mean 6.2, range 1.8-11.7 years) post-op. We also documented whether patients previously failed closed reduction. Univariate and multivariable Kaplan-Meier and Cox regression models were used to identify predictors of AVN and FCS.

RESULTS: MAOR and AAOR cohorts were similar regarding age at open reduction, gender, laterality and follow-up duration. One MAOR and one AAOR hip had AVN prior to open reduction due to failed closed reduction thus were excluded from AVN analysis. At two years post-op, 3/18 (17%) MAOR and 7/18 (39%) AAOR met criteria for AVN grade 2 or higher (p=0.26). At latest visit, 4/18 (22%) MAOR and 5/18 (28%) AAOR met criteria for AVN grade 2 or higher (p=1.0). No predictors of AVN could be identified by regression analysis. Presence of an ossific nucleus pre-operatively was not a protective factor (p = 0.27 in all groupings). FCS was required in 4/19 (21%) MAOR and 7/19 (37%) AAOR hips, not a significant difference (p = 0.48). However, six of 12 (50%) hips failing closed reduction required FCS compared to 5/26 (19%) hips without prior failed closed reduction (Kaplan-Meier log-rank test = 8.28, p = 0.004). Multivariable Cox regression showed that patients failing closed reduction had an annual risk of requiring FCS six times that of patients without closed reduction (95% CI 2.24, p = 0.009) independent of surgical approach (p = 0.55).

DISCUSSION AND CONCLUSION: In this study of age-matched patients having either MAOR or AAOR, we found no association between surgical approach and risk of AVN or FCS. We identified no increased risk based on approach, no protective benefit of a pre-operative ossific nucleus, and also identified no reason to delay open reduction as both of our cohorts resulted in AVN rates well within the accepted range established in studies featuring patients with more mature vasculature. However, failing closed reduction was associated with a six-fold increased annual risk of requiring FCS. Our study’s major limitation is cohort size. Further research investigating these observations is merited.
INTRODUCTION: There are several surgical treatments for unstable osteochondritis dissecans (OCD) lesions of the knee. If the unstable osteochondral fragment or loose bodies of OCD lesions are left in the joint with the adequate conditions for fixation, internal fixation should be the preferred method of treatment, since it preserves the natural contour of the distal femur. The purpose of this study was to evaluate the functional and radiographic outcome of fixation of the osteochondral fragment for patients with unstable OCD of the knee after minimum three years follow up.

METHODS: Fifty unstable OCD lesions in 45 patients who were treated with fixation of the osteochondral fragment and followed up for more than two years were included in this study. They were 33 males and 12 females with an average age of 14.8 years (range:11-22). Fixation of the OCD lesion was performed through arthrotomy in 32 knees and under arthroscopy in 18 knees using PLLA pins. The functional outcomes were evaluated using the Lysholm score at an average follow up of 5.2 years after the surgery and healing of the lesions were confirmed using plain radiographs and MRI.

RESULTS: The average Lysholm score significantly improved postoperatively (from 78.4 to 96.8). Forty-eight of 50 lesions healed after fixation of the lesion. Healing was achieved at an average of 2.4 months on plain radiographs and 4.2 months on MRI. Two lesions which did not heal required additional surgery. Thirty-six of 40 patients who had been involved in sports activities returned to their previous activities without reduction of their activity levels within six months after the operation.

DISCUSSION AND CONCLUSION: This study clearly demonstrated that fixation of the lesions was an effective treatment option for patients with unstable OCD of the knee, as proved by their functional and radiographic improvement.

INTRODUCTION: Internal rotation (IR) contracture of the shoulder is the most common deformity in patients with brachial plexus birth injury, and many different surgical procedures have been proposed, with none demonstrating superiority. The purpose of this investigation is to describe the indications, technique, and results of the subscapularis slide (SS) procedure. It is hypothesized that IR contracture release by SS leads to a good functional outcome and has a low recurrence rate.

METHODS: A total of 117 patients at two institutions treated with SS between 1997 and 2010 were identified. All surgeries were performed by one of the senior authors. Charts were retrospectively reviewed, and surgical and clinical data abstracted. Patients were divided into five groups based on the index procedure performed: SS alone (group 1); SS with a simultaneous microsurgical reconstruction (group 2); primary microsurgical brachial plexus reconstruction followed by a later SS (group 3); primary microsurgical brachial plexus reconstruction followed by a later SS combined with muscle transfers for shoulder external rotation (group 4), and SS with simultaneous muscle transfers (group 5). For each group, indications are reviewed, and results including complications and the rates of revision surgery are analyzed. The technique of SS involves the release of the subscapularis muscle origin off the scapula. The anterior shoulder structures, including the subscapularis tendon, are preserved. The technique may be combined with pectoralis major lengthening, coracohumeral ligament release, coracoid resection, and Y-fasciotomy. Standard post-operative protocol is used with all patients, and includes casting, aggressive occupational and physical therapy, and shoulder manipulation with botulinum toxin injections as needed.

RESULTS: Average age at the time of surgery was 32 months, and average follow up was 42 months. There were 73 females and 44 males. Eighty-six patients had lesions involving C5-C6, 17 had lesions involving C5-C7, and 14 patients had global brachial plexus injury. There were nine patients in group 1, 56 patients in group 2, 16 patients in group 3, 21 patients in group 4, and 29 patients in group 5. Full passive external rotation was achieved in the operating room in all cases. There were no wound or other post-operative complications, and no cases of anterior instability.

DISCUSSION AND CONCLUSION: Internal rotation contracture of the shoulder following brachial plexus birth injury can be effectively managed with the technique of subscapularis slide, while avoiding the complication of shoulder instability. In some cases, simultaneous associated procedures are required to complete the release. Satisfactory shoulder outcomes can be achieved in the majority of the cases, but secondary procedures may be required.
a mother who received oxytocin versus a mother who did not (OR 95% CI: 1.19-5.37; p=0.0135). The odds of a NBPP injury were 3.7 times higher for a mother who experienced tachysystole during labor versus a mother who did not (OR 95% CI: 1.71-7.85; p=0.0006). The odds of a NBPP injury were 2.2 times higher for a mother who experienced excessive weight gain over the entire gestational period (OR 95% CI: 1.05-4.6; p=0.0356). Epidural and prostaglandin administration were not statistically significant (p=0.2432 and p=0.4698, respectively). A multivariate logistic model containing antepartum and intrapartum variables had an area under the curve of .8655, indicating a high probability of predicting a NBPP injury. (Figure A) DISCUSSION AND CONCLUSION: Tachysystole, excessive weight gain by the mother, and oxytocin administration are associated with a significant increase in the odds of a NBPP injury at birth. To the best of our knowledge this is the first study identifying oxytocin and tachysystole as NBPP risk factors. The results of the current study provide evidence for additional obstetric risk factors of NBPP. Further research to determine if a reduction in these risk factors reduces the incidence of NBPP is warranted.

Figure A. Receiver Operating Characteristic (ROC) curve for the model: birth weight >26.5 years + length of stage 2 labor >61.5 minutes.

PAPER NO. 680

Arthroscopic Treatment of Internal Rotation Contracture and Glenohumeral Dysplasia in Brachial Plexus Birth Palsy
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INTRODUCTION: The purpose of this study was to report on the one and three year radiographic and clinical outcomes of children who underwent arthroscopic anterior release, with or without tendon transfer, to maintain shoulder joint alignment in children with brachial plexus birth palsy.

METHODS: Forty-four patients who underwent arthroscopic release, with or without tendon transfers, for glenohumeral dysplasia in children with brachial plexus birth palsies were prospectively followed for a minimum of three years. Clinical data collected included active abduction, external rotation, and Mallet scores. Magnetic resonance imaging (MRI) data collected included the amount of retroversion and the percentage of the humeral head anterior to the middle of the glenoid fossa (PHHA). As per standard of care, patients were seen; all data points were collected pre-operatively, and at one and three years post-operatively. Tests of fixed effects were performed to assess statistical significance between data points at different times.

RESULTS: Retroversion improved from -34° pre-operatively to -19° at one year and -44° at three years (p<0.001). Similarly, PHHA improved from 19% pre-operatively to 33% at one year and was maintained at 36% at three years. Passive external rotation improved from -26° preoperatively to 48° at one year, and was maintained at 49° at three years. Likewise active abduction improved from 112° preoperatively to 130° at one year and 132° at three years (p<0.01). Individual Mallet components were significantly improved (p<0.001) for external rotation, hand to neck, and hand to mouth when comparing preoperative scores to those at one and three years.

No statistical improvement was noted in Mallet abduction or hand to spine (p>0.05). All improvements were maintained between one and three years but no significant improvement was noted over this time.

DISCUSSION AND CONCLUSION: Arthroscopic anterior release, with or without tendon transfers, results in improved glenohumeral alignment and joint remodeling. The positive post-operative outcomes found at one year were successfully maintained at three year follow up. We believe that prompt recognition, timely diagnosis, and early surgical intervention results in a better aligned joint and superior function. Arthroscopic release is easier in the young child with less deformity compared to an older shoulder with severe joint subluxation and glenoid retroversion. In addition, less subscapularis release is required to obtain joint reduction, which preserves midline function.

PAPERS, POSTERS & SCIENTIFIC EXHIBITS PEDIATRICS
compared to nine (69%) without bone in the lesion (p=0.128).

DISCUSSION AND CONCLUSION: OCD lesions with the presence of bone on pre-treatment MRI scans had significantly increased rates of healing compared to those without bone. This information will help the treating physician to counsel patients as well as to guide treatment of this condition. It should improve the accuracy of multi-variate OCD healing predictive nomograms.

There was one concentric, six posterior concentric and 12 pseudoglenoids. Glenoid version and PHHA averaged -27° and 27° for involved shoulders vs. -7° and 49° for normal shoulders, respectively. ER, PHHA and version were all correlated (p < 0.02). The arc radius of the most anterior sector showed strong negative correlations with ER, PHHA and version. (p<0.0003).

