

## ABSTRACTS

## EPOS 35th Congress Meeting

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## EP1

**Correlation of gestational age with clubfoot severity, treatment, and outcome**Ehud Lebel<sup>1</sup>, Liran Hanan<sup>2</sup><sup>1</sup>Shaare-Zedek Medical Center, Affiliated with the Hebrew University of Jerusalem, Jerusalem, Israel; <sup>2</sup>School of Medicine, The Hebrew, Jerusalem, Israel

## Level-4

**Club-foot****Introduction** Clubfoot is a congenital foot deformity, where etiology is unknown in >90 % of cases. One possible etiology is retained fetal position that did not mature during a full-term pregnancy into a normally-positioned and moveable limb. We sought to explore whether gestational age of the newborn and/or other characteristics impact clubfoot outcome and developmental milestones.**Materials and methods** Data was collected retrospectively regarding babies born between 2008 and 2014 who were followed until independent walking age. Clubfoot severity score at each stage, number of casts, age at completion of casting, and achievement of developmental milestones (age and clubfoot score) were correlated with length of pregnancy and neonatal demographics.**Results** 150 babies were included (95 males, 55 females); 22 babies were born preterm (<37 weeks). There was no significant difference in initial Pirani score between groups in numbers of casts required or in rates of Achilles tenotomy. Syndromic background was found to be correlated with delayed achievement of milestones and longer treatment course (more casts or need for tenotomy). Although preterm babies achieve developmental milestones at a later age, their clubfoot status is comparable to that of full-term at each milestone.**Conclusion** Clubfoot presentation and management course is similar in preterm neonates as in full-term neonates.**Significance** Prematurity in itself does not pose a specific adverse risk for clubfoot management.

## EP2

**Results of surgical treatment of flatfoot with Evans–Mosca’s technique**Vincenzo De Luna<sup>1</sup>, Vito Potenza<sup>2</sup>, Gabriele Bernardi<sup>2</sup>, Pasquale Farsetti<sup>2</sup>, Ernesto Ippolito<sup>2</sup><sup>1</sup>University of Rome “Tor Vergata”, Rome, Italy; <sup>2</sup>University of “Tor Vergata”, Rome, Italy

## Level-2

**Foot and ankle****Introduction** Most children with flexible flatfoot are asymptomatic and they do not require any treatment. However, especially in adolescence, there are cases of severe symptomatic flexible flatfoot that require surgical treatment.**Materials and methods** Eighteen patients with 26 flat feet were operated on between 2005 and 2012. They represented about 5 % of all the children and adolescents who visited our clinics for flexible flatfoot during the same time period. The main symptoms were pain, plantar callosities and uncoordinated running. Surgery was carried out according to the technique of Evans modified by Mosca, characterized by a calcaneal lengthening osteotomy associated with a plication of talo-navicular joint capsule and tensioning of tibialis posterior tendon. Patients age ranged from 11.5 to 15 years with an average of 12.8 at the time of surgery. Follow-up length after surgery ranged from 2 to 9 years, with an average of 4 years. All the patients underwent a standing radiographic examination of the feet in anteroposterior and lateral view and answered a questionnaire (The Foot and Ankle Disability Index, FADI-Score) before surgery and at the final follow-up evaluation.**Results** Preoperative Meary’s angle was on average 24.6° whereas it measured 1.4° at the final follow-up, with an average improvement of 23.2°. Preoperative Costa-Bertani’s angle was a mean 156° and had decreased to a mean 131° at the final follow-up, with an average improvement of 25°. The mean preoperative FADI-Score was 67.5 and 99 % at the final follow-up with a mean improvement of 31.5 %

whereas the mean preoperative FADI-Score Sport was 54.2 and 98.9 % at final follow-up, with an average improvement of 44.7 %. Patients were no longer painful and the callosities had disappeared, whereas the range of motion of the foot was similar to the preoperative ROM or minimally reduced in 7 ft.

**Conclusion** The Evans–Mosca's procedure gave us excellent and good results. It corrects the flexible flatfoot deformity by lengthening of the lateral hinge, which in turn restores the normal relationships by rotating the anterior facet of the subtalar joint plantaromedially thus providing the physiologic support for the talar head. The whole procedure corrects the flatfoot deformity without limitation of the foot ROM otherwise present in other surgical techniques based on arthroereisis of the subtalar joint.

### EP3

#### Evaluation of hip muscle strength in long-term follow-up after open reduction by medial approach in developmental dysplasia of the hip

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#### Level-4

##### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** The impact on long-term weakness of hip flexion of complete iliopsoas tenotomy during open reduction of developmental hip dysplasia (DDH) with a medial approach has not yet been fully clarified. The purpose of this study was to investigate the isokinetic muscle strength (IMS) of hip flexor and extensor muscles in these patients and also to analyze the effect of reattachment of the iliopsoas muscle on IMS measurements.

**Materials and methods** The study included 20 patients. Earlier magnetic resonance imaging (MRI) examination of all the patients revealed reattachment of the iliopsoas in 18 (90 %) patients. IMS measurements were performed at 60°/s and 150°/s. The peak torque (PT), total work (TW), average power (AP), work fatigue (WF) and agonist to antagonist muscle ratio of the operated and non-operated hips were recorded separately for flexors and extensors. The effect of iliopsoas reattachment on IMS was also evaluated.

**Results** The mean follow-up period was 16.65 ± 2.16 (13–20) years. TW ( $p = 0.013$ ), and AP ( $p = 0.009$ ) of the flexor muscles and WF of the extensor muscles ( $p = 0.030$ ) of the operated hip were significantly decreased when compared with the non-operated hips at 150°/s. There was no significant difference between the flexor muscles of the operated and non-operated hips ( $p < 0.05$ ) at 60°/s and extensor muscles ( $p < 0.05$ ) at 150°/s. In addition, for patients with reattached iliopsoas, there was no significant difference in the IMS measurements between the operated and non-operated hips at both angular velocities, although patients without reattachment had lower IMS in the operated hips.

**Conclusion** Flexor muscle strength was decreased in the operated hip after prolonged activities such as sports in long-term follow-up after

iliopsoas tenotomy. However in forceful activities flexor muscle strength was retained due to iliopsoas reattachment. Reattachment of the iliopsoas tendon substantially preserves muscle strength.

**Significance** Flexor muscle strength was decreased after iliopsoas tenotomy during open reduction by medial approach, however reattachment substantially preserves muscle strength.

### EP4

#### The use of 3-dimensional printing in orthopaedic resident education: enhanced understanding of triplane fractures

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#### Level-3

##### Upper and lower extremity trauma

**Introduction** The purpose of this study was to evaluate the ability of 3-dimensional (3D) printing to improve orthopaedic resident education. The hypothesis was that the use of 3D printed models as part of a comprehensive educational programme would result in improved resident confidence and performance treating transitional ankle fractures in adolescents.

**Materials and methods** In this IRB-approved, prospective, controlled trial, orthopaedic residents of various training levels were randomized to the study or control groups. Each participant took a 28-question self-assessment designed to evaluate knowledge of transitional ankle fractures. Evaluation of self-confidence in treating these injuries was done using a 5-point Likert scale for six questions (e.g., “I feel comfortable making a surgical plan for adolescent triplane fractures.”) Following initial testing, residents attended lectures, received a textbook excerpt, and scrolled through representative CT images. The study group was additionally given the opportunity to manually manipulate 3D-printed models of triplane fractures. Participants in both groups re-took the self-assessment and then performed reduction and fixation of a sawbones triplane fracture model. Completed sawbones were graded by three pediatric orthopaedists blinded to participant identity and training level. Paired t-tests were used to determine between-groups differences for performance on written and practical assessments and Likert responses. ANOVA models were used to determine differences as a function of training year and sex.

**Results** Sixteen residents (13 male, 3 female) participated. Both study and control groups demonstrated significant improvement in testing scores following the educational session ( $p < 0.01$ ). There was a trend toward greater improvement in testing scores for residents in the study group, although this did not achieve statistical significance. Similarly, there was a trend for higher sawbones scores amongst residents in the study group. Importantly, only residents in the study group consistently demonstrated statistically significant increases in Likert scores ( $p < 0.05$ ). Neither training level nor sex was significantly associated with improvements in testing scores, although there was a trend toward greater improvement for residents in the study group at lower training levels.

**Conclusion** The use of 3D printed models of paediatric transitional ankle fractures as part of a teaching module for orthopaedic residents

resulted in statistically significant improvements in self-reported resident confidence managing these complex injuries.

**Significance** By enhancing resident education, 3D printing may ultimately result in improvements in the safety, quality, and value of care provided to patients with triplane fractures.

## EP5

### Can the increase of anterior pelvic tilt after crouch gait treatment in cerebral palsy be prevented?

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#### Level-3

##### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Surgical lengthening of the hamstrings has been used frequently for the correction of knee flexion deformity (KFD) in cerebral palsy (CP). However, many authors described an increase of anterior pelvic tilt post-operatively. The purpose of this study was to analyze if the increased anterior pelvic tilt also occurs after distal femur extension osteotomy (DFEO) and patellar tendon shortening (PTS).

**Materials and methods** A retrospective comparative study was conducted. The inclusion criteria were: (1) diagnosis of spastic diplegic CP, (2) GMFCS levels I-III, (3) patients who underwent DFEO and/or PTS and (4) complete documentation in the gait laboratory before and after intervention. Ninety-five individuals were considered for this study and were divided into 3 groups, according to the procedures performed for crouch gait treatment: PTS (19 patients/34 lower limbs), DFEO (54 patients/88 lower limbs) and PTS + DFEO (22 patients/42 lower limbs). Demographic data, hip and knee physical exam and kinematics were analyzed and the results compared among groups.

**Results** Patients from DFEO group (12.8 years) were younger ( $p = 0.004$ ) at the time of surgery than those from the PTS group (15.7 years). The mean follow-up time was similar among groups, ranging from 28.8 to 34.3 months. GMFCS level III patients were more prevalent in all groups. The mean KFD on physical examination was reduced from  $5.6^\circ$  to  $-0.3^\circ$  in the PTS group ( $p < 0.001$ ), from  $15.5^\circ$  to  $7.0^\circ$  in the DFEO group ( $p < 0.001$ ) and from  $15.1^\circ$  to  $6.4^\circ$  in the PTS + DFEO group ( $p = 0.002$ ). During stance phase, knee flexion decreased from  $41.6^\circ$  to  $13.6^\circ$  in the PTS group ( $p < 0.001$ ), from  $46.0^\circ$  to  $30.7^\circ$  in the DFEO group ( $p < 0.001$ ) and from  $52.3^\circ$  to  $29.5^\circ$  in the PTS + DFEO group ( $p < 0.001$ ). Anterior pelvic tilt increased  $14^\circ$  in the PTS group,  $6.6^\circ$  in the DFEO group and  $7.1^\circ$  in the PTS + DFEO group after surgical intervention. The increase of anterior pelvic tilt was similar between DFEO and PTS + DFEO groups ( $p = 0.956$ ). The PTS group presented more significant deterioration of pelvic tilt than the DFEO ( $p = 0.002$ ) and PTS + DFEO ( $p = 0.001$ ) groups.

**Conclusion** The increase of anterior pelvic tilt was observed in all patient groups undergoing orthopedic surgery for crouch gait and it was more significant for those who received a PTS.

**Significance** The increase in anterior pelvic tilt seems to be a consequence of crouch knee gait treatment irrespective of the approach used.

## EP6

### Comparison of anchor versus pull-out suture of the anterior tendon transfer for residual supination in clubfoot after initial Ponseti treatment

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#### Level-2

##### Club-foot

**Introduction** This study aims to compare the anterior tibial tendon transfer using a tissue anchor with that using a *pull-out* suture in clubfoot patients treated by the Ponseti method who showed dynamic supination at follow-up.

**Materials and methods** We selected 25 patients (34 ft) treated with a anterior tibial tendon transfer and compared the use of the technique using a metal anchor with the traditional *pull-out* suture, dividing the patients into 2 groups: Group I (metal anchor) with 13 patients (18 ft) and Group II (pull out) with 12 patients (16 ft). In group I, the average age of patients at surgery was 5.1 years (range 4.2–5.6 years) and mean follow-up of 2.98 years (range 1.25–4.2 years). In group II, the average age of patients at surgery was 5.54 years (range 4.3–7.2 years) and mean follow-up of 2.98 years (range 2.0–5.2 years). The evaluation was based on the restoration of muscle balance and correction of dynamic supination.

**Results** In group I, there were 15 good (83.4 %), 3 fair (16.6 %) and no poor results. In group II, there were 14 good (87.5 %), 2 fair (12.5 %) and no poor results. The groups had statistically similar results ( $p = 0.732$ ).

**Conclusion** The anterior tibial tendon transfer shows good results in correcting the deformity in dynamic supination and the results are similar between the two groups

**Significance** When treating dynamic supination as a residual deformity in clubfoot the transfer of the anterior tibial tendon as recommended by Ponseti is a useful procedure and the type of suture used does not affect the results and may be the choice of the treating surgeon.

## EP7

### The “triradiate bump”: a novel radiographic sign that may confound assessment of femoroacetabular impingement

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#### Level-2

##### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Radiographic evaluation of femoroacetabular impingement (FAI) involves assessment for signs of acetabular retroversion, including the ischial spine sign. We have identified a novel radiographic sign (seen on anterior-posterior plain films of the pelvis) wherein the triradiate cartilage transiently projects medially within the pelvic brim around the time of triradiate closure, mimicking the ischial spine sign. The purpose of this study is to characterize this

newly identified radiographic sign using a longitudinal radiographic study.

**Materials and methods** We identified 73 subjects from a historical, longitudinal radiographic study of healthy adolescents, each with at least four consecutive, annual AP radiographs of the left hip, including physeal closure. Images were reviewed to identify the presence of the triradiate bump, the year at which it was most prominent, and the number of years relative to triradiate closure after which it had completely remodeled. Standardized radiographic markers and the sacrococcygeal joint to pubic symphysis distance were used to confirm <10 degrees of rotation in utilized films. Differences between genders were compared for rate of incidence, age at prominence, and remodeling relative to triradiate closure. Significance level was set at  $p < 0.05$ .

**Results** The transient medial projection of the triradiate cartilage (“triradiate bump”) was identified in 30/41 (73.1 %) females and 22/32 (68.8 %) males ( $p = 0.68$ ). It was most prominent at age  $10.8 \pm 0.8$  years in females and  $12.6 \pm 0.7$  years in males ( $p < 0.001$ ) and projected a mean 4.7 mm or 5.1 mm in females and males, respectively ( $p = 0.29$ ). In all cases, the projection was qualitatively noted to be just superior to the ischial spine and completely remodeled at a mean of  $0.1 \pm 0.3$  or  $0.3 \pm 0.5$  years after triradiate closure in females and males, respectively ( $p = 0.22$ ).

**Conclusion** The transient medial projection of the triradiate cartilage within the pelvic brim (the “triradiate bump” sign) is a common radiographic finding in healthy adolescents around the time of closure of the triradiate cartilage. This radiographic sign can mimic the ischial spine sign and falsely suggest that a patient has acetabular retroversion. However, the two signs can be distinguished as the projection of the ischial spine is located slightly more inferiorly within the pelvic brim and the triradiate cartilage also has a horizontal limb of radiolucency extending to its medial border.

**Significance** Understanding the transient medial projection of the triradiate cartilage within the pelvic brim will improve clinicians’ radiographic assessment of the developing hip, particularly in the setting of FAI.

## EP8

### Capital femoral growth plate extension predicts cam morphology in a longitudinal radiographic study

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Recent evidence suggests that CAM morphology may be related to alterations in the capital femoral growth plate during adolescence. The purpose of this study was to evaluate the relationship between capital femoral growth plate extension and CAM morphology in a longitudinal radiographic study.

**Materials and methods** We utilized a historical, longitudinal radiographic collection to identify 96 healthy adolescents (54 males and 42 females) with at least five consecutive, annual films of the left hip including closure of the capital femoral physis. We reviewed 554 anterior posterior (AP) films of the left hip to measure the AP modification of the alpha angle of Notzli and anterior–superior epiphyseal

extension ratio (EER), measured as the ratio of extension of the capital femoral epiphysis down the femoral neck relative to the diameter of the femoral head. Measurements were made at three points in femoral head maturation corresponding to the Oxford Bone Age (OBA) femoral head stages 5, 6, and 7/8.

**Results** There was a mean increase in AP alpha angle ( $10.7 \pm 14.0^\circ$ ) and EER ( $0.12 \pm 0.08$ ) between OBA stages 5 and 8, corresponding to maturation and closure of the capital femoral physis. There was a positive correlation between final AP alpha angle and both final EER ( $r = 0.60$ ) and the change in EER ( $r = 0.58$ ). A receiver operating characteristic curve generated to predict AP alpha angle  $>78^\circ$  through EER demonstrated an area under the curve of 0.93, reflecting that increasing EER was highly sensitive and specific for predicting concurrent CAM morphology. Males had a greater final alpha angle than females ( $63.3 \pm 14.0^\circ$  versus  $53.9 \pm 11.4^\circ$ ;  $p < 0.001$ ) and a greater final EER ( $0.81 \pm 0.07$  versus  $0.77 \pm 0.05$ ;  $p = 0.005$ ). AP alpha angle was measured on a subset of 25 subjects with additional films taken 1–2 years after capital femoral physeal closure. Paired samples *t* test revealed no difference in AP alpha angle between the time of physeal closure and 1–2 years after physeal closure ( $p = 0.46$ ).

**Conclusion** Anterior–superior epiphyseal extension was directly and temporally associated with an increase in AP alpha angle and more CAM-like morphology. This alteration in the capital femoral epiphysis occurred immediately before physeal closure (OBA7/8). Given its association with activities that increase shear forces across the physis, we propose that epiphyseal extension may be an adaptive mechanism to stabilize the physis and prevent slipped capital femoral epiphysis.

**Significance** Bettering our understanding of the etiology of CAM morphology will improve our ability to manage patients with femoroacetabular impingement.

## EP9

### Outcome of de-threaded vs standard screws for treatment of slipped capital femoral epiphysis at skeletal maturity—a case matched study with prospective follow up

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** There is renewed interest in persistent growth after stabilisation of SCFE, a technique that is not new, but of possible importance in reducing the long term complications of a slip. This is of particular significance in the younger patients, and may reduce the current trend for more aggressive capital re-alignment surgery.

**Materials and methods** A matched cohort of 12 patients (18 hips) with an average age of 19.3 years (median 19, range 16–23) treated with 2 distally non-threaded Titanium screws (leaving non-threaded fixation across the physis) or single cannulated screws were studied. Matching was carried out for sex, BMI, degree/type of slip and Oxford bone age. Prospective standardised radiographs were assessed during growth with pin/joint and pin-physis ratios and at skeletal maturity with radiological indices of femora-acetabular impingement and hip joint abnormalities. Clinical outcomes were measured with ASK scores during growth, modified Heyman and Herndon outcomes and the modified Harris Hips score/tests for femora-acetabular impingement at skeletal maturity.



**Results** Persistent growth and ‘remodelling’ was seen in both groups but was more significant in those treated with non-threaded screws. Re-operation rates for exchange of screws as expected were more common in the non-threaded screw group. Despite the requirement for exchange of screws with ongoing growth, significantly better clinical and radiological outcomes were seen in the non-threaded screw group at skeletal maturity with a lower incidence of symptoms and need for further surgery.

**Conclusion** Despite the requirement for exchange of Screws with ongoing growth, significantly better clinical and radiological outcomes were seen in the non-threaded screw group at skeletal maturity with a lower incidence of symptoms and need for further surgery.

**Significance** This may alter management of SCFE, particularly in milder slips with remaining growth potential with the aim of improving long term outcomes.

## EP10

### Minimally invasive intralesional excision of extremity-located osteoid osteomas in children

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#### Level-4

#### Tumours

**Introduction** The standard treatment for patients with osteoid osteoma is complete removal of the nidus. Currently, the most commonly preferred treatment methods include excision of the nidus with minimally invasive intralesional extended curettage and percutaneous radiofrequency thermoablation of the lesion under computerized tomography (CT) guidance.

**Materials and methods** Forty-seven children [29 males, 18 females; mean age 10.5 years (range 4–19 years)] with osteoid osteoma of the extremities underwent minimally invasive intralesional extended curettage. The exact localization of the nidus was determined preoperatively by thin-section (1–1.5 mm) CT scans, and complete excision of the nidus was performed by a modified burr-down technique. None of the procedures required bone grafting or internal fixation. The median follow-up was 59 months (range 12–136 months).

**Results** Histopathological confirmation of osteoid osteoma was achieved following all procedures. All patients had immediate and complete relief of lesional pain after surgery. Preoperative and postoperative (at the time of discharge) mean VAS scores, were  $7.7 \pm 1.2$  and  $0.3 \pm 0.6$  respectively, confirming complete removal of the nidus. Early motion of the involved extremities and mobilization of the patients were achieved within 2 days. The children resumed normal function within 3 weeks. There were no postoperative complications and no recurrences.

**Conclusion** Minimally invasive intralesional extended curettage for the management of osteoid osteomas of the extremity in children provided high success rates with low morbidity and complication rates. Rapid functional recovery was also possible with this technique.

**Significance** Even though, percutaneous radiofrequency thermoablation is accepted as the treatment of choice for extra-spinal osteoid osteomas, this technique requires a regional reference institution. Minimally invasive intralesional extended curettage can be applied in conventional institutions by orthopaedic surgeons with high success and low morbidity rates and a rapid functional recovery.

## EP11

### Bone fracture healing enhancement by parenteral G-CSF. An experimental study in rats

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#### Level-2

#### Basic science

**Introduction** Circulating mesenchymal stem cells contribute to bone repair. Their incorporation in fracture callus is correlated to their bioavailability which can be transiently increased by cytokines responsible for their medullary mobilisation. Besides the mobilisation of medullary haematopoietic progenitors, G-CSF induces the release of vascular and mesenchymal progenitors. The aim of this study was to analyze the impact of parenteral administration of G-CSF on bone healing in rats. We hypothesise that this glycoprotein stimulates fracture healing.

**Materials and methods** 27 adult male Sprague–Dawley rats underwent a midfemoral osteotomy stabilised by intramedullary pinning and were divided into 3 groups. In the “control” group, rats were injected subcutaneously with 0.25 ml saline solution for 5 days, starting at the time of surgery. The “postoperative” group received the same volume of G-CSF 0.5 µg/kg/day following the same schedule. The “preoperative group” received the same injections 5 days preoperatively. Healing was followed up radiographically. After sacrifice at day 35, the operated femurs were studied histologically and 20 underwent biomechanical tests.

**Results** At 5 weeks, radiographic scores demonstrated a significant increase in the treated groups (mean 7.71, SD 0.43) compared with the control (mean 6.75, SD 0.69) ( $p = 0.0052$ ). Biomechanical tests confirmed a threefold increase in callus rigidity in the treated groups (mean 102 MPa, SD 51.1) compared with the control group (mean 32.2 MPa, SD 17.6) ( $p = 0.0037$ ) and a twofold increased mean max load (57.8 N, SD 22.6 and 30.7 N, SD 9 respectively) ( $p = 0.0037$ ), without significant difference between the pre and post-op subgroups.

**Conclusion** In this model, pre or postoperative G-CSF injection strongly enhanced the early course of femoral fracture healing.

**Significance** Level II.

## EP12

### Mechanisms and predisposing factors for non-traumatic proximal tibia epiphysiolysis in adolescents during sportive activities: a case series and literature review

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#### Level-4

##### Upper and lower extremity trauma

**Introduction** Non-traumatic proximal tibial epiphysiolysis (NTPTE) is an uncommon injury in teenagers. Our literature review revealed only case reports and case series describing the fracture and its treatment. The purpose of this study was to determine a common denominator as well as a biomechanical explanation for proximal tibial epiphysiolysis using a retrospective analysis of 15 cases in combination with a systematic review of literature.

**Materials and methods** A retrospective review of medical charts was performed to identify all children and adolescents who had been treated for an NTPTE at our institution from January 2003 until December 2012. Clinical records were screened for patient demographics (age and gender), sports activity at the time of injury, mechanism of injury, previous knee trauma and treatment protocols. Additionally a search of the MEDLINE database, the Cochrane Library, and the Google Scholar search engine regarding NTPTE was conducted. Articles were included if the proximal tibial fracture was an epiphyseal or physeal fracture and if the accident described was not due to a direct trauma.

**Results** A total of 81 cases accounting for 86 fractures were evaluated in this study. Fractures were classified as Salter–Harris (SH) type II in 68 cases, type IV in 9 and as type I in 9. Seventy-three patients were male, 6 female and in 7, no information concerning gender could be found. Thirty-three accidents occurred during basketball training, 10 during long or high jumping and 9 while playing soccer. The most frequently described mechanism was either take-off or landing after a jump. Mean patient age was 14.6 years. Forty-one fractures were treated with closed reduction and cast, 19 required k-wire or percutaneous screw fixation and in 26 cases open reduction and internal fixation was necessary.

**Conclusion** NTPTE affects predominantly male teenagers at the time of physiological physiodesis. Associated sports activities are basketball, long and high jumping and soccer. The triggering event seems to be forceful eccentric contraction of the quadriceps and the hamstrings during landing or before jumping generating enough tensile forces for growth plate failure. In addition neuromuscular fatigue alters coordination and proprioceptive accuracy during landing from a vertical jump and thus perturbs sagittal shock absorption. Thus we strongly recommend that teenage athletes undergo specific proprioceptive training and training for vertical jumping, in order to improve coordination and to attenuate tensile forces during the landing phase.

**Significance** Level IV case series and review of literature.

#### EP13

##### Serum leptin levels as an indicator for nutritional status in children with cerebral palsy

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#### Level-3

##### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Adequate nutrition is one of the most essential components for successful treatment of children with cerebral palsy (CCP)

as unfavorable outcomes are found more frequently in malnourished CCP. Previous studies have shown that conventional assessments were inadequately correlated with nutritional status. Leptin, a hormone secreted from adipocytes to regulate energy expenditure, could be a better marker in these patients. The aim of the study was to determine the correlations between anthropometric measurement, biochemical data and serum leptin levels in CCP.

**Materials and methods** Eighty-six CCP, aged  $9 \pm 2$  (range 6–12) years old, were enrolled. Weight, calculated height, subscapular (SST) and triceps (TST) skin thickness were obtained. Body mass index (BMI) and weight for height (WH) Z scores were calculated using the normative data of Thai children with the same age and gender. Complete blood count and serum levels of leptin and albumin were collected. CCP were classified as moderate to severe undernourished if their WHZ were  $< -2$  as recommended by the World Health Organization. Different between parameters in CCP with normal and undernourished were compared. The correlation between anthropometric measurements, biochemical data and serum leptin levels was evaluated using linear regression analysis.

**Results** Eleven CCP (12 %) were undernourished. Eight CCP were graded as moderate and 3 CCP were grade as severe, respectively. The parameters of CCP who were undernourished were statistically significant different ( $p < 0.05$ ) when compared to their normal counterparts including SST ( $8.15 \pm 6.2$  vs.  $5.39 \pm 1.2$  mm), serum leptin ( $5.42 \pm 6.24$  vs.  $2.94 \pm 1.62$  ng/ml), hemoglobin levels ( $129 \pm 10$  vs.  $121 \pm 8$  g/L) and hematocrit ( $38.65 \pm 2.58$  vs.  $36.31 \pm 2.58$  percent). Other parameters (TST, serum albumin, total lymphocyte count and platelets) did not reveal a difference between the groups. SST and TST demonstrated a significant strongly positive correlation with serum leptin level with Pearson's  $r$  of 0.83 and 0.72, respectively ( $p < 0.001$ ). Serum leptin level is the only biochemical marker that correlates moderately with WHZ ( $r = 0.45$ ,  $p < 0.001$ ). Serum leptin level of 2.213 ng/ml is the optimum cutoff point to define an adequate nutritional status in CCP with sensitivity of 86 % and specificity of 36 %.

**Conclusion** Serum leptin level correlated more closely with nutritional status, as graded by WHZ, than the biochemical measurements utilized previously. Anthropometric measurements, though easily performed, may not depict the actual nutritional status.

**Significance** Serum leptin level could be employed as an objective parameter and included into a CCP care scheme to determine the adequacy of their nutritional status.

#### EP14

##### Have changes in treatment of late-detected DDH during the last decades led to better radiographic outcome at skeletal maturity?

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#### Level-4

##### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Despite considerable changes in the treatment of late-detected congenital or developmental hip dislocation (DDH) during the last 50 years, it is unclear whether and to what degree these changes have led to better long-term outcome. The aims of this study were to see whether decreasing use of skin traction and instead a more

aggressive approach to open reduction resulted in improved radiographic appearance of the hips at long-term follow-up and changes in the proportion of patients developing avascular necrosis (AVN).

**Materials and methods** Two groups of patients were compared retrospectively. Inclusion criteria were patient age older than 3 months and younger than 5 years at the initiation of treatment, no associated anomaly, and available radiographs from diagnosis to skeletal maturity. Group A consisted of 56 patients (51 girls, 91 %) primarily treated during the period 1958–1962. Group B comprised 38 patients (36 girls, 95 %) treated during the period 1996–2002. The mean age at the time of hip reduction was 20 months in Group A and 17 months in Group B. The mean time in skin traction had decreased from 35 days (16–76) to 11 days (0–28) over the years. Closed reduction was achieved in 92 % of the hips in Group A and 62 % in Group B ( $p < 0.001$ ). The mean immobilization time in the hip spica had decreased from 9 to 6 months. The indication for secondary procedures to correct residual dysplasia was a centre-edge (CE) angle  $< 20^\circ$ . The Severin radiographic classification was used to compare the results.

