

EPOS 35th Congress Meeting

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April 7

Basic Science Session
08:20–10:00

OP1/08:20–08:25

Assessment of angulations of the physis and changes in lower limbs alignment in growing children using EOS®

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Level-3

Basic science

Introduction Our study aimed at verifying if measuring the lower limb alignment using growth plates as radiologic landmarks (bypassing the epiphysis) (a) provided enough reliability to distinguished variations in angular activity among the different physis with growth and (b) allowed planning of a larger study to establish physal angles reference values according to age.

Materials and methods Ninety-one EOS® of children aged 3–15 years (43 girls, 48 boys) have been evaluated. Exclusion criteria were: frontal limb malalignment, intraosseous pathology, lower limb inequality >2 cm, metabolic disease and past lower extremity fracture. Each femur and tibia was screened to rule out frontal malrotation. For each lower limb, we measured the mechanical axis deviation (MAD) and 4 physal-based angles: proximal (PFPA) and distal (DFPA) femoral physal angles, and proximal (PTPA) and distal (DTPA) tibial physal angles. To test the reproducibility of measurements, we measured (for PFPA, PTPA, DTPA) one angle and its opposite. Patients were divided into 3 age groups (3–6, 7–10 and 11–15 years old). For statistics, X2 test, ANOVA F Statistics and linear regressions were used. Reproducibility was assessed by computing the intra-class coefficients (ICCs).

Results All lower limbs showed a neutral MAD. The distal portion of femurs and tibias showed a high angular variation during growth. DFPA ($p < 0.0002$ right, $p < 0.0015$ left) and DTPA ($p < 0.0160$ right, $p < 0.0264$ left) showed statistically significant differences according to age groups in boys and girls. PFPA differed significantly according to age in girls only. For PTPA no change with age was detected. Reproducibility of angle measurement was excellent: ICCs ranged from 0.88 to 0.98.

Conclusion This study based on children with well-aligned lower limbs is encouraging showing that:

1. The distal growth plate of femurs and tibias shows significant angular activity during growth.
2. The reliability in physal angle measurements using EOS® is excellent.
3. PFPA varies with age in girls but not in boys possibly secondary to increase in pelvic width in girls during adolescence.
4. While there are few changes in PTPA with age, this questions the correction speed in proximal tibia hemi-epiphysiodesis.
5. There are different angular values according to age in PFPA, DFPA and DTPA.

Significance There are convincing different angular values according to age (evolving curve) with potential for the establishment of a reference base of normal values based on the physis, avoiding the errors of measurement due to variations in epiphysal growth.

April 7

Basic Science Session
08:20–10:00

OP2/08:25–08:30

Effects of the guiding tibial rotational growth on the geometries of the tibial plateau and menisci in rabbits: an anatomical study

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Level-3

Basic science

Introduction The aims of the study were to determine the effects of the guided growth on the geometries of the tibial plateau and menisci in a rabbit model of tibial axial rotation and to find out whether or not there exists any rebound effect concerning the aforementioned geometries.

Materials and methods 30 male rabbits were 6 weeks old when the two oblique plates were applied medially and laterally to the proximal left tibias. Four weeks later, 15 rabbits were sacrificed (Group 1) while the plates were removed from the tibias of the remaining 15 rabbits (Group 2). The rabbits in Group 2 were kept a further 4 weeks and then sacrificed. Right knees were regarded as the control group. The obtained variables were the medial and lateral tibial slopes, lengths (tibia, meniscus, tibial plateau), widths (menisci, tibial plateau) and ratio of the menisci over the tibial plateaus. A paired *t* test was used to compare the differences between the control and operated limbs in each group.

Results The most striking differences were decreasing lateral tibial slope and the ratio of the lateral plateau covered by the meniscus in Group 1. The lateral tibial slope was $28.3 \pm 3.34^\circ$ in control limb and was $10.8 \pm 9.65^\circ$ in operated limb ($p = 0.000$). The ratio of the lateral plateau covered by the meniscus was $71.9 \pm 6.18\%$ in control limb and was $61.3 \pm 6.21\%$ in operated limb ($p = 0.001$). On the other hand the lateral plateau area and length, medial plateau area, medial meniscus width and area in the rabbits of Group 1 increased. In Group 2, the rebound effects for the aforementioned variables were determined except the meniscal variables. The lateral tibial slope was $25.9 \pm 4.25^\circ$ in control limb and was $29.8 \pm 5.88^\circ$ in operated limb ($p = 0.244$) and the ratio of the lateral plateau covered by the meniscus was $76.5 \pm 9.65\%$ in control limb and was $77.2 \pm 12.2\%$ in operated limb ($p = 0.757$). The meniscal geometries continued to change after removing the plates and all meniscal variables increased in the operated limbs compared to the control limbs except the lateral meniscus width in Group 2.

Conclusion The guided growth using oblique plates led to change the tibial plateau geometry, and the rebound effect was observed. However, the rebound effect was not determined in the meniscal geometry since the meniscal variables continued to increase. The guided growth for the restoration of tibial axial rotation deformities changes anatomy of the applied metaphysis. The rebound effect resolves these side effects except meniscal variables.

Significance The rotational guided growth has an effect on the tibial plateau geometry but these changes are reversible due to the rebound effect.

April 7

Basic Science Session
08:20–10:00

OP3/08:30–08:35

Dynamic knee joint loading in children and adolescents with idiopathic genua valga: the results following surgical correction of axial malalignment

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Level-2

Basic science

Introduction Previous studies have shown that children and adolescents with genua valga exhibit considerable compensatory mechanisms during gait cycle. These children demonstrated significantly decreased internal knee valgus moments and different transverse plane gait patterns such as decreased external knee rotation and increased external hip rotation. The purpose of this study was to re-evaluate these children after surgical correction of their lower limb alignment using hemiepiphysiodesis in order to determine if knee joint loading and rotational gait patterns were normalized after the intervention.

Materials and methods We evaluated 20 children (8 female, 12 male), with a mean age of 13.6 years (range 11.8–14.8 years) at the time of the explantation of the hemiepiphysiodesis device (“8-plate”) with gait analysis. Nineteen bilateral, and one unilateral case were included in the analysis, accounting for a total of 39 limbs. Radiographic indices according to Paley et al. (e.g. MAD, LDFA, MPTA) and predefined gait parameters (frontal knee moments, foot progression angle, hip and knee rotation, knee valgus angle) were documented, and pre-postoperative comparisons were performed.

Results Surgical correction of limb alignment resulted in a significant normalization of frontal knee moments and frontal knee angle ($p < 0.0001$). Foot progression angle and hip rotation, however, showed no significant changes ($p = 0.804$, $p = 0.966$). Moreover, knee rotation changed significantly with an increased internal rotation ($p = 0.008$). All radiographic parameters were significantly improved ($p < 0.001$). Compared to a reference cohort of healthy children, there remained a significant decreased external knee rotation ($p = 0.006$) as well as a significantly increased hip external rotation ($p > 0.0001$) in the long term.

Conclusion Our results suggest that correction of limb axis in children with idiopathic genua valga is highly beneficial in improving knee joint loading during gait analysis. Distinct rotational gait patterns have not been influenced by these surgical procedures and may reflect pre-existing gait abnormalities in this patient cohort. The results indicate that the decreased external knee rotation might be compensated by a muscle-driven increase of external hip rotation.

Significance These results highlight the fact that there may remain relevant compensatory torsional abnormalities after surgical correction of genu valgum. These rotational patterns may have significant implications on the eventual development of recurrent valgus deformity and even osteoarthritis in the long-term.

April 7

Basic Science Session
08:20–10:00

OP4/08:45–08:50

The clinical and biomechanical effect of paediatric flexible flat feet on the knee, hip and back: an observational study

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Level-2

Basic science

Introduction We undertook an investigation into the relationship between foot posture and the proximal joints in children with flexible flat feet. It was hypothesised that reduced arch height would be associated with proximal joint symptoms and altered gait kinematics and kinetics particularly in the transverse plane at the hip and knee joints.