DISCUSSION AND CONCLUSION: The normal humeral articular surface in the young child is usually flatter in the middle than at the periphery, and also in the region of articular contact presumably due to compressive forces on the malleable cartilage. The involved side lacked symmetry seen on the normal side and were also characterized by distortion of the cross section of the proximal humerus, the skew axis. The severity of internal rotation contracture correlated with flattening of the anterior humeral articular surface.

PAPER NO. 683
Complications of Medial Patellofemoral Ligament Reconstruction for Patellar Instability in Adolescent Patients
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INTRODUCTION: The role of medial patellofemoral ligament (MPFL) as a primary restraint to lateral subluxation of patella has been increasingly recognized. The early success of MPFL reconstruction for patellar stabilization has overshadowed the potential complications which are frequently underreported. The aim of this study was to evaluate the clinical and radiographic outcomes of MPFL reconstruction in young (less than 21 years) patients, with emphasis on early (less than two years) complications.

METHODS: In a retrospective study (2006-2010), all patients who underwent MPFL reconstruction at one institution by one of the two surgeons, were identified. Their charts and radiographs were reviewed to identify complications and clinical outcomes after surgery. The complications were considered major if the patient required hospitalization or revision surgery related to MPFL reconstruction. Each complication was further analyzed if it was related to technical factors which could have been avoided.

RESULTS: A total of 187 patients underwent MPFL reconstruction during the study period. There were 34 complications in 29 patients; 29 major (15.5%) and five minor. There were eight patellar fractures (Fig A); five of six transverse fractures through patellar tunnels required surgery and two superior pole avulsion fractures secondary to restricted range of motion required quadriceps tendon repair. Four patients underwent a revision MPFL reconstruction due to increasing patellofemoral arthritis; all were related to anterior placement of femoral tunnel (Fig B). Three patients underwent revision MPFL reconstruction due to recurrent instability. Six patients had arthrofibrosis which resolved with manipulation under anesthesia in first three months. Other major complications included three patients with deep venous thrombosis (one had pulmonary embolism), two wound dehiscence requiring surgery, one implant related pain requiring removal of femoral tunnel screw, one debridement for suture irritation and one subsequent tibial tubercle osteotomy. The five minor complications included three recurrent patellar subluxation, one wound dehiscence, and one complex regional pain syndrome controlled with medications. Eighteen of 34 (52.9%) complications were secondary to technical factors and were considered preventable.

DISCUSSION AND CONCLUSION: There is a learning curve related to MPFL reconstruction. Most complications following MPFL reconstruction in young patients are due to technical factors (patellar tunnel position, femoral tunnel position, graft isometry,
gait tensioning). Patients should be adequately counseled preoperatively regarding potential complications.

### Table 1. Watanabe Classification.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Complete*</th>
<th>Incomplete*</th>
<th>Wrisberg variant*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral patients</td>
<td>65%</td>
<td>22%</td>
<td>13%</td>
</tr>
<tr>
<td>Unilateral patients</td>
<td>30%</td>
<td>68%</td>
<td>2%</td>
</tr>
</tbody>
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*p <0.001

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**PAPER NO. 684**

**Symptomatic Bilateral Discoid Menisci in Children: A Comparison with Unilaterally Symptomatic Patients**

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**Stephanie Cody, BS, Philadelphia, PA**

**Theodore J. Ganley, MD, Philadelphia, PA**

**INTRODUCTION:** In previous studies, 5% to 20% of patients with a discoid lateral meniscus eventually require surgery bilaterally for symptomatic discoid menisci. However, there is little published data specifically on children who require surgery for discoid menisci in both knees. The purpose of this study is to identify differences in clinical and arthroscopic findings and outcomes between children who require bilateral versus unilateral treatment for symptomatic discoid lateral menisci.

**METHODS:** We retrospectively reviewed the records of all children treated arthroscopically for discoid lateral meniscus between 1998 and 2007. Data were collected on 16 patients (32 knees) treated for symptomatic bilateral discoid menisci and 60 patients treated unilaterally with an asymptomatic contralateral knee, with mean follow up of 19.5 months (range 6 to 96 months).

**RESULTS:** At initial presentation, children who were treated bilaterally for discoid menisci were younger than those treated unilaterally (10.4 vs. 12.5 years; *p* = 0.021). Patients under 12 years of age were 4.58 times more likely to eventually require surgery on both knees (*p* = 0.015). Classification by the Watanabe system was significantly different between the bilateral and unilateral groups (Table 1). The odds of current or future bilateral symptoms requiring treatment were 4.45 times higher in patients with a complete discoid meniscus (*p* = 0.0017) and 8.43 times higher in those with a Wrisberg type (*p* = 0.048). A tear of the lateral meniscus was more likely to be found intra-operatively in unilateral knees than bilateral (90% vs. 72%; *p* = 0.037). There was no statistically significant difference between the two groups in terms of sex, incidence of injury preceding pre-operative symptoms, peripheral instability of the discoid meniscus, location of meniscal tears, or intra-operative findings of anatomic variation or chondral lesions.

**DISCUSSION AND CONCLUSION:** Patient education and long-term follow up are important for children who present with a discoid meniscus at a young age or with a complete or Wrisberg type, as these patients may be at increased odds of symptomatic discoid meniscus in the contralateral knee. Furthermore, evaluation and treatment of discoid lateral meniscus requires vigilance for meniscal tears.

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**PAPER NO. 685**

**Effects of Surgical Treatment for Recurrent Patella Instability in Adolescent Patients on Knee Extensor Mechanics**

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**Michael Lee, San Diego, CA**

**Eric W. Edmonds, MD, San Diego, CA**

**INTRODUCTION:** Patellar instability is a complex disorder that occurs most commonly in adolescents. It involves 29 to 43 of 100,000 children between the ages of 10 and 17 years. The Insall procedure is a method of treatment that was developed to realign the extensor mechanism and redirect the patella tracking medially during active knee extension. It always requires a later retinaculum release. Another procedure utilized currently in the treatment of patella instability is the medial patella-femoral ligament (MPFL) reconstruction. This utilizes a tendon graft to recreate the medial check-rein to lateral displacement. Both procedures are now being used by surgeons based on short-term follow-up studies. Using MRI and x-rays, the purpose of this study was to evaluate the extensor mechanics in adolescents after surgical treatment with either of the clinically relevant techniques (Insall vs. MPFL) and compare those to normal subjects. The hypothesis was that altered knee extensor mechanics seen in the Insall procedure would predispose the patello-femoral joint to higher joint reaction forces.

**METHODS:** A review of 30 adolescent (10 MPFL, 10 Insall and 10 healthy adolescents) sagittal MR images and x-rays were evaluated of the knee. Actual moment arm (M-act) was measured as the vertical distance from the tibio-femoral axis of rotation to the patellar ligament. Quadriceps moment arms (M-q) and patellar ligament moment arms (M-pl) were measured as the vertical distances from the patella-femoral contact point to the respective tendons. The ratio of the patellar ligament/quadriceps tendon force (F-pl/F-q) was then determined by the ratio of M-q/M-pl. The mechanical effective moment arms (M-eff) were calculated by F-pl/F-q(M-act). Compression from the patellar ligament and quadriceps tendon forces was estimated using the angles that the quadriceps tendon, retropatellar surface, and patellar ligament formed with the vertical. These angles and the F-pl/F-q ratio were used to calculate the ratio of patella-femoral joint reaction force (F-r) to quadriceps force F-q. Statistical analysis was performed using SPSS with significance set at *p*<0.05.

**RESULTS:** There was no statistically significant difference in M-act, in F-pl/F-q, or M-eff between any of the surgical groups and the normal subjects. However, there was a significant difference in the patella-femoral joint reaction force with respect to the quadriceps force F-r/F-q. Adolescents within the Insall group 1.1 (SD 0.1) had larger F-r/F-q than those in the normal group 0.7 (SD 0.0) with *p*<0.01.

**DISCUSSION AND CONCLUSION:** There is a difference between normal knee joint reaction forces and those seen in a knee after an Insall procedure, with the latter being significantly greater. Unchanged M-eff between treatment and normal groups indicates that the mechanical efficiency of the quadriceps has been restored in all groups. These observed parameters for knee extensor mechanics suggest that individuals who undergo an Insall procedure may experience greater patella-femoral joint reaction forces to overcome the same knee flexion moment in the range of 0-60 degrees of knee flexion. Further study utilizing 3D evaluation of the patella position prior to and after surgery is currently in process and will add more precise information regarding the outcomes of the different procedures. However, this study is the first to define reproducible radiographic parameters for the evaluation of surgical outcomes for adolescent patella instability. This improved understanding of the
Meniscal Tears in Skeletally Immature Patients: Analysis of Location, Type, and Associated Injuries
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INTRODUCTION: Meniscal tears are being recognized more commonly in skeletally immature patients. Few studies have reported on meniscal tears seen in children and specifically compared tears that are repaired versus trimmed. The purposes of this study are to classify meniscal tear location, morphology, and associated injuries as well as identify factors that deem some tears amenable to repair.

METHODS: A total of 353 arthroscopic meniscus surgeries in 305 skeletally immature patients were identified between 1/1/2000 and 1/1/2009 at our institution. Patients were included if their initial surgeries were between ages 5-14 years for females and 5-16 years for males. Operations were performed by four experienced surgeons with identical requirements for weight bearing and return to activity. A retrospective review of operative notes and outpatient records was performed to determine demographic factors, BMI, tear location, type of tear, associated injuries, and whether repaired. Univariate and multivariate statistical analysis compared partial meniscectomies and repairs to identify differences in tear location, type, and associated injuries.