**Results** Secondary procedures to correct residual hip dysplasia was performed in 38 % of the hips in Group A and 18 % in Group B ( $p = 0.025$ ). At skeletal maturity, the proportion of patients with satisfactory radiographic results (Severin Grades I/II) was larger in Group B (33 of 40 hips, 82 %) than in Group A (46 of 74 hips, 62 %) ( $p = 0.025$ ). The mean CE angle was greater in Group B than in Group A ( $26^\circ$  versus  $22^\circ$ ;  $p = 0.016$ ). There was no difference in the proportion of AVN (9 % in Group A and 13 % in Group B;  $p = 0.614$ ).

**Conclusion** The move away from prolonged use of skin traction and toward more frequent open reduction for children with late-detected DDH resulted in fewer secondary procedures and a better radiographic appearance of the hip at skeletal maturity.

**Significance** We cannot conclude whether preliminary traction is needed; this question should be evaluated in future prospective long-term studies.

## EP15

### Management of patellar dislocation in children with down syndrome: a long term follow up

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#### Level-4

#### Upper and lower extremity reconstructions

**Introduction** Chronic patellar instability in the skeletally immature population has been widely investigated although its management remains challenging. Due to the joint instability and ligamentous laxity of Down patients, conservative treatment of patellar instability often fails and patients develop patellar dislocation that leads to limping, pain and impaired knee range of movement. In these patients, patellar dislocation can also be associated with trochlear groove dysplasia, leading to patella-femoral arthritis in some cases if untreated. Surgical management is necessary in these patients, even though there is no consensus on the best surgical technique to use.

**Materials and methods** Between 2000 and 2012, 19 patients (23 knees) with patellar instability/dislocation and Down syndrome were

managed with a modified Roux-Goldthwaith surgical procedure. All patients had Dugdale grade III, IV and V patellar dislocation. Trochlear groove dysplasia was present in 15 patients. Each patient was evaluated using clinical examination, conventional radiographs, pre and postoperative Kujala score and pre and postoperative modified Lysholm score. The mean follow-up is 10 years.

**Results** The modified Lysholm score showed significant improvement from a mean preoperative value of  $61.1 \pm 6.8$  to a mean postoperative value of  $94.7 \pm 1.4$  ( $p < 0.05$ ). The Kujala score showed significant improvement from a mean preoperative value of  $39 \pm 6.3$  to a mean postoperative value of  $93.3 \pm 7.1$  ( $p < 0.05$ ). Radiographs performed at latest follow-up showed a normal trochlear groove shape without signs of osteoarthritis.

**Conclusion** Managing this patient population is often very demanding because postoperative management and compliance to treatment in this group are difficult, moreover it should be emphasized that children with Down's syndrome usually have a greater degree of instability and can not be considered and managed as 'normal' children. Our results are encouraging and suggest that the modified Roux-Goldthwaith procedure can be used in the treatment of patellar instability/dislocation and Down syndrome, as it is a safe, effective and reliable surgical technique.

**Significance** The present study adds important findings in the literature, as there are only few studies focusing on patellar instability and Down syndrome and we present the higher group of patients with a long-term follow-up.

## EP16

### The morphological changes of the labrum in unstable DDH

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#### Level-2

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Aim of this retrospective study was to verify the morphological changes of the labrum in unstable dysplastic hips (types D, III and IV hips according to Graf) during treatment.

**Materials and methods** Between January 2013 and April 2015, data was collected of 52 (45 F; 7 M) patients (age range 1 day–134 days; average age 53 days) previously treated for DDH. The US examination was performed according to Graf's technique. We collected a total of 75 dysplastic hips (28 monolateral; 23 bilateral), which were divided in: type D ( $n = 13$ ), type III ( $n = 40$ ) and type IV ( $n = 22$ ). For the evaluation of the US images in patients with a monolateral involvement, the contralateral healthy hip was used as control, instead, in patients with a bilateral involvement a control group ( $n = 50$ ) was created.

The labrum was evaluated for its echogenicity and its dimensions. An inter- and intra-observer test (4 health workers) was conducted on US images. The following tests were performed: TEST 1 (comparison of the labrum in a US image DDH diagnosis and a randomly chosen US image); TEST 2 (comparison of the labrum in a US image at DDH diagnosis and a US image of the same patient on average 6 weeks after the beginning of the treatment); TEST 3 (comparison of the

labrum in a US image at DDH diagnosis and a US image of the same patient at the end of treatment). Statistical analysis was performed using Cohen's  $k$  coefficient for the intra-observer comparison and Fleiss's coefficient for the inter-observer comparison.

**Results** Test 1 showed a very good and good concordance for echogenicity and dimensions ( $k$  0.61–1); Test 2 showed a very good, good and moderate concordance for echogenicity and dimensions ( $k$  0.41–1); Test 3 showed a very good concordance for echogenicity ( $k$  0.81–1) and a very good and moderate concordance for dimensions ( $k$  0.41–0.6; 0.81–1). The labrum was less echogenic in Test 1 (72 % of observers' answers), more echogenic (81 %) in Test 2 and most echogenic (95 %) in Test 3. The labrum's dimensions were smaller in Test 1 (70 %), bigger in Test 2 (67 %) and biggest in Test 3 (94 %). **Conclusion** In Test 3 where we compared the labrum at the moment of unstable DDH diagnosis and in the same patient at the end of treatment, there was a very good strength of agreement in intra-observer and inter-observer evaluation, meaning that the labrum surely undergoes morphological changes in increasing echogenicity and dimension during treatment.

**Significance** The labrum acts as an active stabilizer of the femoral head after its reduction, showing an increase of fibrous tissue (echogenicity) and size (morphology).

## EP17

### Evaluation of hand involvement in patients with hereditary multiple exostoses

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#### Level-4

##### Tumours

**Introduction** The purpose of this study was to evaluate the hand involvement in patient with multiple hereditary exostoses (MHE)

**Materials and methods** We reviewed retrospectively 42 patients (21 male, 21 female) (82 hands) with hand involvement in MHE from 2004 to 2015. Mean age was 11.6 years (2–63). Two patients did not have right hand radiographs. Presence of an exostosis and its specific location in each bone and status of deformities were recorded.

**Results** Four-hundred thirty-six exostoses were found in 80 hand films for an average of 5.3 exostoses per hand (2–14). The proximal phalanges and metacarpals were most often involved, with the highest incidence in the ring finger metacarpal bone (85.4 %). 77.9 % (328) were juxtaepiphyseal lesions, diaphyseal and apical lesions represented 1.7 % (7) and 20.4 % (86) cases respectively. 170 fingers showed relative shortening (brachydactyly), and long, ring, little fingers were most commonly involved, with the highest incidence in the ring finger (75.61 %). However, shortening did not appear in all involved metacarpal bones and could occur even with out an exostosis. Angular deformities were observed in 12 fingers (11 hands). MCP joint angular deformity resulted from a volume effect of the lesion at the metacarpal base. One patient showed improved status of angular deformity at the last visit with lesions in base of the proximal phalanx, otherwise, 2 patients with lesions in head of proximal pha-

lanx and base of middle phalanx showed increasing deformities with joint subluxation. One patient underwent surgery either to excise exostoses and perform corrective osteotomy through the neck of proximal phalanx. 12 hands had carpal bone involvement: trapezium was the most common site, followed by the scaphoid and trapezoid.

**Conclusion** Hand involvement is common in patients with MHE but significant deformity rarely occurs. However, angular deformities and shortening of digits can lead to limitation of range of motion and cosmetic problems and occasionally erosion through the skin. These problems can be prevented by early surgical excision especially with the lesion in the opposite site of the epiphyseal region. Lesions can appear at an early age. In addition, contrary to previous reports, carpal bone involvement is not uncommon. Careful attention should be paid to the carpal lesions which may cause wrist instability.

**Significance** Hand lesions with MHE patients are easily neglected, however, they are common in HME patients.

## EP18

### Low radiation radiographs improve reliability of upper thoracic sagittal measurements for children with scoliosis

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#### Level-3

##### Spine

**Introduction** Proximal Junctional Kyphosis (PJK) is a reported complication of distraction-based treatment for Early Onset Scoliosis. A definition of Proximal Junctional Angle (PJA), measured from upper instrumented level (UIL) + 2 to UIL2, has been used for identifying PJK in young children. However, because of the superimposition of surrounding anatomy, the visualization of upper thoracic landmarks can be challenging on conventional radiographs (CR). The EOS image is a new modality that uses slot-scanning technology with a relatively low radiation dose. As children with scoliosis undergo serial radiographs and are exposed to a significant radiation burden, the principle of "as low as reasonably achievable" (ALARA) radiation exposure should be a goal for these patients. The purpose of this study was to compare the reliability of PJA measurements for young children with scoliosis between EOS imaging and conventional radiography. We hypothesize that EOS imaging has equivalent reliability as compared to conventional radiography for PJA measurements.

**Materials and methods** Sixteen radiographs of 8 children who were treated with rib-based distraction surgery were analyzed by 6 reviewers. One CR and 1 EOS image per patient were randomized, analyzed at T1 time point, and re-randomized/analyzed at least 14 days later (T2 time point). Individual consistency-agreement intraclass correlation (CAICC) using two-way random effects models was performed using Stata 13.0.



**Results** Diagnoses were as follows: 3 infantile, 3 congenital, and 2 syndromic scoliosis. Mean values at time of insertion: Age 4.1 year (1.5–9.5 years), scoliosis 67° (32°–84°), kyphosis 15° (2°–40°). Initial postoperative scoliosis 53° (15°–78°) and kyphosis 19° (2°–44°). Mean time between first and most recent radiographs was 19mo (9–29mo). Mean PJA: 20° CR T1, 24° CR T2, 20° EOS T1, 20° EOS T2. Interrater ICC's: 0.49 (Fair) CR vs. 0.66 (Good) EOS. Intrarater ICC's: 0.67 (Good) CR vs. 0.78 (Excellent) EOS.

**Conclusion** Low radiation dose imaging provided more reliable measures of PJA as compared to conventional radiographic techniques in a group of young children treated with rib-based distraction surgery.

**Significance** New imaging technologies such as the EOS need to be tested in real-life conditions to prove they can at least match or, preferably, surpass the existing modalities, along with other benefits they offer.

## EP19

### Early MRI detection and closed bone graft epiphysodesis may alter the course of avascular necrosis following unstable slipped capital femoral epiphysis

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Unstable slipped capital femoral epiphysis (SCFE) has an increased incidence of avascular necrosis (AVN). Early identification and intervention for AVN may help preserve the femoral head.

**Materials and methods** We retrospectively reviewed 48 patients (50 hips) with unstable SCFE managed between 2000 and 2014. Based on two different protocols during the same time period, 17 patients (17 hips) had a scheduled MRI between 1 and 6 months from initial surgery, with closed bone graft epiphysodesis (CBGE) or free vascularized fibular graft (FVFG) if AVN was diagnosed. Thirty-one patients (33 hips) were evaluated by plain radiographs. Outcomes analyzed were Steinberg classification and subsequent surgical intervention. We defined Steinberg class IVC as failure in treatment because all of the patients referred for osteotomy, arthroplasty, or arthrodesis in our study were grade IVC or higher.

**Results** Overall 13 hips (26 %) with unstable SCFEs developed AVN. MRI revealed AVN in 7 of 17 hips (41 %) at a mean of 2.5 months postoperatively (range 1.0–5.2 months). Six hips diagnosed by MRI received surgical intervention (4 CBGE, 1 FVFG, and 1 repinning due to screw cutout) at a mean of 4.1 months (range 1.3–7.2 months) postoperatively. None of the 4 patients treated with CBGE within 2 months postoperatively progressed to stage IVC AVN. The two patients treated after 4 months postoperatively both progressed to stage VC AVN.

Radiographically diagnosed AVN occurred in 6 of 33 hips (18 %) at a mean of 6.8 months postoperatively (range 2.1–21.1 months). One patient diagnosed with stage IVB AVN at 2.4 months had screw cutout and received CBGE at 2.5 months from initial pinning. The remaining 5 were not offered surgical intervention. Five of the 6

radiographically diagnosed AVN, including the one treated with CBGE, progressed to stage IVC AVN or greater.

**Conclusion** None of the 4 patients with unstable SCFE treated with CBGE within 2 months post pinning developed grade IVC AVN, while all patients treated with other procedures after 2 months developed IVC or greater AVN.

**Significance** Early detection and treatment of AVN after SCFE may alter the clinical and radiographic progression.

## EP20

### Elastic stable intramedullary nailing in displaced tibia shaft fracture: results and complications in children weighing 50 kg (110 lb) or more

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** The main objective of this study is to evaluate retrospectively the clinical and radiographic outcomes of displaced tibial shaft fractures in children weighting 50 kg (110 pounds) and more treated by Elastic Stable Intramedullary Nailing (ESIN) and to assess effects of increasing weight and age on treatment outcomes. The secondary aim is to identify potential correlation between nail size/medullary canal diameter ratio and outcome, the hypothesis being the higher the ratio, the better the clinical and the radiological outcome. **Materials and methods** 106 consecutive children treated surgically for displaced tibial shaft fractures were recorded during the study period. For inclusion in the study, patients must have had a closed displaced tibial shaft fracture without any associated neurovascular injury, weight >50 kg (110 pounds) and surgical management by ESIN: there were 26 such fractures.

Valgus, varus, procurvatum, recurvatum and translation were assessed on plain radiographs in all patients. Nail diameter (in millimeters), and internal diameter of tibia medullary canal (in millimeters) were calculated in order to obtain the nail size/medullary canal diameter ratio.

All patients underwent regular clinical and radiographic follow-up for at least 1 year after their index surgery.

**Results** The average patient age at the time of injury was 13.5 ± 1.3 years (range 11.3–16.1 years). The mean patient weight was 57 ± 8 kg (range 50–80 kg). Mean follow-up was 23 ± 8 months (range 12–38 m). Four (15.4 %) complications were observed: 3 were classified as minor, one as major. Pre-operative mean valgus angulation was 7° ± 7°, mean varus angulation was 6° ± 3°, mean procurvatum angulation was 8° ± 4°, and mean recurvatum angulation was 5° ± 3°. Mean pre-operative translation was 28 ± 23 %. At last follow-up, mean valgus angulation was 3° ± 3°, mean varus angulation was 2° ± 3°, mean procurvatum angulation was 1° ± 2°, mean recurvatum angulation was 4° ± 3°, and mean translation was 1 ± 3 %.

**Conclusion** This study showed no poorer outcome in the use of ESIN for displaced tibial shaft fractures in children and adolescents weighting >50 kg (110 pounds) and older than 13 years of age. Fur-

thermore no correlation between nail size/medullary canal diameter ratio and outcome as observed

**Significance** The use of ESIN for displaced tibia shaft fractures in children and adolescents weighing >50 kg (110 pounds) and older than 13 years of age is not contraindicated.

## EP21

### Younger age at the time of closed reduction minimizes acetabular dysplasia in children with DDH

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** To determine if early closed reduction and cast immobilization reduces the need for later pelvic osteotomy in children with congenital hip dysplasia (CDH).

**Materials and methods** We retrospectively reviewed all patients at a single center from 1980 to 2008 who had a closed reduction for CDH prior to 3 years of age. We excluded patients with less than 2 years of follow-up. Medical records were reviewed to determine demographic information, common CDH risk factors, operative and non-operative treatments attempted, length of spica casting, and the eventual need for pelvic osteotomy. Radiographs at the time of closed reduction and 2 years following were measured to determine the acetabular index (AI).

**Results** 223 children underwent closed reduction during the study period of which 205 (80 %) had a successful closed reduction. 143/205 (70 %) did not have further pelvic surgery and 62 (30 %) underwent a subsequent Pemberton or Salter type osteotomy for residual acetabular dysplasia. Patients who needed acetabular surgery for residual dysplasia were significantly older (54.8 versus 31.3 weeks,  $p < 0.01$ ) and heavier (7.8 vs. 9.7 kg,  $p < 0.01$ ) at the time CDH was diagnosed than those that did not require later surgery. They were also older at the time of closed reduction (0.8 versus 1.2 years,  $p < 0.01$ ) than those who did not require further surgery. The AI at the time of closed reduction was a significant predictor of residual dysplasia: patients treated without further surgery had an average pre-reduction AI of 30.8° (range 15°–45°) vs. 36.3° (range 27°–45°) in those undergoing later pelvic osteotomy ( $p < 0.01$ ). We were unable to find a statistically significant difference in the need for later acetabular surgery when comparing duration of casting, family history, adductor tenotomy, description of medial dye pool, presence of bilateral disease, or the use of pre-reduction traction.

**Conclusion** Children undergoing successful closed reduction for CDH who did not need for further surgery to correct residual acetabular dysplasia were on average 23 weeks younger at the time of diagnosis and 4.5 months younger at the time of closed reduction than patients requiring later pelvic osteotomy. Patients with less severe dysplasia at reduction, have a reduced likelihood for later pelvic osteotomy.

**Significance** Closed reduction attempted at early ages may reduce the possibility of residual acetabular dysplasia. This should influence surgeons to attempt reductions whenever other treatments fail, rather than waiting until an older age for a more traditional closed vs. open reduction procedure.

## EP22

### Characterization of radiation exposure in adult and pediatric populations with osteogenesis imperfecta

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#### Level-3

#### Other

**Introduction** The clinical evaluation and management of patients with osteogenesis imperfecta (OI) requires longitudinal imaging studies and potential exposure to high cumulative background and effective doses of ionizing radiation. The purpose of this study was to quantify and evaluate the longitudinal cumulative and yearly effective ionizing radiation exposure, number of radiographic procedures performed, and cumulative background radiation in adults and pediatric populations undergoing treatment for OI to evaluate factors that place patients with osteogenesis imperfecta at risk of potentially dangerous radiation exposure.

**Materials and methods** Data were collected via retrospective review of the records of all patients with osteogenesis imperfecta longitudinally evaluated and treated over a 13-year period (2002–2014). Diagnostic radiographs, computed tomography (CT), nuclear medicine studies, and intraoperative fluoroscopy durations were identified and analyzed for radiation exposure. Cumulative and yearly effective ionizing radiation doses, cumulative background radiation, and total radiograph studies performed were determined and compared between pediatric and adult populations.

**Results** 21 patients had 1,258 imaging studies (mean 50.3/pt) and an average of 6.4 years longitudinal treatment duration. The mean estimated cumulative effective radiation dose per patient during follow-up was 33.7 mSv (range 2.3–115.0) with an average yearly dose of 6.0 mSv (range 0.4–24.8). Pediatric OI patients received significantly more radiograph studies per year than adults ( $p = 0.0055$ ) and greater average yearly effective radiation doses. Radiograph study frequency and yearly effective radiation doses have negative correlations with age ( $R^2 = 0.33$  and 0.43, respectively) after reaching adulthood ( $\geq 18$  years old).

**Conclusion** Ionizing radiation is an inevitable side effect of OI trauma evaluation and management in paediatric and adult populations. There are differences in the frequency of radiograph studies performed, as well as effective radiation doses among paediatric and adult OI populations. Due to the significantly increased rate of radiograph studies observed in the paediatric OI population, care should be taken to decrease the amount of effective ionizing radiation dose by limiting the amount of imaging studies performed.

**Significance** Awareness of the complications and potential for high doses of effective radiation exposure may lead to the development of strategies to reduce radiation exposure and associated morbidity.

## EP23

### Musculoskeletal pain in a total population of children with cerebral palsy

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**Level-2****Neuromuscular/Cerebral Palsy/AMC/MMC**

**Introduction** Pain in cerebral palsy (CP) is associated with reduced quality of life and less participation in society. In Sweden, CPUP, a national registry and follow-up programme, systematically follows approximately 95 % of all children with CP. Presence and location of pain are included in the CPUP assessment. The aim was to assess the occurrence of self or proxy-reported presence of pain, and the location of pain in children with CP based on the Gross Motor Function Classification System (GMFCS), age and gender in this population.

**Materials and methods** This is a cross-sectional study based on CPUP data from the last visit of all children born 2000–2012 reported in the registry 2013–2014. The GMFCS-level is determined by the child's physiotherapist. In addition to a physical assessment the physiotherapist fills out a survey that includes a "yes/no" screening item on pain. ("Does the child, or the parent, state that the child is in pain?"). If the answer is "yes" a follow-up question regarding the site/s of pain is asked. If the child is able to communicate s/he will self-report, if not the parent or legal guardian serves as proxy.

**Results** A total of 2777 children aged 1–14 years (median 7) were included, 1595 (57.4 %) were boys. Overall, 900 (32.4 %) reported pain, 1799 (64.8 %) reported no pain, and 78 (2.8 %) had missing data on this item. Pain was more frequent in girls (35.5 %) than boys (30.1 %) ( $p < 0.05$ ). Pain increased with age, from 17 % in children aged 2 years to 50 % in children aged 14 years (OR 1.11,  $p < 0.01$ ). Pain was most common in the lower extremities ( $n = 624$ ), back ( $n = 84$ ), head-neck ( $n = 82$ ) and arms ( $n = 81$ ). Pain in hip-thigh were most frequent in GMFCS V, knee pain in GMFCS III and pain in the lower leg in GMFCS I ( $p < 0.05$ ).

**Conclusion** One-third of the population of children and adolescents with CP in Sweden reported pain. Although still high, it is a lower prevalence than that which is generally reported in the literature. Differences in methodology or the CPUP hip surveillance programme are possible explanations for the lower prevalence rate. Pain was frequent in all GMFCS levels, but the pain site profile differed significantly with different GMFCS-levels.

**Significance** Musculoskeletal pain is common in children with CP. Pain increases with age and pain site profiles differ with GMFCS levels.

**EP24****Both family history and swaddling are correlated with the occurrence and hip types in developmental dysplasia of the hip**

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**Level-3****Hip/DDH/Legg-Calvé-Perthes/SCFE**

**Introduction** We aimed to revisit the risk factors as well as to assess correlation between the risk factors and ultrasonographic (US) hip typing in developmental dysplasia of the hip (DDH).

**Materials and methods** Data of 760 healthy newborns (mean age 33 days) with bilateral US documented normal hips (control group) were compared with one of 192 patients (mean age 105 days) having US diagnosis of unilateral or bilateral DDH (study group). Family history, breech presentation, postnatal swaddling, intrauterine packing (foot deformities, torticollis, multiple pregnancy), oligohydroamnios and first-born girl were recorded as "risk factors". US hip typing was made according to Graf's system

and hips were further classified as stable (IIa-, IIb, IIc) and unstable (D, III, IV). Stable hip group was composed of patients, having unilateral or bilateral stable hips. Meanwhile, unstable hip group contained patients having at least one unstable hip. The number of patients in stable and unstable hip groups was 141 and 51, respectively. Chi square test and binary logistic regression analysis were used to assess the data.

**Results** Study group had higher number of subjects having at least one risk factor than control group (65 vs 47 %,  $p < 0,001$ ). Rate of having at least two risk factors was higher in study group than in control group (33 vs 21 %,  $p < 0,001$ ). When risk factors were assessed independently, rate of family history (16 vs 7 %,  $p < 0,001$ ), breech presentation (13 vs 7 %,  $p = 0,015$ ) and swaddling (16 vs 6 %,  $p < 0,001$ ) were higher in study group than in control group. Packing, first-born girl and oligohydroamnios were not correlated with the occurrence of DDH. Multivariate analysis revealed that family history ( $p < 0,001$ ), breech presentation ( $p = 0,015$ ) and swaddling ( $p < 0,001$ ) were significant risk factors related with the occurrence of DDH. Independent analysis of each risk factor revealed that, rates of family history (28 vs 11 %,  $p = 0,007$ ), swaddling (28 vs 11 %,  $p = 0,007$ ) and oligohydroamnios (18 vs 6 %,  $p = 0,018$ ) were higher in unstable hip group than in stable hip group. However, multivariate analysis revealed that only family history ( $p < 0,001$ ) and swaddling ( $p < 0,001$ ) were significant risk factors correlated with the occurrence of hip instability.

**Conclusion** Family history, swaddling and breech presentation are the three most significant risk factors related with the occurrence of DDH. If a baby has more than one risk factor, DDH is significantly more common and both family history and swaddling significantly increase the occurrence of US hip instability.

**Significance** Babies having history of either DDH in relatives or postnatal swaddling need to be considered carefully for DDH.

**EP25****Repeat surgical intervention following definitive instrumentation and fusion for adolescent idiopathic scoliosis: a 25-year update**

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**Level-3****Spine**

**Introduction** Recent trends in the surgical treatment of AIS have included increased use of all-pedicle screw constructs, more posterior-only approaches, and improved correction techniques. The purpose of this study is to determine the rate of reoperation in AIS patients undergoing spine fusion from 2008–2012, to determine the reasons for reoperation in this study population and to compare these results to the previous 20 years of clinical experience from the authors' institution.

**Materials and methods** IRB approved, single institution, retrospective review of prospectively collected data on 467 AIS patients undergoing spinal fusion from 2008 to 2012. Demographic, clinical, radiographic, and surgical data were collected on all patients for the index procedure and any reoperations. This cohort was compared to previously published cohorts of patients from the authors' institution who underwent spinal fusion for AIS between 1988 and 2007.

**Results** The rate of reoperation in this 5-year cohort of patients was 9.9 %. The most common indications for reoperation were infection

(4.5: 2.4 % delayed infections and 2.1 % acute infections), symptomatic implants (2.1 %), and misplaced pedicle screws (1.7 %). When compared to the 2003–2007 cohort, the rate of reoperation for acute infection and misplaced pedicle screws increased significantly ( $p = 0.01$  and  $p = 0.04$ ), while the rate of reoperation for curve progression decreased ( $p = 0.01$ ). Reoperations for acute infections and misplaced pedicle screws also increased significantly ( $p = 0.047$  and  $p = 0.042$ ) compared to the 1988–2002 cohort, while the rate of reoperation for pseudarthrosis decreased ( $p = 0.002$ ).

**Conclusion** Despite the use of newer implant systems and improved surgical techniques, the rate of reoperation after spinal fusion for AIS was stable. A decrease in pseudarthrosis and curve progression occurred, but we noted an increase in infection and malpositioned pedicle screws. Higher infection rates were seen in patients with stainless steel implants, increased implant densities and fusion above T4.

**Significance** The rate of reoperation following spinal fusion for AIS has not changed significantly over time, although the indications for reoperation continue to evolve.

## EP26

### Pathologic fractures of the proximal femur secondary to benign bone tumors in children

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#### Level-4

#### Tumours

**Introduction** In children, when fractures of the proximal femur occur through a benign bone tumor, many variables such as fracture site, type of bone tumor, location and size of primary lesion, combined deformities and patient age should be considered. The purpose of the current study is to analyze treatment experience in relation to pathologic fractures of the proximal femur secondary to benign bone tumors in children.

**Materials and methods** Between 1995 and 2014, 27 patients who underwent treatment for pathologic fractures of the proximal femur were reviewed retrospectively. The mean age of the patients (male 18, female 9) was 9.2 years (2.4–16.5 years). Pathologic fractures were classified into neck, intertrochanteric, subtrochanteric and shaft based on fracture site. The underlying benign bone tumors consisted of 10 simple bone cysts, 15 aneurysmal bone cysts and 2 enchondromas. Radiological evaluation including teleoroentgenography was done at 3, 6 months and every 6–12 months thereafter. The mean follow-up duration was 59.9 m (4.9–130.1 m).

**Results** 10 displaced fractures and 17 non-displaced fractures were observed and neck and subtrochanteric fractures were most common in this study (9 patients). Fractures of the proximal femur were treated with internal fixation using a variety of devices (22 patients) and cast immobilization (5 patients). Twenty-five benign bone tumors of the proximal femur were managed surgically by curettage and cavity filling procedures using allograft bone, calcium sulfate, fibular strut autograft. The mean fracture healing time was 3.3 months and there was no nonunion. Four recurrences of the primary lesion and two limb length discrepancy and one malrotation after fracture healing were noted.

**Conclusion** Pathologic fractures of the proximal femur with benign bone tumor in children are successfully treated by considering loca-

tion and extension of primary lesion, fracture site and patient age. Internal fixation using various devices for fractures offers secure fixation and extensive curettage decreases the recurrence. Although good fracture healing and primary control of the lesion were obtained in most children, awareness of the risk of late recurrence is important. **Significance** The present study suggested a classification based on the location of primary lesion and treatment through internal fixation using a variety of devices and cavity filling procedures.

## EP27

### Outcomes following operative treatment of adolescent mallet fractures

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** Many surgeons advocate for the surgical intervention of adult mallet fractures involving more than one-third of the articular surface or with associated subluxation. Minimal data exists regarding the efficacy of operative fixation in the adolescent population.

**Materials and methods** Seventeen patients with bony mallet fractures that were treated surgically were retrospectively reviewed. Twelve of these patients were treated by closed reduction with an extension block pinning technique. The average age of patients was 15.2 years (13–18 years). All the injuries occurred during sports except for one. The average time from injury to presentation to clinic was 17 days and the average time from injury to surgical fixation was 24.5 days. Nine patients were noted to have subluxation at the distal interphalangeal (DIP) joint and all fractures involved at least one-third of the articular surface.

**Results** The average time from surgery to pin removal was 27.9 days (19–46 days). The average follow-up time was 106.1 days (22–461 days). In all cases the distal phalangeal physis was either closed or nearly closed. Only one patient reported pain at the last follow-up. Two patients were noted to have major complications. One patient had an extension contracture postoperatively, but did not attend occupational therapy, and had a re-fracture 5 months following his initial injury requiring repeat fixation. The second patient was treated in a delayed fashion (32 days) and had a loss of fixation requiring repeat surgery as well as a superficial infection requiring oral antibiotics. This patient was noted to have an extensor lag postoperatively. One additional patient who had delayed treatment (44 days) had an extensor lag at his last follow-up.