Materials and methods Ninety-five children (aged 8–15) with either flat feet (FF, n = 48) or neutral feet (NF, n = 47) based on their arch height index (AHI) [1] were recruited to this study. Body mass index (BMI) was calculated and flexibility assessed using the lower limb assessment score. The frequency of knee and hip/back pain in the participants was documented. Each participant also underwent three dimensional gait analysis capturing kinematic and ground reaction force data. Logistic regression was used to assess the effect of the predictors AHI, age, BMI, sex and flexibility on the presence of symptoms. Correlational analysis was used to assess the relationship between AHI and gait parameters. The Student’s *T* test was used to assess the relationship between gait parameters that had a significant association with AHI and the presence of proximal joint symptoms in the FF group ($\alpha = 0.05$).

Results Reduced arch height was predictive of an increased odds of knee symptoms ($p < 0.01$) and hip/back symptoms ($p = 0.01$). Increased BMI was also predictive of increased odds of hip/back symptoms ($p = 0.02$). Age, sex and flexibility were not significant predictors of the presence of proximal joint symptoms. A flat foot posture was also significantly associated with a reduction in the second peak of the vertical ground reaction force ($p = 0.01$), which concomitantly affected late stance hip and knee internal moments. A reduced AHI was associated with increased pelvic retraction and increased knee valgus in midstance. No kinematic and kinetic parameter deviations associated with a flat foot posture related to the presence of proximal joint symptoms in the FF group.

Conclusion Children with a flatter foot posture are more likely to have pain or discomfort at the knee, hip and back; however, the mechanisms by which this occurs remain unclear. The observed kinematic and kinetic deviations did not necessarily relate to the presence of symptoms.

Significance Whilst flat feet are associated with the presence of proximal joint symptoms, without explicit understanding of the pathomechanics of this condition planning treatment protocols is difficult. Further work is required in this area.

1. Williams (2001) Clin Biomech 16:341–347

April 7

Basic Science Session

08:20–10:00

OP5/08:50–08:55

Do we have to tension wires? A biomechanical study of circular external fixation using a hindfoot model

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Level-1

Basic science

Introduction Thin tensioned wires used in circular external fixation for limb lengthening and deformity correction are well tolerated in the hindfoot. However, the placement of the wires may prolong surgical time, increase frame complexity, and cause frame deformation. The purpose of this study was to determine whether an increase in wire diameter can provide comparable stiffness in a foot model under axial (AX) compression, anterior-posterior (AP) bending (simulating dorsiflexion/plantar flexion), and medial-lateral (ML) bending (simulating pronation/supination) loads and eliminate the need for wire tensioning. We hypothesize that non-tensioned 2.8 mm diameter wires will be comparable in stiffness to tensioned 1.8 mm diameter wires.

Materials and methods A simulated foot model circular external fixator was constructed using a double row aluminum foot plate closed anteriorly with a half ring. A 38 mm diameter Delrin cylinder was used to simulate a foot. Four different frame configurations with differing calcaneal fixation were tested: (1) two crossed 1.8 mm diameter tensioned wires, (2) two parallel 1.8 mm diameter tensioned wires, (3) two crossed 2.8 mm non-tensioned wires, and (4) two parallel 2.8 mm diameter non-tensioned wires. The simulated forefoot was stabilized using a 4 mm diameter half pin. Each wire configuration was tested for five cycles under AX, AP bending, and ML bending loads. The linear region of the load-displacement curves were analyzed and average stiffness was calculated for each frame configuration in each loading mode.

Results In all loading modes (Table 1), crossed and parallel frame configurations with two non-tensioned 2.8 mm diameter wires had statistically greater stiffness than the 1.8 mm diameter tensioned wire frame configurations ($p < 0.001$). The crossed wire configuration in nontensioned 2.8 mm diameter wires was significantly stiffer compared to parallel wires in a simulated AX compression load. In tensioned 1.8 mm wires, the parallel configuration was statistically stiffer than the crossed pattern. A comparison of crossed and parallel wire configurations for either wire type did not demonstrate a statistically significant difference in either AP bending and ML bending stiffness despite a trend towards increased stiffness in crossed wire configurations.

Conclusion Two non-tensioned 2.8 mm diameter wires provide significantly increased stiffness than two tensioned 1.8 mm diameter wires in axial compression, AP bending and ML bending. While these measures are statistically significant, the absolute measured difference in stiffness is unlikely to be of clinical significance. As such, the use of 2.8 mm non-tensioned wires may be clinically comparable for hindfoot fixation to 1.8 mm tensioned wires and reduce surgical time and complexity. Clinical relevance of the measured biomechanical differences should be tested.

Significance Non-tensioned wires may be used in external fixation and may provide comparable stiffness without the added complexity and possible complications of wire tensioning.

Table 1 Stiffness of frame constructs using two tensioned vs. non-tensioned wires

Loading Mode	Two cross wires			Two parallel wires		
	1.8 mm	2.8 mm	p-value	1.8 mm	2.8 mm	p-value
AX Compression (N/mm)	87.07	131.53	0.0001	96.92	118.49	<0.0001
AP Bending (N/mm)	22.48	28.24	0.0006	21.57	27.17	<0.0001
ML Bending (Nmm/deg)	2.95	3.76	<0.0001	2.50	3.68	<0.0001

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Basic Science Session
08:20–10:00

OP6/09:02–09:07

Both decreased and increased relative acetabular volume are associated with increased hip arthritis in an osteological review of 1090 hips

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Level-3**Basic science**

Introduction Recently, there has been considerable interest in quantifying the associations between bony abnormalities about the hip joint and osteoarthritis. The relationships between acetabular undercoverage, acetabular overcoverage, and femoro-acetabular impingement (FAI) with hip joint osteoarthritis (HOA) remain controversial.

Materials and methods 545 cadaveric skeletons (1090 hip joints) from the Hamann-Todd osteological collection were obtained. Femoral head volume (FHV), acetabular volume (AV), the ratio between femoral head volume and acetabular volume (FHV/AV), acetabular version, alpha angle, and anterior femoral neck offset (AFNO) were measured. A validated grading system was used to quantify HOA as minimal, moderate, or severe. Multiple linear regression was used to determine the independent correlates of FHV, AV, and FHV/AV. Multinomial logistic regression was used to determine which factors increase the risk of HOA.

Results Females had smaller FHVs (standardized beta -0.382 , $p < 0.001$), and AVs (standardized beta -0.351 , $p < 0.001$), although the ratio of FHV/AV was unchanged. Every 1-degree increase in alpha angle increased the probability of having moderate HOA compared to minimal HOA by 7.1 %. Every 1-mm decrease in AFNO increased the probability of having severe or moderate HOA, compared to minimal HOA, by 11 and 9 %, respectively. The relative risk ratio of having severe HOA compared to minimal HOA were 7.2 and 3.3-times greater for acetabular undercoverage and overcoverage, respectively, relative to normal acetabular coverage.

Conclusion Acetabular undercoverage and overcoverage were independent predictors of increased HOA. Alpha angle and AFNO had modest effects, supporting the view that bony abnormalities both in the dysplastic and FAI spectrum increase the risk for more severe HOA.

Significance Both acetabular undercoverage and overcoverage are associated with hip arthritis, supporting the growing viewpoint that overcorrection of either condition is unfavorable.

April 7

Basic Science Session
08:20–10:00

OP7/09:07–09:12

Hip-Spine syndrome: the relationship between cam deformity and osteoarthritis of the lumbar spine

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Level-3**Basic science**

Introduction The term hip-spine syndrome (HSS) has traditionally been used to describe patients with coexisting hip arthrosis and lumbar spine disorders. To date, the treatment of hip pain in the setting of HSS has focused on patients with hip arthrosis, but the relationship between pre-arthritic hip pathology and lumbar spine disease has generally been ignored. We examined a large osteological collection to assess the relationship between well-described means of quantifying cam deformities and osteoarthritis of the lumbar spine (SOA). Our hypothesis was that the presence of a cam deformity would increase rates of SOA.

Materials and methods Alpha-angle (AA) and anterior femoral neck offset (AFNO) were measured on paired femurs of 550 well-preserved cadaveric skeletons (1100 total femurs) from the Hamann-Todd Osteological Collection using standardized cephalocaudal images. Degenerative disease of these specimens in the lumbar spine was graded from 0 to 4 using an established grading system. Proximal femurs demonstrating lippling, osteophytes, or other obvious arthritic changes that could potentially alter AA and AFNO measurements were excluded. Correlations between AA and AFNO with SOA were evaluated via multiple regression analysis.