RESULTS: Average age at surgery was 13.4 years. A total of 143 (41%) surgeries were performed on females. A total of 164 (47%) were on the right knee and 189 (53%) on the left. Seventy-four (21%) were medial meniscal tears, 245 (69%) were lateral, and 34 (10%) were both. For reported locations, 25% of tears were in the anterior horn, 14% midsubstance, 64% posterior horn, and 16% central intrasubstance delamination. For reported zones, 28% of tears were in the red-red zone, 52% red-white zone, and 35% white-white zone. The five most common tear types were degenerative (26%), bucket handle (22%), vertical cleavage (18%), intrasubstance delamination (17%), and horizontal cleavage (10%). Eighty-one (23%) were isolated meniscal tears, 141 (40%) were associated with an ACL tear, 103 (29%) were discoid, 48 (14%) had other intraarticular knee injuries. A total of 167 (47%) were repaired and 186 (53%) were trimmed. When comparing repaired to trimmed, age and BMI were not significantly different. Factors favoring repair included: red-red zone tears (OR 25.9; p<0.001), vertical cleavage (OR 19.5; p<0.001), bucket handle (OR 6.0; p<0.001), posterior horn (OR 3.7; p<0.001), and both menisci (OR 2.6; p=0.01). Factors favoring partial meniscectomy included: complex tears (OR 19.2; p<0.001), white-white zone (OR 14.9; p<0.001), degenerative (OR 5.3; p<0.001), intrasubstance delamination (OR 4.6; p=0.03), and midsubstance (OR 4.0; p<0.001).

DISCUSSION AND CONCLUSION: At our institution, a large number of meniscal injuries were noted in school-aged skeletally immature patients and a significant percentage of those were repairable. Most tears were of the lateral meniscus and involved the posterior horn. Nearly a third were discoid and over half were associated with intraarticular knee injuries. Tears found to be repairable were red-red zone, vertical cleavage, bucket handle, both menisci, and posterior horn tears. Our study suggests that tear location, type, and associated injuries were important factors to consider when choosing the appropriate form of surgical treatment.

Comparison of Multiplanar Fluoroscopic Imaging and CT for Measurement of TT-TG Distance in Patellar Instability
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INTRODUCTION: Cross-sectional computerized tomography (CT) imaging is considered the “gold-standard” modality for the assessment of the tibial tubercle-trochlear groove (TT-TG) distance in patients with patellar instability. Given the potential risks of ionizing radiation in children, there has been an increased effort to limit the use of CT scans in this population. We hypothesize that multiplanar fluoroscopic imaging can be utilized to less radiation exposure and reproducibly measure the TT-TG distance with less radiation exposure when compared to conventional CT.

METHODS: Eight knees from four matched pair cadaveric specimens underwent conventional CT scan and multiplanar fluoroscopic imaging. TT-TG measurements were determined for each specimen in a randomized manner by two musculoskeletal radiologists. The effective dose of radiation exposure was calculated for each modality.

RESULTS: Average effective radiation doses measured 0.1 mSv (milliSieverts) for multiplanar fluoroscopic imaging and 0.3 mSv (milliSieverts) for conventional CT. The intraclass correlation coefficient (ICC) for radiographic agreement between fluoroscopic and CT measurements were 0.91 and 0.85 for each examiner, indicating excellent agreement.

DISCUSSION AND CONCLUSION: Multiplanar fluoroscopic imaging provides accurate and reproducible assessment of the TT-TG distance with a 66% reduction in radiation exposure when compared to conventional "gold-standard" CT imaging. Given the equivalent accuracy in measuring the TT-TG distance and the decrease in radiation exposure, multiplanar fluoroscopic imaging may serve as a useful imaging modality in the evaluation of pediatric patients with patellar instability.

Adolescent Rotator Cuff Tears
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INTRODUCTION: Rotator cuff tears in adolescents are uncommon, with few reports existing in the literature. The accuracy of magnetic resonance imaging with arthrography (MR) in diagnosing rotator cuff pathology in this age group has not been studied and treatment outcomes are unknown.

METHODS: A retrospective chart review was performed at our institution between August 2008 and August 2010 on all patients under age 19 years with a rotator cuff tear diagnosed at our institution. Imaging controls consisted of children.
who underwent shoulder arthroscopy without pre- or intraoperative evidence of a rotator cuff abnormality. After release to full activity without restriction, patients were contacted and three outcome measures were obtained: Quick Disability of the Arm, Shoulder, and Hand (DASH), Quick DASH sports subscore, and the Single Assessment Numerical Evaluation (SANE). RESULTS: Sixty-one adolescents with evidence of a rotator cuff tear met inclusion criteria. There were 38 boys and 23 girls with a mean age of 16 years. The mean duration from injury to presentation was 5.8 months, with throwing and being tackled the most common etiologies. Eighty-seven percent underwent a trial of at least six weeks of physical therapy, while the remaining 13% received immediate operative intervention due to recurrent instability. Fifty-seven percent failed physical therapy and required surgical treatment. MR was 42% sensitive, 97% specific (PPV 88%, NPV 73%), and had an overall accuracy of 76% in the diagnosis of rotator cuff tears. Patients requiring operative treatment were 2.4 times more likely to have associated pathology (95% CI 1.1-5.0, p=0.005), with posterior and posterosuperior labral tears seen in 36% and anterior labral tears seen in 26% of patients. Five patients had a posterosuperior hypertrophic synovitis lesion at the time of arthroscopy. All rotator cuff tears seen in this cohort were partial articular sided tendon avulsions (PASTA), and surgical treatment consisted of debridement of pathologic tissue to stable edges, as no tear measured greater than 50% of the thickness of the tendon. Associated pathology was treated as necessary. Post-treatment Quick DASH and SANE scores were not statistically different between the non-operative and operative groups (6.3 vs. 8.7, p=0.544 and 84.1% vs. 82.0%, p=0.732, respectively), but the Quick DASH sports subscore was significantly better in the non-operative group (4.9 vs. 26.3, p=0.033) when stratified for isolated PASTA lesions, the sports subscore was still significantly different between the non-operative and operative groups (5.2 vs. 40.6, p=0.031). The sports subscore had a better correlation with the SANE score than the Quick DASH (r=-0.594 vs. r=-0.720).

DISCUSSION AND CONCLUSION: Partial rotator cuff tears in adolescents are associated with other pathology in the shoulder 51% of the time. MR was specific, but not sensitive, with 76% accuracy for PASTA injuries. Isolated PASTA injuries can be treated successfully with physical therapy with return to sports expected; however, over half of children with PASTA lesions failed to improve, most often secondary to the associated pathology. Improvement in pain and function can be achieved with surgery after failed conservative management, but the adolescent athlete will often have residual shoulder complaints during sports participation.

PAPER NO. 689

Meniscal Tears in the Skeletally Immature: Analysis of Patients Requiring Repeat Arthroscopic Surgery

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INTRODUCTION: Meniscal tears in skeletally immature children have increased in recent years. A surgical intervention is often needed for symptomatic tears. Whenever possible, tears are repaired to maintain anatomical integrity. However, some are not repairable and require partial meniscectomies (PMs). Few studies have assessed meniscal tears in children, and specifically identified factors necessitating repeat intervention. The objective of this study is to identify risk factors for a return to the operating room for a repeat surgery on the same meniscus of the same knee (ROR) in children following an initial arthroscopic meniscus surgery. METHODS: We identified all skeletally immature females aged 5-14 years, and males aged 5-16 years from 1/1/1999 - 6/30/2008 who received arthroscopic meniscus surgery at our institution. Repeat operations were screened up to 6/30/2010 for follow up of at least two years. Operations were performed by four experienced surgeons with identical requirements for weight bearing and return to activity. Operative notes and outpatient records were reviewed to determine BMI, tear location, tear type, associated injuries, whether repaired vs. meniscectomy, and type of repair. Multivariate statistical analysis was performed to identify risk factors for ROR. RESULTS: A total of 297 surgeries were performed on 277 patients. A total of 137 (46%) were meniscal repairs (MRs) performed on 125 patients, and 160 (54%) were PMs performed on 152 patients. Thirty-two patients returned to the OR; 10 had an initial MR vs. 10 who had an initial PM. Multivariate analysis revealed that MR (16.1% with MR vs. 6.25% with PM; p=0.033) and midsubstance tears (29% vs. 9%; p=0.002) were independent risk factors for ROR. MRs were 2.5 times more likely to ROR than PMs (p = 0.023). Midsubstance tears were four times more likely to ROR (p=0.01). No specific tear type was identified as a risk factor for ROR. Age, gender, BMI, type of repair (inside out vs. all inside), discoid meniscus, ACL tears, or other associated intraarticular injuries were not significant.

DISCUSSION AND CONCLUSION: MRs and PMs offer two options for treatment of symptomatic meniscus tears in children. Meniscal repairs preserve anatomical integrity and have been shown to benefit the long-term health of the articular cartilage, however there is a significant risk of repeat surgery compared with partial excisions. Our analysis shows that repairs and midsubstance tears demonstrated an increased risk for re-intervention. Our study suggests that types of intervention and tear location are important parameters for repeat surgeries.

PAPER NO. 690

Access to Anterior Cruciate Ligament Care for Children with Medicaid versus Private Insurance

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INTRODUCTION: Previous studies have shown that children with upper extremity fractures who are on Medicaid experience decreased access to care. The purpose of this study was to see if this same relationship existed for children with an acute anterior cruciate ligament injury. METHODS: The offices of 42 orthopaedic surgeons in the greater Cincinnati area were telephoned on two separate occasions. The two different calls were separated by a period of two to four weeks. The common script for all calls was, "My 14-year-old son [has a confirmed] ACL tear and I've been told to get an orthopaedic appointment within the next two weeks." The independent variable was the patient’s insurance status, either Medicaid or private insurance. Statistical comparison of the rates of successful appointment scheduling was performed via Fisher's Exact test. This project was reviewed by our Institutional Review Board and granted exempt status as it did not meet regulatory criteria for research involving human subjects.