**Conclusion** To our knowledge, this is the largest study on adolescent mallet fractures. Operative treatment of mallet fractures involving more than one-third of the articular surface or with associated subluxation appears to be effective.

**Significance** Based on the maturity of the physis in these patients we suspect that bony mallet injuries are transitional fractures. Pin removal at 4 weeks postoperatively appears to be adequate. Complications occurred in cases involving delayed presentation and lack of compliance with occupational therapy.



## EP28

### Complications in SESA (subtalar extra-articular screw arthroereisis)

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#### Level-2

##### Foot and ankle

**Introduction** Flexible flatfoot (FFF) is one of the most frequent skeletal disorders in children and a minimally invasive treatment option is the subtalar extra-articular screw arthroereisis (SESA), which has a low complication rate, a low surgical risk and is reversible in case of failure. The aim of the study was to analyze the complications of SESA and their management.

**Materials and methods** During the period 2004 and 2012 data was collected on complications post SESA in 25 (6.3 %) of 398 patients while 93.7 % had a good outcome. The average age at first surgery was 11.5 years  $\pm$  1.81 SD. The complications were divided as follows: Group A: ankle joint effusion or haemarthrosis, in absence of acute inflammatory signs, with an important decrease of range of motion and painful weight-bearing; Group B: contracture of the peroneal muscles due to an antalgic position in pronation from the immediate post-operative period; Group C : stress fractures of the 4th metatarsal bones due to abnormal gait with excessive weight-bearing on the 4th–5th rays.

**Results** The treatment of Group A (n = 8) was early removal of the screw (average time: 8 months post-SESA), after unsuccessful conservative treatment. At revision surgery, it was observed intraoperatively that all patients had an osteolysis of the talus lateral process (where there was contact with the screw head). In Group B (n = 14) a cast in supination was applied for 2 weeks in 3 cases and, subsequently, physiotherapy and plantar orthoses were prescribed until symptom resolution: in 6/15 cases this was successful. In 5 cases, injections of methylprednisolone acetate (1 ml) were performed twice locally at the level of the screw head with symptom resolution. In Group C (n = 3) no treatment was performed as these 3 patients showed up at the out-patient clinic complaining that they had had pain on the lateral border of the midfoot (on average 3 months post-op). In all 3 cases, the x-rays showed a healed fracture of the 4th metatarsal.

**Conclusion** SESA is a minimally invasive technique for the treatment of FFF and 93.7 % of cases have a good outcome. The low complication rate has been confirmed in this study.

**Significance** Complications in SESA occur in 6.3 % of cases, and in most patients may be easily resolved without removing the screw.

## EP29

### Internal rotation stress testing improves radiographic outcomes of type 3 supracondylar humerus fractures

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#### Level-3

## Upper and lower extremity trauma

**Introduction** The purpose of this study was to determine if routine use of an intraoperative internal rotation stress test (IRST) would reduce the incidence of loss of reduction following percutaneous pin fixation of type 3 supracondylar humerus fractures.

**Materials and methods** An intraoperative protocol for type 3 supracondylar humerus fractures was adopted at our institution, consisting of fracture reduction, placement of two laterally based divergent pins, and then an internal rotation stress test (IRST). If rotational instability was observed, then additional fixation was utilized to achieve rotational stability, either a medial pin or a 3rd lateral pin. Medial pins were placed via a small open approach. Fractures treated with the prospective IRST protocol were compared with a retrospective cohort prior to adoption of the protocol (no-IRST). Baumann's angle, the humerocapitellar angle, and the rotation index were measured on final intraoperative fluoroscopic images and compared with healed radiographs at final follow up. Complications were recorded.

**Results** There were 78 fractures in the retrospective cohort (no-IRST) and 49 in the prospective cohort (IRST). Rotational loss of reduction ( $>10^\circ$ ) was less common in the IRST cohort (1/49 vs. 13/78,  $p = 0.009$ ). Major loss of reduction ( $>10^\circ$  change in Baumann's angle) was only noted in the no-IRST cohort (3/78 vs. 0/49,  $p = 0.28$ ), although the difference was not statistically significant. There were no significant differences in humerocapitellar angle or minor changes in Baumann's angle ( $5^\circ$ – $10^\circ$ ) between the cohorts. Loss of proximal pin fixation with need for re-operation also occurred in the no-IRST cohort (3/78) but not in the IRST cohort (0/49,  $p = 0.28$ ). There were two superficial infections in the no-IRST group, and no postoperative nerve injuries in either cohort.

**Conclusion** Intraoperative internal rotation stress testing (IRST) after placement of two lateral pins assists with the decision for additional fixation to achieve rotational stability (medial pin or 3rd lateral pin). In the prospective cohort, routine use of the IRST significantly reduced the incidence of rotational malunion. Although not statistically significant, there were three fractures with major postoperative changes in Baumann's angle and three fractures with loss of fixation in the retrospective cohort (no-IRST), and none in the prospective cohort (IRST).

**Significance** Assessment of fracture stability by performing an intraoperative internal rotation stress test after placement of 2 lateral column pins may help guide decision making around the need for additional fixation of type 3 supracondylar humerus fractures.

## EP30

### Guide to forearm fracture treatment in adolescents using bone age-plates and screws or intramedullary nails?

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#### Level-4

## Upper and lower extremity trauma

**Introduction** This study aims to evaluate and compare the functional and radiological outcomes of forearm fractures in adolescents using flexible intramedullary nails vs plates and screws using Sauvegrain bone age measurement as a guide.

**Materials and methods** A 5-years retrospective single institution review of 168 children with displaced forearm fractures within the

age group of 10–16 years was conducted. The surgical notes, as well as radiographs of these patients were reviewed. The fracture outcomes were noted, these include the rate of union and presence of complications. The rate of union was defined according to the number of weeks taken for fracture union, whilst the rate of complications were defined as the rates of non-union, malunion, delayed union, limited range of motion and functional disability

**Results** There was no statistically significant difference for the rate of union ( $p = 0.31$ ) and complications ( $p = 0.99$ ) when comparing intramedullary nailing with plating. This lack of significance was confirmed even after accounting for bone age using the Sauvegrain method. Other variables, including gender, number of forearm bones involved and impact of initial injury and presence of associated injuries also did not show any significance. However, the mean operating time for intramedullary nailing was significantly less ( $p < 0.01$ ) compared to plating which was 62.61 and 126.25 min respectively

**Conclusion** Surgical management has been increasingly used for adolescent forearm fractures. This study shows that both intramedullary nailing and plating have comparable outcomes in terms of rate of union and complications regardless of chronological or bone age. Intramedullary nailing is thus recommended for forearm fractures even in older children as it is less invasive and more biological with reduced operating time.

**Significance** Forearm fractures are common injuries among children. While closed reduction and cast immobilization is useful in the younger children, as they approach adolescence these fractures become increasingly unstable and require surgical fixation. Currently, the common available options include closed or open reduction with flexible intramedullary nails and open reduction with plates and screws. Current literature has not established the superiority of one surgical method over the other. This study ‘debunks’ the idea that plates and screws are better for the older adolescents even when bone age is taken into account. Intramedullary nailing is less invasive with reduced operating time thus preferred and recommended.

## EP31

### Is percutaneous medial hamstring myofascial lengthening as effective and safe as the open procedure?

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#### Level-2

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Medial hamstring fractional lengthening is commonly performed in children with cerebral palsy (CP). Percutaneous procedures are gaining more and more popularity even in the pediatric population with equivocal results. The purpose of this paper was to determine the efficacy and safety of percutaneous medial hamstring myofascial lengthening (PHL).

**Materials and methods** This is a cross-over randomized controlled trial including 31 consecutive knees from 18 patients with cerebral palsy (CP) scheduled for medial hamstring tenotomy in the setting of multilevel tendon lengthening procedures in a university hospital. Other concomitant lower extremity surgeries were not exclusion factors. A first pediatric orthopedic surgeon executes the percutaneous

medial hamstring presumed myofascial lengthening (PHL) at one level as recently described in the literature. Another surgeon opens and extends the wound to explore what had been cut during the PHL, and completes fractional lengthening (OHL) of both semi-membranosus (SM) and semi-tendinosus (ST) when possible. Popliteal angle (PA) was assessed by a third surgeon immediately before PHL, after PHL, and then after OHL, using a goniometer, in a standardized reproducible manner. All 3 surgeons were blinded to the others’ findings. Primary endpoints included easiness to perform PHL, the percentage of tendon-fascia/muscle portion sectioned percutaneously, and improvement of PA. Comparison between PA after PHL and OHL was done using a paired t-test with a 95 % confidence interval.

**Results** The first surgeon was at ease in palpating and identifying through the skin both medial hamstrings before PHL in 10 cases only. PHL led to undesirable cut of the semi-membranosus muscle fibers to more than 50 % of the muscle section area in 30 cases (<50 % in 23 cases and up to 75 % in 7 cases), and of the semi-tendinosus muscle fibers to more than 50 % in all cases (complete rupture in 6 cases, more than 75 % in 8 cases, and approximately 50 % in 17 cases). Mean PA measured 52° preoperatively and decreased to 40° after PHL. After OHL, PA averaged 22°. There was a significant difference between the PA angle after PHL ( $M = 40.39$ ,  $SD = 11.8$ ) and the PA angle after OHL ( $M = 22.52$ ,  $SD = 8.7$ ),  $P < 0.0001$ . The gain in PA did not correlate with the extent of semi-membranosus muscle divided ( $P = 0.38$ ) nor with the extent of semi-tendinosus muscle divided ( $P = 0.35$ ). No major iatrogenic neurovascular injury was observed.

**Conclusion** To the authors’ knowledge, this is the first prospective study concerning the anatomic effects of PHL. Although it is a quick procedure, it is often associated with difficulty by the operating surgeon to identify and evaluate what should be cut percutaneously, leading to abusive injury of the muscle itself rather than the fascia alone. In addition, the gain in PA is statistically less following PHL than following OHL despite undesirable extensive muscle injury following PHL. This may be due to the multiple fascial cuts (fractional lengthening) usually performed in OHL.

## EP32

### Long-term follow-up outcome of arthroereisis for pediatric flatfoot

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#### Level-3

#### Foot and ankle

**Introduction** Various surgical techniques for symptomatic pediatric flatfoot have been reported without a clear consensus of treatment: soft-tissue procedures, osteotomies, arthrodesis or arthroereisis. Arthroereisis involves the use of a nonbiologic implant in young children. The purpose of this study is to evaluate the long-term clinical outcome of arthroereisis for pediatric flatfoot.

**Materials and methods** The pediatric orthopedic outpatients clinic medical reports between 1970 and 2007 were carefully reviewed to look for patients with flexible flatfoot who had had an arthroereisis. Patients with neuromuscular disorders were excluded. Medical records of 64 consecutive patients (117 ft) with an arthroereisis were reviewed looking for demographic data, age at surgery, preoperative symptoms, additional procedures added to arthroereisis, further

operative procedures needed and complications. A telephone survey was conducted in 37 patients, a mean 24 years after surgery (SD 5.6): patient satisfaction with arthroereisis, presence of pain, need to use insoles, problems related to shoes, ability to perform normal activities, and new surgeries performed were evaluated. Seven patients returned for clinical evaluation (aspect, motion and function).

**Results** Sixty-four patients (117 ft) were included in the study. The procedure was bilateral in 83 % of the cases, with a male:female ratio of 2:1. Mean age at surgery was 7 years (5–13). The Viladot implant was used in all cases. Additional procedures were present in 34 cases: naviculocuneiform arthrodesis 9, Achilles lengthening 6, Kidner procedure 16, re-tensioning tibialis anterior tendon 3. There was some complication in 48 % of the patients: implant breakage 17 %, implant removal because of implant-related pain 28 % (average 18 months after surgery), and superficial infection 3 %.

37 patients were contacted by phone 24 years after surgery: 22 % reported pain (16 % needed pain medication), 9 % reported limitation of daily activities, 57 % noted limitation of recreational activities such as sports, 11 % needed comfort footwear, 22 % require a shoe insert, and 40 % had required further surgery. However, 86 % of the patients were satisfied with the result. Seven patients came back to clinic at the time of the study: all patients showed a flatfoot with hindfoot valgus in 6 cases and midfoot abduction in 4 cases; there was a marked restriction of subtalar joint motion in all cases, a peroneal tendon contracture in 2 cases; difficulty standing on tiptoes in 3 cases.

**Conclusion** Arthroereisis using the Viladot implant for pediatric flatfoot presented a high incidence of complications (48 %), with implant related pain being the most frequent complication.

**Significance** Arthroereisis presented a long-term fair result with high incidence of complications. However, patients were satisfied.

### EP33

#### Reductions of pediatric fractures at the emergency department without C-arm use: is sedation and analgesia enough for good fracture reduction?

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#### Level-3

##### Upper and lower extremity trauma

**Introduction** Paediatric displaced fractures presenting to the emergency department need to be reduced. This can be done under formal anesthesia in the operating room or by a combination of sedation and analgesia in the emergency department: in the latter instance there is no C-Arm control during the reduction manoeuvre.

**Materials and methods** Thirty-seven consecutive patients with displaced fractures that did not need primary surgical reduction and fixation presented during the year 2014. Demographic data, fracture location, analgesia and sedation medication received, pain during procedure and radiological reduction results were collected.

**Results** Patients treated were a mean 9 years old (range 3–15 years old) and the most frequent fracture was that of the distal third of radius (27 %) followed by both bones fracture (19 %) and Galeazzi fracture dislocation (8 %). Procedures took place, during normal working hours, with nitrous oxide and fentanyl in 54 % of the cases and 38 % with fentanyl alone. Analgesia during reduction was sat-

isfactory in 83 % of patients. Radiological results were classified as good in 83 % of patients and those that did not achieve a satisfactory reduction (17 %) were subsequently reduced in the operating room.

**Conclusion** Paediatric fracture reduction under a combination of sedative and analgesic agents is an effective procedure to achieve a painless and satisfactory reduction in the emergency department but still a number of patients need to be treated in the operating room.

**Significance** The addition of analgesia and sedation to routine procedures such as fracture reduction is essential in a paediatric emergency department. Good analgesia aids fracture reduction and may help avoid secondary reductions in the operating room.

### EP34

#### Injectable liquid bone substitute in treatment of subtrochanteric pathological fractures due to simple bone cyst in children

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#### Level-4

##### Tumours

**Introduction** Simple Bone Cysts (SBC) represent about 3 % of all primary bone lesions mainly affecting proximal humerus and proximal femur especially in young patients. Although they may be asymptomatic, pathological fracture can be the presenting symptom. Many options are proposed to treat femoral subtrochanteric pathological fractures due to SBCs in children, but to our knowledge no research; to date, has described the use of injectable liquid bone substitute in filling the residual cavity after curettage in such cases.

**Materials and methods** We prospectively evaluated the results of augmenting our primary fixation of subtrochanteric pathological fractures of the femur due to SBC using the injectable liquid bone substitute. From May 2013 to April 2015, 11 children (8 males and 3 females) presented to our orthopaedic department with a history of pain and disability in the affected lower limb following pedestrian injuries in 7 patients, trivial trauma during outdoor activities in 2 patients and no history of trauma in remaining 2 cases. Only 3 patients had a history of diagnosed proximal femoral SBC prior to the trauma while in the remaining 8 patients it was discovered incidently on review of the X-rays.

Patients' age ranged from 8 to 15 years with mean of 11.5 years, right to left involvement was 5:6. Patients were operated on by open curettage of the cyst cavity, reduction and internal fixation with pediatric dynamic hip screw and filling of the cavity with injectable liquid bone substitute.

**Results** Follow-up ranged from 6 to 16 m with a mean of 12.6 m. Partial weight bearing with crutches started from 4 to 6 weeks according to the cyst size and stability of the fixation. Full weight bearing started from 8 to 12 weeks according to radiological signs of healing at the fracture site. Full union of the fracture was achieved from 10 to 14 weeks with a mean union time of 12 weeks, and by 6 months complete resorption of the synthetic bone substitute was documented.

Complications included 2 cases of superficial wound infection treated with antibiotics.

**Conclusion** We have found that augmenting the internal fixation in treatment of pathological subtrochanteric fractures in SBCs in chil-

den using the injectable liquid bone substitute provides a reliable cyst obliterating scaffold that will be completely replaced by normal bone. **Significance** Evaluation of using injectable liquid bone substitute in augmenting internal fixation intreatment of pathological subtrochanteric fractures due to SBC in children

## EP35

### Elastic intramedullary nails in treatment of subtrochanteric fractures of the femur in children

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** Subtrochanteric femoral fractures in children remain a decision making challenge in terms of most reliable treatment choice. Different lines of treatment were proposed ranging from traction, as the least invasive choice, up to open reduction and fracture fixation with plates and screws. Intramedullary elastic nail fixation is one of the suggested methods of fixation in subtrochanteric femur fractures in children, carrying the advantages of the minimally invasive surgical technique with a satisfactory relative stability in comparison to other conservative treatment option.

**Materials and methods** From May 2013 to May 2015, 18 children, 11 males and 7 females, with subtrochanteric fracture of the femur were treated with internal fixation using elastic intramedullary nails. Age of patients at time of surgery ranged from 7 to 15 years with mean of  $10.8 \pm 2.4$  years. Different patterns of subtrochanteric fractures were observed, including three comminuted fractures (16.7 %), one oblique (5.6 %), 4 spiral (22.2 %) and 11 transverse and short oblique fractures (55.6 %). Time to surgery after injury ranged from 0 (same day of injury) in 7 cases (38.9 %), next day in 7 cases (38.9 %), 2 days in 2 cases (11.1 %) and 7 and 14 days in only 1 case (5.6 %) each - the delay being due to accompanying injuries.

All fractures were reduced under general anaesthesia, 14 cases (77.8 %) with closed reduction and 4 cases (22.2 %) with open reduction through small incision that permits the use of a bone elevator or bone hooks to achieve reduction followed by fixation using 2 elastic intramedullary nails inserted under fluoroscopic guidance from distally to be secured in divergence in the trochanteric bone stock blocking rotation at the fracture site. No postoperative cast splinting or spica was used.

**Results** Follow-up visits were planned to evaluate fracture stability and union progress, evidence of union callus was observed at 5–8 weeks with mean of  $5.8 \pm 1$  weeks, and full union was achieved in all the patients by 9–14 weeks with mean duration of  $11.4 \pm 1.4$  weeks. Complications included one case (5.6 %) of wound infection that was treated by oral antibiotics and resolved completely in 10 days, and pin tract infection in 4 patients (22.2 %).

**Conclusion** We have found that elastic intramedullary nail fixation in subtrochanteric femoral fractures in children provides a reliable choice that demonstrated fracture stabilization via minimally invasive incisions and resulted in union with minimal complications.

## EP36

### Pediatric spine infections: a multicenter retrospective study on clinical, biological and bacteriological characteristics

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#### Level-2

#### Multicentre and innovative studies

**Introduction** Pediatric spondylodiscitis (SD) and vertebral osteomyelitis are rare. A triphasic age distribution has been suggested. *Kingella kingae* (*Kk*) is considered as the leading cause of osteoarticular infection (OAI) in children aged 6–48 months. Detection of *Kk* DNA in oropharynx has been shown to provide strong evidence it is responsible for the OAI. We hypothesized that most cases of primary spine infections (PSI) in this age group may also be caused by *Kk*.

**Materials and methods** Patients with MRI evidence of PSI were retrospectively identified at 4 institutions from 2004 to 2014. Demographic, clinical, and biological parameters were collected. Bacteriological investigations including blood cultures, *Kk*-specific real-time polymerase chain reaction (KkPCR) assays from peripheral blood and throat swabs, and cultures from bone or disc aspirations when performed were recorded. Patients were divided into 3 groups according to their age: <6 months (Newborn Group: NG), 6–48 months (Infantile Group: IG), and >48 months–18 years (Juvenile and Adolescent Group: JAG).

**Results** One hundred and three patients with a mean age of  $40.8 \pm 43.3$  months were included (NG: 1, IG: 81, JAG: 21), 66 (64 %) were male. Infections were classified as SD in 97 % of IG and 76 % of JAG ( $p = 0.004$ ). Mean delay in establishing the diagnosis was  $27.5 \pm 40.4$  days (IG:  $23.8 \pm 24.5$ , JAG:  $42.2 \pm 74.9$ ,  $p < 0.001$ ). Five patients were febrile when admitted (IG: 2 (2.5 %), JAG: 5 (15 %),  $p = 0.021$ ). WBC was normal on presentation in all patients with a mean  $11020 \pm 3386$  per mm<sup>3</sup> (IG:  $11463 \pm 3127$ , JAG:  $9201 \pm 3931$ ,  $p = 0.007$ ). Median CRP level was 12 mg/L (IG 12, JAG: 28,  $p = 0.047$ ). Blood cultures taken at admission were positive in 8 % of cases (IG: 2.6 %; 1 *Kk* and 1 *S. epidermidis* (SE), JAG: 33 % ( $p = 0.0001$ ), 6 methicillin-sensitive *S. aureus* (MSSA)). Disc/bone aspiration was performed in 21 cases and yielded positive cultures in 7 patients (IG: 2; 1 *Kk*, 1 SE, JAG: 5; 5 MSSA). In the IG, KkPCR was done in 13 cases from peripheral blood (23 % +) and oropharynx (100 % +), and in 1 case on disc aspiration (+).

**Conclusion** This large study on PSI definitively demonstrates a triphasic age distribution, with newborn form being the rarest, and infantile form the commonest, presenting with significantly different clinical, biological and bacteriological parameters from the juvenile and adolescent form.

**Significance** *Kk* is the leading cause of PSI in the infantile age and could be indirectly but reliably detected from KkPCR assays from throat swabs. At the juvenile and adolescent age, MSSA appears the most frequent pathogen.



## EP37

**Outcomes following supination-inversion ankle fractures in children**

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**Level-3****Foot and ankle**

**Introduction** The purpose of this study was to analyze clinical and radiographic outcomes following the most common ankle fracture pattern in children: Dias–Tachdjian supination-inversion injuries.

**Materials and methods** We performed a chart and x-ray review of patients who sustained supination-inversion type II injuries from 2003 to 2014. Inclusion criteria were skeletally immature patients with radiographic follow-up of: (a) 1 year, or (b) 6 months with obvious growth resumption as indicated by Park-Harris growth lines parallel to the physis. All injury films were examined, and fracture displacement recorded. Evidence of growth disturbance and other complications were sought. Patients were also contacted by phone to complete the FAOS (Foot and Ankle Outcome Score).

**Results** There were 47 patients in the surgical group and 7 in the non-surgical group. The average age in the surgical group was 12 years (range 7–15 years) and the average age in the non-surgical group was 11 yrs (range 6–14.5 years). There was a 15 % (7/47) major complication rate in the surgical group. Analysis via Fisher exact test revealed that there was a significantly ( $p = 0.025$ ) higher rate of complications in the non-surgical group (57 %, 4/7), and there was a significantly higher ( $p = 0.019$ ) rate of complications in the surgical group when post-operative fracture displacement was  $> 2$  mm. No significant differences in FAOS scores were detected.

**Conclusion** When comparing surgical and non-surgical treatment of supination-inversion type II injuries we found a statistically higher complication rate with non-surgical treatment.

**Significance** Our study reasserts the value of modern surgical treatment of type II supination-inversion ankle fractures in children. The goal should be stable internal fixation with fracture fragments reduced with  $< 2$  mm residual displacement.

## EP38

**Extensor tendon injury following flexible nail treatment of pediatric forearm shaft fractures: systematic review of 28 cases and 5 new cases**

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**Level-4****Upper and lower extremity trauma**

**Introduction** The purpose of this study was to evaluate cases of extensor tendon injury following flexible nail treatment of pediatric forearm fractures that have been reported in the literature and those identified at our institution.

**Materials and methods** We performed a systematic review of the literature using Pubmed MEDLINE database, the Cochrane database, Scopus, Web of Science, and Embase. We also conducted a retrospective review of the charts of patients undergoing ESIN at our institution. Clinical data included operative technique, diagnosis, treatment, and outcomes data. Twenty-eight cases of EPL injury following ESIN of the radius were identified in the literature along with an additional five cases from our institution. Nine cases did not meet our inclusion criteria.

**Results** All 33 pediatric cases of EPL tendon injury occurred in association with radial nail insertion via the dorsal approach. EPL injury was diagnosed at an average of 10 weeks following the index procedure. Extensor indicis to EPL transfer was performed in 15 patients, tendon release/lysis of adhesions in 5, EPL repair in 2, EPL graft reconstruction from palmaris longus tendon in 1, and 3 patients refused further intervention. By 12 months follow-up, all operatively treated patients had a good functional outcome with normal extension at the thumb interphalangeal joint, no pain, and no further complication.

**Conclusion** Our study included 33 pediatric patients who sustained EPL injury following dorsal entry ESIN fixation of the radius.

**Significance** If a surgeon intends to utilize the dorsal entry point for ESIN fixation of the radius, particular attention needs to be paid to protecting the EPL tendon.

## EP39

**Ponseti treatment of rigid residual deformities in congenital clubfoot after walking age**

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**Level-4****Club-foot**

**Introduction** The Ponseti method is a consolidated approach to treating idiopathic congenital clubfoot (ICCF) in infants. No established treatment exists for the management of rigid residual deformities of ICCF after walking age. In the present study we retrospectively reviewed the results of Ponseti method in children with residual deformities of ICCF after walking age.

**Materials and methods** We retrospectively evaluated 68 clubfeet of 44 patients whose average age was 3 years 8 months (range: from 1 year 4 months to 8 years 0 months). All the patients had been treated since birth in other institutions by various conservative and surgical methods. Before treatment, residual deformities were clinically classified according to an original scale based on the number of the residual basic deformities of ICCF. Clubfeet were also radiographically evaluated. Particular attention was paid to the shape and relationships of the osteocartilaginous anlagen of the foot, and the following angles were measured: antero-posterior talus-first metatarsal angle, lateral talo-calcaneal angle, and lateral first-fifth metatarsal angle. Two to four plaster casts were applied after manipulations under sedation for 2–4 weeks according to the age of the patients. Percutaneous Achilles tendon tenotomy and plantar fascia release as well as tibial anterior tendon transfer was performed as complementary surgery in patients who required it. At follow-up,

the results of treatment were evaluated clinically according to the Alves et al. scale, whereas the same pre-operative radiographic parameters were measured and compared to those of normal feet. All our data were analyzed statistically.

**Results** Before treatment, 26 ft had three deformities, 27 ft, four deformities, and 15 ft, five deformities. At follow-up, 28 ft were rated excellent, 29 ft, good, and 11 ft, fair. Measurements of the radiographic angles after treatment showed a statistically significant improvement in comparison to those taken before treatment ( $p < 0.001$ ), and the difference with normal was not statistically significant. Mild to moderate radiographic alterations in shape and articular relationships of the osteocartilaginous anlagen of the foot were observed in all cases at follow-up.

**Conclusion** Ponseti re-manipulation and casting associated in several cases with Achilles percutaneous tenotomy or lengthening, plantar fascia release, and tibialis anterior tendon transfer, gave us 84 % excellent and good results. At follow-up all the feet were plantigrade and supple, and our patients did not show any limitation of their daily activities.

**Significance** Ponseti re-manipulation and casting represents a reasonable option to treating residual deformities of ICCF after walking age.

## EP40

### Outcomes of operative treatment for pediatric jones fractures

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#### Level-4

##### Foot and ankle

**Introduction** The purpose of this retrospective case series was to assess radiographic and functional outcomes in pediatric patients who underwent operative intervention for Jones fractures.

**Materials and methods** Hospital records were reviewed to identify pediatric Jones fracture patients treated operatively between 2001 and 2013. Charts were reviewed for demographic, clinical, and surgical information. Characteristics of the patient population, injury type, length of time to radiographic healing and to return to activity after operative fixation were evaluated. Pre-operative and follow-up radiographs confirmed diagnosis and skeletal maturity. Patients were contacted at least 1 year after surgery to complete the Foot Function Index (FFI), a validated outcomes questionnaire that assesses pain, stiffness, activity limitation, difficulty, and social effects of foot pathology. The FFI score is reported as a ratio out of 100, with higher scores indicating greater dysfunction.

**Results** Fourteen patients (12 male, 2 female) with 17 surgically treated Jones fractures were identified. Average clinical follow up was 54.5 months (range 13.5–124 months). The age at the time of surgery averaged  $15.6 \pm 1.0$  years (range 13–17 years). Twenty-one percent (3/14) of fractures occurred in patients with open physes on radiographs at the time of injury. Twelve of 17 fractures evaluated were the result of acute injuries. Surgical treatment consisted of a single cannulated screw in 94.1 % (16/17) of fractures, with percutaneous pinning used for one fracture. One patient underwent subsequent hardware removal. One patient re-fractured and underwent revision of hardware. The time to return to activity averaged  $18.6 \pm 15.0$  weeks (range 5–46 weeks). After operative fixation, radiographic healing

occurred by  $21.1 \pm 15.9$  weeks (range 4–59 weeks). All fractures went on to radiographic healing. 10 patients completed the FFI (71.4 %), an average of 5.4 years after surgery (range 1.2–10.3 years). The average FFI score was  $21.8 \pm 4.9$  (range 17–28), indicating little to no dysfunction. No patients reported activity limitations. 6/10 patients denied dysfunction in any category. 4/10 patients reported mild to moderate pain and stiffness. One patient, with osteogenesis imperfecta and multiple subsequent ipsilateral foot fractures, reported significant problems finding footwear.