Results The average patient age was 47.8 ± 16.2 years. There were 456 males and 94 females, 335 Caucasians and 215 African-Americans. The mean AA and AFNO were $52.4^\circ \pm 11.4^\circ$ and 6.8 ± 1.5 mm, respectively. There was a significant correlation between increasing AA and SOA (standardized beta = 0.061, $p = 0.041$). There was also a significant correlation between decreasing AFNO and SOA (standardized beta = -0.067 , $p = 0.025$). There was a strong correlation between age and SOA (standardized beta = 0.582, $p < 0.0005$). Inter-rater reliability was 0.90 for combined lumbar SOA scores. Inter-observer ICC was 0.81 and 0.88 for AA and AFNO measurements, respectively. **Conclusion** Our results are the first to demonstrate that the cam-type deformity markers of increasing AA and decreasing AFNO are significant predictors of osteoarthritis of the lumbar spine.

Significance Cam deformity in the younger individual may contribute to the accelerated development of SOA in later life. The improvement in hip internal rotation after femoral osteoplasty to correct cam deformity may theoretically decrease lumbo-pelvic stress and pain and have the long-term benefit of lower rates of SOA. A more thorough understanding of the hip-spine connection will likely aid in the evaluation and management of femoro-acetabular impingement in the young patient.

April 7

Basic Science Session
08:20–10:00

OP8/09:12–09:17

The behavior of the vertebral growth plate after surgical correction of scoliosis in an animal model

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Level-2

Basic science

Introduction The aim of the experiment was to evaluate the behavior of the growth plate subjected to asymmetric compression and then distraction simulating the rise and correction of scoliosis. The results should allow an answer to the question about the possibility of the biomechanical impact on the growth of the deformed spine.

Materials and methods The study group consisted of 24 animals. The study used a 49 day rats weighing 119–127 g. The first step—for 3 weeks—we've made the mechanical compression from one side of two adjacent vertebrae of the tail. After this time wedging of vertebrae was obtained. Then—for the next 3 weeks—distraction of growth plates from the concave side of the deformation was performed. For the purposes of the experiment an external fixator operating on the principle of Ilizarov apparatus was constructed. The control group were vertebrae not included in the stabilization. The tail of each animal was subjected to radiological examination, the cartilage growth of deformed vertebrae were examined histologically (hematoxylin and eosin and methyl blue). We analyzed the thickness of the growth cartilage, and hypertrophic chondrocyte zone on its convex and a concave side, and in the central portion of the growth plate.

Results Histological examination confirmed the supposition of inhibition grow on the side subjected to compression; the hypertrophic chondrocyte layer in this region has been flattened, and the proliferative zone lost its compactness and became irregular. The structure of the growth plate on the convex side of the curvature was changed as well: a cell distribution was random, and the columns of hypertrophic and proliferative zones were arranged obliquely to the growth plate. However, compared to the control group, it wasn't activated. Changing the forces on the fixator simulated the start of the correction of the deformed spine. Introduction the distraction on the concave side relieved the compressed growth plate. There has been a change in the behavior of cartilage. On both the concave and convex sides of curvature the layers returned to their initial activity. The Columnar arrangement of cells improved.

Conclusion 1. Correction of an experimentally induced uniplanar scoliosis by decompression of the compressed growth plate allows a return to its physiological activity and reduces the deformation of the vertebral body.

2. The results of the experiment may be a starting point for considering the possibility of correction of spinal deformity by appropriate manipulation of the forces acting on the growth plate.

Significance The results should allow an answer to the question about the possibility of the biomechanical impact on the growth of the deformed spine.

April 7

Basic Science Session
08:20–10:00

OP9/09:27–09:32

Bone antibiotic bioavailability in skeletally immature animal. A pharmacokinetic study

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Level-1

Musculoskeletal infections

Introduction Osteomyelitis is relatively frequent in childhood and represents approximately 5 % of hospital admissions. The clinical protocols recommend antibiotics with a sequential pattern, first intravenously and then orally, with a minimum duration of 4 weeks for the whole treatment. There is, however, a lack of consensus about the minimum duration of intravenous treatment.

The aim of the study is to design an animal model for oral and intravenous antibiotic administration to get pharmacokinetic data and bone bioavailability in skeletally immature animal.

Materials and methods This is an experimental study in skeletally immature rabbits of 8 and 13 weeks of life and skeletally mature rabbits of 30 weeks of age. We developed the technique of oral and intravenous administration and blood and bone sampling for cloxacillin and amoxicillin clavulanate. Subsequently, we perform the pharmacokinetic study to obtain data of distribution and bone antibiotic bioavailability for every antibiotic, every age and every route of administration.

Results The pharmacokinetic study as a bicompartimental model gave as a stationary time 10 min after intravenous administration and 35 min after oral administration.

The bone antibiotic bioavailability compared to plasma for intravenous cloxacillin was 37, 18 and 5 % in rabbits of 8, 13 and 30 weeks respectively. The bone antibiotic bioavailability compared to plasma for oral cloxacillin was 10 % in rabbits 8 weeks old and 2.3 % in rabbits 30 weeks old.

Conclusion The bone antibiotic bioavailability is higher in more skeletally immature animals. The bone antibiotic availability is much lower when orally administered.

Significance This study shows interesting data for clinical decisions using antibiotics in skeletally immature bone infections

April 7

Basic Science Session
08:20–10:00

OP10/09:32–09:37**Interferon β protects against ischemic osteonecrosis through IL6 inhibition and SIRT1 upregulation**

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Level-1**Basic science**

Introduction LCPD is a childhood ischemic osteonecrosis (ION) of the femoral head. Hip joint synovitis is a common feature, which produces pain, loss of hip joint motion, and is associated with a poor clinical outcome. Silent information regulator transcript-1 (SIRT1), an NAD-dependent deacetylase, mediates NF- κ B deacetylation, and inhibits its function. SIRT1 may affect synovitis-mediated signaling pathways and ischemic damage of the bone. Interferon β (IFN- β) has pleiotropic effects, but whether it can be used to treat ION remains globally controversial. Thus, in this study we investigated the effects of IFN- β on surgery-induced ION model mice.

Materials and methods ION was surgically induced using a dissection microscope in the distal femur of mice, and the animals were divided into the following groups: (1) sham operated group (sham group), (2) sham operated group, IFN β injected (sham-IFN- β group), (3) ION, no injection group (ION group), and (4) ION, IFN- β -injected group (ION-IFN- β group) (n = 20/group). Endogenous IFN- β expression in the distal femur of ION model mice was evaluated by quantitative real-time PCR (qRT-PCR). The effects of exogenous IFN- β were assessed using hematoxylin eosin and safranin-O with fast green counterstain histology, microCT, and tartrate-resistant acid phosphatase (TRAP) staining. The RAW 264.7 cell line was differentiated into osteoclasts with RANKL stimulation and then treated with exogenous IFN- β .

Results The expression of inflammatory cytokines (IL-6, MMP-3, and RANKL) were significantly higher in ION group. After IFN- β intervention, the expression of IL-6, MMP-3, and OPG) significantly decreased. Exogenous IFN- β directly inhibited RANKL-induced osteoclastogenesis. MicroCT obtained 4 weeks after injection revealed better preservation of the architecture of the distal femur in the ION-IFN- β group compared with the ION group. Histological findings indicated increased trabecular bone and vascularity and decreased osteoclast bone resorption activity in the ION-IFN- β group compared with those in the ION group. The IFN- β treatment increased phosphorylation of Smad1/3/5, p38, Akt, and SIRT1 and decreased IL-6 expression.

Conclusion IFN- β administration reduces inflammation and bone destruction due to ischemic damage through SIRT1 upregulation. Our work suggests that both SIRT1 and SIRT1-related cytokines are useful targets for treating patients with ION.

Significance The IFN- β treatment may be a clinically useful therapeutic application in ION.

April 7

Basic Science Session
08:20–10:00

OP11/09:37–09:42**Biomechanical analysis of retrograde flexible intramedullary nail constructs in a simulated pediatric femur fracture model**

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

Introduction The purpose of this study is to compare the rotational and bending stiffness of two flexible intramedullary nail constructs in a paediatric femur fracture model.