RESULTS: We found that 38 of 42 orthopaedic surgeons (90%) offered the privately insured 14-year-old ACL patient an appointment within two weeks, while only six of 42 (14%) offered the Medicaid patient such an appointment. The difference

The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e. the drug or medical device is being discussed for an off label use). For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
in these rates was statistically significant (p<0.0001) with the odds of getting an appointment with private insurance being 57 times higher than with Medicaid [95% CI 12.87, 288.62]. DISCUSSION AND CONCLUSION: Access to orthopaedic care for children on Medicaid continues to be a problem in the United States. Previous pediatric studies have documented that the reason for these discrepancies in access are related primarily to Medicaid reimbursement rates (approximately 50% of private insurance). Ours is the first study to show that these same limitations exist for teenagers with acute knee injuries likely to require surgery.

POSTERS

POSTER NO. P241
ALTERNATE PAPER: PEDIATRICS III
MRI Scans can Predict Acetabular Coverage after Bone Maturation in Patients with Developmental Dysplasia of the Hip
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INTRODUCTION: Acetabular development and subluxation should be considered when treating developmental dysplasia of the hip (DDH). The treatment strategy, such as surgery, should be decided on the basis of these conditions. However, this decision is not easy, because these patients are of growing age. Using magnetic resonance imaging (MRI), we evaluated the insufficient acetabular formation and persistent subluxation at an early stage. When cartilaginous acetabular coverage is adequate, surgery is contraindicated despite insufficient bone formation. In this study, we report the accuracy with which MRI can predict the actual acetabular coverage after bone maturation.

METHODS: We selected 48 DDH patients (three boys and 45 girls) with insufficient acetabular formation and subluxation that persisted until two years of age. We evaluated 55 hips (right, 28; left, 11; and bilateral, eight). The patients were treated with the Pavlik harness and were followed up until six years of age. Using MRI imaging, we measured the cartilaginous acetabular angle and center-edge (CE) angle of the patients at two years of age. Similar measurements were carried out using X-ray imaging to evaluate the bony acetabular formation in these patients at the age of two, and these measurements were compared with those obtained at the age of six years. The patients were categorized into the sufficiency and insufficiency group on the basis of preliminary results. Sufficient acetabular coverage was observed when the acetabular angle of the bony formation was ≤26º and the corresponding CE angle was ≥10º at the age of six. Finally, we constructed receiver operating characteristic (ROC) curves for each factor and computed the cutoff angles for MRI analysis at two years of age.

RESULTS: At two years of age, substantial differences between the bony and cartilaginous angle measurements were observed. X-ray imaging showed a bony acetabular angle of 30.7º ± 4.3º and a bony CE angle of 0.0º ± 9.9º. MRI showed that the cartilaginous acetabular and CE angles were 17.2º ± 5.2º and 11.6º ± 10.5º, respectively. At six years of age, the acetabular angle was 24.5º ± 5.6º and the CE angle was 13.2º ± 6.9º. At two years of age, the cartilaginous acetabular angle was 15.6º ± 4.0º in the sufficient group and 20.9º ± 5.7º in the insufficient group. The cartilaginous CE angle was 14.6º ± 9.3º and 4.2º ± 10.0º, respectively. Statistical significant differences were observed on comparing the results of the sufficient and the insufficient group. The ROC curve showed that the cutoff value was 18º for the acetabular angle and 12º for the CE angle on MRI analysis at two years of age.

DISCUSSION AND CONCLUSION: Substantial differences were observed between the bony and cartilaginous angle measurements obtained at an early age. Cartilaginous angle measurements obtained with the MRI performed at two years of age correlated with the bony angle measurements obtained with X-ray imaging. In conclusion, acetabular coverage after bone maturation can be predicted using MRI scans obtained in the early stages of DDH. If the cartilage coverage is adequate, good bone development is observed, and there is no need for surgery.

POSTER NO. P242
Bier Block Regional Anesthesia for Forearm Fractures: Safety in the Pediatric Emergency Department Setting
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Meagan M. Fernandez, DO, Harrisburg, PA

INTRODUCTION: Bier block regional anesthesia was first described in 1908, however it is uncommonly used for fears of safety. Additionally, most emergency departments feel that splint placement is safer than casting following acute forearm fracture reduction in the pediatric population. The goal of this study was to assess the safety and efficacy of Bier block regional anesthesia and immediate cast application following closed reduction of pediatric forearm fractures.

METHODS: A retrospective review of patients treated for forearm fractures in a two-year period at a major metropolitan pediatric hospital. Rate of complications as well as length and cost of procedure were analyzed.

RESULTS: A total of 600 patients were treated with Bier block regional anesthesia and 645 were treated with conscious sedation for displaced fractures of the forearm in the two-year study period. No complications requiring admission were necessary in either group. No patient experienced compartment syndrome or need for re-admission secondary to cast application. Some 2.2% and 4.3% (p=0.382) of patients in the Bier block and sedation groups respectively needed their cast bivalved secondary to swelling. The average time from initiation of procedural sedation to discharge was one hour and 42 minutes, while the time to discharge from initiation of Bier block regional anesthesia was 47 minutes (p<.0001). The average cost for a patient...
treated with procedural sedation was $6,313 while the average cost for the Bier block regional anesthesia group was $4,956. DISCUSSION AND CONCLUSION: Bier block regional anesthesia is safe, efficient and cost effective in the reduction of pediatric forearm fractures. Immediate cast application can be employed without fear of major complications. Level of Evidence: Level III - retrospective review.

POSTER NO. P243
The Posterior Sloping Angle as a Predictor of Contralateral Slip in Slipped Capital Femoral Epiphysis
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INTRODUCTION: Controversy exists regarding whether or not to prophylactically pin the contralateral hip of patients presenting with slipped capital femoral epiphysis (SCFE) and how to predict which patients will develop a subsequent contralateral slip. Prophylactic pinning may help preserve anatomy and prevent the future morbidity of a contralateral slip. The primary aim of this study was to assess the utility of the posterior sloping angle (PSA) as a predictor of contralateral slip and to generate a threshold PSA value where pinning might be recommended. Secondary aims were to assess the utility of the PSA in the Polynesian population who have a substantially higher incidence of SCFE and to analyze the effect of relevant variables on PSA.

METHODS: A case control analysis of 90 patients with a unilateral slip and 42 patients who subsequently developed a contralateral slip was performed. Radiographic analysis of the PSA in the unaffected hip at original presentation was used to stratify the future risk of slip. Data regarding ethnicity, age, slip severity and slip type was also collated. Intention to treat analysis was used to assess the clinical benefit of prophylactic pinning.

RESULTS: Patients with a contralateral slip had a significantly higher PSA than those with a unilateral slip (17.2±6.1 vs. 10.8±4.3, p<0.001) and were younger (11.1±1.2 vs. 12.2±1.6, p= <0.01). Multiple regression analysis showed that PSA was not independently affected by gender, age, ethnicity, slip grade or stability. At a PSA threshold value of 14º for prophylactic pinning, 35 out of 42 (83%) of contralateral slips would have been prevented and 19 out of 90 hips would have been pinned unnecessarily. Intention to treat analysis demonstrated that 1.79 hips require pinning to prevent one subsequent contralateral slip.

DISCUSSION AND CONCLUSION: Elevated PSA is directly associated with an increased incidence of contralateral slip in SCFE. Predicting which patients will go on to develop a contralateral slip is likely to improve long term outcome if prophylactic pinning is performed. We recommend a threshold value of 14º to guide prophylactic pinning.

POSTER NO. P244
Health Care Reform 2012: Medicaid and Medicare Parity in Pediatric Orthopaedics
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INTRODUCTION: Healthcare reform is occurring now. The American Academy of Pediatrics advocates for parity with Medicare and Medicaid services to include pediatric surgical subspecialties. The purpose of this study is to report a practice management analysis of the differences in payment for common CPT codes for a pediatric orthopaedic practice comparing Medicaid with Medicare reimbursement rates.

METHODS: Medicaid and Medicare payments for two outpatient office visit CPT codes, five global fracture CPT codes, and 15 surgical CPT codes from 2007 were compared. Outpatient codes evaluated included: 99203, 99213. Global fracture codes compared included: 23500 25500; 27750; 28470; 24650. Surgical CPT codes included: 20680; 22802; 22843; 24538; 25479; 25565; 25605; 27258; 27506; 27766; 27394; 27485; 27685; 2988; 29888.


For outpatient office visits, Medicaid reimbursements were an average of 27% less than Medicare. For global fracture codes, Medicaid paid an average of 48% less than Medicare. For surgical codes, Medicaid paid an average of 39% less than Medicare.

DISCUSSION AND CONCLUSION: Healthcare reform is intended to improve the quality, affordability, and accessibility of healthcare services for children and families. Increased Medicaid reimbursements to physicians will improve access to care for children.

If healthcare reform included parity with Medicare and Medicaid services, then pediatric orthopaedic surgeons in this practice could expect an overall increase in Medicaid reimbursements of 38%. However a current 21% reduction in Medicare reimbursement based on the “sustainable growth rate formula” is pending in Congress. This legislation will minimize the purity gap between Medicaid and Medicare reimbursement with no improvement in access to care for children. Currently, the overhead cost for a pediatric orthopaedic surgeon to treat a patient with Medicaid exceeds the reimbursement. Increased Medicaid re-imbursements to physicians will improve access to care for children.

POSTER NO. P245
Correlation and Reproducibility of 2D and 3D Spinal Measurements
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INTRODUCTION: Scoliosis is widely recognized as a three-dimensional (3D) deformity, yet analyses of spinal deformation in 3D are scarce. This study introduced spinal deformity by anterolateral spinal tethers in a mini-pig model. Conventional 2D measurements from plain X-rays/CT were compared to 3D computed tomography (CT) reconstructions. The objective of this study was to quantify 2D and 3D spinal deformation. In particular: 1) the reproducibility of each method and 2) the inter-method correlation were explored.