**Conclusion** Surgical treatment of Jones fractures in the pediatric population leads to radiographic healing and return to sport at an average of 5 months, and no patients reported activity limitations after a minimum of 1 year.

**Significance** Operative treatment of Jones fractures in the pediatric population is an effective treatment for both acute and chronic injuries.

## EP41

### Epidemiology of the discoid lateral meniscus

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#### Level-2

##### Upper and lower extremity reconstructions

**Introduction** The purpose of this study is to determine the incidence, demographics, presentation and treatment patterns for discoid lateral meniscus (DLM).

**Materials and methods** Retrospective chart review of an integrated health system electronic medical record from 2011 to 2013. Patients of any age diagnosed with a DLM via magnetic resonance imaging (MRI) or arthroscopy was included for study. Age of presentation and diagnosis, gender, ethnicity, laterality, presence and location of tear and type of treatment were recorded. A Chi squared test was performed for statistical comparisons between groups.

**Results** A total of 219 DLM were identified from a database of 3.6 million patients for an incidence of approximately 2/100,000 people (0.002 %). The average age at diagnosis was 24 years (3–65) and the average body mass index (BMI) was 24.6 (14–47). 103 (47 %) were male and 116 (53 %) were female. 117 (53 %) were hispanic, 50 (23 %) were white, 23 (10 %) were Asian, 10 (5 %) were Afro-American and 129 (8 %) were other ethnicities. 172 (79 %) DLM were symptomatic at presentation and 123 (56 %) had a tear. The most common location of the tear was in the body (20 %) followed by the anterior horn (18.5 %) and posterior horn (16.3 %). 127 patients (58 %) underwent surgery for DLM. 70 % of symptomatic patients with DLM underwent surgery vs. 13 % of asymptomatic patients ( $p < 0.0001$ ). Hispanics were more likely to present with a symptomatic DLM ( $p = 0.06$ ) and also undergo surgery ( $p = 0.013$ ) while whites were less likely to be symptomatic ( $p = 0.01$ ) and less likely to undergo surgery ( $p = 0.002$ ). Tear type did not influence whether a DLM was symptomatic (0.066) or whether it underwent surgery ( $p = 0.374$ ). Age and BMI did not influence whether a DLM was symptomatic and the BMI was not increased in those with DLM.

**Conclusion** DLM is a rare diagnosis that affects men and women equally and can become symptomatic in any age group. At least half of symptomatic DLM will have a tear. Symptomatic tears are more

likely to require surgery and Hispanics may have a higher rate of symptomatic DLM than other ethnicities.

**Significance** Symptomatic DLM is not just a paediatric diagnosis and this data can help guide clinicians managing patients who present with knee pain.

## EP42

### Are there patient characteristics associated with an increased risk for open reduction in the treatment of supracondylar humerus fractures?

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#### Level-2

##### Upper and lower extremity trauma

**Introduction** Current recommendations for treating supracondylar humerus (SCH) fractures include closed reduction and percutaneous pinning. However, if difficulties with closed reduction arise, open reduction may be utilized. The purpose of this study is to identify the patient and treatment characteristics more commonly associated with open versus closed reduction of SCH fractures.

**Materials and methods** A retrospective chart review of patients treated for SCH fractures from 2010 to 2014 at a tertiary care children's hospital was performed. Patients were excluded with type I or II SCH fractures. There were 207 patients who met inclusion criteria with 73.4 % (152/207) classified as type III SCH fractures and 26.6 % (55/207) as type IV. Mean age at admission was 5.2 years (range 0.4–13.0 years).

**Results** A total of 191 (92.3 %) closed and 16 (7.7 %) open reductions had complete records that could be studied. A number of different physical exam and fracture characteristics were found to positively correlate with open reduction. Skin puckering was found in 5.1 % (9/178) of closed reductions and 35.7 % (5/14) of open ( $p < 0.001$ ). Correlated vascular exam findings included no palpable pulse (closed = 13.8 % [26/188], open = 81.2 % [13/16]) ( $p < 0.001$ ), lack of perfusion (closed = 0.6 % [1/175], open = 6.7 % [1/15]) ( $p = 0.026$ ), cool subjective temperature of the ipsilateral hand (closed = 0.6 % [1/174], open = 7.7 % [1/13]) ( $p = 0.016$ ), and  $>2$  s capillary refill (closed = 1.3 % [2/151], open = 20.0 % [2/10]) ( $p < 0.001$ ). Exam correlations also included findings of nerve palsy (closed = 22.6 % [43/190], open = 93.7 % [15/16]) ( $p < 0.001$ ) as well as the specific palsy types median ( $p < 0.001$ ), radial ( $p = 0.036$ ) and AIN ( $p < 0.001$ ). Gartland classification type IV fractures were more likely to require open reductions than type III fractures (closed = 24.6 % [47/191], open = 50.0 % [8/16]) ( $p = 0.027$ ). A significant difference was found in the time to OR for closed (mean =  $14.3 \pm 17.6$  h) versus open (mean =  $25.4 \pm 34.8$  h) reduction. No significant difference was found in average age (closed =  $5.2 \pm 2.5$  years, open =  $5.8 \pm 1.2$  years,  $p = 0.077$ ) or amount of flexion type fractures (closed = 1.0 % [2/191], open = 6.2 % [1/16],  $p = 0.094$ ) in closed versus open reductions.

**Conclusion** Positive associations with open reduction included Gartland type IV fracture, longer time to OR, and higher severity of physical exam findings such as skin puckering, compromised vascular supply, and nerve palsies.

**Significance** Open reduction is associated with a higher severity of injury and longer time to operation.

## EP43

### Hip dysplasia in hypotonic cerebral palsy

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#### Level-4

##### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Central congenital hypotonia (hypotonic cerebral palsy) can result from heterogeneous abnormalities in the upper motor neuron system. Little has been reported about the orthopaedic manifestations in this context. This study aimed to evaluate the natural history of the hip in a population of children with central hypotonia.

**Materials and methods** Records of all children with central congenital hypotonia, seen between 2004 and 2014, were reviewed. Children with Down syndrome were excluded. Pelvic radiographs were reviewed and categorized into four age groups ( $<2$  years; 2–4.9; 5–7.9 and  $>8$  years). One radiograph per patient per year was reviewed. Migration percentage (MP) and acetabular index (AI) were measured. Patients with minimum 2 years radiographic follow up were identified to assess the progression over time. For surgical cases, Tonnis, lateral center edge and neck shaft angles were also measured.

**Results** A total of 63 children (52 % males, 48 % females) were identified. In 79 % of cases, no underlying cause of hypotonia could be identified. Developmental delay was encountered in 92 % of children and 60 % were independent ambulators (GMFCS I and II). MP showed a significant increase after age 5 and was at its highest between 5–8 years (more hips with MP  $>40$  % were noted in this age group).

Twenty-three children were followed for an average of 4.2 years (2–8.8 years). Mean age at first and last evaluation was 3.4 and 7.6 years, respectively. MP did not show a clinically significant change over follow up (20–24 %) and an increase of MP after age 5 could not be confirmed. Considering 8 % a true change in MP; 14 hips had higher MP, 7 hips had lower MP and the remaining 25 hips did not show a true MP change during follow up. Similarly, AI did not show a clinically significant change (21–17°).

Four patients (3 at GMFCS IV and 1 at GMFCS V) needed surgery for hip dysplasia and MP  $>50$  %; their ages were between 5.6 and 9.2 years. Hip morphology measurements improved after surgery.

**Conclusion** Children with hypotonic cerebral palsy may develop hip dysplasia without pain or movement limitation. Most of the hips tend not to be progressive even if they subluxate.

**Significance** Early normal screening ( $<5$  years) does not prevent the risk of later displacement. Radiographic surveillance is recommended and evaluations could be performed every 2–4 years (longer intervals than spastic hips) since in the majority of hypotonic hips, subluxation is not progressive.

## EP44

### Pseudarthrosis of the radius after fracture through normal appearing bone in pediatric neurofibromatosis patients: systematic review of 5 cases from the literature and 3 new cases

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#### Level-4

#### Other

**Introduction** The purpose of our study was to summarize reported cases of pseudarthrosis of the radius developing after fracture through normal-appearing bone in pediatric neurofibromatosis patients and to offer three new cases.

**Materials and methods** A systematic review was conducted to identify published articles that contained accounts of forearm pseudarthrosis developing in previously normal bone in children <18 years old.

**Results** Sixty-seven cases of pseudarthrosis of the forearm were identified in English literature, of which 5 were children with neurofibromatosis who developed pseudarthrosis of the radius after fracture through radiographically normal bone. To these we add 3 new cases. The age at diagnosis of pseudarthrosis in these 8 pts ranged from 8 months to 9 years. There were 6 males and 2 females. Six patients were treated via open reduction internal fixation: 5 were successful (bony union) and included bone grafting, the other was unsuccessful and did NOT include bone grafting. The other two patients were treated non-operatively, with one achieving bony union following closed osteoclasia.

**Conclusion** We are aware of 8 documented cases of forearm pseudarthrosis (radius) developing in pediatric NF patients following fracture through radiographically normal bone.

**Significance** Pseudarthrosis of previously normal appearing lower extremity bones is a well-known in pediatric NF patients. Our study presents the first collection of patients demonstrating the same phenomenon in the upper extremity.

## EP45

### The patello-femoral pain syndrome in young gymnasts: our experience

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#### Level-4

#### Other

**Introduction** The patello-femoral pain syndrome (PFPS) is a common clinical manifestation which causes anterior knee pain in children and adolescents, particularly in individuals who perform intense sports activities. Girls are more affected due to anatomic factors such as malalignment of the lower extremities especially at knee joint and muscular imbalance, compounded by over activity. There is no

general consensus on terminology, aetiology or imaging techniques. Symptoms typically consists of peripatellar pain, poorly localized and exacerbated by push-up movements (jumping, squatting, prolonged sitting position, etc.). Instrumental investigations are generally negative. The treatment is conservative.

The aim of this study is to evaluate the presence of patella-femoral pain syndrome in young female gymnasts.

**Materials and methods** Between January 2012 and August 2013, 21 female gymnasts (Group A) aged between 9 and 16 years were evaluated and compared with a control group consisting of individuals of the same age, sex, weight and height, but not practicing any sport activity (Group B). Neither subjects of Group A nor Group B showed clinical evidence of intra or extra articular pathologies of the lower limbs, including infections or malignancies. All subjects were evaluated using the Kujala questionnaire (0–100 points), in order to assess the presence of disorders related to specific movement or position parameters. All subjects underwent physical examination of the knee and lower limbs and specific clinical tests (tilt, glide, grind, apprehension test). Statistical analysis was performed to compare the differences between the two groups.

**Results** Seven subjects of Group A (33.3 %) and 3 of Group B (30 %) reported the maximum Kujala score (100 points). The incidence of breech anomalies and lower limb is not statistically significantly different between Groups A and B (33.3 % in Group A and 38.4 % in Group B). Results were also comparable in the positivity to clinical trial (14 % group A vs 30 % group B). The average of the score obtained in the test of Kujala was  $98.62 \pm 2.38$  in Group A and  $98.92 \pm 2.29$  in Group B.

**Conclusion** The present study showed no significant differences between the two groups, with results that are overlapping in the examinations performed. According to this study sport, even if practiced at high levels, is not a real risk factor for the onset of patello-femoral pain syndrome in developmental age.

**Significance** No statistically significant relationship in terms of positivity to clinical trials between the 2 two groups examined ( $p = 0.3868$ –39 %).

## EP46

### Guided growth for idiopathic coronal plane deformity around the knee

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#### Level-4

#### Multicentre and innovative studies

**Introduction** Guided growth by tension band plating is commonly used to correct coronal plane deformity around the knee. The purpose of this study was to measure the effect of temporary hemiepiphysiodesis and to further define parameters that influence success in patients with idiopathic etiology.

**Materials and methods** Retrospective multicenter study including data on 372 physes in 206 patients (110 males 96 females), with an average follow-up of 14–16 months after plate insertion. Alignment



analysis was compared preoperatively and in at least 2 measurements postoperatively; rate of correction (ROC) was calculated, univariate and multivariate analysis was performed to determine parameters that influence rate and amount of correction.

**Results** The mean age at plate implantation was 12.56 years (2.5–19.33,  $\pm 2.34$ ). 82 % of deformities were valgus.

Of the femoral physes 92 % finished the treatment and of those, 93 % achieved standard alignment (mLDFA 85°–89°); 2 % of the patients had not reached standard alignment while 5 % were over-corrected. Of the tibial physes, 93 % finished the treatment; of these, 92 % achieved standard alignment (mMPTA 85°–89°); 2 % of the patients had not achieved standard alignment while 6 % were over-corrected. 8 % of the femoral physes, and 7 % of the tibial physes have not yet achieved correction but are still growing.

Factors found to significantly influence success and ROC: age at plate implantation, and type, location and extent of deformity.

- ROC of the femur was significantly faster than that of the tibia: 0.85 compared to 0.78°/month respectively ( $p = 0.05$ ).
- ROC in valgus deformity of the femur was significantly faster than in varus deformity: 0.90 compared to 0.77°/month respectively ( $p = 0.04$ ). This difference has not been found in the tibia.
- Patients with more than 38 remaining months to grow (12–59.33,  $\pm 20.24$ ) i.e., girls <12 years and boys <14 years, had a statistically significant better chance to achieve full correction for both femur and tibia ( $p = 0.119, 0.022$  respectively).
- Gender did not influence the success of the treatment.

Complications included 1 % of early postoperative infection and 1 % of early limited range of motion, but no screw breakage was recorded.

**Conclusion** Success and ROC in the idiopathic group are high, with low rate of complications in coronal plane deformity around the knee. ROC in the femur is faster than the tibia; valgus femoral deformities are corrected faster than varus'.

**Significance** This study validates parameters that influence success of guided growth for idiopathic coronal plane deformity around the knee.

## EP47

### Allografts in children aged under 10 years old after resection of malignant long bone tumors. Mid to long-term follow-up

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#### Level-4

#### Tumours

**Introduction** Musculoskeletal tumours in children are still a challenge for surgeons. Big bone defects after tumour resections are difficult to manage, especially when patients are still growing. In patients younger than 10 years, allografts or vascularized bone grafts are common. However, there are not many studies showing long-term results. We present a case series of primary malignant bone tumors in children aged under 10 years old, treated in our centre and reconstructed with allograft. We aim to describe survival and outcomes at long-term follow-up.

**Materials and methods** Eighteen cases of primary malignant bone tumors of long bones (femur, tibia or humerus) in children aged <10 years who were treated between 1994 and 2002 were reviewed

retrospectively. Clinical histories, radiological and pathological studies were studied and the type of resection, complications and survival results were recorded.

**Results** Median age at diagnosis was 7.6 years (range 2–10 years). There were 12 male and 6 female. Osteosarcoma was the commonest diagnosis ( $n = 10$ ). There were 7 cases affecting the femur, 6 tibia and 5 in the humerus. Distal ( $n = 7$ ) and proximal ( $n = 5$ ) metaphysis were the most affected zones in the bone. 11 cases had a soft tissue mass and 2 patients presented with metastasis at diagnosis. Wide resection was performed in all cases. Metaphyseal ( $n = 6$ ), diaphyseal ( $n = 4$ ) and transepiphyseal ( $n = 4$ ) resections were the most frequent procedures. Fourteen intercalary allografts were used. Median allograft follow-up was 102.6 months (range 8–156 m). Average patient follow-up was 106.6 months (range 8–156 m). 14 patients had a complication with the allograft, including 3 infections, 1 local recurrence, 2 graft fractures, 3 graft resorptions, 2 degenerative osteoarthritis, 6 pseudoarthrosis and 2 problems with soft tissues cover. Sixteen patients (88.9 %) needed further operative procedures on the same or on the contralateral side. Four allografts had to be removed. Twelve of 18 patients were still alive at the end of the follow-up period.

**Conclusion** Allograft reconstruction in skeletally immature patients is a procedure with a high rate of complications. Its use remains an alternative to manage big defects in growing patients when a prosthetic replacement cannot be performed. It also provides bone stock for future procedures.

**Significance** Allografts remain an option to manage large bone defects after resection of malignant long bone tumours.

## EP48

### Routine removal of paediatric metalwork—opinions of adult hip surgeons vs. paediatric orthopaedic surgeons

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Hip metalwork implanted in childhood can lead to long-term complications; however there is little evidence to support routine removal. As complications can present to adult services years later, the paediatric surgeon may be unaware of these. Our aim was to compare opinions of adult hip and paediatric orthopaedic surgeons on removal of metalwork, with the long-term aim of developing a protocol for elective removal.

**Materials and methods** We designed an online questionnaire asking if the respondent would recommend routine removal of different hip metalwork, namely Salter pins, proximal femoral metalwork (PFM) for developmental dysplasia of the hip (DDH), total body cerebral palsy (CP) and Perthes disease, and slipped upper femoral epiphysis (SUFE) screws. Additionally we asked if the respondent had encountered migration or stress-shielding caused by retained metalwork and what metalwork they had found most difficult to remove. For all questions the respondent was allowed to leave comments. The questionnaire was distributed via the British Society of Children's Orthopaedic Surgeons (BSCOS) and the British Hip Society (BHS). Results were analysed using a Mann–Whitney U test.

**Results** The groups agreed with each other on most types of metalwork, supporting removal of PFM for DDH and Perthes and favouring

retention of SUFE screws and PFM for CP. The groups disagreed on Salter pins for DDH, where 45 % of BHS supported removal compared with 84 % of BSCOS ( $p < 0.000$ ). However despite general agreement, there were significant differences between the percentages of each group supporting removal for all types of metalwork, with the exception of PFM for CP. Similar proportions had encountered migration (33 % of BHS and 40 % of BSCOS,  $p = 0.414$ ) but more BHS respondents had observed stress shielding (85 % compared to 58 % of BSCOS,  $p < 0.000$ ). BHS thought femoral plates and SUFE screws were most difficult to remove, and BSCOS found Salter pins problematic.

**Conclusion** Difficulty in future total hip arthroplasty (THA) was the most commonly cited reason for supporting removal by both groups of responders. Routine removal may therefore depend on likelihood of THA being required in adulthood, and the difficulty the implant may cause at future THA. There was strong agreement between the two groups that femoral metalwork in CP does not need to be electively removed.

**Significance** This study was useful to elicit adult orthopaedic opinions on paediatric metalwork. Ultimately more research is required to produce a protocol for or against elective removal.

## EP49

### Body mass index as a predictor of outcomes in supracondylar humerus fractures

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#### Level-2

#### Upper and lower extremity trauma

**Introduction** Several studies have previously pointed out the impact that childhood obesity has on orthopaedic conditions, including fractures. The purpose of this study is to explore the association between body mass index (BMI) and outcomes of operatively treated supracondylar humerus (SCH) fractures.

**Materials and methods** A retrospective chart review of patients treated for Gartland type III and IV SCH fractures from 2010 to 2014 at a tertiary care children's hospital was performed. Patients with type I or II SCH fractures were excluded. There were 207 patients who met inclusion criteria, and height and weight data were available for 80 of these (38.6 %). Body mass index for age and percentile by sex was calculated for all patients. Data was collected on patient demographics, fracture characteristics, surgical interventions and outcomes.

**Results** Average BMI for age was 17.2 (range 11.4–39.3) and average BMI percentile was 64.0 (range 1.10–99.90). There was no significant difference in BMI by sex, fracture classification, or age. Patients who presented with a nerve palsy pre-op had a significantly higher BMI percentile than those who did not ( $72.7 \pm 21.0$  vs  $60.0 \pm 29.8$ ,  $p = 0.029$ ). There were no significant differences with regards to other physical exam findings at presentation including skin puckering, antecubital ecchymoses, perfusion, or capillary refill. Patients who required open treatment trended towards a higher BMI percentile ( $73.5 \pm 15.4$  vs  $62.8 \pm 29.2$ ), but this difference did not reach statistical significance ( $p = 0.100$ ). Post-operatively, there was no association between final Bauman's angle or the position of the anterohumeral line and BMI percentile. There was no association with BMI per-

centage and post-operative complications, including pin tract infection, malreduction, cubitus varus, decreased range of motion, or re-operation.

**Conclusion** Patients with type III and IV SCH fractures had a mean BMI on the 64 percentile. Within this group, patients with nerve palsies had significantly higher BMI percentiles.

**Significance** Children with higher BMIs may be at an increased risk of type III and IV SCH fractures compared to the general population, and are at increased risk for nerve palsies if they have a fracture.

## EP50

### Rectus femoris transfer surgery in cerebral palsy patients with stiff knee gait

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#### Level-2

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Previous research found minimally ambulatory patients do not benefit from distal rectus femoris transfer surgery (DRFT) due to increased stance knee flexion post-operatively. This study compared postoperative knee kinematics in patients with cerebral palsy (CP) and stiff knee gait in two groups: those who underwent DRFT and those who did not.

**Materials and methods** A retrospective study of 53 children with CP and stiff knee gait who underwent multilevel surgery and preoperative and postoperative gait analysis was undertaken. Twenty-seven subjects underwent DRFT (DRFT, age  $8.0 \pm 2.1$  years) and 26 subjects did not (CTRL, age  $8.8 \pm 2.7$  years). Data were compared using t-tests,  $\times 2$  tests and multiple regression analysis.

**Results** Age at surgery, time of follow-up and concomitant surgeries were similar between groups. Baseline range of motion, strength and kinematic variables did not differ between groups. Distribution of Gross Motor Function Classification System (GMFCS) levels differed between groups ( $p = 0.02$ ), with the CTRL group having a larger percentage (61 vs 31 %) of GMFCS III and IV subjects.

Significant post-operative improvements in maximum knee extension in stance were seen for both DRFT ( $D8.2^\circ \pm 12.9$ ,  $p = 0.003$ ) and CTRL ( $D12.7^\circ \pm 21.1^\circ$ ,  $p = 0.001$ ) groups. Decreased post-operative peak knee flexion in swing was found for both DRFT ( $D5.2^\circ \pm 11.7$ ,  $p = 0.03$ ) and CTRL ( $D12.4^\circ \pm 15.2$ ,  $p < 0.0001$ ) groups. Timing of post-operative peak knee flexion in swing (percentage of gait cycle) occurred earlier in both DRFT ( $D5.1 \pm 4.6$  %,  $p = 0.004$ ) and CTRL ( $D2.1 \pm 5.2$  %,  $p = 0.02$ ) groups. No significant change in total knee ROM was found for either group.

DRFT group had significantly greater improvement in timing of post-operative peak knee flexion in swing than the CTRL group (difference 3 % [0.4 %, 5.6 %],  $p = 0.02$ ). CTRL group had a significantly greater decrease in post-operative peak flexion in swing compared to DRFT group (difference  $7.2^\circ$  [14.5, 0.1],  $p = 0.05$ ). No difference between groups was found for knee total ROM. After adjusting for GMFCS level, a significant difference between groups was found for post-operative change in maximum knee flexion in swing only.

**Conclusion** Minimally ambulatory patients who undergo hamstring lengthening without DRFT improve their knee extension in stance, maintain knee range of motion from stance to swing, and experience

similar improvement in timing of peak swing knee flexion to those who undergo DRFT.

**Significance** DRFT is not indicated in minimally ambulatory patients with CP.

## EP51

### Outcomes of McHale procedure

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** There are multiple procedures that have been described for the treatment of painful dislocated hips in patients with neuromuscular diseases, including the McHale (proximal femoral resection and valgus osteotomy), Girdlestone (femoral head resection), Castle (femoral head resection and interposition arthroplasty), and Schanz (valgus osteotomy). The purpose of this study is to evaluate long-term outcomes and complications of patients who have had the McHale compared to the alternative procedures.

**Materials and methods** Retrospective review of cerebral palsy patients who were treated between January 1, 1990 to January 7, 2015 with McHale, Girdlestone, Castle, and Schanz procedures was performed. Patients with less than 6 months follow-up were excluded. Variables collected included pain, necessity of repeat surgery, and post-operative complications. Radiographs of the pelvis from the immediate postoperative and most recent clinic appointments were evaluated for femur migration, heterotopic ossification, and bone resorption.

**Results** During this study period, 45 hips were treated with either the McHale (18), Castle (18), Girdlestone (4), or Schanz (5) procedure. The principal diagnosis was cerebral palsy with painful dislocated hip, and mean age for all patients was 14.2 years old (no significant age difference between groups). In the McHale group, 9 (50 %) of patients experienced complications including wound infection, hardware prominence, and pressure sores compared to 3 (16.7 %) Castles, 4 (100 %) Girdlestons, and no Schanzes ( $p = 0.002$ ). All McHale patients showed some amount of bone resorption, mostly around the tips of screws ( $p < 0.001$ ). Ten (55.6 %) McHale patients eventually required revision surgery compared to 1 (5.6 %) Castle, 1 (25 %) Girdlestone, and none of the Schanz patients ( $p = 0.003$ ). Incidence of heterotopic ossification was seen in 4 (100 %) of Girdlestone patients, followed by 9 (64.3 %) Castles, 4 (23.5 %) McHales, and no Schanzes ( $p = 0.007$ ). Similarly, femur migration was evident in all Girdlestons, 6 (42.8 %) Castles, 7 (41.2 %) McHales, and none of the Schanz ( $p = 0.07$ ). In all groups, there was no significant relationship between treatment type and post-operative wound infection or improvement of pain following surgery.

**Conclusion** This study demonstrated that all four procedures provided pain relief after surgery. However, bone resorption and rate of revision surgery were more commonly seen in patients after the McHale procedure compared to other treatment modalities.

**Significance** Bone resorption, which can cause irritation in patients post-operatively, is an important consideration when treating dislo-

cated hips with the McHale procedure and is likely associated with higher rates of revision surgery.

## EP52

### Health-related quality of life and satisfaction with orthoses in a Swedish population of children with arthrogryposis (AMC)

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#### Level-2

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Joint contractures are the main characteristics in AMC and is often associated with muscle weakness. Gait efficiency and functional exercise capacity have been reported as lower in children with arthrogryposis multiplex congenita (AMC) than in healthy controls (HC). To enable or facilitate walking, orthoses are often used. The aim of this study was to describe health-related quality of life (HRQoL) and satisfaction with orthoses in a group of ambulatory children with AMC.

**Materials and methods** Thirty-three children with AMC with a mean age 10.5 (SD 4.2) years participated in the study. Questionnaires measured HRQoL (CHQ-PF and EQ-5D-Y), mobility and self-care (PEDI), and satisfaction with orthoses (QUEST 2.0). Children were divided into groups based on use of orthoses: Ort-D were dependent on orthoses for walking; Ort-ND used orthoses but were not dependent on them for walking; Non-Ort did not use orthoses. Twenty-eight children had undergone lower-limb orthopaedic surgery and 2 children spine surgery. Foot and ankle surgery differed between the groups ( $p = 0.045$ ) with less surgery procedures performed in Non-Ort than in Ort-D and Ort-ND. CHQ-PF (Parent Form) was compared between AMC and a Swedish reference group of 60 HC, mean age 12.9 (SD 1.5). Parametric and non-parametric statistics were performed with SPSS version 23.0.

**Results** Children with AMC had significantly lower CHQ scores in nine of 12 subscales compared to HC. When comparing groups with AMC, Ort-D had lower CHQ physical functioning than Ort-ND ( $p = 0.011$ ) and Non-Ort ( $p = 0.002$ ). The children's reported perception of health with EQ-5D-Y did not show any difference between the groups. PEDI showed less mobility in Ort-D than in Non-Ort ( $p = 0.012$ ), whereas there was no difference in self-care. In total, both Ort-D and Ort-ND were "quite satisfied" with their orthoses, however Ort-D was less satisfied with orthosis weight than Ort-ND ( $p = 0.014$ ). As the most important factor concerning orthoses, Ort-D preferred "comfort" and Ort-ND preferred "easy to use".

**Conclusion** Children with AMC had lower physical HRQoL than HC. Between the groups with AMC, lowest physical functioning was found in Ort-D. As confirmed with PEDI, mobility was lowest in Ort-D. When reported by the children, EQ-5D-Y did not discriminate in perception of health between the groups. As reported by QUEST, children in both groups were "quite satisfied" with their orthoses.

**Significance** This study contributes to knowledge of HRQoL in ambulatory children with AMC and how they perceive their orthoses,

emphasizing the importance of each child's opinion when prescribing orthoses.

## EP53

### Contracted muscle in cerebral palsy displays gene expression that favors collagen production and impairs muscle growth

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#### Level-3

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Children with cerebral palsy (CP) have thin, short, and weak muscles. Compared to typically developed children (TD) muscle function is decreased and muscle composition is altered. Despite a static cerebral lesion, muscle pathophysiology progresses and muscle function deteriorates with advancing age. No underlying mechanism has been identified and no effective countermeasures developed.

In this study we aimed to characterize the biceps muscle with respect to gene expression, pro-fibrotic processes and muscle size homeostasis, collagen content and satellite cell number in CP as compared to TD children.

**Materials and methods** Open muscle biopsies were taken during surgery in children and adolescents with CP, who due to elbow flexion contractures were planned for biceps tendon lengthening's (n = 18, mean age 15.6 years, range 9–18 years). Control muscle was harvested from age-matched healthy donors (TD) post-mortem following accidental deaths (n = 10, mean age 15 years, range 7–21 years). Collagen content was assessed histologically using Picro Sirius red staining. Satellite cells were quantified using immunofluorescence-based labeling of CD56 positive nuclei within the muscle laminin border. mRNA levels of selected transcripts were quantified using qRT-PCR.