Materials and methods Eighty adolescent-sized composite femurs were used to create transverse (40 femurs) and oblique (40 femurs) mid-diaphyseal fractures. Retrograde flexible intramedullary nailing (FIMN) of the femurs was performed using either 3.5 mm titanium (Ti) flexible nails or 3.5 mm stainless steel (SS) flexible nails. Each type of nail was inserted in one of two configurations: two “C” shaped nails placed through medial and lateral entry sites or one “C” shaped nail and one “S” shaped nail placed through a single lateral entry site.

Models were tested in 10 cycles of axial rotation to ± 1 Nm of torque at a rate of 0.5°/s under 36 kg of compression using a servo-electric material testing system. The models were then tested in axial compression to 10° of varus bending. Relative angulation between the proximal and distal fragments was monitored using an Inertial Measurement Unit with bending stiffness defined as the maximum force required to create 10° of varus at the fracture site.

Results No differences were noted in rotational stiffness comparing Ti and SS nails regardless of nail configuration or fracture pattern. Comparable rotational stability was found for C + C and C + S configurations with SS implants for both fracture patterns. The C + S construct (0.6 nM/°) was stiffer in torsion than the C + C construct (0.4 nM/°) with Ti implants in the transverse fracture model (p = 0.03).

The C + S construct demonstrated statistically significant superiority in bending stiffness regardless of implant material or fracture pattern (p < 0.5). SS nails provided greater bending stiffness than Ti nails in both fracture patterns regardless of nail construct.

Conclusion A C + S FIMN construct confers greater bending stiffness than the C + C construct, regardless of implant material for both transverse and oblique fractures. In the transverse fracture model, the C + S construct provided greater rotational stiffness for Ti nail fixation only. While Ti and SS implants conferred comparable rotational stiffness, SS nails were superior at resisting bending forces in both fracture patterns.

Significance In the first biomechanical study to compare different retrograde FIMN constructs, the C + S nail configuration demonstrated superiority in resisting coronal plane deformation than the more commonly used C + C construct.

April 7

Basic Science Session
08:20–10:00

OP12/09:42–09:47

Validation of an experimental model of developmental dysplasia of the hip

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Level-2

Basic science

Introduction Developmental dysplasia of the hip (DDH) has an incidence of 1/1000 in the newborn and is the leading cause of total hip replacement in the young adult population. Current treatments cannot avoid the onset of osteoarthritis of the hip in all cases. Experimental models allow us to perform further investigation of the pathology and to try new ways of treatment. The purpose of the study is to validate a previously described experimental model of DDH.

Materials and methods Twenty-four New Zealand rabbits of 3 weeks aged were used. We created two groups of 12 animals: normal and dysplastic. The left knee of the dysplastic group was immobilized in extension with a Kirschner wire in order to produce a DDH. After sacrifice, an antero-posterior x-ray of the pelvis was taken and radiographic parameters were measured: Shenton line, acetabular index, Sharp angle, Wiberg angle, neck-diaphyseal angle and physal-diaphyseal angle. The morphology of the hip was studied and measured. This included the joint cartilage, the femoral head, the joint capsule, the *labrum* and the *ligamentum teres* was macroscopically evaluated with a morphological score ranging from 0 to 6 was used. A morphometric study was performed measuring with a caliper femoral length, femoral head diameters, acetabular diameters, and acetabular depth. We compared, in the dysplastic group, the left and right hips. We also compared the left hip of the dysplastic group with the left hip of the normal group.

Results The left hips of the dysplastic group showed a significantly higher acetabular index ($p = 0.011$), physal-diaphyseal angle ($p = 0.047$) and morphological score ($p < 0.001$) than the contralateral hips. They also showed a higher acetabular index ($p < 0.001$), Sharp angle ($p < 0.001$), physal-diaphyseal angle ($p = 0.047$) and morphological score ($p = 0.004$) than the left hips of the control group. There were also statistical differences between - femoral length ($p = 0.009$), femoral head diameters ($p = 0.013$ and $p = 0.007$), antero-posterior diameter of the acetabulum ($p = 0.047$), and acetabular depth ($p = 0.005$) between the left and right hips of the dysplastic group. We also found statistical differences between the dysplastic and control groups regarding femoral length ($p = 0.003$), femoral head diameters ($p = 0.01$ and $p = 0.003$), antero-posterior diameter of the acetabulum ($p = 0.007$), and acetabular depth ($p = 0.008$).

Conclusion Immobilization of the knee in extension in New Zealand rabbits provokes hip abnormalities that mimic the abnormalities found in children with DDH, both radiographically and macroscopically.

Significance This experimental model of DDH is reliable and can be used to assess new treatment modalities.

April 7

Limb reconstructions
10:30–12:00

OP13/10:30–10:35

Ankle complications in fibular hemimelia

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Level-4

Upper and Lower Extremity Reconstructions

Introduction Fibular hemimelia is the most common congenital long bone deficiency. Knee and Ankle joint anomalies are common in Fibular hemimelia which significantly affect the prognosis in cases treated by lengthening and deformity correction. However, the ankle complications after tibial lengthening had been ignored in many reports or described as increased ankle instability in some cases. The aim of this study is report our results and to discuss the following points: (1) True incidence of this complication, (2) Is it a complication or a part of natural history? (3) Instability, (4) The importance of prophylactic treatment, (5) Does arthrodesis stop deformity progression?

Materials and methods Between 1990 and 2011: 178 patients [Type I: 76, Type II [complete]: 102 were referred to our institution. Age at first presentation ranged from 6 months to 18 years. 306 Tibial lengthenings were performed. Single Tibial lengthening in 58, twice in 112, three times in 8 patients. Femoral lengthening concomitant with Tibial lengthening was done in 69 patients. Lengthening was unifocal, bifocal or trifocal. Treatment methods: (1) The application of the external fixator to the Tibia and foot, gradual distraction and translation to reduce the joint. (2) In cases with short fibula, corticotomy and downward lengthening of the fibula was undertaken. (3) In case with vestigial fibula, gradual downward bloodless distraction was applied (4) Supra-malleolar osteotomy. (5) Arthrodesis. The patients were evaluated clinically and radiographically at last follow up for the ROM, pain, functional activity level, mechanical axis deviation.

Results Ankle complications [106] were evident in 38 % of cases: 1-Progression of Valgus deformity in 87 cases 2-Instability [subluxation or dislocation] in 26 cases. 3-Spontaneous fusion in 3 cases. There was no statistical difference of development of this complication between the patients who had prophylactic foot frame or not.

Conclusions (1) Ankle complications after tibial lengthening in FH is an underestimated problem. The incidence is 38 % [116/306]. (2) The reason behind the progression of the valgus deformity in most cases can be related either to the effect of distraction on the physis or the pathoanatomy of the disease. There is a need for a control group in future studies to delineate this issue. (3) Downward distraction of the fibula is a valid option to guard against progressive valgus deformity. (4) Ankle dislocation can be reduced gradually followed by fibular engthening. (5) Management of ankle complications can be

performed concomitant with another stage of lengthening in selected cases

April 7

Limb reconstructions
10:30–12:00

OP14/10:35–10:40

Free vascularized fibular harvest: donor-site morbidity in children

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Level-4

Upper and lower extremity reconstructions

Introduction Free fibular flap harvest in the paediatric population is a reliable therapeutic option especially in oncologic reconstruction for bone defects. Few studies focused particularly on harvesting's donor-site morbidity in children. We want to show this approach's low long-term morbidity.

Materials and methods Our retrospective and monocentric study has included 27 patients with mean age 9 years old, with still growth potential. All these children underwent vascularized fibular graft in any reconstruction with a bone defect. The mean follow-up was 5 years. We analyzed clinical and radiological morbidity of the donor-site. A valgus ankle was determined, on X-rays, by LDFA <85°.

Results 18 patients had 25 clinical complications. 80 % of these complications have vanished without any consequences. There are 22 % surgical re-intervention in donor-site. 67 % of them were significant, 33 % were minor. Residual fibular length was 7.49 cm. Short residual fibular length is significantly associated with high radio-clinical morbidity in younger patients under 9 years ($p = 0.001$). 52 % of the patients developed valgus ankle deformities. In younger children, there were more valgus ankles ($p < 0.008$). 88 % of our population underwent ankle stabilization procedures. These procedures couldn't prevent ankle deformities ($p = 0.76$).