METHODS: Twelve seven-month-old mini-pigs received anterolateral vertebral screws in four consecutive thoracic vertebrae (T8-11). In half of the animals (n=6), screws were connected by a polyethylene tether across three adjacent motion segments, while six animals received no tether (n=6) for sham surgical comparison. For the 2D evaluation, X-rays (Figure A) and 2D CT (Figure B) scans taken six months post-operative were used to measure scoliosis and kyphosis Cobb angle, vertebral body (VB) and intervertebral disk (IVD) space wedging, anterior, posterior, left and right disc height. Using Mimics, 0.625mm CT images were segmented semi-
automatically and 3D surfaces reconstructed. A custom MATLAB script automatically extracted from 3D CT reconstructions the same parameters that were made with the 2D evaluation (Figures C, D). Additionally, maximal plane of deformation, maximum Cobb angle, maximum VB and IVD wedging off the 3D were documented. To determine 2D reproducibility, two researchers measured all parameters on two different occasions and inter- and intra-class correlations (ICC) were assessed. Linear regression determined inter-method correlation (IMC) between 2D and 3D. The means from each correlation were compared by repeated ANOVAs.

RESULTS: X-rays, 2D and 3D CTs demonstrated significant 3D deformity creation in the tethered spines compared to sham controls. Excellent correlation of 2D and 3D coronal and sagittal Cobb measurements with high ICC (0.97) indicated good reproducibility. ICC and IMC were good for the remaining parameters, except for VB (0.093) and IVD-space (0.048) wedging. Care has to be taken when the deformity is very large and the deviation between local (vertebra) and global coordinate systems increases. In such cases, 2D views don’t allow for accurate capture of the 3D characteristics and lead to larger errors as seen in the evaluation of the vertebral body wedging.

DISCUSSION AND CONCLUSION: 3D results show subtle deviations from 2D measurements, even though there is good correlation between both methods for most evaluated parameters. The small angles involved make 2D evaluations very sensitive to the lines drawn by the user resulting in low ICC and IMC. The automated procedure used for the 3D analysis allows for a consistent, unbiased selection. In addition, 2D measurements are dependent on the plane at which the image was taken. The maximal planes of deformation are frequently located outside the pure coronal or lateral view. New evaluation measures were possible when extending the analysis into 3D space. The 3D view allowed for analysis of screw placement accuracy and for identification of the maximal plane of deformation, both of which are not possible with either of the 2D methods. These new 3D advanced imaging and measuring techniques will allow for more precise description of spinal morphology and better patient care.

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PAPERS, POSTERS & SCIENTIFIC EXHIBITS  PEDIATRICS

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The FDA has not cleared the drug and/or medical device for the use described in this presentation (i.e. the drug or medical device is being discussed for an off label use). For full information refer to page 14. An alphabetical faculty financial disclosure list can be found starting on page 19.
INTRODUCTION: Differentiating between the infectious etiologies in the pediatric acute irritable hip is challenging. While validated clinical algorithms can predict an infectious cause, the true pathology can be difficult to localize early in its course. Advanced imaging (bone scan and MRI) is often used in the early work-up of these patients; however, the role of advanced imaging in the initial management of the acutely irritable hip has not been well studied. The purpose of this study was to evaluate the effect of early advanced imaging on the management and outcome of children with a suspected septic hip.

METHODS: A retrospective chart review from 2003 - 2009 of all patients admitted due to likely septic arthritis of the hip joint was performed. The patients were then classified into two groups according to treatment protocol: those who received early advanced imaging prior to any aspiration or surgical intervention (early advanced imaging) versus those who underwent immediate hip aspiration prior to any advanced imaging (primary hip aspiration). Age, gender, laboratory values, temperature, clinical exam, radiographic findings, need for re-operation, and length of hospitalization were recorded. Statistical analyses included chi-square tests to compare patients according to advanced imaging status and multivariate logistic regression to identify predictors of re-operation. In all statistical tests, a p-value of less than 0.05 was used to declare significance.

RESULTS: A total of 130 patients met the inclusion criteria, with 53 patients in the primary hip aspiration group and 77 patients in the early advanced imaging group. There were no statistically significant differences in age, lab values, temperature, and clinical exam between the two groups. Among the primary hip aspiration group, 36 patients (68%) were diagnosed with a septic hip. Nine patients (17%) had additional pathology (osteomyelitis, abscess, etc.), unable to be diagnosed with a joint aspiration, and 15% of the time no septic arthritis was present. Among early advanced imaging patients, 35 (45%) had a septic hip requiring drainage and in 55 (71%) a change in management was made based on the imaging study. Among primary hip aspiration patients, 17 (32%) required a re-operation versus 13 (16.8%) patients in the early advanced imaging group. Multivariate analysis results demonstrated that after adjusting for age, re-operation was 2.8 times (95% CI 1.12-6.78) more likely to occur in patients who did not receive early advanced imaging compared to patients who underwent early advanced imaging (p=0.03).

DISCUSSION AND CONCLUSION: Clinical predictive algorithms can be used in differentiating between infectious and non-infectious etiologies; however, they do not isolate the diagnosis. In patients with a high likelihood of septic arthritis, aspiration results can be misleading, and additional or other pathology is common. We have shown that advanced imaging in patients suspected of having septic arthritis of the hip can assist the physician in elucidating the diagnosis, and may decrease the rate of re-operation in these patients.

**POSTER NO. P247**

**Early Advanced Imaging Decreases Need for Re-operation in Pediatric Patients with Suspected Septic Hip**

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**POSTER NO. P248**

**Measured Spasticity and Function Do Not Correlate in Children with Cerebral Palsy**

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**INTRODUCTION:** Spasticity is a component of the disability of children with cerebral palsy yet it is difficult to quantify, and difficult to determine the degree to which it affects function. Our purpose was to measure spasticity in children with idiopathic toe walking and in children with cerebral palsy of different functional levels.

**METHODS:** Spasticity was defined as the difference in ROM when measured awake and under anesthesia. Our assumption was that spasticity is absent under anesthesia, and therefore this difference is a proxy measure. We measured the difference in joint ROM awake and under anesthesia at the hip, knee and ankle in 12 patients with idiopathic toe walking and 128 patients with cerebral palsy of different Gross Motor Functional Classification System (GMFCS) levels in which level I walks independently and level IV uses a wheelchair in the community (GMFCS I: 23, GMFCS II: 32, GMFCS III: 39, GMFCS IV: 34). The first author made all the measurements, all with the same technique, to determine the joint position at the first catch. Hip abduction was measured with the hip flexed 90° and the pelvis level. Popliteal angle was measured with the hip flexed at 90°. Ankle equinus was measured with the knee in extension.

**RESULTS:** The idiopathic toe walker group showed no difference in ROM between awake and anesthesia states and therefore no increased spasticity. There were differences between the idiopathic toe walker group and the cerebral palsy group that were both clinically significant and statistically significant: hip abduction 17° (p = .0008), popliteal angle 14° (p = .004) and ankle equinus with the knee extended 16° (p = .0002). This demonstrated that there was increased spasticity in the cerebral palsy group.

**Regression analysis of the GMFCS I, II, III and IV data showed that there were no increases in the measure of spasticity with increasing GMFCS level at the hip or knee. This indicates that the more involved children with less functional ability did not have more spasticity at the hip or knee that could have explained their disability. Only at the ankle was there a small increase in the spasticity measure (5°) for every 1-unit change in GMFCS (p = .0014). Since the ankle is not as critical as the hip and knee for function, this change is probably not clinically significant.**

**DISCUSSION AND CONCLUSION:** By this new measure of spasticity, idiopathic toe walkers did not show an increase in spasticity, which agrees with the clinical presentation. In children with cerebral palsy an increase in spasticity was measured at the hip and knee compared to therapist observations. Regression analysis of the GMFCS I, II, III and IV data showed that there were no increases in the measure of spasticity with increasing GMFCS level at the hip or knee. This indicates that the more involved children with less functional ability did not have more spasticity at the hip or knee that could have explained their disability. Only at the ankle was there a small increase in the spasticity measure (5°) for every 1-unit change in GMFCS (p = .0014). Since the ankle is not as critical as the hip and knee for function, this change is probably not clinically significant.

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Risk Factors for Coronal Decompensation Following Spinal Fusion for Adolescent Idiopathic Scoliosis

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INTRODUCTION: Segmental posterior spinal instrumentation and fusion (PSIF) has become the standard of care for surgical treatment of severe adolescent idiopathic scoliosis (AIS). Coronal decompensation is a potential complication of spinal instrumentation for AIS. This can result in problems requiring revision surgery. The purpose of this study was to investigate risk factors for coronal decompensation two years after PSIF for AIS.

METHODS: Retrospective review of a large, multicenter dataset identified 890 patients with AIS and at least two years of follow up following PSIF. Demographic, clinical and radiographic measures were reviewed. Coronal decompensation was defined as a change further away from midline (or horizontal) from six weeks to two years in any one of the following radiographic parameters: change in LIV Tilt Angle > 10°; change in Coronal Position of the LIV > 2 cm; change in Thoracic Trunk Shift > 2 cm; or change in Coronal Balance > 2 cm. Patients with coronal decompensation were compared to those without. The relationship between the lowest instrumented vertebrae (LIV) and lowest end vertebra (LEV) was also examined as an independent variable.

RESULTS: A total of 6.4% (57/890) of patients exhibited coronal decompensation at two years postop. Univariate analysis demonstrated that decompensated patients were more likely to be males, have lower preop Risser scores, a more cephalad LIV, and lower percent major curve correction (58.7 vs. 64%). Multivariate regression demonstrated that decompensated patients were twice as likely to be male, to have lower preop Risser score, and lower percent major curve correction. The relationship between the LIV and LEV was not significant.

DISCUSSION AND CONCLUSION: A total of 6.4% of patients with AIS exhibit radiographic decompensation two years after PSIF. AIS patients with male gender, low preoperative Risser score and smaller percent major curve correction following PSIF are more likely to exhibit coronal decompensation at two years postoperatively. While this study did not demonstrate a significant association between the relationship of LIV and LEV and decompensation two years postoperatively, results of this study indicate that skeletal immaturity, male gender and less correction of the major curve may be related to higher rates of decompensation.
growth plate tissue requires recapitulation of the columnar architecture of the native growth plate, as this imposes directionality upon longitudinal bone growth. The Wnt Planar Cell Polarity (PCP) signaling pathway has been implicated as an important regulator of growth plate column formation in vivo, and we hypothesized that activation of this pathway in a three-dimensional pellet culture model would promote column formation in vitro.