**Results** Biceps muscle collagen content was increased in CP as compared to TD subjects ( $6.6 \pm 2$  vs  $5 \pm 1.2$  %,  $p < 0.05$ ). Satellite cell content in CP muscle was decreased  $-40$  % as compared to control ( $p < 0.05$ ). qRT-PCR data showed increased expression of pro-inflammatory cytokines (*IL1B*, *IL6*, *TNF*) and elevated levels of pro-fibrotic regulators and extracellular matrix associated genes (*CTGF*, *TGFBI*, *TGFBR2*, *LOX*, *COL1A1*). Analysed genes involved in muscle size homeostasis revealed increased expression of atrophic factors (*MSTN*, *FBXO32*) and decreased expression of amino acid transporters (*CD98*, *PAT1*). Ribosome biogenesis, as indicated by 45S pre-rRNA abundance, was suppressed ( $-37$  %,  $p < 0.05$ ) and ribosome content reduced (28S rRNA,  $-57$  %,  $p < 0.05$ ).

**Conclusion** Muscle gene expression analysis indicates a pro-inflammatory/pro-fibrotic state in skeletal muscle from children with CP. This gene signature likely drives collagen production, impairs maintenance of the satellite cell niche and negatively affects growth capacity and size homeostasis of skeletal muscle in CP.

**Significance** Treatments aiming at normalizing this transcriptional profile could potentially decrease contracture formation, and thus the need for surgical release of contracted muscles.

## EP54

### Do sagittal spinal alignment and pelvic morphology affect gait kinematics in children with cerebral palsy?

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#### Level-4

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Balance of children with Cerebral Palsy (CCP) during gait is altered due to muscle tone abnormalities and skeletal deformities in the spine, pelvis and lower limbs [1, 2]. Sagittal spino-pelvic alignment and pelvic morphology of CCP and their correlation with gait abnormalities has yet to be described. The aim of this study is to compare spino-pelvic parameters of ambulant CCP to those of typically developing (TD) children and study their correlation with lower limb kinematics during gait.

**Materials and methods** 28 ambulatory spastic CCP (hemiplegia: N = 7, diplegia: N = 21- GMFCS levels I:N = 16, II:N = 12, age =  $11 \pm 3$  years) had undergone an EOS<sup>®</sup> biplanar X-ray exam with 3D reconstruction of spine, pelvis and lower limbs. The CP population was age-matched to 12 TD children (age:  $10 \pm 1$  years). Spino-pelvic parameters were: thoracic kyphosis (TK) T1/T12 and T4/T12, lumbar lordosis (LL) L1/L5 and L1/S1, pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), sacro-acetabular angle (SA)[3], acetabular parameters (rotation of the acetabulum around the following axes of the pelvis: vertical axis for ante/retroversion, antero-posterior axis for abd/adduction, medio-lateral axis for tilt). All CCP had undergone 3D Gait Analysis in order to calculate lower limb kinematics (max, min, mean, ROM). Statistical differences between CP and TD groups were evaluated for spino-pelvic parameters. Pearson correlations between spino-pelvic parameters and lower limb kinematics were calculated in the CP and TD groups.

**Results** PI was significantly larger in CCP compared to TD children ( $48^\circ \pm 10$  and  $43^\circ \pm 8$  respectively,  $p = 0.004$ ). This was also true for SS and SA angles ( $41^\circ \pm 9$  in CCP vs.  $34^\circ \pm 10$  in TD,  $p = 0.014$  and  $64 \pm 12$  in CCP vs.  $58 \pm 9$  in TD,  $p = 0.02$  respectively). Significant moderate correlations were found between spino-pelvic and kinematic parameters in the CCP but not in the TD group: pelvis sagittal kinematics to TK ( $r = -0.43$ ) and SS ( $r = 0.44$ ); pelvis frontal kinematics to PT ( $r = -0.6$ ), PI ( $r = 0.34$ ) and acetabular anteversion ( $r = -0.43$ ); hip horizontal kinematics to SA ( $r = -0.3$ ) and acetabular abduction ( $r = -0.3$ ); knee sagittal kinematics to LL ( $r = 0.33$ ) and PT ( $r = -0.4$ ).

**Conclusion** Both morphological and positional anomalies of the pelvis in CCP, reflected by increased PI, SA and SS angles, were shown to affect pelvis and hip kinematics. Even though TK, LL and acetabular parameters did not significantly differ between the CCP and TD groups, they were shown to be correlated to lower limb kinematics only in the CCP group. A larger CCP population with subgroups of homogeneous gait profiles could help us better understand how these patterns relate to spino-pelvic parameters.

**Significance** This is the first study to assess the relationship between gait and spino-pelvic parameters in CCP.

[1] Theologis, 2013. [2] Suh, 2013. [3] Lazennec, 2004.



## EP55

### Radiological characterization of full-size bioresorbable elastic stable intramedullary nailing implants in a growing sheep model

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#### Level-4

##### Basic science

**Introduction** Paediatric ESIN osteosynthesis enables early weight bearing without a cast and the resulting micromotions during the healing process may be beneficial for fracture healing and callus formation. A second operation is required for removal of implants, which leads to additional morbidity for the patient. Magnesium implants promise suitable mechanical properties and render a second surgical intervention unnecessary. Rare-earth (RE) elements are frequently used for alloying to decrease degradation speed. Nonetheless, they are considered to be noxious for the human body and not suitable for a growing skeleton.

Aim of this pilot study was to evaluate the degradation of fully sized RE-free Zn-poor Mg–Zn–Ca ESIN implants in an in vivo sheep model, under clinical conditions and close to those of the paediatric trauma case.

**Materials and methods** 7 sheep tibiae were implanted with two RE-free magnesium alloys, (Austrian Ministry of Science, Research and Economy accreditation number BMWFW-66.010/0049-WF/II/3b/2014): alloy ZX10 (Mg–1Zn–0.3Ca,  $N = 3$ ) and alloy ZX00 (Mg–0.3Zn–0.4Ca,  $N = 4$ ). The materials were extruded to rods with a diameter of 3 mm and cut to a length of 25 cm, according to a pre-operative length measurement of the sheep tibia.

A standard implantation according to paediatric trauma osteosynthesis was performed using 2 ESINs (of diameter 3 mm) in the sheep tibia, filling 2/3 of the medullary cavity diameters according to standardized clinical conditions.

10 female lambs were used in this pilot study, including 3 control animals. All surgical interventions were performed under sterile clinical conditions.

Continuous clinical CT imaging (Siemens Sensatom 64) was performed with a resolution of 0.6 mm per voxel at 2, 6, 12, 24 and 52 weeks after implantation. Volume, surface and gas evolution were quantified with Materialise MIMICS, ver. 17.

**Results** A faster degradation and increased hydrogen gas production was seen in the alloy ZX00, visible degradation started after 2 weeks in vivo. No adverse effects could be noticed.

**Conclusion** The slightly different Zn and Ca contents led to faster degradation of ZX00 than the higher Zn alloy ZX10. Clinical CT evaluations were suitable for the distinction and characterisation of different rates of degradation and hydrogen gas release.

**Significance** Our investigations in a sheep model show that the degradation characteristics of RE-free Mg alloys achieve the prerequisites for its use in paediatric orthopedics.

## EP56

### Alterations in acetabular and proximal femur geometry in subjects with down syndrome

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#### Level-4

##### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Subjects with Down syndrome (DS) are known to present an increased prevalence of hip pathologies such as hip instability [1]. While previous studies have found that DS subjects have increased femoral and acetabular anteversion in supine position [2, 3], no studies have investigated the anomalies of the hip in the remaining planes. Moreover, hip parameters are more relevant when assessed in load bearing position [4]. The aim of this study is to describe acetabular and proximal femur geometry of DS subjects, in the 3 planes and in standing position, compared to an asymptomatic control group.

**Materials and methods** 41 subjects (13F, 28 M, age  $17.4 \pm 6.2$  years) with DS, without history of cardiac surgery, have undergone EOS<sup>®</sup> biplanar X-ray exam with 3D reconstructions of their pelvis and lower limbs in standing position. These subjects were age and gender-matched to 41 asymptomatic subjects (13F, 28 M, age  $17.7 \pm 5.4$  years). The following parameters were calculated: femoral neck shaft angle, femoral head diameter normalized to femoral length, neck length normalized to femoral length, femoral offset normalized to femoral length, external coverage angle, Idelberg and Frank angle, acetabular coverage of the femoral head, acetabular tilt, abduction and anteversion, posterior and anterior coverage of the acetabulum. Parameters were compared between the 2 groups using Student and Mann–Whitney tests ( $\alpha$ -level = 0.05).

**Results** The following parameters were significantly higher in DS group compared to the control group: femoral head diameter (1.08 vs 1.03 %,  $p = 0.002$ ), femoral offset (0.98 vs 0.92 %,  $p = 0.013$ ), neck length (1.32 vs 1.20 %,  $p = 0.001$ ), external coverage acetabular angle (33.3° vs 31.4°,  $p = 0.03$ ). The abduction of the acetabulum (53.5° vs 55.1°,  $p = 0.02$ ) was significantly smaller in the DS group. The angle of Idelberg and Frank (53.2° vs 53.0°,  $p = 0.9$ ), acetabular tilt (19.3° vs 20.7°,  $p = 0.16$ ) and the acetabular anteversion (15.0° vs 15.0°,  $p = 0.8$ ) did not differ between both groups (DS vs Control respectively).

**Conclusion** The acetabular anteversion was shown to be similar between groups, in contrast to previous studies [3]. This could be due to the difference in subject positioning when calculating hip parameters. Furthermore, subjects with DS presented a more abducted acetabulum which could predispose them to femoral-acetabular impingement and osteoarthritis. Treatment of hip instability and impingement in DS subjects should take into consideration these anatomical differences in their functional position for a better patient-oriented management.

**Significance** This is the first study that describes 3D anatomy of the acetabulum and proximal femur in subjects with DS in standing position.

[1] Bennet 1982. [2] Shaw 2012. [3] Sankar 2012. [4] Babisch 2008

## EP57

### Epidemiology of the long bones fractures surgically treated in children and adolescents

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#### Level-3

#### Upper and lower extremity trauma

**Introduction** Methods of surgical treatment of long bone fractures in children is a problem that has been recently addressed with growing attention. Unique specifics of fractures in developmental age in comparison to fractures in adult patients requires an accurate approach. Disregarding the issue may lead to long-lasting complications including severe skeletal deformities

**Materials and methods** Analysis concerns 852 children (581 boys, 271 girls) admitted to hospital with long bones fractures. Data were gained from medical histories between 2005 and 2014.

**Results** Long bones fractures were the cause of hospitalizations in 59.98 % during spring-summer period. Average age was 12 years old. Fractures occurred more often in boys. Main cause of fractures in test group was indirect trauma during sport activities (64.4 %). Fractures of distal metaphysis and epiphysis of the radius bone were the most common result of trauma in children and adolescents (13.5 % of all fractures). 32.7 % fractures in upper limb concern radius bone and 22.3 % concern supracondylar humeral bone fractures. In lower limb fractures the most common site was distal part of tibia bone (18.2 % of all patients). In surgical treatment 374 (43.9 %) K-wires were used. Plate stabilisation was performed 196 times (23 %), screws fixations 136 times (16 %), FIN/ESIN fixations 122 times (14.3 %), tension bands 19 times (2.0 %), intramedullary nailing 12 times (1.4 %), external stabilizations 5 times (2.0 %). Fracture healing complications were observed in 3 cases in patients with polytrauma

**Conclusion** 1. The risk of long bone fracture increases with child age. Fractures are more common in boys.

2. We observed tripled number of fractures that needed surgery yearly from 2003 to 2015. The increase was linear.

3. Choice of surgical treatment method depends of fracture type, dislocation size and patient age.

**Significance** Fracture, long bone, children, surgical treatment.

## EP58

### Magnetic resonance imaging in symptomatic children with hereditary multiple exostoses of the hip

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#### Level-4

#### Tumours

**Introduction** This study aimed to describe the findings of MR Imaging/Arthrography (MRI/MRA) for symptomatic children with HME and hip osteochondromas. The role of this imaging modality in making surgical decisions was also assessed.

**Materials and methods** Records of children with HME and hip osteochondromas, who had hip MRI/MRA, were reviewed. The presence of chondral lesions and labral tears, as well the presence of IFI, was recorded. IFI was defined as abnormalities (edema or fatty replacement/atrophy) in the quadratus femoris muscle (QFM) or decrease of the space for this muscle between the ischium and the proximal femur. The measurements used to determine the space included the ischiofemoral space (IFS), the quadratus femoris space (QFS) and the minimum ischiofemoral space (MIFS). All measurements were performed on axial T1-weighted images. A comparison of the three measurements was made between groups of hips with QFM abnormalities and hips with no QFM abnormalities, using t test.

**Results** Ten children were included (4 males, 6 females). In 2 patients, MRI was unilateral, therefore a total of 18 hips were analyzed. The indication for MRI was hip pain. Mean age, when MRI was performed, was 11.7 years. Labral tears were found in 44 % (8/18) and chondral lesions in 33 % (6/18) of the hips. Mean IFS was 17.2 mm (SD7.3); mean QFS was 14.9 mm (SD5.3) and mean MIFS was 12.8 mm (SD5.9). IFI was seen in 44 % (8/18) of hips. Two patients had bilateral IFI. MIFS was less than 10 mm in all hips with IFI (8/8). Out of these hips, 88 % (7/8) had edema of the QFM and 38 % (3/8) had fatty replacement/atrophy in the muscle. Osteochondromas were seen in the lesser trochanter in all hips with IFI (8/8) and in the ischium in 50 % of them (4/8). A significant difference ( $p < 0.05$ ) was found in MIFS and QFS between the hips with QFM abnormalities and hips with no QFM abnormalities. No significant difference was found in the IFS.

**Conclusion** A high percentage of children with HME had ischiofemoral impingement and intraarticular lesions. These findings can play an important role in the indication and planning of a surgical approach.

**Significance** In symptomatic children with HME of the hip, MRI is helpful in detecting the source of pain and directing the next step in management.

## EP59

### Locked vs. non-locked two-hole plates in growth modulation: a Sawbones© study

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#### Level-2

#### Other

**Introduction** Guided growth has gained popularity in treating deformities around the knee in children. Non-locked, two-hole plates are commonly used for growth modulation due to the ease of application and removal, and the on/off effect. However, time to effect is still controversial. We are not aware of any study that utilized a locked construct. The purpose of this study was to examine the difference in biomechanical properties exhibited by an alternative two-hole plate in a non-locked vs. locked configuration in a Sawbones model.

**Materials and methods** A hybrid model was created to simulate the pediatric metaphyseal corti-cancellous bone. Two Sawbones materials, a 1 mm layer of closed-cell urethane foam and a 3 cm medium-density open-cell urethane foam, were bound into a block. The two control groups utilized a conventional two-hole plate, one in parallel screw configuration and the other with divergent screws. For the experimental groups, we selected an alternative two-hole plate that

allows for application in a non-locked or locked fashion, and fixed them with parallel screws. There were four specimens in each of the four groups. A pulley system loading apparatus was used to test the different constructs with sequential weight increments of 500 g up to a maximum of 2500 g. The amount of distraction between the blocks was measured.

**Results** A statistically significant difference was found between the different constructs at loads of 1500 g ( $p = 0.0188$ ), 2000 g ( $p = 0.0022$ ), and 2500 g ( $p = 0.0021$ ). Post hoc analysis demonstrated a significantly greater amount of distraction for the conventional two-hole plate regardless of screw configuration and the alternative, non-locked two-hole plate than the alternative, locked two-hole plate.

**Conclusion** A locked two-hole plate appears to be more resistant to distraction forces than its non-locked counterpart in a Sawbones pediatric physal model as well as to conventional non-locked two-hole plates.

**Significance** When compared to non-locked plates, locked plates for guided growth could decrease the lag time to effectiveness.

## EP60

### What is the magnitude and rate of correction produced by the eight-plate in hemi-epiphysiodesis?

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#### Level-3

#### Other

**Introduction** The purpose of this study was to evaluate the magnitude and rate of correction produced by the eight-plate in hemi-epiphysiodesis of the distal femur (DF) and proximal tibia (PT).

**Materials and methods** We conducted a retrospective review of all guided-growth procedures performed at our institution with use of the eight-plate. Subjects were included in this study if they underwent hemi-epiphysiodesis without any associated procedures and were followed with serial limb-length radiographs until skeletal maturity or the time of implant removal.

**Results** Hemi-epiphysiodesis with the eight-plate was performed in the DF in 11 cases and the PT in 18 cases. The average age at the time of surgery was 12 years (standard deviation, SD, 2.05). In DF cases, the lateral distal femoral angle (LDFA) changed a mean of  $5.1^\circ$  and the mean axis deviation (MAD) changed 15 mm over the course of treatment ( $p = 0.0029$ ). Femoral length increased about 9 mm ( $p = 0.012$ ) and the physal width increased 6 mm ( $p = 0.0048$ ). Two of 11 DF cases had a pre-operative limb length discrepancy (LLD) greater than 1 cm. These both improved and no new LLD >1 cm was created. In the proximal tibia, the mean proximal tibial angle (MPTA) changed about  $4^\circ$  ( $p = 0.031$ ) and the MAD was corrected by 15 mm ( $p = 0.0002$ ). Tibial length increased 20 mm and physal width increased 4 mm ( $p = 0.0001$  for both). Seven of 18 PT cases had a pre-operative LLD >1 cm compared to 5/18 after treatment. The angle between the screws in both DF and PT plates

increased  $13^\circ$  over the treatment period ( $p = 0.0001$ ). The correction rate of the MAD was about 30 mm/year for the DF and 13 mm/year for the PT. The change in LDFA was  $8^\circ$ /year for the DF and  $2.8^\circ$  for the PT while the MPTA changed  $3.8^\circ$ /year for the DF and  $4.5^\circ$ /year for the PT. The only complication was infection in 1 patient. No implant failures, extrusion, or new LLD were observed and no patients required repeat hemi-epiphysiodesis or osteotomy.

**Conclusion** The eight-plate is a relatively safe and efficient means by which to correct angular deformity in skeletally immature patients. As expected, the rate of correction is greater in the DF than in the PT.

**Significance** While the eight-plate provides a similar rate and magnitude of angular deformity correction to older techniques, it allows precise insertion with a very low complication rate.

## EP61

### Prognostic factors affecting outcome of ACL reconstruction in adolescents

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#### Level-3

#### Upper and lower extremity reconstructions

**Introduction** An increased incidence of ACL ruptures in skeletally immature patients has been observed. Correct diagnosis and proper treatment leads to a return to full sporting activity.

**Materials and methods** Between 2007 and 2011, we did 99 surgical ACL reconstructions: 24 patients were excluded from further analysis due to short follow-up. 50 patients participated in a review examination: 30 boys and 20 girls. Average age at the time of reconstruction was 16 y.o. (14–17). Average follow up was 2 years (8–56 months). All patients from this group went through ACL reconstruction procedure with arthroscopy. All patients also had autograft from semitendinosus and gracilis muscle tendon or bone-patellar tendon-bone. During the examination we did stability tests, ROM of the knee joint, function of the joint with Lysholm's and IKDC scale, and evaluated activity level with the adapted Tegner scale and a functional trial; jump on one leg. We compared all results with gender, time between injury and reconstruction procedure, type of procedure (transtibial or anatomical reconstruction), age at the time of reconstruction, postoperative procedures including type of rehabilitation.

**Results** In the study group the average knee joint function result according to Lysholm's scale was 77, in IKDC scale 77.12; average activity level (Tegner scale) before injury was 6.2 and after treatment 5.1. 31 patients could jump on one leg. 29 patients returned to their pre-injury activities. 9 patients had instability of the knee on clinical examination and 4 of these had confirmed autograft rupture on arthroscopy. Significantly worse results in functional and objective tests were seen in patients that had no rehabilitation or inadequate programmes. Slightly worse results were seen in girls compared with boys. Age at the start of treatment, time between injury and surgery and reconstruction type did not have any impact on outcome.

**Conclusion** The most important prognostic factor of ACL reconstruction is proper rehabilitation. Best results were in patients with highest level of activity before injury, with very early reconstruction procedure and proper rehabilitation. Anatomical ACL reconstruction in control group had no advantage compared with transtibial reconstruction.

## EP62

### Reliability of a modified complication classification system in paediatric orthopedic patients

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#### Level-2

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** There is currently no standardized complication grading classification routinely used for paediatric orthopedic surgical procedures. The Clavien–Dindo classification used in general surgery was modified and validated in 2011 by Sink et al. and has been used regularly to classify complications following hip preservation surgery. The aim of this study was to adapt and validate Sink et al.'s modification of the Clavien–Dindo classification system for grading complications following surgical interventions of the upper and lower extremities and spine in paediatric orthopedic patients.

**Materials and methods** Sink et al.'s modification of the Clavien–Dindo classification system was further modified for paediatric orthopaedic procedures. The modified grading scheme was based on the treatment required to treat the complication and the long term morbidity of the complications. Forty-five complication scenarios were developed. Seven paediatric orthopedic surgeons were trained to use the modified system and they each graded the scenarios on two occasions. The scenarios were presented in a different random order each time they were graded. Fleiss' and Cohen's  $\kappa$  statistics were performed to test for inter-rater and intra-rater reliabilities, respectively.

**Results** The overall Fleiss'  $\kappa$  value for inter-rater reliability was 0.772 (95 % CI, 0.744–0.799). The weighted  $\kappa$  was 0.765 (95 % CI, 0.703–0.826) for Grade I, 0.692 (95 % CI, 0.630–0.753) for Grade II, 0.733 (95 % CI, 0.671–0.795) for Grade III, 0.657 (95 % CI, 0.595–0.719) for Grade IVa, 0.769 (95 % CI, 0.707–0.831) for Grade IVb and 1.000 for Grade V (p value <0.001). The Cohen's  $\kappa$  value for intra-rater reliability was 0.918 (95 % CI, 0.887–0.947). These tests show that the adapted classification system has high inter- and intra-rater reliabilities for grading complications following pediatric orthopedic surgery.

**Conclusion** Given the high intra- and inter-rater reliability and simplicity of this system, adoption of this grading scheme as a standard of reporting complications in paediatric orthopaedic surgery could be considered.

**Significance** The evaluation of surgical outcomes should include the ability reliably to grade surgical complications. A reproducible,

reliable system to assess pediatric surgical complications will be a valuable tool for improving surgical practices and patient outcomes.

## EP63

### VEPTR implantation to treat children with early onset scoliosis without rib abnormalities: a prospective multicenter study

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#### Level-3

#### Spine

**Introduction** The purpose of this prospective study was to evaluate the use of VEPTR for preventing further progression of scoliosis and for allowing spinal growth in the treatment of children with progressive early onset scoliosis (EOS) without rib abnormalities.

**Materials and methods** Prospective multi-centre observational cohort study on patients with EOS treated with VEPTR with 2 years follow up. Analysis was based on measurements that were done pre-implant, immediate post-op and at 2 years follow up.

**Results** Sixty-three patients met the inclusion criteria: 35 males and 28 females. Mean age at time of implantation was  $6.1 \pm 2.4$  years. Aetiologies included congenital (n = 6), neuromuscular (n = 36), syndromic (n = 4), and idiopathic (n = 17). Mean follow up was  $2.2 \pm 0.4$  years. Scoliosis ( $72^\circ \pm 18^\circ$ ) decreased after implant surgery ( $47^\circ \pm 17^\circ$ ) followed by slight increase after 2 years of follow up ( $57^\circ \pm 18^\circ$ ),  $p < 0.0001$ . Maximum kyphosis ( $48^\circ \pm 22^\circ$ ) also showed significant decrease after surgery ( $40^\circ \pm 14^\circ$ ) but increased after 2 years ( $48^\circ \pm 16^\circ$ ),  $p < 0.0001$ . Height measurements including T1–T12 ( $15.7 \pm 3$  cm) and T1–S1 ( $25 \pm 6$  cm) showed significant increase after surgery ( $17.7 \pm 4$  cm and  $28.6 \pm 6$  cm respectively) and at 2 years ( $18.4 \pm 4$  and  $29.1 \pm 5$  cm respectively),  $p < 0.0001$ . No difference was seen between aetiological groups. These increases in spine height represent 139 % of expected age-matched T1–T12 growth and 186 % of expected age-matched T1–S1 growth.

**Conclusion** At 2 years follow up, VEPTR is effective in treating EOS without rib abnormalities with improvements in scoliosis and with an ability to provide greater than 100 % of expected age-matched spine growth.

**Significance** At 2 years follow up, this large prospective, multi-centre study demonstrated the ability of VEPTR to treat EOS (without rib abnormalities) effectively. Goals of preventing further scoliosis progression and of maintaining normal spine growth were achieved.



## EP64

**Ponseti-treated idiopathic clubfeet—is brace compliance in the first 90 days predictive of outcome?**Benjamin Richards<sup>1</sup>, Shawne Faulks<sup>2</sup>, Kevin Felton<sup>2</sup>, ChanHee Jo<sup>3</sup><sup>1</sup>Texas Scottish Rite Hospital for Children, Dallas, United States**Level-2****Foot and ankle**

**Introduction** With Ponseti-treated clubfeet, strict adherence to bracing is considered essential for successful outcomes. The purpose is to determine the treatment outcomes at 2 years of age relative to the amount of time bracing was used in the first 90 days.

**Materials and methods** Following correction of their idiopathic clubfeet, infants were braced with a temperature data logger imbedded in a shoe. The orthoses were prescribed 22 h per day for the first 90 days followed by 12 h per night until 2 years of age. Data was downloaded regularly. A minimum follow-up of 22 months was required. Relapses requiring further casting or surgery were recorded.

129 patients with 193 clubfeet were reviewed. All patients had wear data recorded for the first 90 days. 68 of these 129 patients (102 ft) had wear data recorded/downloaded for each interval during the 18 month collection period (Group 1), while 61 patients (91 ft) lacked  $\geq 2$  intervals of data downloads over this time span (Group 2).

**Results** In Group 1, over the first 90 days the braces were worn 20.2 h/day. 98 of the 102 ft (96 %) were plantigrade at 2 years follow-up. The remaining 4 ft required either limited surgery or posteromedial release to regain a plantigrade foot. For those patients in Group 1 who experienced relapse, the braces were worn during the first 90 day period 19 h/day (NS).

In Group 2, over the first 90 days the braces were worn 15.1 h/day. 72 of the 91 ft (79 %) were plantigrade at 2 years follow-up, while 19 ft required surgery following  $\geq 1$  relapse. Over the first 90 days in those who did not experience relapse, the braces were worn 17.1 h/day, while those 21 patients who relapsed averaged 11.4 h/day ( $p = 0.02$ ).

**Conclusion** Those who reliably returned for their brace wear download had a high success rate. However, approximately 50 % of clubfoot patients' caretakers did not return regularly beyond the first 90 days for data download (Group 2). This patient group experienced less wear during the first 90 days when compared to Group 1 ( $p < 0.01$ ). Those in Group 2 who experienced relapses and needed surgery showed significantly less wear when compared to those who did not experience relapse in Group 2 ( $p = 0.02$ ).

**Significance** Though not applicable to everyone, objective monitoring of brace wear during the first 90 days does identify those most at risk for relapse and the ultimate need for surgery.

## EP65

**Purposeful closed reduction and pinning in unstable slipped capital femoral epiphysis does not result in increased risk for avascular necrosis**Joshua Napora<sup>1</sup>, William Morris<sup>2</sup>, Allison Gilmore<sup>2</sup>, Christina Hardesty<sup>2</sup>, George Thompson<sup>2</sup>, Raymond Liu<sup>2</sup><sup>1</sup>University Hospitals Case Medical Center, Cleveland, United States**Level-3****Hip/DDH/Legg-Calvé-Perthes/SCFE**

**Introduction** The treatment of stable Slipped Capital Femoral Epiphysis (SCFE) is generally accepted as in situ pinning; however, significant controversy exists involving the treatment of unstable SCFE, which is associated with a high rate of avascular necrosis (AVN). Zaltz et al. recently reviewed 15 studies with a wide variety of reduction techniques and determined the overall unstable SCFE AVN rate to be 24 %. In their review the largest study reporting purposeful reduction found a 47 % AVN rate in 26/30 patients. The purpose of this study was to further investigate the AVN rate with purposeful closed reduction and pinning of the capital femoral epiphysis.

**Materials and methods** We retrospectively reviewed 221 patients with 302 hips with SCFE between 2000 and 2014. 48 patients (50 hips) presented with unstable SCFE, of which 17 patients (17 hips) had a scheduled MRI between 1 and 6 months postoperatively from surgery, while 31 patients (33 hips) were evaluated using only plain radiograph to detect AVN. All unstable SCFEs were treated by a gentle reduction method. The patient was placed on a fracture table, traction was applied, and the affected leg was mildly internally rotated with patella never passing further than perpendicular to floor allowing for a gentle reduction. Closed pinning was performed using one or two cannulated screws. Southwick angles were measured prior to reduction and at first postoperative visit.

**Results** No stable SCFEs went on to develop AVN. Thirteen (26 %) unstable SCFEs developed AVN. Of patients screened with MRI AVN developed in 7/17 (41 %) hips at a mean of 2.5 months (range 0.9–5.0 months) postoperatively. Of patients followed with plain radiographs alone, AVN developed in 6/33 (18 %) hips at a mean of 6.8 months (range 2.1–21.1 months) after surgery. Mean follow up for MRI screened unstable SCFEs was 29.2 months compared to unstable SCFEs followed by only plain radiographs of 22.1 months. Southwick angles were measured in a subset of 24 patients that had adequate pre-reduction and post-reduction radiographs. Mean change in Southwick angle was  $19^\circ \pm 17^\circ$ .

**Conclusion** Despite potentially inflating our rate with the use of early detection MRI scans, we found an AVN rate comparable to the published literature with the use of gentle reduction on a fracture table with traction and internal rotation.