Conclusion Vascularized fibular harvest is correlated with high radio-clinical morbidity of the donor site, but some of these complications decreased without any consequences. The ankle stabilization procedures weren't efficient enough to avoid ankle deformities.

Significance The limb reconstruction is a crucial challenge in children. Several procedures can be used. The outcomes of the reconstruction and the morbidity of the bony donor site must be considered for the choice of the procedure.

April 7

Limb reconstructions
10:30–12:00

OP15/10:47–10:52

Limb lengthening in children with a distraction nail (Fitbone®)

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Level-4

Upper and lower extremity reconstructions

Introduction Limb length discrepancy in children with open growth plates were treated until now conservatively or by callus distraction using external fixation. Fully implantable systems are available only after maturity. Could it be an option to use these systems earlier in cases where the lengthening needs to be done in two steps because of the huge amount needed? Which option can be offered by the Fitbone-System?

Materials and methods In 16 patients (9 female, 7 male) with the medium age of 11.8 years (8–15) fully implantable distraction nails (Fitbone TAA) were used on the femur in a special minimal invasive technique to correct a limb length discrepancy of >4 cm. In 5 cases a relevant deformity was corrected in the same surgery. In all cases a final step of lengthening was planned at the femur and at the tibia at maturity.

Results In 15 cases the goal of lengthening was achieved without any complication. In one case of proximal femoral deficiency lengthening has to be stopped because of increasing tendency of knee joint luxation. Bone formation occurred circumferentially around the nail. Full load bearing was possible on the average after 2.2 day/mm. No technical problems occur. 11 patients had a temporarily reduction of range of motion during lengthening which recovered completely. In one case growth irritation in the lateral X-ray was observed which can be corrected at the final step. At the end functional and cosmetic result was perfect in all 15 cases.

Conclusion Fully implantable distraction nails (Fitbone) are a favorable option in the femur even for children with open growth plates to correct limb length discrepancy and axis deviation. The treatment has a low pain level, is comfortable and very few scars are visible. The treatment needs experiences with minimal invasive nailing technique and should be done in specialized centers only. Preoperative planning and clinical and radiological control by the surgeon himself is mandatory. At the tibia there is no experience up to now.

Significance Fully implantable distraction nails can avoid external fixation to perform lengthening of the femur even if the growth plates are still open.

April 7

Limb reconstructions
10:30–12:00

OP16/10:52–10:57

Precision of the “PRECICE”: accuracy of acute correction and gradual lengthening using a retrograde femoral intramedullary lengthening nail

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Level-2

Upper and lower extremity reconstructions

Introduction In mature patients with a combination of angular deformity (AD) and leg length discrepancy (LLD) traditionally unilateral fixators are used to obtain deformity correction and lengthening [1, 2]. For several years intramedullary lengthening nails have become a more comfortable, but equally safe alternative for lengthening [3]. By the additional use of blocking screws angular

deformities may be acutely corrected, obviating the need for external fixation. However, precise preoperative analysis and planning as well as exact intraoperative realisation are absolutely mandatory to achieve the desired correction results. This study evaluates the outcome of deformity correction and lengthening using retrograde femoral lengthening nails focusing on the accuracy of the acute correction.

Materials and methods A cohort of 21 patients (9 male, and 12 female, average age = ~19.4 years) with secondary LLD and coronal AD (varus = 9, valgus = 12; right = 10, left = 11) treated by acute correction and subsequent gradual lengthening using a retrograde femoral lengthening nail (PRECICE[®]) with distal blocking screw was retrospectively evaluated. Intraoperative parameters like time for surgery (cut–suture) and for fluoroscopy were assessed. All radiographic measurements before surgery and after complete consolidation were done on long standing radiographs using a calibrated digital radiology system (Centricity[™] PACS). Preoperative deformity analysis and (reverse) planning of correction was performed using TraumaCad[®]. Accuracy of femoral lengthening and particularly of acute angular correction were measured and were related to the precision of osteotomy level (OTL) and blocking screw level (BSL). Usual parameters of distraction osteogenesis were evaluated. Complications were recorded during surgery as well as during distraction and consolidation period.

Results Accuracy of distraction distance was close to 100 % in all cases. MAD was corrected dramatically to normal ranges in both subgroups. mL DFA also improved in both subgroups, however reaching normal values only in the valgus group. Accuracy of angular correction was dependent on the precision of the intraoperative implementation of the planned correction. In four cases (varus = 3, valgus = 1) significant deviations of the OTL and the BSL were observed leading to severe undercorrections (Fig. 2a). Disregarding these cases the accuracy of angular correction was close to 90 % with an accuracy of OTL and BSL of more than 90 % in the entire cohort and both subgroups. Including these cases the accuracy of correction and of OTL and BSL of course were lower, particularly in the varus subgroup. Parameters of distraction osteogenesis were as expected. Four major complications (malfunction of the nail, screw migration, knee dislocation) requiring reoperation occurred (19.0 %).

Conclusion The PRECICE lengthening nail exactly reaches the desired distraction distance. Acute correction of femoral angular deformities by use of the femoral retrograde lengthening nail in combination with blocking screws may reach an accuracy of close to 90 % if the preoperatively planned correction is strictly implemented during surgery. Malpositioning of OTL and/or blocking screw level may lead to severe over- or undercorrection.

Significance Clinical important, improvement of surgical technique.

April 7

Limb reconstructions
10:30–12:00

OP17/10:57–11:02

FlexTack[™] and RigidTack[™]: new devices for correction of angular deformities and leg length discrepancies by temporary epiphysiodesis

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Level-2

Upper and lower extremity reconstructions

Introduction Epiphysiodesis is the first-line-treatment for moderate leg length discrepancies (LLD) and angular deformities of the knee (ADK) in growing children. Modern implants like the eight-Plate[™] solved many problems that were observed using conventional-staples for temporary epiphysiodesis. Rather than creating rigid compression-forces on the growth-plate like conventional-staples, the fulcrum of correction of the flexible eight-Plate[™] is located extraphyseally for guided-growth. The resulting tension-band-effect is appropriate for AD-correction, but using the eight-Plate[™] for LLD-correction may lead to anatomical joint-line-deformation and iatrogenic AKD. Additionally, implant-design, surgical technique and biomechanical alignment of the plate remain suboptimal leading to implant-associated complications and biomechanical problems.

Materials and methods Our group developed new devices for temporary ED consisting of anatomically preformed staples with cannulated legs ensuring a simple and precise implantation-technique of the eight-Plate[™]. The 13°-trapezoid-shaped design properly fits to the anatomic shapes of the physal regions of the knee- and other joints. Two different constructions were engineered to meet the divergent requirements for ADK-correction and LLD-equation. Staples with flexible bar (FlexTack[™]) are used for ADK to constitute the extraphyseal tension-band-effect. To ensure a complete and evenly distributed arrest of the entire growth-plate and therefore to prevent the mentioned complications, staples with rigid bar (RigidTack[™]) are implanted in LLD. A prospective cohort of 149 patients (male = 96, female = 53; age = ~11.9 years) with 330 FlexTack[™]-implantations for knee-valgus-(n = 102, FlexTacks[™] = 228), knee-varus-(n = 31, FlexTacks[™] = 61) and other (n = 16, FlexTacks[™] = 41)-corrections with a follow-up of ~1.0 year (max. 2.0 years) were compared with 17 patients (male = 11, female = 6; age = ~11.9 years) with 47 RigidTack[™]-implantations with a follow-up of ~6 months (max. 9 months) each was compared to a historical cohort of 93 patients (male = 53, female = 40; age = ~11.7 years) with 246 eight-Plate[™]-implantations with a follow-up of ~1.0 year (max. 2.4 years). Intraoperative parameters like operation-time(cut–suture) and fluoroscopy-time were assessed. Clinical and radiographic follow-up examinations every 3–6 months were performed. Correction-speed (MAD/LLD-correction[mm]/month/epiphysiodesis-location) was analysed. Complication-rates were evaluated focusing on implant-associated and biomechanical problems. Statistical analysis was done using Mann–Whitney-U-Test and Fisher's-Exact-Test.