METHODS: Epiphyseal chondrocytes were isolated from four-day old Sprague-Dawley rats, transfected with plasmid DNA encoding full-length Fzd7 or a deletion mutant of Fzd7 lacking the Wnt binding domain, and cultured as three-dimensional cell pellets. Recombinant Wnt5a was added to the culture medium for three weeks. Cellular morphology and alignment of cells into columns were assessed using histomorphometric measurements.

RESULTS: Activation of the Wnt PCP pathway promoted stacking of growth plate chondrocytes after three weeks of culture. Oriented chondrocyte columns were clearly present in toluidine blue stained sections of cartilage pellets treated with transfection of full-length Fzd7 and addition of Wnt5a. Additionally, chondrocytes displayed a flattened morphology following treatment with exogenous Wnt5a, with or without overexpression of Fzd7.

DISCUSSION AND CONCLUSION: Activation of the Wnt Planar Cell Polarity (PCP) pathway through overexpression of Fzd7 and addition of Wnt5a promotes columnar architecture in growth plate chondrocytes cultured in vitro. Our results are consistent with previous in vivo data demonstrating the importance of Wnt PCP signaling and morphogen gradients in establishing the columnar architecture of the native growth plate, and represent an important step toward the engineering of functional growth plate tissue in vivo.

Histomorphometric analysis of column formation. Column index was calculated as the product of the percentage of cells participating in columns of at least 3 cells and the average column length in pixels. ANOVA for the 4 treatment groups demonstrated a significant difference from treatment compared to the 1% FBS control (P = 0.01). The aspect ratios for individuals cells were calculated as longest dimension/shortest dimension. Cells were binned into aligned (long axis 55-115 degrees from perpendicular to pellet edge) or misaligned (other cells), then average aspect ratio compared within each treatment group. Treatments demonstrated flattening of aligned cells compared to misaligned cells, while the 1% FBS control group did not.
Environmental Factors Affecting Pediatric Orthopedic Consults

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INTRODUCTION: In the pediatric emergency room, orthopedic injuries account for a large majority of visits and admissions yearly. At first glance, fluctuations in the volume of pediatric orthopedic injuries appears to be by chance and relatively unpredictable. However, there is anecdotal evidence that several environmental factors may contribute to these fluctuations. Based on a literature review, extreme weather patterns including temperature, precipitation, and sunshine hours have been attributed to various adult emergency room visits ranging from asthma to penetrating trauma. By isolating certain environmental factors, it may be possible to gain insight into pediatric fractures volumes. If a relationship between temperature, weather conditions, lunar phase, and pediatric fracture volumes could be established; it could predict increased patient volumes and could allow for better allocation of orthopedic and emergency room personnel as well as material resources.

METHODS: A retrospective review was performed from January 2007 to December 2009 based on orthopedic trauma ICD-9 codes at a MidSouth pediatric hospital. All orthopedic injuries presenting to the emergency department were collected. Temperature, weather conditions, precipitation, and lunar phase were retrieved from the National Oceanic and Atmospheric Administration (NOAA) over the same time period. Statistical analysis was performed to determine the relationship between environmental factors and pediatric orthopedic injuries.

RESULTS: There were 6,770 consultations for pediatric orthopedic trauma in the three-year time frame, averaging 6.2 injuries per day. Average daily temperature predicted pediatric orthopedic injuries. There were 7.4 consultations per day when the averaged daily temperature was between 70° and 79°. When the temperature fell below 20°, the number of pediatric orthopedic injuries fell to two. Minimum temps below 37.5° and maximum temps under 67.5° had lower heavy consultation days (p<0.001). In regard to seasons, winter months had the lowest number of heavy consult days (>10 consultations) while the spring months had the highest (p<0.0001); 14 and 63 respectively. Logistic regression modeling was used to determine that May represented 56% of the heavy consultation days. Precipitation was also evaluated. Precipitation of any amount lowered the number of pediatric consults from 6.4 to 5.7 (p=0.0043). Lunar phase and day of the week did not have any statistical significance for pediatric orthopedic injuries.

DISCUSSION AND CONCLUSION: It was important to the authors of this paper to confirm anecdotal experience with clinical evidence. Moreover, in a push to become more cost conscious, human and emergency resources can become better allocated with evidence based data. While predicting a pediatric fracture seems futile, certain environmental factors can influence the allocation of resources to better serve our patients.

Cost Analysis of Implants for Surgical Correction of Scoliosis: Implications of Construct Design

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INTRODUCTION: Surgery is required in patients with progressive adolescent idiopathic scoliosis (AIS), and implant costs associated with this procedure are of increasing concern to hospitals and surgeons. There are a number of clinically acceptable surgical constructs that result in successful curve reduction; however, the economic implications of differential implant utilization have not been studied.

METHODS: For each Lenke curve type I-VI, we identified three possible construct designs using either all-pedicle screws, alternate-pedicle screws wherever possible, or a hybrid design wherever possible, confirmed by three scoliosis surgeons. Unit cost to the hospital for all individual implants used in each construct was averaged across the three manufacturers, and the total construct cost calculated. A unique stochastic decision tree model was developed to compare costs; complication and correction rates were held constant. A modified Monte Carlo simulation was conducted using identical theoretical populations of 100,000 pediatric patients modeled from 2008 Census Data. Individually simulated patients were “screened” based on age and sex specific incidence for thoracic AIS, “trialed” with conservative bracing treatment, and if surgery was indicated, accrued hardware costs for posterior spinal fusion across six to 10 vertebral levels based on incidence of specific Lenke curve type.

RESULTS: Per 100,000 patient years, implant costs for the all-pedicle screw construct were $266,087 (95%CI $219,813 to $312,362), for the alternate-pedicle screw construct were $192,958 (95%CI $155,678 to $230,237), and for the hybrid construct $158,842 (95%CI $126,573 to $191,111). ANOVA and individual student’s t-tests between groups was significant at p<0.0001. The annual incremental implant cost differential in the United States between using only all-pedicle screw constructs and a management strategy of alternate-pedicle screw construct were $8,799,557, and between using only all-pedicle screw constructs and a management strategy of hybrid construct wherever possible is $12,904,587. DISCUSSION AND CONCLUSION: The economic implications of surgical construct selection on implant costs are substantial in the operative management of AIS. If surgical correction and complication rates are similar, utilization of alternate-pedicle screw or hybrid constructs results in significant annual cost savings in the United States. Any shift in construct design towards either of these would contribute to the reduction of scoliosis surgery associated costs.
Comparison Between the Graf Method and a New 50/50 Method of Interpreting Sonograms in Developmental Hip Dysplasia

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INTRODUCTION: We have encountered radiological reports of ‘normal Graf -angles’ when the femoral head was subluxed. We therefore developed a simple method to determine femoral acetabular congruency known as the 50/50 method, figures 1 & 2. We compare our method to the established Graf method.

METHODS: Two identical, randomly assorted sets of 100 ultrasound images were evaluated. All ultrasonograms were of patients under three months of age within our Developmental Hip Dysplasia (DDH) screening program. The images were assessed to be either ‘normal’ or ‘abnormal’ by six junior doctors using each method after reading brief instructions. (Images were classified as normal or abnormal by consensus between an orthopaedic consultant and radiologist who also examined and preformed dynamic screening on each infant).

RESULTS: The mean proportion of abnormal scans with agreement and normal scans with agreement was 0.52 (95% CI 0.39-0.69) and 0.92 (CI 0.87-0.96) respectively, indicating moderate agreement (kappa 0.41, CI 0.12-0.71) for inter-observer variability using the Graf method. On average the inter-observer variability using the 50/50 method for abnormal and normal scans with agreement was 0.60 (CI 0.35-0.84) and 0.92 (95% CI 0.85-0.99) respectively with moderate agreement (kappa 0.50, CI 0.20-0.80). Inter-observer variability between the Graf and 50/50 methods revealed moderate agreement (mean kappa 0.41, CI 0.17-0.66) with the average proportion of abnormal and normal scans with agreement of 0.50 (CI 0.32-0.69) and 0.91 (CI 0.83-0.98) correspondingly. The accuracy of each test was equal, ranging from 84% to 93%.

DISCUSSION AND CONCLUSION: The 50/50 method is straightforward to both use and teach. Moreover, it successfully serves as “red dot” system to flag up abnormal hips at clinic. The 50/50 method is at least as good as Graf with regard to accuracy, inter-observer and intra-observer variability. We recognize that dynamic screening remains the gold standard.

The Use of Antifibrinolytics Substantially Reduces Blood Loss During Surgery for Cerebral Palsy Scoliosis

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INTRODUCTION: Scoliosis surgery in children with cerebral palsy (CP) is associated with substantial intraoperative blood loss. The purpose of this study was to evaluate the safety and efficacy of antifibrinolytic agents on blood loss during these procedures.

METHODS: A multi-center, prospective study was conducted of 84 consecutively enrolled patients (age <18yrs) with CP who underwent posterior spinal fusion and instrumentation as part of their spinal deformity correction. Estimated blood loss was expressed as a percent of blood volume (EBL/BV), and then normalized for weight (cc/kg). The use of antifibrinolytic (AF) agents was noted (tranexamic acid (TXA), aminocaproic acid, aprotinin, or none) and based on surgeons randomization. Blood loss in these groups was compared utilizing analysis of covariance (controlling for deformity magnitude) with Bonferroni post hoc comparisons (p<0.05).