**Significance** Purposeful gentle reduction appears to be a reasonable low morbidity option in the treatment in unstable SCFE and does not appear to increase the risk of AVN.

## EP66

### SCFE in Southern Europe. A preliminary epidemiological study

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#### Level-2

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Slipped capital femoral epiphysis (SCFE), has showed a large variation between geographical areas: no study has been done in Southern Europe looking at disease characteristics

**Materials and methods** The data of 130 SCFE, from 5 different teaching hospitals in Spain were reviewed.

The demographic data included were age, weight, height, ethnicity and season of the year when diagnosed. Data related to stability, onset of symptoms and amount of displacement were also recorded.

Finally, data were collected in relation to the applied treatment and the presence of avascular necrosis (AVN).

**Results** The incidence in boys was twice that of girls. The age of presentation was 12.8 years in boys (median 13) and 11.6 in girls (median 11) ( $p = 0.005$ ).

When we looked at the body parameters of the patients, both boys and girls were heavier than their age group but they were also taller. Therefore, the BMI for boys was on average 23.9 (median 23.5) and 24.05 for girls (median 23.2), ruling out obesity in this group of children.

When looking at ethnic origin, 80 % were Caucasian, and a surprising 16.5 % were gypsies (Spanish gypsy population 1.6 %). The time of diagnosis was distributed evenly throughout the year 78 % (102) were stable and 22 % unstable (28), with the same sex distribution and age of presentation. However, when we looked at the relationship between weight and stability, at least in boys, the children with unstable SCFE were 10 kg lighter on average than the whole group ( $p = 0.027$ ).

Displacement was measured using the Wilson and the Southwick methods; both methods show a high concordance ( $\kappa = 0.78$ ). Around 60 % were minimally displaced. The ages for the different degrees of displacement were similar.

Unstable SCFE were always more displaced than the stable, this relationship was significant for both boys ( $p < 0.001$ ) and girls ( $p = 0.005$ ).

Only 8 patients presented AVN; 5 were stable and 3 unstable. By sex 6 were females (4 stable/2 unstable) and 2 male (1/1). AVN occurred in a 4.2 % of unreduced SCFE and in a 8.6 % of reduced cases, so chances of AVN after reduction doubled ( $p = 0.5$ ).

**Conclusion** Patients with SCFE, at least in our background, are not overweight but rather are bigger than their peers.

Gypsy population may have a bigger susceptibility to SCFE.

**Significance** First epidemiological SCFE study performed in the Southern of Europe that may add some more information in the understanding of this condition.

## EP67

### Not fully centered femoral head after closed reduction in children with developmental dysplasia of the hip: immediate re-reduction is not necessary

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** MRI is the best imaging modality to confirm correct reduction after closed reduction and spica cast application for DDH. The aim of this study is to propose a quantitative method to measure centering of the femoral head in the post-reduction MRI. Further, we evaluated the natural course in patients with a subluxated femoral head with repeat MRI after 2 weeks.

**Materials and methods** We retrospectively reviewed all patients between 2008 and 2014. A first MRI without anesthesia was performed within 24 h after closed reduction and cast application. Patients with subluxated femoral head on the axial plane without interposed labrum were observed and a follow-up MRI was obtained 2 weeks later. We propose as quantitative method to measure hip centering on the axial plane the hip-centering index (HCI). A HCI of 1 correlates to a perfect reduction and a HCI  $< 0.5$  can only be found in dislocated but not in subluxated hips. The degree of hip abduction was measured on axial MRI sequences as well.

**Results** A total of 43 patients underwent closed reduction and spica cast application during the study period. 7 patients had an immediate cast change or went on to undergo open reduction. In 12 of the remainder 36 patients, post-reduction MRI showed a subluxated femoral head. Mean age at time of reduction was 56 days. The mean HCI in those 12 patients on the initial MRI was 0.74 (range 0.56–0.93) and improved to 0.86 (range 0.67–1) after 2 weeks, whereas no significant change could be observed on the healthy side. The mean HCI was 0.87 (range 0.76–1) vs. 0.89 (range 0.83–1) at follow-up.

The mean abduction of the dysplastic hips in the cast as seen on MRI was 43° (range 12°–55°). Improvement of HCI over the 2-week period was statistically significant correlated with the amount of hip abduction ( $p = 0.004$ ). In 2 of 12 hips the spica cast was changed due to surgeon's decision after follow-up MRI. These two hips showed a HCI below 0.7 and a hip abduction of less than 45°.

**Conclusion** The HCI can reliably quantify centering of the femoral head. Immediate re-reduction of a mildly decentered hip is not necessary since spontaneous improvement occurs in most cases after 2 weeks. Abduction of less than 40° in the spica cast might be a reason for a more generous cast change in the case of hip subluxation.

**Significance** Our work might help to avoid additional anesthesia or intervention in the very young with DDH.

## EP68

**Varus osteotomy with trochanteric distalisation: preserving hip mechanics**Oliver Birke<sup>1</sup>, David Little<sup>2</sup><sup>1</sup>The Children's Hospital at Westmead, Sydney, Westmead, Sydney, Australia; <sup>2</sup>Children's Hospital Westmead, Westmead, Sydney, Australia**Level-4****Hip/DDH/Legg-Calvé-Perthes/SCFE****Introduction** Proximal femur varus osteotomies are typically performed to improve femoral head coverage and containment in Perthes Disease and Hip Dysplasia. However the traditional technique unfavourably alters hip mechanics leaving the greater trochanter high resulting in abductor dysfunction. Our aim was to avoid this problem with our operative technique.**Materials and methods** The trochanter-flip approach keeps the greater trochanter (GT) attached to both the vastus distally and gluteus medius and minimus proximally thus preserving their function. The GT-flip can then be distalised and optimally positioned at the end of the procedure.

The traditional 90°/100° varus osteotomy plates have a built-in plate-offset to allow medialisation of the shaft and maintain appropriate hip offset, but these plates interfere with the GT-flip refixation.

We developed an operative technique utilising a 130° plate which allows both correct GT-flip positioning and refixation as well as maintenance of hip offset.

**Results** With our technique a 130° canulated blade-plate with a low insertion point can be utilised to allow appropriate space for the GT-flip refixation. However the 130° plate naturally has no built-in plate-offset and would normally lateralise the shaft.

This unwanted lateralisation can be counteracted by the 'release cut' of our osteotomy technique. Prior to guidewire and blade-plate insertion a triangle of the proximal fragment is resected ('release cut'), which has the same angle as the desired angular correction, and thereby incorporates the traditional plate-offset into the osteotomy to allow medialisation of the shaft and maintenance of correct hip offset. Illustrative cases will be presented.

Between 09/2013 and 05/2015 we performed 10 osteotomies in 10 Perthes/Hip Dysplasia patients [mean age 9.4 (6.6–12.1) years]. The GT was re-positioned successfully and appropriated hip offset was maintained in all cases. We did not encounter loss of position, hardware failure, non-union or other significant complications, except one case of deep wound infection after plate removal. Avascular necrosis (AVN) is avoided by subperiosteal dissection of the piriformis fossa around the 'stable trochanter' (GT proportion left behind after the GT-flip) and development of a retinacular soft-tissue flap containing the vessel to the femoral head, before the stable trochanter is resected/removed.

**Conclusion** Our GT-flip varus osteotomy technique allows variation without creating abductor lever-arm dysfunction. The GT can be optimally positioned and the hip offset can be maintained or improved.**Significance** This operative technique may improve the functional outcome for patients requiring varus osteotomies by maintaining or improving their abductor strength.

## EP69

**Wire position on the lateral view is the most important predictor of redisplacement in paediatric supracondylar humeral fractures**Timothy Roberts<sup>1</sup>, Richard Nicol<sup>1</sup>, Roger Walton<sup>2</sup><sup>1</sup>Starship Hospital, Auckland, New Zealand; <sup>2</sup>Alder Hey Children's Hospital, Liverpool, United Kingdom**Level-3****Upper and lower extremity trauma****Introduction** The use of intraosseous wires to fix paediatric distal humeral supracondylar fractures has been the subject of much debate. While study has focused on configuration on the anteroposterior view, sparse literature describes the effect of wire position on the lateral view.**Materials and methods** We undertook a retrospective analysis of 400 displaced supracondylar fractures, treated by reduction and wiring. We recorded the position of the wires on intraoperative lateral views, with particular reference to whether they overlaid the ossified capitellum or metaphysis distal to the fracture line. When wires overlay this region, they were termed 'good'. We recorded post-operative redisplacement on any radiographic view. A change of 6° in Baumann's angle or 12° in the lateral humero-capitellar angle have been shown to indicate true redisplacement and were our primary outcome measures.**Results** Redisplacement occurred in 24.0 % of the entire sample, but was not significantly associated with fracture grade, anteroposterior wire configuration or wire diameter. The number of 'good' wires seen on the intraoperative lateral view was the only factor which had a significant association with redisplacement at the 0.05 level. Of the entire sample, when no 'good' wires were present, redisplacement occurred in 64.8 % of cases. With 1 'good' wire, this reduced to 27.8 % and with 2 'good' wires it was 10.3 %. In cases with 3 'good' wires, redisplacement was seen in 4.3 %. Subanalysis demonstrated a dose dependent effect of increasing numbers of 'good' wires. This dose dependent effect was significant in all fracture grades and in all anteroposterior wire configurations. With 2 crossed wires, when no 'good' wires were present, redisplacement occurred in 52.2 %. With 1 'good' wire 13.7 % redisplaced; with 2 good wires this was 7.8 %. With 2 lateral wires, when no 'good' wires were present, 66.7 % redisplaced. This reduced to 43.8 % with 1 'good' wire and to 6.0 % with 2 'good' wires. The addition of a 3rd 'good' wire to either configuration reduced the rate of redisplacement.**Conclusion** In our experience, wire position on the lateral view is more important than anteroposterior view configuration, fracture grade and wire diameter. Wires should overlaid the ossified capitellum, or metaphyseal portion distal to the fracture line. This measure ensures both fragments have been captured by the wire and significantly reduces the risk of redisplacement.**Significance** Adherence to this simple technical point reduces the rate of fracture redisplacement in routine clinical practice. This technique should be routinely adopted.

## EP70

### The impact of a waiting list initiative on treatment of developmental dysplasia of the hip

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** It has been well reported that age of diagnosis of developmental dysplasia of the hip (DDH) plays an important role in the success of non-surgical treatments. Children who are diagnosed late are more likely to require more aggressive treatment such as closed reductions under general anaesthesia and hence are more likely to suffer from complications of treatment. In Northern Ireland a selective screening policy is implemented with triggers resulting in an ultrasound scan (USS). Year after year we have seen an increase in referral rates, which resulted in a demand for USS exceeding our capacity. As a result a concerning number of children did not have radiological imaging until after the age of 4 months when radiographs are readily available.

We postulated that by reducing the waiting times we would reduce the number of children undergoing closed reductions of the hip. Bringing these concerns to the Public Health Agency lead to an agreement to fund an additional 900 USS per year from January 2013 to address the waiting times.

**Materials and methods** A review of all children treated for DDH between 2010 and 2014 inclusive was performed using the Northern Ireland DDH database collecting information regarding referral, age of diagnosis and treatment methods.

#### Results

- The overall treatment rate for DDH in Northern Ireland remained similar over the study period.
- The mean time from referral to consultation fell from 50.17 days pre-intervention to 33.18 days post intervention
- The mean number of closed reductions performed per year fell from 1.47 per 1000 live births pre-intervention to 0.8 per 1000 live births post-intervention.

**Conclusion** With the implementation of a waiting list initiative for USS we have reduced our delays between referral and consultation. This resulted in a significant decrease in the number of closed reductions performed per 1000 live births.

**Significance** All screening programmes require adequate resources to ensure timely diagnosis. If the capabilities of the screening programme are exceeded then late diagnoses will increase and more invasive treatments will be required. This has implications for patients in terms of outcomes and subjected risks as well as a financial burden to the Health Care System. Monitoring waiting times and investment in diagnosis could result in savings on treatment and compensation claims.

## EP71

### Epidemiology in children treated for scfe in sweden—a national register study

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#### Level-2

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** We describe the epidemiology and current treatment protocols for SCFE in Sweden based on the Swedish national quality register for SCFE.

**Materials and methods** All 34 hospitals that take care of SCFE in Sweden participates in the register. The database contains all consecutive cases reported since 2007. In the present study all children treated 2007–2013 were analysed.

**Results** In total 312 children (178 boys and 134 girls) with SCFE where reported from 34 hospitals. 29 hospitals treated 0–2 cases per year and only 3 hospitals treated >5 cases annually. 55 children had a bilateral slip at first presentation and 34 children not treated with prophylactic pinning later developed a contralateral slip giving a total number of 401 slipped hips. The cumulative incidence was 39 per 100 000 for the age group 9–16 years during these 7 years. The slip was reported as unstable in 57/401 hips and 77 hips had a slip of >50°. The mean age at first surgery was for girls 11.8 (7.2–15.4) years and for boys 13.0 (9.5–16.2) years.

The slip was in 215 hips treated with in situ fixation with the Hansson hook pin, in 143 hips with a screw with a short thread, 26 with a screw with a long thread and 5 with multiple thin pins. Eleven children underwent open reduction and osteotomy according to a modified Dunn technique whereas one child had an open reduction and screw fixation.

Prophylactic pinning of the non-affected contralateral hip was performed in 138 children. 3 patients had their first slip prior to the study period. The 34 later contralateral slips occurred among the remaining 171 unpinned hips (19.8 %).

**Conclusion** This register study represents the total population of children treated for SCFE in Sweden. There are at present several local treatment programmes, several hospitals treating few cases and different opinions regarding prophylactic pinning. In the coming years it will be possible to compare these treatment programmes and to compare the results for different hospitals.

**Significance** A disease specific quality register covering the total population treated makes it possible to analyse the epidemiology and to compare different methods of treatment and the treatment result for different hospitals.

## EP72

### Skeletal healing across dega osteotomies in children with cerebral palsy—a radiostereometric analysis

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#### Level-1

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Around 28–35 % of children with cerebral palsy (CP) develop hip displacement that needs surgical intervention. Treatment by Dega Osteotomy with additional femoral varus derotation osteotomy is preferred. Relapse is experienced in 16–22 % during adolescence. In this study we planned to do a descriptive evaluation of translation and rotation across periacetabular osteotomies in children with CP by radiostereometric analysis (RSA), asking if RSA even is feasible and can RSA predict healing and growth.

**Materials and methods** Project patients had perioperative inserted 4–8 tantalum markers on each side of the Dega osteotomy prior insertion of either bone graft from the femoral shaft or iliac crest. Postoperative RSA follow-ups were performed at time 0, 5, 12 weeks, 6 and 12 months after surgery. Patients were immobilized by casting the first 5 weeks after surgery.



**Results** Eighteen hips were included. Maximum Total Point Motion (MTPM) stagnated after the 5-week follow-up but with increasing mean values. This was also observed for the mean error of rigid body fitting (ME). The mean direction of translation of the acetabular ceiling was superior, medial with no anterior or posterior migration. The mean rotation was in directions of posterior tilt, medial inclination and minimal anteversion.

**Conclusion** RSA across a Dega osteotomies in children with CP is feasible and a valid method to assess migration/growth and healing. The migration stagnates at 5 weeks indicating healing. Increasing mean MTPM and ME values after healing indicates growth. The mean migration acetabular ceiling is the first postoperative year medial and superior with posterior tilt and medial inclination.

**Significance** Level of evidence Level I.

## EP73

### Ante- and retrograde elastic stable intramedullary nailing (ESIN) of humeral shaft fractures in children

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#### Level-2

#### Upper and lower extremity trauma

##### Introduction

**Aim** The aim of this prospective clinical controlled trial was to investigate the results of humeral shaft fractures in children treated with ante- or retrograde elastic stable intramedullary nailing (ESIN).

**Materials and methods** The mean follow-up period was 21 months. 93 children (average age 11.8 years) with traumatic humeral shaft fractures could be included. There were 79 oblique, 15 transverse and 6 wedge fractures. In 28 cases the fracture was located in the proximal third, in 42 cases in the middle third and in 23 cases in the distal third.

**Results** The mean time of fluoroscopy was 1.2 min. In no case was Open reduction required. The Constant–Murley–Score was performed. All children received 100 points and all patients could take part in sports activities like before the accident. 91 children and their parents were very satisfied with the treatment success and two patients satisfied. The following complications were seen: one post-operative damage to the radial nerve in patient with a secondary fracture dislocation (complete remission), 8 skin irritation, one fracture dislocation with axial deviation, one secondary dislocation of the nails after repeated accident and one secondary axial deviation.

**Conclusion** The current results show that elastic intramedullary fixation of displaced humerus shaft fractures in children is a safe, minimally invasive surgical technique producing excellent functional and cosmetic results. It allows an early functional and cast-free follow-up with a quick pain reduction. Elastic stable intramedullary nailing (ESIN) of humerus shaft fractures has a low complication rate if biomechanical principles are paid attention to. The occurred complications are based on mistakes concerning indication or technical errors. The ESIN of humeral shaft fractures is a simple and well reproducible technique with a steep learning curve. Because of the excellent objective and subjective results the operative stabilization of humerus shaft fractures with ESIN should be recommended to the patients and their parents.

## EP74

### Late correction of neck deformity in healed severe slipped capital femoral epiphysis-midterm clinical outcomes

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Contemporary management of neck deformity following a healed severe Slipped Capital Femoral Epiphysis (SCFE) evolve a secondary deformity. This study implemented subcapital neck osteotomy for healed severe SCFE

**Materials and methods:** 18 patients with chronic severe SCFE in the oblique plane (mean = 70°) constituted the study group. 6 patients with an open physis underwent modified Dunn capital realignment and 12 patients with a closed physis underwent surgical dislocation with a corrective neck osteotomy. 10 patients already had in situ pinning done

**Results** The mean follow-up duration was 4.5 years (3–6 years). The mean preoperative Modified Harris Hip Score (MHHS) and Non Arthritic Hip Score (NAHS) were 24 and 40 respectively followed by a score of 89 and 92 respectively at the last followup (p = 0.0002). Radiologically, all the parameters showed a significant correction. The mean pre-and-postoperative values of alpha angle were 79.8 and 34.5 respectively (p = 0.0002); AP slip angle being 36.7 and 14.8 respectively (p = 0.002); lateral slip angle being 54.2 and 13.6 respectively (p = 0.0002); oblique plane slip angle being 70.7 and 20.8 respectively (p = 0.0002) and center trochanter distance being -6.9 and 1.2 (p = 0.002) respectively. The major complications espied were non-union (n = 1/12) in neck osteotomy and chondrolysis (n = 1/6) in the modified Dunn's group. The overall complication rate was 11 %. There was no statistically significant difference between the two groups clinically and radiologically

**Conclusion** Femoral neck osteotomy is a potentially rewarding technique to correct severe neck deformities and restoring hip function in the midterm.

**Significance** Deformity correction at CORA has many functional advantages over the more distal osteotomies.

## EP75

### Achieving union—treatment of pediatric nonunions

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#### Level-3

#### Upper and lower extremity trauma

**Introduction** Delayed and non-unions following fractures or osteotomies are well-known complications in adults. Pediatric non-union is much less common yet poses similar challenges. This is a review of a single level I trauma centres 24 years experience including

demographics, fracture pattern changes and treatment results of pediatric non-unions.

**Materials and methods** One hundred and one patients under age 18 were diagnosed with bony non-unions over a 24 years period. Forty-one patients were excluded from the study due to an underlying condition. The remaining 60 patients consisted the study group.

**Results** The average age at the time of nonunion diagnosis was  $12.1 \pm 4.7$  years, with male predominance. Almost twice as many patients suffered an upper extremity non-union than lower extremity. Bones affected were the femur (9), tibia (11), fibula (1), tarsal navicular (1), clavicle (2), humerus (10), radius (10), ulna (5), scaphoid (10) and other carpal bones (3). Approximately half of the NU resulted from low energy trauma (52.4 %) while the remaining followed high energy trauma (39.9 %) and osteotomies (6.7 %). Thirteen fractures were open, with a higher prevalence in the lower extremities. Twenty-nine of the fractures (48 %) underwent surgery prior to establishment of NU. Twenty-seven of the fractures (45 %) were treated initially non-surgically. Four nonunions followed osteotomies.

**Treatment of nonunion** Of the 58 patients with NU treated successfully by surgery, 24 patients were treated with biological methods alone (bone graft, bone marrow aspirate concentrate injection and debridement), 17 were treated with internal or external fixation and 15 were treated with a combination of both. Failure was less common when the nonunion was treated initially with a combination of bone grafting and stable internal fixation. Seventeen patients (28 %) failed the first attempt and required additional intervention. On average 1.7 surgeries (range 0–5) were performed after the establishment of nonunion. Only 2 patients (ulna and clavicle fractures) did not achieve union during the follow up period. Bone marrow injections were used successfully in 2 humeral fractures.

**Conclusion** Non-union frequently follows non-surgical fracture treatment. The ratio of upper vs. lower extremity NU has shifted towards dominance of upper extremity. The major modes of failure to correct NU consisted of CRIF or debridement alone. NU following open fractures were more difficult to treat. Our experience showed excellent results following mechanical stabilization alone or combined with biological augmentation. The role of bone marrow injection in the pediatric age group, while showing promising results, has yet to be determined

**Significance** Knowing the epidemiology and treatment modalities may improve our ability to avoid non union and if it occurs, to treat it more effectively.

## EP76

### Patellar dislocation in skeletally immature patients: results after semitendinosus and gracilis augmentation for combined medial patellofemoral and medial patellotibial ligament reconstruction

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** Patellar instability is a frequent condition in children and adolescents. The problem can be associated with malalignment resulting from different anatomical abnormalities. A large number of surgical techniques have been proposed for surgical treatment of patellar recurrent dislocation. When surgery is indicated we used a

surgical procedure for reconstructing both the medial patello-femoral (MPFL) and medial patello-tibial ligaments (MPTL) by semitendinosus (ST) tendon with gracilis (G) autograft augmentation. The aim of the study is to verify: the long-term clinical results of this technique; the effectiveness of restoring the patello-femoral congruency both on static and dynamic computed tomography (CT); and determine if pre-operative type of patello-femoral relationship affects the results.

**Materials and methods** The study included 12 patients (14 knees) mean age of 11.8 years, Tanner  $\leq 3$ , with 2–3 episodes of patellar dislocations. The patients were submitted to surgical reconstruction of MPFL and MPTL using semitendinosus and gracilis tendon with a minimally invasive technique. In all 12 patients the knees were routinely submitted to radiographs (antero-posterior and lateral view at 30° of flexion), MRI and static and dynamic CT scans (to assess the patellofemoral relationship) were evaluated pre-operatively and at a minimum 4 years follow-up with static and dynamic CT. Clinical evaluation at F-up was performed using the criteria described by Crosby and Insall.

**Results** This technique is effective and permits satisfactory patellar congruency documented by static and dynamic CT. Clinical results at follow-up were excellent in 76.5 % and good in 23.5 %. Preoperative evaluation showed a high patella in 7 cases. In 11 patients the patello-femoral ligament was injured. The data obtained with static CT shows that the patella achieved a satisfactory congruence in all knees. This finding was confirmed by dynamic CT performed at 4 years follow-up.

**Conclusion** In case of recurrent patellar dislocation with excessive patella alta, severe Q-angle ( $>15^\circ$ ), trochlear dysplasia, TAGT (distance between anterior tuberosity and the deeper part of the groove)  $>1.2$  cm at CT examination and hyperlaxity, this technique is indicated and reaches excellent and good clinical results.

**Significance** The combined use of ST and G does not add morbidity to the intervention which provides more strength and durability of the procedure, bearing in mind that adolescents often have a growing patellar instability linked to several factors. Furthermore the procedure is completely physal-sparing.

## EP77

### Development of the acetabulum after Chiari pelvic osteotomy below the age of 16

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** The Chiari pelvic osteotomy is considered a salvage operation for incongruent dysplastic hip joints. The risk of loss of correction due to the so-called “Anti Chiari effect” has been described when the surgery is performed during childhood and adolescence. The aim of this study was to evaluate if this is a relevant problem on the long-term.

**Materials and methods** Out of a cohort of 518 Chiari pelvic osteotomies a subgroup of 27 under the age of 16 years was analyzed for its clinical and radiological outcome after an average of 35.8 years. Only patients with pre-, postoperative and follow-up Xrays were included. We evaluated the geometry of the acetabulum by measuring the CE angle, the acetabular index, the acetabular head index, the ACM angle, the medialization of the distal fragment and the stage of osteoarthritis.

**Results** 8 patients had received a total hip joint. The remaining patients showed a significant improvement of the femoral head coverage which remained stable on the long-term. At follow-up severe osteoarthritis was present in most patients. The Anti-Chiari effect was observed in very few cases. Insufficient medialization was the reason for the loss of femoral head coverage.

**Conclusion** The Chiari pelvic osteotomy achieves good long-term results in patients operated during growth. A correct surgical technique with sufficient medialization prevents the loss of correction by the “Anti-Chiari” effect.

**Significance** This is the first study evaluating the long-term effects of the Chiari pelvic osteotomy on the development of the acetabulum during growth with a follow up of 35 years.

## EP78

### Validation of the Gait Outcomes Assessment List (GOAL) Questionnaire: a goal based outcome measure for ambulatory children with cerebral palsy

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#### Level-2

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Children with cerebral palsy (CP) undergo a variety of interventions to improve their gait and gait related function. Current outcome measures do not adequately capture their goals for these interventions. The Gait Outcomes Assessment List (GOAL) questionnaire (48 items across 7 domains) was developed through an iterative process involving ambulatory children with CP and their parents, to incorporate their priorities and goals. Health care professionals from multiple disciplines were surveyed to refine the questionnaire. The purpose of this study was to test the reliability and validity of the GOAL<sup>®</sup> as a meaningful outcome measure for this population.

**Materials and methods** 51 children with CP, GMFCS I (11); II (24); III (16), mean (SD) age 13.2 years (3.4 years), and their parents, completed the child and parent versions of the GOAL concurrently with the Gillette Functional Abilities Questionnaire (FAQ) and the Functional Mobility Scale (FMS). 25 children and parents completed the GOAL 2 weeks after the first to measure test–retest reliability using Intraclass Correlation Coefficient (ICC). Internal consistency was measured using Cronbach’s alpha. Children’s and parents’ responses were compared using Pearson correlation coefficient and paired t-tests. GOAL total and domain scores were compared between GMFCS levels using ANOVA, and correlated with the FAQ and FMS using Spearman’s correlation coefficient.

**Results** Test–retest reliability of the GOAL total score was excellent, ICC: 0.93 (95 % CI 0.78–0.98) and 0.98 (0.96–0.99) for child and parent versions respectively. ICCs for domain scores ranged from 0.69 to 0.93. Internal consistency for each domain ranged from 0.74 to 0.97. The mean (SD; Range) GOAL total score for Children was 60.7 (16.7; 25.1–88.9) and for the Parents was 50.9 (17.1; 19–86). GOAL total scores decreased significantly with increasing severity of GMFCS level ( $p < 0.01$ ). Children’s GOAL total scores correlated positively with their parents’ scores ( $R = 0.86$ ;  $p < 0.1$ ) but children consistently rated themselves higher across all domains than their parents ( $p < 0.01$ ). GOAL total scores correlated positively with the FMS ( $r = 0.76$ ;  $p < 0.01$ ) and the FAQ level ( $r = 0.85$ ;  $p < 0.01$ ) with the highest correlations between expected domains of the GOAL and the FAQ & FMS.

**Conclusion** The GOAL questionnaire is reliable, internally consistent, and demonstrates construct and convergent validity. The wide range of total and domain scores indicate no floor or ceiling effects.

**Significance** The GOAL questionnaire has the potential to serve as an important patient/parent reported outcome measure that accounts for intervention goals for children with ambulatory CP.

## EP79

### Nonunion pediatric femoral neck fracture treatment without open reduction

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** Femoral neck fractures in children are rare. They are serious injuries because their complications may lead to a lifelong disability, especially in those cases with AVN. The associated high rate of complications and the limited experience of individual surgeons in treating this entity also diminishes the possibilities for a successful result.

**Materials and methods** Nine children (7 males, 2 females) with an average age of 10.2 years with multiple operations for pediatric femoral neck fractures were seen from 1998 to 2013. A femoral neck fracture nonunions was considered when there had been failure following at least 2 operative procedures. Valgus intertrochanteric osteotomy was performed in all cases without opening the nonunion site. The children were immobilized in a hip spica for 4 weeks postoperatively and weight bearing was started after radiographic healing. Fracture healing, neck-shaft angle, avascular necrosis, and functional outcome were evaluated.

**Results** Nonunion was accompanied by coxa vara and resorption of the femoral neck with AVN in all patients. Seven patients were Delbet Type II displaced fractures with associated nonunion and coxa vara at time of presentation. Ratliff classification was used to evaluate the AVN: 4 had Ratliff Type III, 1 with Ratliff Type II and 4 with Type I. Patients were followed for an average of 68 months (range 36–156 months). All patients had union of their fracture within an average of 16.6 weeks (12–20 weeks) and of the osteotomy site within 8.2 weeks (7–9 weeks). Radiologic signs of AVN were seen in all patients. Radiological findings showed remodeling potential in three patients indicating viability of the femoral head somewhere between 98 to 200 weeks of follow-up. Postoperatively, an average of 135° neck-shaft angle was achieved (range 130°–150°). Significant improvement in the neck-shaft angle was seen compared with the preoperative angle ( $P = 0.001$ ). Chondrolysis were not observed in any patient. Premature proximal femoral physeal closure resulting in a 1- and a 1.5-cm leg-length discrepancy was seen in 6 patients as compared with their normal side. A mild Trendelenburg gait was observed in 4 patients. Using the Harris hip score, 2 patients were graded as excellent, 3 as good and 4 patients were graded as fair.