Results Compared to the eight-Plate[™] operation-time and fluoroscopy-time were significantly shorter using the FlexTack[™] (22.7/36.8 min., resp.[P < 0.001];0.28/0.42 min., resp.[P = 0.005]). Earlier onset and faster speed of correction were measured using the FlexTack[™] for valgus-(1.59 mm/month/3.10 mm/month, resp.[P < 0.001]), varus-(1.44 mm/month/2.02 mm/month, resp.[P = 0.475]) and the RigidTack[™] for LLD-correction(0.50 mm/month/0.76 mm/month, resp.[P > 0.05]). Common complications like wound-infection(1.3 %/1.1 %, resp.[P = 1.000]), hematoma/effusion (3.4 %/3.2 %, resp.[P = 1.000]) and neurovascular damage (0/0, resp.[P = 1.000]) were comparable. However, only one FlexTack[™]-breakage (0.6 %) was observed compared to an implant-associated complication-rate of 10.8 % in the eight-Plate[™]-group [P < 0.001].

Conclusion The Flex-/RigidTack[™] is a reasonable synthesis of staples and cannulated screw/plate-devices. The implantation is simpler reducing operation-time and radiation-exposure. Due to the anatomical shape and biomechanical improvements faster corrections and lower rates of implant-associated problems were achieved. The

system offers the appropriate biomechanical effect for both, ADK-correction and LDD-equation.

Significance Improvement of implants for temporary epiphysiodesis.

April 7

Limb reconstructions
10:30–12:00

OP18/11:12–11:17

Pseudarthrosis following surgically treated forearm fractures in children and adolescents

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Level-4

Upper and lower extremity reconstructions

Introduction Due to the changing attitude of treating paediatric forearm fractures increasingly towards surgical stabilization by elastic stable intramedullary nailing (ESIN) rather than conservative treatment, we are confronted with complications which have not been described previously. Pseudarthrosis following surgically treated forearm fractures in children are only found in single reports with none in the german speaking area. The goal of the study is to define predisposing factors which may lead to pseudarthrosis after surgery for forearm fractures.

Materials and methods From 1990 to 2014 all children having sustained a pseudarthrosis following forearm fractures treated in our institution were included. All children who did not demonstrate a complete consolidation of the forearm fractures after 6 months from injury were considered for the study. Those pseudarthroses which were caused through systemic diseases were excluded.

Results During the 25 years, 16 children were treated who fulfilled the criteria of having a pseudarthrosis. 11 of the 16 children were primarily been treated in an outside hospital, five in our institution. The average age was 10.8 years (7–15 years). There were thirteen ulnar shaft and one radial shaft pseudarthrosis. In thirteen children the pseudarthrosis was located in the middle third and there was one child with a pseudarthrosis in the proximal and distal third of the ulna. There were thirteen ulnar shaft fractures and one monteggia lesion. Twelve of the fractures were primarily closed and there were two open cases. In nine cases an open reduction of the ulna was necessary. The radius was openly reduced in four patients. In five children technical mistakes of the osteosynthesis were identified to contribute to the formation of the pseudarthrosis. Six of the fourteen children had experienced a re-fracture. Ten children had revision surgery. These children were treated by plate osteosynthesis or ESIN. In six patients the pseudarthrosis healed spontaneously without interference. There were thirteen hypertrophic and one hypotrophic pseudarthrosis.

Conclusion Pseudarthrosis of the forearm following surgical treatment of forearm fractures in children and adolescents mainly occurred in the middle third of the ulna. Primarily open fractures or in cases which needed to be openly reduced the risk of pseudarthrosis formation is higher. Inadequate osteosynthetic stabilization is another factor to contribute to difficulties in fracture healing. Despite of the possibility of pseudarthrosis the indication for ESIN treatment in paediatric forearm fractures is beyond doubt. It is important to keep the surgical trauma to a minimum if open reduction is required in order not to disturb the perfusion of the bone.

April 7

Limb reconstructions
10:30–12:00

OP19/11:17–11:22

Lengthening of the ulna by callotasis in children with multiple hereditary osteochondromatosis (MHO): comparison of methods with and without internal fixation

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Level-4

Upper and lower extremity reconstructions

Introduction Aim of the study was to evaluate the results of ulnar lengthening in patients with MHO combined without and with internal fixation.

Materials and methods Our treatment strategy consists of early excision of the exostoses of both bones, and ulnar lengthening as a second step, when relative ulnar shortening exceeds 0.5 cm (6–22 mm). From 1999 to 2015, ulnar lengthening was done in 24 forearms in 17 patients (14 boys, 4 girls, age 7.1–16.6 years) using monolateral external fixation for callotasis after diaphyseal corticotomy. 15 forearms were lengthened without internal fixation (group I), and 9 forearm were lengthened with internal fixation of intramedullary elastic nail (Group II). Preoperatively, dislocation or subluxation of the radial head was obvious in 2 patients. In 3 patients, lengthening was repeated in the ipsilateral ulna in group I. X-rays of the wrists and forearms were evaluated according to Burgess et al. (1993), namely ulnar variance and per cent of ulnar variance (shortening), radial articular angle, per cent of carpal slip and radial bow.

Results The gain of ulnar length exceeded 18–35 mm (mean 24.6 mm) in group I and 23–36 mm (mean 29.8 mm) in group II. Over-lengthening of the ulna were between 0–12 mm (mean 7 mm). Bone lengthening index varied between 13 and 33 (mean 23) in group I and 9–19 (mean 15) in group II, respectively. Bone healing index varied between 44 and 120 (mean 77.7) in group I and between 33.7–67.4 (mean 52.4) in group II, respectively. Both parameters are statistical significant in advance for Group II (p 0.05). Concerning radiological parameters, only carpal slip significantly decreased (31.15 vs. 47.66 %, p = 0.05) in both groups. Range of movement of the wrist and elbow, radial articular angle and radial bow were not changed and dislocation/subluxation of the radial head was not reduced after the lengthening. No major complications were seen. Obstacles and minor complications were present in 33 % in group I and in 22 % of cases group II, respectively.

Conclusion Lengthening and reduction of the ulna at the distal radioulnar joint: 1. Preserves function of the wrist due to reduction of carpal slip, 2. Prevents radial head dislocation, 3. Decreases displeasure with the cosmetic appearance. Over-lengthening of the ulna is recommended in growing children. Significant benefit is seen in lengthening of the ulna combined with internal fixation using one elastic nail (group II) concerning gain, bone lengthening index, bone healing index and rate of complication.

Significance Ulnar lengthening using external device in combination with elastic intramedullary nail is recommended in children of school age.

April 7

Limb reconstructions
10:30–12:00

OP20/11:22–11:27

The use of vascularized flaps for upper extremities reconstruction

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Level-2

Upper and lower extremity reconstructions

Introduction Restoration of function and appearance of upper limb after injury in children is essential. Sometimes, when injuries extensive, this problem is enormous. After removal of scar tissue it may be impossible to use traditional methods of skin grafting. In such cases, the microsurgical methods of treatment have to be employed to cover the exposed anatomically important structures. The use of vascularized tissue complexes in children with electric burns accompanied by deep defects in cutaneous covering, fascia, muscles and bones allows restoration of cover, in a single-stage procedure. The complete cutaneous covering as well as, when necessary, the muscular and the bone, which can be included in autotransplants.

Materials and methods 20 children with a variety of deep defects after injury in early stages and 35 children with the consequences of serious injury have been operated on in our clinic since 2010. All patients have undergone autotransplantations of vascularized tissue complexes on a vascular pedicle. The variants for use of vascularized autotransplants in treating children with extensive tissue injuries can be divided into 3 groups according to the aim to be achieved:

1. In order to restore the integumentary system function—skin-fascia grafts such as Littler flap, radial graft, “kite-flap” and thoracodorsal graft have been used.
2. In order to restore the active muscle function—skin-fascia muscle grafts such as thoraco-dorsal graft with the inclusion of a transplant from the broadest muscle of back have been used.
3. In order to restore the frame function of bones—composite tissue complexes with a bone fragment such as a tissue complex on the basis of the broadest muscle of back with a rib fragment or a fragment of the lateral side of a blade bone.

Results Of the 40 transplanted grafts 39 remained viable. In one case there was thrombosis and subsequent necrosis of thoracodorsal flap due to infection. Upper limb segments were fully restored in 74 % and improved in 15 %. The appearance of the upper extremity after surgical treatment improved in 92 % of cases.