RESULTS: The average preoperative major deformity (kyphosis or scoliosis) was 82 ± 27° and the mean age at surgery was 14.4 ± 2.6 yrs. The groups were well matched - there was no difference between groups in preoperative major deformity (coronal or sagittal), age, use of pelvic fixation or number segments fused. The average number of vertebral levels fused was 16.7 (range 15-18) and 95% of the patients had pelvic fixation. Of the 84 patients, 44 received AF, and 40 received no AF agent (NAF). The total EBL averaged 1684 ml ± 1117 for the AF group and 2685 ml ± 1712 for the NAF group, p=0.002. Normalized blood loss was significantly less in the AF group (48± 30 cc/kg) vs. NAF (87 ± 60 cc/kg), p<0.001. Blood loss as a ratio to blood volume (%BV) in the AF group was significantly lower (70%) than in the NAF group (125%, p<0.001). TXA was more effective than the other two agents. There was more cell salvage transfusion in the NAF group, but no significant differences were found in total transfusion of allogenic products or individual components. There were trends for shorter ICU and inpatient length of stay in the AF group. There were no adverse effects reported due to the use of AF.

DISCUSSION AND CONCLUSION: Blood loss associated with surgery for CP scoliosis procedures was found to be significantly reduced by the use of antifibrinolytics.
POSTER NO. P257
ALTERNATE PAPER: PEDIATRICS II

Does Insurance Status Influence Surgical Outcome for Pediatric Patients with Idiopathic Scoliosis?

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INTRODUCTION: The purpose of this study is to determine whether insurance status influences surgical outcome for pediatric patients with idiopathic scoliosis.

METHODS: An analysis of the Healthcare Cost and Utilization Project Kids’ Inpatient Database 2000, 2003, and 2006 was performed. All patients aged 0 to <18 years with idiopathic scoliosis and no underlying neurologic disorders who underwent fusion were included. National trends, patient, hospital and surgical characteristics, postoperative complications, and risk factors were determined.

RESULTS: An estimated 5,311, 5,392, and 5,869 fusions were performed for idiopathic scoliosis in 2000, 2003, and 2006, respectively. Patients with private insurance were more likely to have surgery than Medicaid patients (7.44 vs. 5.86 per 100,000 capita). Patients with private insurance were older than Medicaid patients at the time of surgery (ages <3: 1.8% vs. 6.1%, p<0.0001; ages 10–18: 98.1% vs. 93.6%, p=0.0001). Medicaid patients had higher prevalence of asthma (10.0% vs. 6.2%, p=0.0009), hypertension (1.3% vs. 0.2%, p<0.0001), hyperlipidemia (0.3% vs. 0.1%, p=0.0456), diabetes (0.9% vs. 0.3%, p=0.002), and obesity (2.3% vs. 1.3%, p=0.0042). Medicaid patients underwent longer fusion (>9 vertebrae: 30.7% vs. 22.9%, p<0.0001) and more refusion (1.3% vs. 0.8%, p=0.0492). Postoperative complications were similar, including death (Medicaid 0.2% vs. Private 0.0%, p=0.0639), neurologic (Medicaid 1.8% vs. Private 1.7%, p=0.6841) and infectious (Medicaid 0.4% vs. Private 0.2%, p=0.0993). Length of stay was longer (6.3 vs. 5.7 days, p<0.0001) and hospital charges higher ($82,286 vs. $72,912, p<0.0001) for Medicaid patients. Younger age, female gender, and surgery being performed at a children’s hospital in the South or Midwest were identified as negative predictors, while cardiac disease, obesity, and osteotomies were positive predictors, of developing neurologic complications.

DISCUSSION AND CONCLUSION: Medicaid patients had more medical comorbidities and underwent longer fusions at younger ages for idiopathic scoliosis than patients with private insurance. However, insurance status did not affect the rate of postoperative complications.

POSTER NO. P258

Methicillin Resistant Staphylococcus Aureus Induces Endothelial Cells to Form a Clot

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INTRODUCTION: Methicillin resistant Staph aureus (MRSA) infections are complicated by deep vein thrombosis (DVT). We show that MRSA directly causes vascular hypercoagulability. The prevalence of MRSA continues to increase yearly despite improvements in care. Concurrently children that develop MRSA infection are known to have an increased risk of thrombotic events such as deep vein thrombosis, pulmonary embolism (PE) and disseminated intravascular coagulation (DIC). While this correlation between MRSA infection and hypercoagulability has been known for some time the physiological nidus for the patients hypercoagulability remains unclear. Here we use a modified thrombin generation assay to assess MRSA capacity to alter an endothelial cells ability to buffer and initiate coagulation.

METHODS: EA.hy 926 cells were in a 96-well plate at 25,000 cells per well and allowed to recover for 6hrs. Cells were then changed into a serum free phenol red free media containing 1% BSA and incubated 18hrs. TNF (concentration for each incubation given in each figure) or heat killed MRSA (cfu/ml to be given in each experiment) was then added and incubated for 5hrs. Cells were washed and plasma was added. Calcium-free PBS was added to the plasma along with the thrombin reporting substrate. Finally calcium chloride was added and the changes in fluorescence was monitored every 30 seconds for 2hrs. The raw fluorescent units (RFU) underwent corrections via a third degree polynomial accounting for substrate depletion and inner filter effect. The first order derivative (Delta slope/time) of the corrected RFUs is then graphed which allow for various parameters such as endogenous thrombin potential (ETP) (a measure of the total amount of thrombin generated during the assay), time to peak height (the time it takes to reach the maximum rate of thrombin generation), lag time (the time it takes to initiate the production of thrombin), to be measured. All experiments N=3.

RESULTS: MRSA concentration dependently increased the amount of thrombin produced in endothelial cells over control unstimulated cells. This increase in thrombin production was statistically significant and at the highest CFU/ml generated the same amount of thrombin as the positive control TNF, an inflammatory cytokine up regulated during MRSA infections. MRSA also concentration dependently decreased the lag time, and time to peak indicating these treated cells would propagate clot formation quicker then untreated cells. These data show for the first time MRSA can directly alter endothelial cells without the presence of immune cells.

DISCUSSION AND CONCLUSION: Here we show MRSA directly increased vascular regulated coagulation by stimulating endothelial cells into a procoagulant phenotype. This alteration of the vascular endothelial cells phenotype may serve as the nidus for infection are known to have an increased risk of thrombotic events such as deep vein thrombosis, pulmonary embolism (PE) and disseminated intravascular coagulation (DIC). While this correlation between MRSA infection and hypercoagulability has been known for some time the physiological nidus for the patients hypercoagulability remains unclear. Here we use a modified thrombin generation assay to assess MRSA capacity to alter an endothelial cells ability to buffer and initiate coagulation.
Socioeconomic Factors Influence Repeat Emergency Department Visits in Pediatric Patients with Closed Fractures

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INTRODUCTION: Timely outpatient follow up is critical to minimize complications during non-operative management of closed pediatric fractures. Previous research has demonstrated both greater difficulty in obtaining follow-up appointments and increased likelihood of return visits to the emergency department (ED) for patients with government-funded insurance plans. This is despite policy-based efforts, such as the Children's Health Insurance Plan, to expand health insurance coverage for American children. The purpose of the current study is to determine whether socioeconomic factors, such as race and insurance type, influence the incidence of repeat ED visits in pediatric patients with closed fractures.

METHODS: A review of ED visit data over a two-year period from a statewide hospital discharge database in New York was conducted. Discharges for patients with a unique person identifier in the database age 17 and younger were examined for an ICD-9 diagnosis of closed upper or lower extremity fracture. The age, gender, race, and insurance type for patients with a return ED visit within eight weeks for the same fracture diagnosis were compared to those without a return visit using standard univariate statistical tests and simple logistic regression analyses.

RESULTS: Of the 68,236 visits reviewed, the revisit rate was 0.85%. Patients who returned to the ED were significantly younger (6.7±5.3 years) than those who did not revisit (8.3±5.0 years; p<0.001). There was no difference in gender composition. Patients of non-white or unidentified race were significantly more likely to have a revisit than white patients (OR 1.27; p=0.006). Patients with government-funded insurance were significantly more likely to have a revisit than those without government-funded insurance (OR 1.55; p<0.001). Patients with private insurance were significantly less likely to have a revisit than those without private insurance (OR 0.72; p=0.001).

DISCUSSION AND CONCLUSION: Our analysis revealed that non-white patients are more likely to return to the ED within eight weeks for the same fracture diagnosis. Patients with government insurance are 55% more likely to have a revisit, while patients with private insurance are 28% less likely to have a revisit. If ED revisits are a proxy for inability to obtain appropriate outpatient follow up, our results suggest that socioeconomic disparities exist in access to orthopaedic care for pediatric closed fractures. Both physicians and policy makers should be mindful of these healthcare disparities when striving to improve access to care among patients and resource utilization in the emergency department.

The Coagulation Protein Plasminogen is Required for Ossification of the Capital Femoral Epiphysis

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INTRODUCTION: It has been shown that development of avascular necrosis of the proximal femoral epiphysis in children may be associated with conditions that favor vascular thrombosis. The coagulation system in children is distinctly different from that in adults resulting in a decreased tendency to form a thrombosis without an increased risk of bleeding. We hypothesized that these differences are essential to support the growing skeleton by supporting an adequate vascularity of developing bone. We tested this hypothesis by monitoring the vascular development, and subsequent ossification, of the proximal femoral epiphysis in growing mice deficient in the key coagulation protease responsible for degrading fibrin clots, plasmin (plg).

METHODS: Radiographs, µCT, and histology were used to determine ossification of the capital femoral epiphysis in control (N=10), plasmin(-/+)(N=12) and plasmin(-/-)(N=20) mice. Microfil technique was used to visualize bone vascularity (N=4).

RESULTS: Vascular invasion, physeal dissolution and ossification of the capital epiphysis occurred at post-natal week (13) in the control mice. Half of the plasmin(-/+)(N=12) and all of the plasmin(-/-)(N=20) mice failed to develop a transphyseal blood supply and therefore failed to ossify the capital femoral epiphysis by post-natal week (20).