**Conclusion** Valgus intertrochanteric osteotomy creates a biomechanical environment conducive to healing of a nonunion of a pediatric femoral neck fracture while simultaneously correcting the associated coxa vara. Open reduction for non union of a pediatric femoral neck fracture following previous surgical treatments was unnecessary in this study. The procedure also seems to have a biological role in helping restore viability to a collapsed femoral head with AVN.

**Significance** Valgus intertrochanteric osteotomy is an effective procedure to treat nonunion of a pediatric femoral neck fracture even in

cases where previous treatment had failed or in cases presenting with AVN and severe bone loss.

## EP80

### The pattern of bicycle injuries and the use of helmets among children aged 6–14 years 1980–2014

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#### Level-3

#### Other

**Introduction** There has been an increase in bicycle helmet use over the last decades. Studies have shown that the incidence of severe head injuries can be reduced by 65 % when wearing a bicycle helmet. However, does the increasing use of helmets change the overall injury pattern? The purpose of this study was to describe the injury pattern in bicycle accidents among children in relation to the use of a bicycle helmet treated in an ED.

**Materials and methods** We included all children age 6–14 years with injuries from bicycle accidents treated at the ED at Odense University Hospital, Denmark 1980–2014. Age, gender, helmet use, and diagnoses were analyzed. We defined head injuries as all injuries involving the head excluding injuries to the face. We defined severe head injuries as skull fractures and intracranial injuries including concussions, intracranial haemorrhages, lacerations of brain etc.

**Results** We included 13661 children, 58.8 % were boys. The use of helmets at the time of injury increased from 0 in 1980 to 19.6 % among girls and 16.9 % among boys in 2014. There was a gradual decrease in head injuries from 30.7 to 14.3 % and a gradual decrease in severe head injuries from 5.9 to 3.2 % in the study period. The proportion of head injuries and severe head injuries among children wearing helmets and children not wearing helmets were 13.9 and 26.6 % in 1980 vs. 2.8 and 4.5 % in 2014. In the study period the proportion of facial injuries, bone fractures, spinal column injuries, and deep injuries in thorax/abdomen remained unchanged. Eighteen children died from their injuries. All had severe head injuries and none of them wore a helmet at the time of the injury.

**Conclusion** The injury pattern from bicycle accidents among children has changed the last decades. The proportion of both head injuries and severe head injuries has been reduced by about 50 %.

## EP81

### The modified dunn procedure for slipped capital femoral epiphysis does not reduce the length of the femoral neck

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#### Level-2

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** The treatment of slipped capital femoral epiphysis (SCFE) is controversial and evolving, with the development of new surgical techniques and skills. In situ fixation of SCFE has a low surgical risk, but the head-neck offset remains abnormal leading to

potential femoro-acetabular impingement. The Modified Dunn procedure restores the normal anatomical alignment of the proximal femur, but the risk of avascular necrosis and chondrolysis is increased. Our aim was investigate if the later procedure modifies the length of the femoral neck.

**Materials and methods** This is a single centre, prospective study, comparing the outcomes of in situ pinning and modified Dunn procedure. Between 2011 and 2014, 9 children (9 hips) underwent the modified Dunn procedure and 10 children (10 hips) pinning in situ for stable and unstable SCFE. Mean age of the patients was 12.7 years (range 11–14) with a median follow-up of 18 months (6–35).

**Results** The Southwick angle improved from 68 (64–71.5) to 9 (7.5–13.5) ( $p < 0.001$ ), head-neck offset from  $-4$  mm ( $-5.25$  to  $-3.65$ ) to  $4.2$  mm ( $3.2$ – $5.3$ ) ( $p < 0.001$ ), while the length of the femoral neck didn't change significantly ( $p = 0.09$ ) in the modified Dunn procedure group. In the pinning in situ group, the Southwick angle and head-neck offset slightly improved:  $34$  ( $23$ – $46$ ) to  $32.5$  ( $21$ – $44$ ),  $p = 0.02$  and, respectively,  $-4.7$  mm ( $-5.7$  to  $-3.4$ ) to  $-4.3$  mm ( $-5.2$  to  $-2.9$ ),  $p = 0.04$ . Postoperative clinical outcomes were slightly better in the modified Dunn procedure group (8 hips out of 9 had good and excellent results according to the Heyman and Herndon classification) compared to the pinning in situ group (8 good and excellent results out of 10 hips) ( $p = 0.04$ ). Within our series the positive impingement test at the latest follow-up was not correlated with the type of surgical procedure ( $p = 0.48$ ). No avascular necrosis was found and there were no cases of chondrolysis.

**Conclusion** Radiographic parameters of the proximal femur assessed in our study improved in all hips that underwent modified Dunn procedure. This technique allows restoration of the anatomic configuration of the proximal femur with improvement of the slip angle and head-neck offset and it does not result in the creation of secondary shortening of the femoral neck.

**Significance** The outcomes in an independent centre, without prior experience in surgical hip dislocation, are comparable to those obtained in the traditional hip preservation surgery centers, after previous surgical training and strictly respecting the procedures.

## EP82

### Calcaneal derotation osteotomy for resistant clubfoot-long-term outcomes of a prospective study

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#### Level-4

#### Club-foot

**Introduction** Despite improvements in clubfoot (CF) management by the development of conservative techniques, surgical procedures still need to be performed in cases of residual or recurrent deformities. The absence of a talo-calcaneal angle reflects the persistence of medial rotation of the calcaneoforefoot unit. It is associated with persistent hindfoot varus, which is a predictive factor of ankle sprains and pain. Many osteotomies have been described for the correction of hindfoot varus. The aim of the current study was to assess long-term results of one surgical technique: the extra-articular calcaneal derotation osteotomy (CDO) first described in 2007.

**Materials and methods:** In this prospective study including 225 patients who underwent surgery for a clubfoot deformity between 1995 and 2009, a CDO associated with a posteromedial release was performed in 44 children (47 CF: 18 non-idiopathic NICF, 29 idiopathic ICF). Twenty-seven patients, mean Dimeglio score of 12, were



followed from birth in the same institution. Mean age at surgery was 5.7 years. At the last follow-up, the International Clubfoot Study Group (ICFSG) score and the hindfoot and midfoot AOFAS score were used to evaluate functional and morphological outcomes. The talo-calcaneal angle was measured while standing on antero-posterior (AP) and lateral view radiographs.

**Results** At a mean follow-up of 7 years, the mean ICFSG score was 7 and the mean AOFAS scores for the hindfoot and the midfoot were 91 and 95.5 respectively. No patient had revision surgery after CDO. The mean ankle range of motion was 20°. Twenty-three feet had no morphological anomaly. One foot showed a dynamic overcorrection, 8 ft a dynamic under-correction (4 adductus/cavus, 1 equinus/varus, 2 adductus/supination and 1 adductus/cavus) and 4 ft a fixed under-correction (3 cavus, 1 supination/medial rotation). Mean AP and lateral talo-calcaneal angles were 24° and 26.5° respectively. There was no radiological over correction.

**Conclusion** Through this surgical technique, correction of the medial rotation is obtained by the lateral derotation of the calcaneoforefoot unit. It has been proved that the subtalar joint is insufficiently derotated by other techniques because of particular stiffening and incongruency of the subtalar joint. The ICFSG score was good in 70 % of cases and the AOFAS score was excellent for all feet. Nonetheless, there were persistent dynamic deformities while walking.

**Significance** CDO for resistant clubfeet restores the physiological morphology of the foot with stable results over time. The aim is not to restore function, which is already altered in severe and stiffened CF.

## EP83

### Day surgery for acl reconstruction in children: a prospective study on feasibility and satisfaction

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#### Level-4

#### Other

**Introduction** The management of anterior cruciate ligament (ACL) tears has increased in recent decades. The practice of ambulatory surgery increases patient satisfaction and reduces the cost for the health system. France is lagging behind in the overall rate of interventions performed in ambulatory surgery compared to international data, including knee surgery. The objective of this study was to evaluate the feasibility of arthroscopic ACL reconstruction in children as outpatients. Our hypothesis was that proper patient selection, appropriate information and, organized course allow this procedure in ambulatory stay mode without difficulty.

**Materials and methods** This was a prospective series of ACL reconstructions using an arthroscopic transphyseal bipolar technique in 20 consecutive patients aged 8–16 years. The ambulatory condition was planned with the patient and its family at outpatient clinics. An age-appropriate illustrated step-by-step booklet was therefore given to the patient. Grade one and two analgesics associated with cryotherapy by inflatable knee brace ensured postoperative analgesia. The primary endpoint was the failure of the stay mode (such as an unexpected overnight stay after the procedure or an admission within the first postoperative week). Secondary endpoints were the rate of postoperative complications, postoperative pain, quality of life and patient

satisfaction on day 1, day 7 and month 1 by questionnaires and PSOQ score.

**Results** No unexpected overnight stay or re-admission were required. All patients and families had a satisfaction level of over 90 % on PSOQ score. Quality of life on day7 was “very satisfactory” for all patients. The early complication rate was less than 5 % (mainly minimal bleeding). Postoperative pain at home was on average higher by 2 points (5/10) than immediate post-operative pain but subsided with the treatment provided.

**Conclusion** Ambulatory surgery is a way of hospitalization that can be offered to a well-informed population target, including paediatric population for anterior cruciate ligament reconstruction.

**Significance** This is the first prospective paediatric study to evaluate the feasibility of outpatient surgery in ACL reconstruction in children. A high level of patient satisfaction and their families was observed without a major adverse event.

## EP84

### Habilitation of patients with proximal femoral focal deficiency (PFFD)

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#### Level-3

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** The purpose of this work is the analysis of the characteristics and results of the prosthetics and surgical treatment in the habilitation of patient with PFFD.

**Materials and methods** The results of the habilitation of 120 patients at the age from 6 months to 18 years were analyzed for the period since 1970 to 2014 years: 65—dextral lesion, 41—sinistral lesion, 14—bilateral reduction. According to the classification of G.T. Aitken (1969) the type A was observed in 34 %, B-20 %, C –19 %, D –27 % of cases; A.M. Pappas (1983) the most frequent classes of lesions were P4, P2 (34, 27 %). The atypical prosthetics of femur were conducted in 100 % cases, primarily in the earliest possible age. The surgical treatment in most of cases was the preparatory stage for the prosthetics and was aimed at stabilization of the lower extremity and the improvement of it's support and the correction of the limb's deformations.

**Results** The efficiency of prostheses usage and the speed of prosthesis mastering directly depended on the age of primary prosthetics and the regularity of following stages. The stabilization of lower extremity we carried out by method of ilio-femoral synostosis. The correction of the external rotation implemented by methods of derotation osteotomy of femur. These operations were indicated with C and D Aitken classes of lesion (P2, P3 and P4). The reconstruction of the extremity in order to provide the opportunity of more functional prosthetics consisted of rotationplasty by Van Nes and was carried out in patients with monolateral lesion, the C and D classes of hypoplasia of femur according to Aitken provided the preservation of both legs bones and 4 or 5 ray foot (P4).

**Conclusion** Atypical prosthesis is the main method of habilitation of patients with severe reduction.

Surgical treatment is an important aspect of habilitation and in most cases is a preparatory stage for prosthesis.

**Significance** PFFD is a rare and severe form of hypoplasia of lower limbs, which requires an individual approach and a comprehensive habilitation starting in the first year of life.

**EP85****Guided growth in children with bilateral spastic paresis for knee flexion deformity: clinical aspects and effect on gait**Melinda Witbreuk<sup>1</sup><sup>1</sup>Vumc, Amsterdam, Netherlands**Level-4****Neuromuscular/Cerebral Palsy/AMC/MMC**

**Introduction** Knee flexion deformity (KFD) occurs frequently in children with a spastic paresis and it is often accompanied by negative consequences for their gait and mobility. The aim of this study was to evaluate the outcome of anterior hemi-epiphysiodesis, using eight-plates, on knee flexion deformity and gait in children with a spastic paresis.

**Materials and methods** We retrospectively reviewed the effect of anterior hemi-epiphysiodesis for KFD in children with a spastic paresis treated at our center between 2011 and 2014 with the goal to maintain or improve standing and/or walking function. Outcome measures were degree of passive knee extension and knee kinematics during gait.

**Results** 19 children (33 knees), age 10–17, GMFCS I–IV, were included in the study. Since the knees of children who underwent bilateral surgery were not independent of each other and barely differed from one another in the degree of deviation, all analyses in bilateral operated patients were conducted with the averages of both knees. The passive knee extension improved in 12 children, remained equal in 3 children and decreased in 4 children. There was a mean improvement in KFD of 12.09°,  $P = 0.003$ , after 1–1.5 years and 9.34°,  $P = 0.016$ , after a follow-up of >2 years. Furthermore, an overall improvement in knee kinematics during the stance phase was seen, with a significant improvement of 8.79°,  $P = 0.048$ , in knee extension at terminal stance. There were complications in 4 children (1 infection 1, hydrops, 1 anterior knee pain and 1 neuropathic pain)

**Conclusion** Guided growth treatment by anterior hemi-epiphysiodesis of the distal femur with eight-plates is an effective and relatively safe method for improving KFD and knee kinematics during gait in growing children with a spastic paresis.

**Significance** This is the first article that describes a large group of children with spastic paresis treated by guided growth for flexion deformity of the knee.

**EP86****Elastic stable intramedullary nailing for displaced radial neck fractures; avoiding complications**Manish Kiran<sup>1</sup>, Colin Bruce<sup>1</sup>, Neeraj Garg<sup>1</sup>, Roger Walton<sup>1</sup><sup>1</sup>Alder Hey Children's Hospital, Liverpool, United Kingdom**Level-4****Upper and lower extremity trauma**

**Introduction** We report the functional and radiological results for displaced radial neck fractures treated with elastic stable intramedullary nailing (ESIN) and analyse methods to avoid complications.

**Materials and methods** 30 patients with displaced fractures who underwent ESIN with a mean age of 8.96 years (4.5–12.7 years) were included. There were 18 Judet type III fractures, 7 type IVa fractures and 5 type IVb fractures. Sharp tipped ESIN (K wires) were used in

10 patients (33.3 %) and blunt tipped ESIN in 20 patients (66.6 %). Radiological results were graded based on angulation at union. Functional results were evaluated by the Metaizeau functional scoring system and Oxford Elbow score.

**Results** Closed reduction and fixation with ESIN was performed in 20 patients. In 5 patients, a K wire was used as a joystick to improve the position. Varying degrees of open reduction were required in 5 patients. Redispacement of the fracture occurred in 5 cases (16.6 %). Blunt tipped nails had been used in four of these cases. In all cases of redispacement, the nail was not twisted 180° opposite to the direction of initial displacement. Pin penetration into the radio-capitellar joint occurred in 5 cases, all of which had sharp tipped nails. Sclerosis of the radial epiphysis was seen in 5 cases and heterotopic ossification in one case. The final result was excellent in 20 patients (66.6 %), good in 4 cases (13.3 %), fair in 4 cases (13.3 %) and poor in 2 cases (6.6 %). Radiological results were excellent in 25 cases and good in 5 cases. The mean Oxford Elbow score was 44.32 (34–48). The mean follow-up was 40.11 months (6–86 months).

**Conclusion** In our experience, sharp tipped ESIN has a lower risk of fracture redispacement but carries the risk of joint penetration. While blunt tipped ESIN may have a higher risk of fracture redispacement, this risk can be negated by ensuring that the pre-bent nail tip is twisted to lie 180° opposite to the initial direction of displacement. We conclude that ESIN is effective with acceptable results if the above pitfalls are avoided.

**Significance** When ESIN is employed in the treatment of displaced radial neck fractures, we recommend the use of blunt tipped nails. Regardless of the mode in which the nail is used, the tip should be twisted to lie 180° opposite the initial direction of displacement  $p < 0.001$

**EP87****The impact of table choice on surgery-related factors for fixation of slipped capital femoral epiphysis**Jose Herrera Soto<sup>1</sup>, Jonathan Phillips<sup>1</sup>, Raymond Knapp<sup>1</sup>, Matthew Butterfield<sup>2</sup>, Patrick Wright<sup>3</sup><sup>1</sup>Arnold Palmer Hospital, Orlando, United States; <sup>2</sup>Arnold Plamer Hospital, Orlando, United States; <sup>3</sup>Mississippi Children Hospital, Jackson, United States**Level-3****Hip/DDH/Legg-Calvé-Perthes/SCFE**

**Introduction** Screw fixation of the hip is the gold standard for the treatment of slipped capital femoral epiphysis (SCFE). There are two methods to position these patients in the operating room. The most commonly used means today is on a fracture table. We will determine if there are any fixation accuracy issues or other complications when the radiolucent table is used and whether or not it is affected by slip severity. Also, we want to determine if the described technique is time efficient, especially in those patients that require bilateral fixation during the same procedure and compare it to the fracture table. Last, we will compare radiation exposure time between the two types of tables used.

**Materials and methods** We retrospectively reviewed 62 patients who underwent screw fixation for SCFE at our institution with similar age and BMI. These included timing in and out of surgery, surgical time per se and fluoroscopy time. We calculated the accuracy using the methods described by Blasier and Aronson.

**Results** There were 34 patients (40 hips, one prophylactic fixation) in the fracture table group. The total anesthesia time was 92 min./patient

or 36 min when considering 6 bilateral cases; and surgical wasery took 36 min per side, total fluoroscopy time was 160 s.

There were 31 patients (44 hips, 6 fixed prophylactically) treated on the radiolucent table. The total anesthesia time was 81 min/patient or 59 min per hip when considering 12 bilateral fixations; and the surgery took 26 min per hip, total fluoroscopy time was 66 s. The screw position accuracy was similar to both groups. Bilateral fixation was 49 min on the radiolucent table versus 77 on the fracture table.

**Conclusion** In conclusion, the use of a radiolucent table is a safe, reproducible and efficacious method of fixation of SCFE regardless of the BMI, slip severity or acuity.

**Significance** The use of a radiolucent table decreases the total anesthesia, and preparation time. It demonstrated a similar surgical time and accuracy. The radiation exposure was less for the radiolucent table. The radiolucent table is ideal for patients that need bilateral fixation.

## EP88

### The fate of the neuromuscular hip after spinal fusion

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#### Level-4

#### Spine

**Introduction** The goals of treatment of neuromuscular scoliosis are to achieve a balanced spine and level pelvis with most constructs including pelvic fixation. However, the pelvis can become a stiff “end vertebra” that prevents compensatory mechanisms adjusting to hip deformities in this patient population. The purpose of this study is to determine the frequency of hip pathology and surgery following spinal fusion in this patient population.

**Materials and methods** We performed a retrospective chart and radiographic review of cerebral palsy patients that underwent posterior spinal fusion at our institution from 2005 to 2011. We collected radiographic data of pre and post operative pelvic obliquity and hip reduction status and position (up, level, down). We further evaluated patients requiring hip surgery (containment or salvage).

**Results** Of 47 patients with an average follow up of 3.5 years after spinal fusion, 21 (45 %) underwent a hip procedure. Thirty-eight patients (81 %) demonstrated or developed hip subluxation/dislocation. Hip pathology occurred more often in the up hip, but the abnormal down hip more often underwent hip surgery. Eight new hip subluxation/dislocations occurred after spine surgery. Three (38 %) of the new post-operative subluxation/dislocations required hip surgery; all had pelvic obliquity <6°. 11 patients underwent hip surgery prior to PSF, 7 were varus femoral osteotomies for subluxation while 5 hips required salvage. In follow-up after PSF, none of these had a new dislocation. 10 patients required hip surgery after PSF at a mean of 1.6 years after PSF. Eight patients had a salvage procedure for painful hip and 2 varus femoral osteotomies for subluxations.

**Conclusion** In our cerebral palsy patients that underwent PSF, 45 % of these patients required a hip procedure. In the patients that had containment prior to PSF, the hips maintained reduction after spinal fixation. After correction of pelvic obliquity, 17 % of patients had new onset hip subluxation/dislocation following PSF. Post-operative subluxation/dislocation was not dependent on whether the hip was up or down pre-operatively.

## EP89

### Bioexpandable prostheses: bone lengthening after resection of malignant bone tumours in children

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#### Level-4

#### Tumours

**Introduction** Expandable endoprostheses can be used after resection of malignant bone tumors of the lower extremities in children and adolescents not only to bridge the defect but also to overcome limb length discrepancy. To achieve equal limb length at maturity a new concept is to lengthen not the prosthesis but the remaining bone (MUTARS BioXpand, implantcast, Buxtehude, Germany) by callus distraction.

**Materials and methods** The MUTARS BioXpand can be equipped with the motorized FITBONE device (Wittenstein intens, Igersheim, Germany) which obtains external wireless electromagnetic energy for lengthening. After surgery the skin is closed. The initial tumour surgery does not differ. To perform lengthening at maturity or when limb length discrepancy exceeds 3-4 cm the shorter bone has to be osteotomized and the initially implanted polished stem has to be replaced by a fully implantable lengthening nail allowing bone growth by 1 mm/day using the method of callus distraction.

**Results** 6 patients (3 male, 3 female) were treated with BioXpand. In 4 cases the femur and in 2 cases the tibia were lengthened at maturity 4 (3-5) years after resection of an osteosarcoma (4) or an Ewings-Sarcoma (2). All patients underwent a complete chemotherapy protocol (COSS/EICESS). No patient received radiotherapy. The mean age of the patients was 16.3 years (15–20 years) at the time of lengthening. The mean lengthening was 82 mm. In one case of with a large discrepancy the lengthening was performed in 2 steps. In all patients lengthening was completed successfully. In 2 patients over-lengthening was done to reduce the size of the final definitive prosthesis. In 3 patients, the lengthening device could be removed and a coated stem was implanted to allow bone ingrowth.

**Conclusion** The MUTARS BioXpand is the first device worldwide which combines a tumor prosthesis with a fully implantable lengthening device for lengthening the bone and not the prosthesis. The modular “bioexpandable” tumor prosthesis is available for all frequent lower limb tumour locations. The latest versions do not need any additional invasive surgeries at the location of the prosthesis after the initial surgery, neither at the femur (BioXpand II) nor at the tibia (BioXpand III).

**Significance** Due to the fact that the remaining bone is lengthened and therewith the lever arm forces are reduced by lengthening, better long term biomechanical results can be expected.

## EP90

### Correction of hip internal rotation in walking cerebral palsy adolescent using a soft tissue procedure

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#### Level-3

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Hip internal rotation (HIR) during gait is one of the main functional disorders related to cerebral palsy (CP) in children. Most of the procedures proposed to treat gait disorders in CP children use a rotational osteotomy of the femur (FRO) (and/or tibia) to improve this. However, multilevel surgery (SEMLS) including osteotomy implies a more difficult and longer rehabilitation. When bone deformity is moderate, the authors hypothesized that FRO could be avoided. They developed a soft tissue procedure to improve HIR. The aim of the study was to assess the results of this procedure.

**Materials and methods** In walking CP treated for gait disorders, the authors selected patients who presented with femoral anteversion less than 40°. Those presenting with HIR were selected for a soft tissue procedure alone (no bone procedure). Patients had undergone prior 'testing' with botulinum toxin injection of the hamstring muscles. The SEMLS included the following procedure: lengthening of semimembranosus, transfer of semitendinosus associated with tenotomy of the gracilis and gluteus minimus muscles. All the patients who underwent the soft tissue procedure and had full pre and post-operative data (clinical, kinematics and kinetics) were included. Data (i.e. foot intoeing, dynamic hip internal rotation in stance phase, hip rotation moment) were collected from medical charts and gait analysis. Moreover, feet deformities and their treatments have been analyzed. Follow-up was at least 1 year after SEMLS.

**Results** The 19 selected patients presented functional improvement at final follow-up. 22 lower limbs were studied. Rotation of the pelvis did not differ significantly before and after surgery ( $p = 0.21$ ). Hip rotation in stance phase (50 %), presented significant improvement from 16.5° intoeing before surgery to 0.5° external rotation post surgery ( $p < 0.0001$ ). Feet angulation related to walking direction was also significantly improved, from 13° intoeing to 0.5° external rotation ( $p < 0.0001$ ) without any rotational osteotomy of the tibia.

**Conclusion** HIR is a frequent gait disorder in CP. In walking adolescents with CP the bone deformity of femoral anteversion is not as severe as supposed in most cases. Thus, the aetiology of the HIR seems to be related to muscle contractures and spasticity. Recently, in the literature, soft tissue procedures presented a renewed interest in HIR. The soft tissue procedures presented improved HIR significantly rendering a FRO unnecessary. Rehabilitation should be easier.

**Significance** The authors report a soft tissue procedure to improve the HIR gait pattern in CP and advocate that this reduces the indications for bone procedure and makes rehabilitation after SEMLS easier.

## EP91

### Long-term outcomes of slipped capital femoral epiphysis (SCFE) treated with in situ pinning

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Slipped capital femoral epiphysis (SCFE) is the commonest hip disorder in adolescents and mostly occurs in children 9–16 years old. In situ pinning is still the gold standard for treatment, but lately there is a growing tendency to procedures with open reduction and internal fixation for unstable as well as stable slips. These procedures, however, are technically demanding with relatively high complication rates, and unknown long-term outcomes. The problem is whether the more demanding and risky open procedure is justified.

This study describes functional outcome and radiological signs of osteoarthritis in patients more than 10 years after in situ fixation of SCFE and indicates which patients have a high chance for worse outcomes, and would therefore be suitable for open reduction.

**Materials and methods** All patients treated for SCFE with in situ fixation between 1980 and 2002 in 4 different hospitals were asked to participate in this study. Patients were divided in three groups, based on severity of the slip on pre-operative X-rays. Patients were invited in the outpatient clinic for physical examination, X-rays, and were asked to fill out the questionnaires HOOS, EQ-5D, and SF-36. ANOVA was used to analyze differences between groups.

**Results** 60 Patients with 78 slips filled out the questionnaires. There were 47 mild, 23 moderate and 8 severe slips. Patients with severe slips had significantly worse HOOS-scores on pain, symptoms, ADL, and Quality of Life, worse score on EQ-5D, and worse scores on SF-36 physical and pain. All patients with severe slip had some degree of osteoarthritis after more than 10 years follow-up, compared to 27 % in the mild group, and 39 % in the moderate group.

**Conclusion** Patients with a severe slip had significantly worse outcomes compared to patients with mild and moderate slips, with more osteonecrosis, and more placement of total hip prostheses.

**Significance** For patients with severe slips an open reduction and internal fixation procedure is justified, because the extensive procedure with higher risks outweighs the worse long-term outcome in in situ fixation.



## EP92

**Management of chondral lesions in patients with patellofemoral (PF) dislocations**

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**Level-3****Upper and lower extremity reconstructions**

**Introduction** The incidence of patellofemoral instability in patients 10–17 years is 30 per 100.000. The etiology depends on the relative contributions of bony and soft tissue components such as patella alta and ligamentous laxity or disruption. They are frequently associated with chondral injuries. The aim of this case series study was to present the incidence, the characteristics and the treatment options for the combined cartilage lesions after patella dislocation.

**Materials and methods** Seventeen patients (male: female 6: 11 mean age 16.45/12–18 years), out of 30 with patella dislocation during the last 3 years, are included in the study cohort. They presented either after first acute patella dislocation (n = 7), or after an episode of recurrent patella dislocation or were referred because of recurrent patella dislocation (n = 10). Chondral lesions (grade 3 and 4 Outerbridge) were diagnosed by MRI in 15 cases, whereas in two cases (11.8 %), chondral lesions were missed during the 1st evaluation. In 15 cases (88.2 %) there were lesions of the patella medial facet or/and inferomedial pole, and in 6 cases of lateral femoral condyle. For patella dislocation, the surgical procedures performed were MPFL repair (n = 7), MPFL reconstruction (n = 9) and tibial tubercle anteromedialization (Fulkerson procedure) (n = 1). For the cartilage defects, in 7 cases absorbable pin fixation was used, whereas in the rest 10 cases ACI (n = 3) and MACI (n = 7) were performed. The outcome analysis was based on KOOS and IKDC forms, whereas the non-parametric Wilcoxon Signed Rank test was used to determine the differences between the pre- and postoperative values (p < 0.05).

**Results** No complications or adverse events were reported. No new episode of dislocation or subluxation of the patella was recorded. Analysis of the results (mean follow-up 16.8 months) showed a significant increase in the mean values of the IKDC total score (from 46.1 to 74.5 p = 0.05) and all KOOS subscales only after the 12th post operative month.

**Conclusion** Chondral lesions in combination with a patella dislocation is a relatively common injury. A high awareness of cartilage injury is needed after an acute patella dislocation. The surgical treatment of patella dislocation and the chondral lesion in one stage is a demanding but reproducible procedure.

**Significance** The management of patellofemoral dislocations with chondral lesions should aim to restore knee biomechanics and repair the cartilage defect.

## EP93

**Is there a relation between offset-loss and gait in transverse plane after SCFE?**

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**Level-2****Hip/DDH/Legg-Calvé-Perthes/SCFE**

**Introduction** Residual deformity of the femoral head after SCFE might be accompanied by a loss of femoral offset and may lead to femoro-acetabular impingement (FAI). A more externally rotated gait pattern due to SCFE has been described before [1]. This study aimed to analyze whether a decreased femoral offset leads to gait deviations in the transverse plane and whether the extent of deviations correlates with the severity of offset-loss.