Conclusion The data obtained from the analysis of treatment results proves that the microsurgical transplantation of tissue complexes has very good outcome and is *indispensable when treating* children patients with extensive injuries involved with electric burns of upper extremities. The method also allows us to perform early surgery and to restore, in a single-stage procedure, the complete cutaneous

covering as well as, when necessary, the muscular tissue and the bone of upper extremities.

April 7

Limb reconstructions
10:30–12:00

OP21/11:37–11:42

Combined pharmacologic and biological treatment of congenital pseudoarthrosis of the Tibia; 100 % union; no refractures!

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Level-3

Upper and lower extremity reconstructions

Introduction Can a new method of treatment of CPT lead to union in all cases and prevent refractures.

Materials and methods Since 2007, nineteen cases of CPT were treated by a single surgeon. 13/19 also had neurofibromatosis, and 6/19 were idiopathic. The average age was 54 months (range 11–145). All patients were treated by the following protocol: preoperative infusion of Zolidronic Acid, resection of fibrous hamartoma, shaping, mating and straightening of the bone ends, intramedullary rodding of tibia and fibula, subiliacus muscle periosteal graft to the CPT site, extreme iliac bone harvest of cancellous only, bone graft by hollowing the iliac bone between the cortical tables all the way down to the acetabulum, triradiate, SI notch and SI joint regions, bone graft of CPT to create a crossunion between tibia and fibula, insertion of BMP2 between soft tissues and bone graft application of circular external fixator (Ilizarov apparatus with 4 olive wires) for rotation and length control second infusion of Zolidronic Acid at time of external fixator removal.

Results Radiographic union was achieved in 3–4 months in 19/19 cases (100 %).

Conclusion Combined pharmacologic and biomechanical treatment is very successful at obtaining and maintaining union in patients with CPT. The rationale for this treatment is based on sound principles including: The Zolidronic Acid infusion prior to bone graft harvest makes the bone graft resistant to resorption and counters the prolific number of osteoclasts associated with CPT and NF. After removal of the fixator it also ensures that the new bone formation is also resorption resistant. The hamartoma resection removes the osteoclastic constricting membrane around the bone. The acute deformity correction reduces bending forces on the CPT. The rodding of the two bones gives stability but also braces the bone from within to prevent refracture. An antegrade telescopic growing rod locked into the proximal and distal epiphysis is preferred. The periosteal grafting replaces the pathologic periosteum with healthy periosteum. The cross union between the tibia and fibula create a very wide bone especially in young children whose bone diameters are very narrow making refracture less likely. Cross union in young children requires a large volume of bone graft achieved by hollowing of the ilium. Adding BMP speeds healing which CPT bone is slow. Rotational and length stability is provided by the circular external fixator allowing full weight bearing postoperatively.

Significance This new treatment has the highest ever reported union and lowest ever reported recurrence rate.

April 7

Limb reconstructions
10:30–12:00

OP22/11:42–11:47

Long-term follow-up of free vascularized fibula transfer for treatment of congenital pseudoarthrosis of the Tibia

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Level-4

Upper and lower extremity reconstructions

Introduction Congenital pseudoarthrosis of the tibia is difficult to treat and it is associated with a high risk of non-union. Different treatment options have been described with no consensus among them. Free vascularized fibula transfer has proved to obtain good result regarding consolidation. However, there is insufficient data regarding its long-term follow-up. The aim of the study is to investigate the long-term follow-up of free vascularized fibula transfer for treatment of congenital pseudoarthrosis of the tibia (CPT).

Materials and methods We carefully evaluated 15 patients with CPT treated with a free vascularized fibula transfer. Data regarding age at the time of surgery, previous surgeries, surgeries needed after fibula transfer, and complications were noted.

Results This study evaluates 15 patients with CPT treated with a free vascularized fibula transfer when they were an average of 5.5 years old (SD 4.5; median 3.5). Average follow-up was 15 years (SD 10; median 16). There were equal girls to boys (ratio 1) with left tibia more commonly affected (ratio left:right 2.2). Neurofibromatosis was present in 14 patients. 12 patients have a previous surgery with an average of 1.2 surgeries (SD 1; median 1.5). Consolidation was obtained in 14 of the 15 cases. The case without consolidation underwent amputation. All cases showed some complications: seven fractures, twelve malalignment of the tibia, nine deformities of the ipsilateral ankle, two deformities of the contralateral ankle, eight patients with tibial shortening (average 6 cm), two infections, and six pseudoarthrosis (one of the initial CPT that underwent amputation, and the other five were pseudoarthrosis of a fracture or osteotomy for malalignment correction). Surgery was needed for the complication of treatment in eleven cases.

Conclusion Although free vascularized fibula transfer obtains a high rate of consolidation in the treatment of CPT, it is associated with a high incidence of complications. Malalignment of the tibia and deformity of the ipsilateral ankle are the commonest complications.

Significance Free vascularized fibula transfer for treatment of CPT is associated with a high incidence of complications in the long-term follow-up.

April 7

Limb reconstructions
10:30–12:00

OP23/11:47–11:52

Meta-analysis and economic decision model for first-time traumatic patella dislocation in children and adolescents

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Level-2

Upper and lower extremity reconstructions

Introduction Surgical versus non-surgical management of first time traumatic patella dislocation in children and adolescents remains controversial with a potentially higher rate of treatment failure in this population. The purpose of this study was (1) to perform a comparative analysis to determine the rate of repeat dislocation and clinical outcome between operative and non-operative management of first time traumatic patellar dislocation in children and adolescents and (2) to use these analyses to inform an economic decision model comparing the cost-effectiveness of: (a) non-operative treatment only; (b) initial non-operative management with surgery for recurrent dislocation and (c) immediate surgery.

Materials and methods A systematic review of the MEDLINE database identified 11 eligible studies. Meta-analysis was performed using weighted mean pooled cohort statistics and these results informed a markov decision analysis. Cost analysis for the model was performed from a societal perspective using both direct and indirect costs. Surgical cost was obtained from a statewide ambulatory surgery database and indirect costs from anticipated caregiver (parental) lost productivity (work absenteeism). Effectiveness was expressed in quality adjusted life year (QALY) estimates derived from the literature.

Results 637 knees were included in our meta-analysis; 470 non-operative and 157 operative. Conservative management was associated with a 31 % rate of recurrent dislocation whereas operative management had a 22 % recurrence rate ($p = 0.04$). Compared to non-operative management, immediate surgical treatment was associated with a significant minimal clinically significant difference in quality of life and sporting domains. In the base case for our model, the non-operative treatment only strategy was the least costly (\$7670) but also the least effective (6.72 QALY); initial non-operative management with delayed surgery cost \$11,010 for a 7.01 QALY benefit while immediate surgical treatment cost \$17,690 and provided 7.10 QALY benefits. Compared to non-operative treatment only, initial non-operative treatment with delayed surgery was associated with an ICER of \$11,150/QALY. When immediate surgery was compared to a strategy of delayed surgery, immediate surgery provided incremental benefit at an ICER of \$75,150/QALY.

Conclusion Operative treatment of first time patella dislocation in children and adolescents is associated with a lower risk of recurrent

dislocation and higher health related quality of life and sporting function.

Significance Initial non-operative management with delayed surgery or immediate surgical treatment of first time patella dislocation in adolescents are both cost effective treatment options. However, immediate surgical treatment provides the highest QALY gains and the cost effectiveness is within societal willingness to pay.

April 7

Trauma I

14:20–15:40

OP24/14:20–14:25

Elastic stable intramedullary nailing in displaced femur fractures. 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 was to evaluate retrospectively the clinical and radiographic outcomes of displaced femur shaft fractures in children weighting 50 kg (110 pounds) and over treated by ESIN and to assess the effects of increasing weight and age on treatment outcomes. The secondary aim was to identify the potential correlation between nail size/medullary canal diameter ratio and outcome. The hypothesis was the higher the ratio, the better the clinical and the radiological outcome.