DISCUSSION AND CONCLUSION: We determined that mice deficient in plasmin, the key protease of the fibrinolytic system, fail to develop transphyseal vasculature resulting in a persistently avascular, non-ossified capital femoral epiphysis. The gene-dose dependency of plasmin found in this study provide evidence that factors that change the balance of coagulation, genetic polymorphisms, environmental toxins, or pharmaceutical agents, may directly affect skeletal development in the growing child leading to permanent skeletal deformity such as Perthes disease.
Complications of Elastic Stable Intramedullary Nailing in Pediatric Fracture Management
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Introduction: Elastic stable intramedullary nailing (ESIN) is increasingly accepted as treatment of choice for management of long bone fractures in children. The initial indications for ESIN were mid diaphyseal fractures but they have been expanded to include proximal and distal shaft fractures, metaphyseal fractures and comminuted fractures. With expanding indications and widespread use of ESIN, it is important to realize the potential for complications and its management. The aim of this exhibit is to present the surgical technique of elastic nailing in children, focus on how to anticipate, avoid and manage complications. Materials and Methods: Ideal indications for ESIN - Children 5-12 years of age - Weight < 112 lbs (for femoral fractures) - Diaphyseal fracture of long bones Expanded indications - Children < 5 or > 12 years - Weight > 112 lbs (for femoral fractures) - Proximal and distal shaft or metaphyseal fractures - Comminuted fractures Ideal surgical technique video including reduction techniques and extended indications (15 min) Complications - Nail protrusion, prominence, entry site irritation, tendon rupture (wrist) - Malunion - shortening, angulation - Iatrogenic comminution - Neurovascular issues, compartment syndrome - Infection - Physeal injury during nail insertion - Complications due to retained hardware Results: (Each case would provide a brief summary with preoperative and postoperative radiographs) Case examples (extended indications) Case 1. Skin issues 1 week after spica cast application for femoral shaft fracture, necessitating use of ESIN in a 3 year old child Case 2. Distal metaphyseal femoral fracture treated with antegrade ESIN (C and S shaped nails) Case 3. Subtrochanteric femoral fracture treated with retrograde ESIN Case examples (complications): Case 1: Postoperative shortening of 4 cm after ESIN for comminuted femoral shaft fracture requiring submuscular plating to maintain the length (Fig A) Case 2. Malunion (varus and procurvatum) after ESIN of femoral shaft fracture. Patient underwent osteotomy for correction of deformity one year after his index surgery Case 3. Physeal distraction and growth arrest during forceful insertion of elastic nail for radius shaft fracture (Fig B) Case 4. Fracture of the radius at the tip of a retained elastic nail, four years after fracture treatment. Case 5. Recurrent injury with Nonunion of ulna fracture after open reduction and ESIN for both bone forearm fracture (Fig C). It required removal of nail, bone graft and plate for ulna osteosynthesis Case 6. Iatrogenic comminution of distal femoral shaft fracture while trying to insert flexible nails. This required a intraoperative change of plan to open plating Case 7. Compartment syndrome after ESIN of tibial shaft fracture, necessitating fasciotomy Case 8. A rupture of extensor pollicis longus tendon due to attrition at the end of the nail needing a tendon reconstructive procedure Discussion: Technical tips to avoid complications: Ideal insertion points (retrograde, antegrade) Fracture Reduction techniques Ideal nail (size, material, bend) Postoperative adjunct support (knee immobilizer, cast, brace) Postoperative physical therapy, weight bearing status Removal of hardware and hardware related issues

POSNA - Operating Room Set-up and Positioning for Common Pediatric Orthopaedic Injuries
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Introduction: Careful patient positioning and thoughtfull set-up of operating room equipment can maximize surgical efficiency when treating several common pediatric orthopaedic conditions. The purpose of this exhibit is to describe the typical set-up used by members of the Pediatric Orthopaedic Society of North America (POSNA) for several commonly performed pediatric orthopaedic procedures. Methods: We describe the typical patient positioning and operating room set-up for three different pediatric orthopaedic procedures: closed reduction and percutaneous fixation of supracondylar humerus fracture, in situ screw fixation of a slipped capital femoral epiphysis, and the treatment of a femoral shaft fracture with titanium elastic nails. In each case, photographs and accompanying descriptions are provided to describe a step-by-step approach to the surgical set-up and treatment of these conditions. Alternative approaches to operating room set-up and patient positioning are also presented. Results: Supracondylar humerus fractures in children are generally performed with the patient supine. Because of the small size of the typical child sustaining this injury, the patient often needs to be translated on the OR table such that the arm and shoulder can hang off the end. The image intensifier is typically reversed to act as a “hand table” and is brought in parallel to the bed. Placing an arm board proximal to the image intensifier is helpful to support the head during fracture reduction. For extremely unstable fracture patterns, however, it often better to use an actual hand-table to support the limb; this allows the C-arm to be rotated to obtain lateral images rather than risk loss of reduction from rotating the arm itself. The monitor for the C-arm is best placed on the opposite side of table so that the surgeon can easily visualize it during surgery. Slipped capital femoral epiphyses (SCFE) are generally treated supine on a radiolucent flat top table. The image intensifier is brought in from the contralateral side directly perpendicular to the bed, with the monitor placed down by the feet. The leg is rotated internally until the broadest neck is visualized, a guide pin is placed over the skin in the proposed trajectory of the screw, and this line is marked with a skin marker. A 1-2 cm incision is made on the anterolateral thigh in line with this mark and a guide pin is placed down to bone. The pin is advanced a short distance into bone on the AP fluoroscopic view, and (while protecting the pin from bending) the patient is brought into the frog lateral position to confirm proper trajectory. The pin may then be advanced to the appropriate depth before over-drilling and placement of the cannulated screw. Elastic nailing of femoral shaft fractures may be performed on either a radiolucent table or a fracture table. If a radiolucent table is chosen, an assistant must achieve proper length, alignment and rotation (primarily from traction). This is the method of choice for younger patients who may not fit typical fracture tables. For older and larger children, a fracture table may allow reduction to be achieved prior to commencing the surgical procedure, thus minimizing the need for additional assistants. If a fracture
table is used, the image intensifier is usually brought in between the patient’s legs to allow for lateral imaging. The surgeon and his or her assistant can then simultaneously insert nails while standing on either side of the thigh. Discussion/Conclusions: By appropriate patient positioning and coordinated set-up of operating room equipment, many pediatric orthopaedic procedures may be streamlined to optimize outcomes and avoid unnecessary surgical delays.

SCIENTIFIC EXHIBIT NO. SE50

**Correlation and Reproducibility of 2D and 3D Spinal Measurements**

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**Introduction:** Scoliosis is widely recognized as a three-dimensional (3D) deformity, yet analyses of spinal deformation in 3D are scarce. While 3D deformity quantification is critically important, it can not be adequately achieved from classical 2D radiographs. Still, most previous research in this area concentrated on 2D geometrical analysis using plain X-Rays. This study introduced spinal deformity by anterolateral spinal tethers in a mini-pig model. Conventional 2D measurements from plain X-Rays/CT were compared to 3D computed tomography (CT) reconstructions. The objective of this study was to quantify 2D and 3D spinal deformation. In particular: 1) the reproducibility of each method and 2) the inter-method correlation were explored.

**Methods:** Twelve 7-month-old mini-pigs received anterolateral vertebral screws in four consecutive thoracic vertebrae (T8-11). In half of the animals (n=6), screws were connected by a polyethylene tether across three adjacent motion segments, while 6 animals received no tether (n=6) for sham surgical comparison. For the 2D evaluation, X-Rays (Figure A) and 2D CT (Figure B) scans taken 6 months post-operative were used to measure scoliosis and kyphosis Cobb angle, vertebral body (VB) and intervertebral disk (IVD) space wedging, anterior, posterior, left and right disc height. Using Mimics, 0.625mm CT images were segmented semi-automatically and 3D surfaces reconstructed. A custom MATLAB script automatically extracted from 3D CT reconstructions the same parameters that were made with the 2D evaluation (Figures C, D). Additionally, maximal plane of deformation, maximum Cobb angle, maximum VB and IVD wedging off the 3D were documented.

To determine 2D reproducibility, 2 researchers measured all parameters on 2 different occasions and inter- and intra-class correlations (ICC) were assessed. Linear regression determined inter-method correlation (IMC) between 2D and 3D. The means from each correlation were compared by repeated ANOVAs.

**Results:** X-rays, 2D and 3D CTs demonstrated significant 3D deformity creation in the tethered spines compared to sham controls. Excellent correlation of 2D and coronal and sagittal Cobb measurements with high ICC (0.97) indicated good reproducibility. ICC and ICM were good for the remaining parameters, except for VB (0.093) and IVD-space (0.048) wedging. Care has to be taken when the deformity is very large and the deviation between local (vertebra) and global coordinate systems increases. In such cases, 2D views don’t allow for accurate capture of the 3D characteristics and lead to larger errors as seen in the evaluation of the vertebra body wedging.

**Discussion:** 3D results show subtle deviations from 2D measurements, even though there is good correlation between both methods for most evaluated parameters. The small angles involved make 2D evaluations very sensitive to the lines drawn by the user resulting in low ICC and ICM. The automated procedure used for the 3D analysis allows for a consistent, unbiased selection. In addition, 2D measurements are dependent on the plane at which the image was taken. The maximal planes of deformation are frequently located outside the pure coronal or lateral view. New evaluation measures were possible when extending the analysis into 3D space. The 3D view allowed for analysis of screw placement accuracy and for identification of the maximal plane of deformation, both of which are not possible with either of the 2D methods. These new 3D advanced imaging and measuring techniques will allow for more precise description of spinal morphology and better patient care.

SCIENTIFIC EXHIBIT NO. SE51

**LLRS: Principles of Limb Lengthening and Deformity Correction**

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This exhibit, sponsored by the Limb Lengthening and Reconstruction Society, will feature the principles essential for successful limb lengthening and deformity correction. These principles include: Knowledge of cross-section anatomy; Correct characterization of deformity; Accurate projection of remaining growth; Paying attention to adjacent joints; Modifying speed of distraction when necessary; and most importantly, knowing when to stop and accept an intermediate result.