**Materials and methods** 36 patients after SCFE (23 male, 13 female, average age 23.2 years, mean BMI 27,7), were included. Inclusion criteria were: (1) uni- or bilateral SCFE, (2) age over 18 years, (3) follow-up of at least 3 years. Exclusion criteria were any other disorder associated with gait deviations. Offset-loss was measured by the alpha-angle according to Nötzli on axial radiographs [2]. Patients were divided into three offset-groups (OG): OG1 (n = 11)—alpha <55°, OG2 (n = 13)—alpha 55–75°, OG3 (n = 12)—alpha >75°. 3D-gait-analysis was performed with a VICON 512 system. Patients walked at a self-selected speed, barefoot. Spatiotemporal, kinematic and kinetic parameters were evaluated and compared to a control group of adults with no gait deviations (7 male, 33 female, average age 28.4 years., mean BMI 21.9). For statistics Pearson correlation analysis and a one-way ANOVA of the controls and offset groups with Dunnett-T3 post hoc comparisons were performed.

**Results** In comparison to the controls patients walked with increased external rotation of the hip, especially at the point of maximum hip flexion during terminal swing phase (90–100 % of the gait cycle): The mean external hip rotation during this period differed significantly across the groups (controls: 6.2° (5.3), OG1: 17.3° (6.3), OG2: 19.3° (8,0), OG3: 20.3° (8.7), p ≤ .001). External hip rotation was increasing with increasing offset-loss.

During hip flexion at the initial contact (0 % of the gait cycle) patients showed an increased external rotation of the hip, too. All OGs differ significantly from the controls (controls: 6.8° (5.4), OG1 16.8° (8.5), OG2 19.2°(8.5), OG3 20.5° (9.5), p ≤ .016) and external hip rotation increases with offset-loss.

During hip extension (40–60 % GC) patients walked in external hip rotation (OG1 4.5° (7.9), OG2 8.5° (8.7), OG3 11.0° (8.8)) whereas controls showed an internal hip rotation (-2.5° (5.8)). OG2 and OG3 differ significantly from the controls (p = .004; p = .001).

**Conclusion** Residual deformity of the proximal femur after SCFE leads to increased external hip rotation during gait. The results of this study suggest that with decreasing femoral offset in SCFE more external rotation is needed to avoid FAI.

**Significance** Offset-loss is compensated during gait by increased external hip rotation during flexion.

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## EP94

### Radiography is not necessary to exclude ddh in breech born children who have a normal clinical examination and normal hip ultrasound

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#### Level-2

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Ultrasound is commonly used to evaluate infants' hips for developmental dysplasia of the hip (DDH). There is controversial information in the literature regarding the need for further follow-up for patients born breech who have a normal screening ultrasound examination. The purpose of this study was to evaluate the need to perform hip radiography in children born in breech presentation, whose initial clinical assessment and ultrasound are considered normal.

**Materials and methods** We performed a retrospective cohort study, including children who were born in breech presentation and sent to our Hospital's DDH Screening Clinic, where they had a clinical examination and hip ultrasound before 6 months of age and an AP pelvis radiograph at or after 6 months of age. We included in this study only children who had a normal clinical examination and a normal ultrasound. We collected data from medical records and evaluated the ultrasound scans and X-rays.

**Results** We identified 24 children who met the inclusion criteria of this study. There were 15 males and 9 females. 2 children resulted from twin pregnancy and in one other case there was reference to oligohydramnios. In 5 cases there were associated pathologies. 16.7 % of children had a family history of DDH. In 70.8 % of cases the child had a primiparous mother. All patients had a normal clinical examination of the hip. The first hip ultrasound hip for DDH screening was performed at  $43.14 \pm 88$  days of age. In 100 % of patients, the femoral head coverage was  $\geq 50$  %. The alpha angle was  $60.04^\circ \pm 3.96^\circ$  for the right hip and  $62.2^\circ \pm 3.5$  for the left hip. All hips were Graf 1. The age at radiography evaluation was  $6.8 \pm 1.5$  months; acetabular index was  $24.96^\circ \pm 3.73$  for the left hip and  $24.25^\circ \pm 4.18$  for the right hip, within the normal range for age.

**Conclusion** In children born by breech presentation and referred to our Hospital, we did not observe any cases of dysplasia on radiography performed during or after 6 months of age, if our initial clinical evaluation and hip ultrasound performed during the first consultation were considered normal.

**Significance** Pelvic radiography is not necessary to exclude DDH in children who are born in breech presentation and have a normal clinical examination and normal hip ultrasound.

## EP95

### Soft-tissue release as treatment of lateral migration of the femoral head in children with spastic cerebral palsy

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#### Level-3

#### Neuromuscular/Cerebral Palsy/AMC/MMC

**Introduction** Subluxation of the hip joint is one of the most frequent complications in children with the spastic cerebral palsy (CP). Development of pain can be expected in up to 50 % of patients with existing hip dislocation. The study evaluates the benefit of soft-tissue release of spastic hip adductors and flexors in treating lateral migration of the femoral head in children with spastic CP. It also analyses how age, gender, laterality, CP type, GMFCS level and migration percentage (MP) at the time of the operation, as well as concurrent distal lengthening of knee flexors, impacted the success of the surgery.

**Materials and methods** Fifty-nine spastic cerebral palsy patients (86 hips) (age  $5.4 \pm 2.1$ ) with migration percentage (MP)  $\geq 30$  % in at least one hip, who underwent open adductor and rectus femoris tenotomy and iliopsoas tendon recession were included. Follow up period was 7.8 years (5.0–14.5). MP was measured on AP X-ray in neutral rotation. Regardless of unilateral or bilateral involvement, in all patients the operation was performed on both sides for reasons of muscle balance.

**Inclusion criteria:** (1) Index surgery was performed as stand-alone surgery or in combination with hamstring releases and/or plantar flexors of the foot in association with single-event multi-level surgery. (2) No previous operation on the hip joints was performed. (3) Patients were excluded if bony surgery was performed along with soft tissue release of the hip. (4) Only patients with the spastic form of CP were included. (5) Minimum follow up was 5 years.

**Results** Average MP at the time of operation was  $48.2 \pm 17.0$  %, and it was  $35.1 \pm 24.6$  % ( $p < 0.001$ ) in follow up  $7.8 \pm 2.6$  years. Left hips were more severely affected, initial MP 45.5 vs. 39.8 % on the right side ( $p = 0.035$ ). Patients with bilateral involvement had higher initial MP 51.8 vs. 42.0 % in patients with unilateral involvement ( $p = 0.025$ ). Improvement of MP was higher in females  $-9.0$  vs.  $-18.0$  % in males ( $p = 0.041$ ). Final MP did not differ significantly in individual subgroups according age ( $p = 0.543$ ), laterality ( $p = 0.805$ ), gender ( $p = 0.100$ ), diparesis/quadruparesis subgroups ( $p = 0.194$ ), only hip surgery/multi-level surgery subgroups ( $p = 0.251$ ), bilateral/unilateral involvement ( $p = 0.139$ ).

**Conclusion** Soft tissue release improved hip lateral migration in all patient subgroups. The MP before the surgery ( $p = 0.001$ ) and GMFCS level ( $p = 0.018$ ) were the only parameters that affected the final MP significantly.

**Significance** This work improves our knowledge about hip dislocation in CP paediatric patients, and evaluates outcomes of soft tissue release of hip flexors and adductors.

## EP96

**In Children with Gartland III supracondylar fractures of the humerus, the presence of an initial neurological injury does not affect the functional prognosis**

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**Level-2****Upper and lower extremity trauma**

**Introduction** About 5–20 % of children with Gartland III supracondylar fractures of the humerus have a neurological injury at the time of presentation. In most cases, a spontaneous recovery of the neurological injury occurs in the first months following the fracture. This study aims to compare the functional results obtained after treatment of Gartland III supracondylar fractures with and without neurological injury at presentation.

**Materials and methods** We performed a retrospective study of patients with Gartland III supracondylar fractures of the humerus, surgically treated at our institution, in the period 2010–2014. Data was collected regarding demographic characteristics, neurological status at first observation, treatment, complications and functional status at follow-up, using the QUICKDASH score. Significant statistical differences were considered if  $p < 0.05$ .

**Results** We included 85 patients in this study, 24.1 % of whom had a neurological injury at presentation: 12 corresponding to the territory of radial nerve, 7 to median nerve and 2 to ulnar nerve. In 2 patients, there was no radial pulse, but it could be palpated after reduction of the fracture. The age of patients without initial neurological injury was  $5.9 \pm 2.1$  years and the age of patients with neurological injury was  $7.0 \pm 2.1$  years. There were 70 % males in the group of patients without initial neurological injury and 71 % of males in those with neurological injury. The right elbow was affected in 66 % (with injury) vs 67 % (no injury) of children. There were no cases of compartment syndrome. Complete neurological recovery occurred in all patients and the average recovery time was 4 months. 48 % of these patients underwent a rehabilitation programme. At a follow-up time of 2 years 4 m  $\pm$  1 years 5 m, patients with initial neurological impairment had a QuickDASH score of  $1.21 \pm 2.7$  and patients without initial neurological injury had a QuickDASH Score of  $1.13 \pm 2.95$  ( $p < 0.05$ ).

**Conclusion** In our study, in Gartland III supracondylar fractures of the humerus, the rate of neurological injury at presentation is relatively high perhaps because our institution is a referral hospital. At midterm follow-up, the functional outcomes for patients with associated neurological injury at first presentation are excellent and overlap those of the patients without associated neurological injury.

**Significance** In children with supracondylar Gartland III fractures of the humerus, the presence of initial neurological injury does not compromise the functional prognosis.

## EP97

**Percutaneous vs open reduction and fixation for tillaux and triplane fractures: a multi-center study**

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**Level-3****Upper and lower extremity trauma**

**Introduction** For Tillaux and Triplane ankle fractures, treatment via both open and percutaneous techniques has been described. A comprehensive literature review demonstrates supportive evidence for both techniques, however there is no general consensus on which is superior with regards to minimising residual gap or preventing growth disturbance. In this study, we present a multi-center initiative comparing the two techniques in a large, cohort comparison.

**Materials and methods** Four academic paediatric orthopaedic centers participated in this retrospective cohort comparison study. Two cohorts were formulated dependent on operative technique: percutaneous (PERC) or open reduction (OPEN). Inclusion criteria included all healthy, adolescent children undergoing operative fixation for either Tillaux or Triplane ankle fractures with minimum 1-year follow-up. Data collected included age, gender, BMI, diagnosis, time to surgery, operative technique, initial displacement, residual gap, and/or radiographic signs of growth disturbance.

**Results** A total of 65 patients met inclusion criteria and were included for analysis. The OPEN group consisted of 48 patients, while the PERC group consisted of 17 patients. There were no significant differences in age, gender, BMI, or diagnosis between the two cohorts. No significant differences were found between groups for initial displacement (4.3 vs 4.4 mm;  $p = 0.83$ ), or presence of growth arrest (0 vs 6,  $p = 0.29$ ). The OPEN group had significantly more complications, including infection, nerve/muscle injury and persistent pain, than the PERC group (19 vs 0 %;  $p < 0.01$ ).

**Conclusion** In this multi-center study, both techniques yielded expected results in regards to growth arrest; being this close to skeletal maturity, we expected very little physeal involvement. However, more importantly is the higher rate of complications noted with an open approach than a percutaneous approach.

**Significance** An open approach in treating adolescent Tillaux and Triplane fractures may result in a higher complication rate when compared to percutaneous technique. Due to a lower concern for physeal involvement, perhaps percutaneous technique should be the

standard, while we await larger, prospective trials to see if a true difference is extrapolated.

## EP98

### Factors that predict instability in pediatric diaphyseal both bone forearm fractures

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** Diaphyseal forearm fractures are among the most common fractures in children. Significantly displaced or angulated fractures are treated with initial closed reduction and immobilization, with follow-up to determine if displacement occurs. The purpose of this study was to determine what factors upon initial presentation would predict failure of initial closed reduction and casting.

**Materials and methods** Radiographic and hospital records of skeletally immature patients that underwent closed reduction and casting of diaphyseal forearm fractures in the emergency department were evaluated. Demographic, time course, and radiographic data were evaluated at presentation and at varying time intervals until union was achieved. Univariate logistic regression analysis of these factors was performed to identify predictors of failure of initial closed reduction and immobilization as defined as requiring a repeat procedure.

**Results** 188 patients meeting the inclusion criteria were identified and analyzed. 174 patients had adequate follow-up to union. The average patient age was 7.7 years and 68 % were male. Nineteen patients underwent a repeat procedure. Patients that underwent a repeat procedure had an average initial reduction time of  $36.9 \pm 22.2$  min, whereas those patients who did not require additional procedures had an initial reduction time of  $23.4 \pm 11.8$  min ( $p < 0.0103$ ). Odds of requiring repeat reduction were the greatest in those patients who presented with fractures translated greater than or equal to 50 % in any plane (odds ratio (OR) = 10.1; confidence interval (CI) 95 3.1–33.1), age greater than 9 years (OR = 4.1; CI 95 1.5–11.3), complete fracture of the radius (OR = 9.1; CI 95 2.0–40.5), follow-up angulation of the radius greater than 15° on lateral radiographs (OR = 5.0; CI 95 1.3–18.6), follow-up angulation of the ulna greater than 10° on anteroposterior (AP) radiographs (OR = 8.7; CI 95 2.7–28.4), and follow-up translation of either bone greater than 50 % (OR = 13.5; CI 95 4.5–40.2).

**Conclusion** Patients requiring lengthy initial reductions are at an increased risk of having a repeat procedure than those with short initial reduction times. Age, initial translation, complete fractures of the radius, and residual translation on follow-up are highly predictive of patients having repeat procedures. These patients require carefully monitored follow-up and families should be counseled appropriately to their risk of repeat intervention.

**Significance** Prolonged sedation times for forearm fracture reductions are correlated with loss of reduction and need for more aggressive intervention.

## EP99

### Do all paediatric both-bone forearm fractures require immediate reduction in the emergency room (ER)?

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#### Level-4

#### Upper and lower extremity trauma

**Introduction** Paediatric both bone forearm (BBFA) fractures are common and often require orthopaedic consultation/management. The practice at many institutions is closed reduction (CR) acutely in the ER in all patients regardless of fracture/patient characteristics. This model of same-stay ER CR has implications for resource utilization including resident duty hours. The purpose of this study was to review a series of BBFA fractures at a level-1 paediatric trauma center to determine the necessity for immediate ER reduction.

**Materials and methods** Patient records and radiographs of consecutive patients presenting with an isolated closed BBFA fracture that underwent same-stay CR were evaluated between 2007 and 2013. Patients with incomplete records, polytrauma, neurovascular injuries, impending compartment syndrome and metabolic bone disease were excluded. Demographic information including time of last meal and distance traveled (zip code) were reviewed. Need for reduction was based on standardized parameters applied retrospectively ( $<20^\circ$  for distal,  $15^\circ$  for midshaft,  $10^\circ$  for proximal in female  $<8$  and male  $<10$ , or  $<10^\circ$  any location in female  $>8$  and male  $>10$ ). Indications for urgent reduction included angulation greater than  $30^\circ$  in any direction regardless of age.

**Results** There were 168 patients (mean age 7.7 years, 68 % male). Of these, 20 (11.9 %) underwent reduction despite being within acceptable parameters, 89 (52.3 %) could have been managed on a delayed basis, and 59 (35.1 %) required same-stay reduction. The ER time of patients not requiring CR (129.1 h, mean = 6.45 h) or delayed CR (506.7 h, mean = 5.7 h) was 635.8 h total with a mean of 5.8 h. There were no immediate complications and all fractures healed clinically/radiographically.

**Conclusion** Using these criteria, only 35.1 % of isolated closed BBFA fractures at a high-volume paediatric trauma center required urgent reduction. The remainder could have been treated in a delayed fashion, saving resources without increased complications.

**Significance** This study demonstrates that urgent CR may not be necessary in all cases of isolated closed BBFA fractures. The development of a treatment algorithm including patient/fracture characteristics can provide more efficient ER and manpower utilization.

## EP100

### Paediatric diaphyseal fractures of the forearm: radiological classification and complications

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#### Level-4

#### Upper and lower extremity trauma



**Introduction** A change in the geometric shape of a part provokes a stress concentration, which increases mechanical stress. The lateral cortex of the diaphysis of the radius changes direction between its distal and intermediate thirds, and between its proximal and intermediate thirds. The aim of the study is to investigate if incidence of forearm diaphyseal fractures and if their complications are related to fracture location according to these stress concentration points.

**Materials and methods** Children with diaphyseal fractures of the forearm treated conservatively were included in the study. The diaphysis of the radius were divided in five regions based of the two changes of direction of its lateral cortex: (1) distal to the distal change of direction; (2) the region of the distal change of direction; (3) the intermediate zone; (4) the region of the proximal change of direction; (5) proximal to the proximal change of direction. Radiographs were reviewed and fractures were classified by radius fracture location according to the different regions of the radius previously described.

**Results** 231 patients with an average age at the time of fracture of 7 years (1–14) were included in the study. Average immobilization was 41 days. Fracture affected both bones in 76 % of patients. Location of radius fracture was: 8 % zone 1; 40 % zone 2; 39 % zone 3; 13 % zone 4; and no fractures in zone 5. The distal radius fragment was angulated dorsally in 78 %. The radius fracture was: 55 % greenstick, 41 % complete, and plastic deformation 4 %. Ulnar fracture was at the same level in 53 % and distal to radius fracture in 43 %. There was a complication in 37 % of patients: malunion 35 %, secondary displacement 10 %, re-fracture 6 %, and limitation of pronosupination 7 %. The rate of complication in the different zones were: 37 % in zone 1, 32 % in zone 2, 38 % in zone 3, and 54 % in zone 4. Limitation of forearm rotation affected 4 % of cases of zone 2 and 27 % of cases of zone 4.

**Conclusion** Malunion is the commonest complication of diaphyseal forearm fractures, being in the majority without clinical relevance. Complications were more frequent in the proximal area. Limitation of pronosupination was present in fractures that affected both regions where lateral cortex changes direction.

**Significance** Complications after conservative treatment of diaphyseal forearm fractures are more frequent when radius fracture affected the proximal region of its diaphysis and, therefore, these fractures may be better treated surgically.

## EP101

### Assessing pelvic rotation and its effects on measurement of the anterior and lateral center edge angle

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#### Level-4

##### Basic science

**Introduction** Radiographic measures of acetabular coverage are often used to characterize bony structures contributing to femoroacetabular impingement or hip dysplasia. The lateral (LCEA) and anterior center edge angle (ACEA) assessed on AP and false profile (FP) pelvic views respectively have been used as markers for acetabular coverage. However, the FP view is susceptible to rotational changes due to a number of factors, such as technician error or patient positioning. The purpose of this study was to determine the tolerance of LCEA and ACEA to changes in pelvic rotation and to devise a method for assessing the amount of pelvic rotation in a FP radiograph.

**Materials and methods** This was a descriptive laboratory study utilizing the Haman-Todd cadaveric research collection. A mathematical

model was derived to calculate the amount of rotation in a pelvic radiograph using the distance between femoral heads in AP and rotated pelvic radiographs. Fluoroscopic images of 5 reconstructed adult pelvis and femora were taken at 11 different positions of rotation. The predicted angle of pelvic rotation was determined using our mathematical model. Intraclass correlation coefficient (ICC) was calculated to determine the strength of our model to predict pelvic rotation. The CEA was determined at each rotational position. Mean and standard deviation for the CEA at each position was determined across all samples.

**Results** ICC for predicted versus actual angle of rotation for our overall model was 0.994 (95 % CI 0.987–0.998). In a FP view of the pelvis, the distance between the centers of the femoral heads was 0.4 times the distance between the centers of the femoral heads on an AP radiograph. The mean LCEA measured on an AP radiograph was 33.8° (95 % CI 27.9°–39.6°). The mean ACEA measured on FP view was 39.4° (95 % CI 35.6°–43.1°). 20° rotation of an AP radiograph produced a 1.3° (95 % CI –1.0° to 3.5°) change in LCEA. 20° rotation of a FP radiograph produced 9.8° (95 % CI 7.4°–12.1°) change in ACEA.

**Conclusion** Rotation in an oblique pelvic radiograph may be accurately predicted using the distance between femoral heads on an AP pelvic radiograph of the same subject. 20° rotational change of an AP radiograph does not appear to significantly alter measurements for the LCEA but has a significant effect on the ACEA.

**Significance** Obtaining a proper false profile view is critical when using ACEA to assess for anterior acetabular coverage. Obtaining an additional AP radiograph can help confirm that a proper false profile view is obtained.

## EP102

### The conservative treatment of midshaft clavicle fractures in teenagers yields excellent functional results

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#### Level-3

##### Upper and lower extremity trauma

**Introduction** The treatment of midshaft clavicle fractures in adolescents is traditionally conservative. Some authors have defended surgical treatment, claiming lower rates of malunion, but it is not proven that it yields better functional results in teenagers. The purpose of this study was to determine the functional outcome of the conservative treatment of midshaft clavicle fractures in adolescents.

**Materials and methods** A retrospective cohort study was performed of adolescents (10–17 years of age) diagnosed with a midshaft clavicle fracture and conservatively treated in a single institution, between 2008 and 2012. Patients who did not have the initial radiography available in the Hospital Imaging Program or who sustained an ipsilateral fracture of the upper limb were excluded from this study. Demographic data and information regarding clinical and radiographic examination were collected from the medical records. The X-rays were reviewed to determine fracture alignment/displacement, angulation and union. Functional outcome assessment was performed using the QuickDASH questionnaire. We also determined patient global satisfaction. Statistical significant differences were considered for  $p < 0.05$ .

**Results** 91 patients were included in this study. 22.7 % of the fractures occurred in spring, 32.5 % in summer, 32.6 % in autumn and 12.3 % in the winter ( $p = 0.293$ ). Age was  $13.7 \pm 2.0$  years and

81.3 % were male. In 51.7 % of patients, the fracture involved the dominant limb. A fall while playing football (33 %) or riding a bicycle (23 %) was the most common causal accident. Type 2A2 fractures were the most frequent (38.4 %) followed by type 2B1 fractures (33.0 %). The type of fracture, displaced or non-displaced, was not influenced by gender ( $p = 0.485$ ) or age ( $p = 0.089$ ). After non-operative treatment, 2 of the 91 patients had a non-union. Functional evaluation was performed in the 49 adolescents who were successfully contacted. The QuickDASH score was  $1.7 \pm 3.3$ , with no differences regarding gender ( $p = 0.562$ ) or fracture type ( $p = 0.096$ ). Of these 49 patients, 28 were very satisfied and 21 satisfied with the final outcome. Applying a model of ordinal logist regression, we verified that an increase in 1 % in the QuickDASH score is associated with a decrease in the satisfaction level ( $p = 0.014$ ).

**Conclusion** Conservative treatment of clavicle fractures in adolescents allows excellent functional results with high satisfaction levels, regardless of the degree of fracture displacement. The QuickDASH score was a good predictor of the adolescents' satisfaction.

**Significance** Although there is an increasing trend toward surgical treatment of midshaft clavicle fractures in adolescents, excellent functional results and high satisfaction levels can be obtained with conservative treatment.

## EP103

### The surgical dislocation for paediatric and adolescent hip deformity

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** Hip deformities due to paediatric pathologies, complex abnormalities leading to femoro-acetabular impingement (FAI), functional limitation and eventually premature osteoarthritis (OA) may be approached with surgical hip dislocation (SHD). The aim of this study is to evaluate the clinical, radiographic short-term results and complications after SHD in young patients ( $\leq 18$  years).

**Materials and methods** Clinical and radiographic outcomes were assessed in patients who underwent a SHD Ganz-type approach between 2008 and 2012. Diagnosis included LCPD, SCFE, FAI, ON, MHE, PVNS. Preoperative and postoperative clinical data, radiographs, modified Harris hip score (mHHS), non-arthritic hip score (NAHS) and short form 12 (SF-12) questionnaires were evaluated. The Stulberg classification, sphericity deviation score (SDS),  $\alpha$ -angle, Reimer index, Sharp, Wiberg, ACM, CCD angles, signs of osteonecrosis and osteoarthritis were used for the evaluation on plain radiographs.

**Results** After a mean 3 years follow-up (range 0.5–6 years) we evaluated 53 hips (51 patients): 15 LCPD, 13 ECF, 18 FAI, four MHE, three miscellaneous. Mean age at surgery was 14 years (range 10–18 years). Through this approach femoral head-neck osteoplasty (33), Dunn-type osteotomy (10), labrum refixation (five),

synovectomy (two), femoral head mosaicplasty (two) open reduction and fixation for SCFE (one) were performed, eventually in association with pelvic (three), intertrochanteric (four) osteotomy or flake repair (two). At FU, better outcome scores were obtained and 90 % of the patients were satisfied with the procedure. ON progression was observed in four cases and in three further patients a THA was implanted; another with LCPD and preoperative osteonecrosis had a functional ankylosis.

**Conclusion** Severe hip deformities in paediatric/young patients may be approached with SHD for the specific treatment of individual structural abnormalities. After 3 years FU results are comparable to previous studies and patients have a high rate of satisfaction.

**Significance** The effectiveness of those procedures have to be proved on the long term. Results and complications seem to be related with preoperative lesion(s) and type of treatment.

## EP104

### The late sequelae of infantile hip infection

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#### Level-4

#### Hip/DDH/Legg-Calvé-Perthes/SCFE

**Introduction** The late sequelae of infantile hip infection include complete destruction of the femoral head and neck, proximal migration of the femur, lower-extremity length discrepancy, abnormal gait, and pain. Asymmetrical physeal arrest within the femoral neck result in alteration in the neck-shaft angle. The purpose of this study was to present results of treatment of the sequelae of septic arthritis of the hip in children.

**Materials and methods** Ten hips in 10 children age from 2 to 22 years suffering septic arthritis in infancy were followed from 50 to 130 months. Four hips were with coxa vara as a sequel to septic arthritis of the hip. All patients were treated operatively: 3 with Total Hip replacement because of painful joint degeneration, 2 with Pelvic support osteotomy for abduction insufficiency in combination with lengthening of the femur and valgus corrective osteotomy. Valgus corrective osteotomy was done in 4 hips and in one case modified greater trochanter arthroplasty. The Trendelenburg sign, pain, range of motion, hip function, Harris hip score and limb-length discrepancy were assessed clinically. Remodelling of the femoral head, hip stability, and arthritic changes in the hip were evaluated radiographically.

**Results** At the time of last follow-up which ranged from 50 to 130 months, the Harris Hip Score (HHS) showed excellent functional outcome in three cases (30 %) treated with Total Hip Replacement, good in 6 cases (60 %), fair in one case (10 %) and was no poor functional outcome. Trendelenburg sign become negative in all but two patients.

**Conclusion** Total Hip Replacement in patients after 18 years is the best choice with excellent functional outcome according Harris Hip Score.

**Significance** Operative treatment of sequelae of neonatal septic arthritis of the hip can successfully correct a Trendelenburg gait and restore knee alignment and correct lower-extremity length discrepancy

## EP105

**Juvenile osteochondritis dissecans of the knee: putting evidence into practice**Hassan Fawi<sup>1</sup>, Mohamed As-Sultany<sup>2</sup>, Andreas Rehm<sup>2</sup><sup>1</sup>Addenbrookes University hospital, Cambridge, United Kingdom**Level-3****Upper and lower extremity reconstructions**

**Introduction** The natural history of JOCD of the knee and its most effective treatment strategies are poorly understood, despite it being a long recognised condition. In addition, it is notorious for failure of spontaneous healing. There has been recent strong evidence correlating limb malalignment with JOCD of the knee. We aimed to assess whether the concept of formally examining and investigating for concomitant malalignment and JOCD of the knee was undertaken in our department over a 10 years period. And secondly to describe our experience of managing 3 cases with concomitant JOCD and malalignment, in view of the recent evidence based literature.

**Materials and methods** 1. All paediatrics case (<18 years old) with confirmed JOCD who were assessed at Addenbrookes University hospital over a ten years period, 2004–2014, were retrospectively reviewed. Clinical letters and radiological investigations were scrutinized for whether they included assessment of lower limb malalignment or not.

2. We prospectively assessed the 3 patients who had JOCD and concomitant malalignment. They all underwent surgical treatment, for refractory symptoms. Data including patients demographics, duration of symptoms, duration of follow-up, visual analogue score, Lysholm knee scores, MRI scans and X-rays before and after surgery, were collected and analysed.

**Results** 1. 34 patients with JOCD of the knee were eligible for inclusion. Nineteen were males and 15 were females. Twenty-seven

were found to have not been formally assessed for lower limb malalignment (79.4 %). Seven were formally assessed including clinical and radiological investigations; of which 3 underwent surgery to address their symptoms.

2. 3 patients underwent surgery: all males. The mean age was 12 years (9, 12, 15 years old) and the mean duration of symptoms was 24 months (12, 24, 36 months). They were all non-traumatic in nature.

The osteochondral fragments were in the medial femoral condyle in 2 cases, and on the lateral tibial plateau in one case.

One had proximal femoral external rotation osteotomy for femoral neck anteversion of 31°. The second patient had growth plate arrest on the lateral femur and tibia and micro-fracture surgery. The third patient had proximal external derotation osteotomy of the tibia. They all had pre and post-surgery interval MRI scan, which showed stability and significant reduction in the osteochondral fragment size. All the patients were very satisfied, and their pre and post-operative surgical scores showed significant improvement.

**Conclusion** Our study highlights that the connection between JOCD of the knee and lower limb malalignment is not one that is formally assessed. When this is taken into consideration the results of surgical management are better.

**Significance** We feel that addressing the osteochondral fragment in isolation, in case of unknown malalignment, might not yield the best surgical outcome for these patients.

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