Materials and methods 117 consecutive children surgically treated for fractures of the femoral shaft were recorded. 20 of them occurred in children weighting 50 kg (110 pounds) and over and were surgically treated by ESIN. For inclusion in the study, patients must have had a closed displaced femur shaft fracture without any associated neurovascular injury, weight 50 kg (110 pounds) and over and surgical management by ESIN. Valgus, varus, procurvatum, recurvatum and translation were assessed on plain radiographs in all patients. Nail diameter (in mm), and internal diameter of tibial medullary canal (in mm) 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 Twenty patients met the inclusion criteria. The average patient age at the time of injury was 13.1 ± 1.8 years (range 10.3 to 15.6). The mean follow-up was 29.4 ± 13.2 months (range 13 to 57). Overall, nine (45 %) adverse events were observed. Five were classified as minor (2 patients suffered from delayed union, 2 from reactive bursitis at the nail tip, and 1 from hardware migration) and four as major complications (2 patients developed malunion, 1 with hypertrophic non-union, and 1 from septic pseudarthrosis). The rate of complications was 67 % in children weighting 55 kg and over and it was 28 % in children weighting between 50 and 54 kg. Moreover, we noted a higher rate of complications among children aged 13 years old or older (72 %), than among children younger than 13 years old (11 %).

Conclusion The study demonstrated that femoral shaft fractures in children and adolescents weighting 50 kg (110 pounds) and over and older than 10 years of age have an increased rate of complications.

Significance Patients older than 13 years of age and weighting more than 55 kg should be preferably treated with rigid fixation systems, due to increased complication rates.

April 7

Trauma I

14:20–15:40

OP25/14:25–14:30

Paediatric femur fracture treatment: a multi-centre review of the pre and post 2009 American Academy of Orthopaedic Surgeons (AAOS) Clinical Practice Guidelines (CPG)

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Level-3

Upper and lower extremity trauma

Introduction The AAOS adopted a CPG (2009) for paediatric femoral shaft fractures when surgical treatment was becoming more popular, especially in younger patients. The purpose of this study was to analyze the treatment of paediatric femoral shaft fractures in the context of the AAOS CPG guidelines at a high-volume, geographically separated, paediatric trauma centers over a 10 year period straddling the AAOS CPG to determine if CPG changed treatment.

Materials and methods We reviewed an IRB-approved consecutive series of paediatric femoral shaft fractures (ages 0–18 years old) from 4 high-volume, geographically distant Level I pediatric trauma centers between 2004 and 2013 (5 years pre and post 2009 CPG). The treatment method was analyzed by centre and age group.

Results Of the 2646 patients with femoral shaft fractures, 1604 (58 %) were treated non-operatively. There were 568 fractures (21 %) treated with flexible intramedullary nailing (FIMN) (mean 7.7 years old; 1.5–17.7 years old), of which, 14 % were <5 years old. There were 309 fractures (11.7 %) treated with locked IM nails (LIMN) (mean 13.3 years old; 6.9–18 years old), of which 53 (17.2 %) were <11 years old. Plating was used 196 fractures (7.4 %) (mean 8.2 years old, 2.6–16.6 years old) and 1.5 % were <5 years old. Analysis pre/post 2009 AAOS CPG publication revealed a significant increase in the use of LIMN in patients <11 years old (0.56–3.84 %) $p < 0.001$. There was an also increase in surgical management regardless of technique for patients <5 years old (6.4–8.3 %). There were treatment differences between centers, most notably 74 % of fractures treated with plating were performed at center 4. Other center based variations include Center 2 having the highest rate (41 %) of FIMN in children <5 years old and Center 1 having the highest rate (63 %) of LIMN <11 years old.

Conclusion A decade-long analysis of pediatric femur fracture treatment at four paediatric trauma centers shows continued trends towards operative management in younger children. Following AAOS CPG publication, significant increases in LIMN in patients <11 years old and the increased surgical treatment in patients <5 years old has occurred. There was considerable variability in treatment method and CPG adherence between centers.

Significance This study highlights the need for further outcome studies to determine the optimal treatment methods for paediatric femoral shaft fractures as well as the fact that there may be a need to update the AAOS CPG guidelines.

April 7

Trauma I
14:20–15:40

OP26/14:37–14:42

Diminished elbow range of motion does not affect functional outcomes in operatively treated supracondylar humerus fractures: a prospective study

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Level-2

Upper and lower extremity trauma

Introduction The purpose of this study is to evaluate prospectively the relationship between elbow range of motion (ROM) and functional outcome in children with supracondylar humerus fractures (SCHFX) using validated outcomes measures.

Materials and methods An IRB approved prospective enrollment of consecutive patients with operative SCHFX was performed over a 3-year period. Elbow ROM and carrying angles for operative and non-operative extremities were documented at final follow-up, and functional outcome was assessed using the Paediatric Outcomes Data Collection Instruments (PODCI) and the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) Outcome Measure. Patients were stratified by arc of motion differences between the operative and non-operative elbow. Paired student's *t* test and ANOVA were used to compare arc of motion to functional outcome scores.

Results 752 patients were enrolled during the study period. 62 (average age 5.4 years) completed functional outcome measures and had complete ROM data at final follow-up (average 13 weeks; range 10–31 weeks). Average flexion–extension arc was 136° in the operative extremity (−1.4° extension, 135° flexion) versus 146° in the nonoperative side (−4.3° extension, 142° flexion) which was significantly different ($p < 0.0001$). There were no differences at final follow-up between the operative and nonoperative extremities in average pronation-supination arc (162° vs. 163°) or average carrying angle (5.3° vs. 5.5°). There were no statistically significant differences in PODCI or QuickDASH scores between those achieving <90 % flexion/extension arc of the nonoperative side when compared to those with ≥90 %, nor for those operative elbows with >1 standard deviation difference from the nonoperative side in flexion/extension arc versus those within 1 standard deviation. Due to the lack of statistically significant differences in outcome measures between these groups, controlling for other injury parameters such as patient age, fracture classification, neurologic injury, and vascular abnormality was not necessary.

Conclusion While operatively treated SCHFX may result in an average 10° decrease in flexion/extension arc of motion, this did not affect functional outcomes in this cohort.

Significance This is the first study prospectively to evaluate the relationship between elbow ROM and functional outcome using validated outcome measures following the operative treatment of children with SCHFX.

April 7

Trauma I
14:20–15:40

OP27/14:42–14:47

Vascular examination predicts functional outcomes in supracondylar humerus fractures: a prospective study

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Level-2

Upper and lower extremity trauma

Introduction To evaluate prospectively the relationship between vascular abnormality at presentation and functional outcome in children with supracondylar humerus fractures (SCHFX) using validated outcome measures.

Materials and methods: An IRB approved prospective enrollment of consecutive patients with operative SCHFX was performed over a 3-year period. Among other injury parameters, the presence and symmetry of the radial pulse in comparison to the uninjured extremity was documented by the treating surgeon at presentation. Doppler examination of all non-palpable pulses was documented as was the perfusion status of the hand. Functional outcome was assessed at final follow-up using the Paediatric Outcomes Data Collection Instruments (PODCI) and the quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) Outcome Measure. Multiple regression analysis was used to determine the relationship between the presence of a vascular abnormality and functional outcome while controlling for other injury parameters including patient age, fracture classification, fracture pattern, neurological deficit and the presence of an open fracture.

Results 752 patients were enrolled during the study period of which 199 (average age 6.7 years) completed functional outcome measures at final follow-up. Of these, 24 (12 %) patients had an abnormal vascular exam at initial presentation: 11 (5.5 %) with a palpable asymmetric pulse and 13 (6.5 %) with a non-palpable pulse. Of those with a non-palpable pulse, 10 (5 %) were dopplerable and 3 (1.5 %) had no identifiable Doppler signal. Patients with a symmetric, palpable pulse demonstrated better outcomes in PODCI pain and comfort scale scores (95.2 vs. 85.2) ($p < 0.002$), PODCI upper extremity scores (93.4 vs. 87.2) ($p < 0.05$), and QuickDASH scores (10.9 vs. 21.6) ($p < 0.003$) compared to those with any abnormal vascular examination. Patients with a palpable pulse, regardless of symmetry, demonstrated significantly higher PODCI pain and comfort scale scores (94.6 vs. 84.7) ($p < 0.02$) compared to those with nonpalpable pulses. No other statistically significant differences in outcome scores were found between patients with different types of abnormal examinations (palpable asymmetric vs. nonpalpable dopplerable vs. nonpalpable nondopplerable).

Conclusions In children with operative supracondylar humerus fractures, the presence of an abnormal vascular examination at presentation is predictive of poorer outcomes with regards to pain and upper extremity function at final follow-up.

Significance This is the first study prospectively to determine an association between vascular examination at presentation and functional outcome using validated outcome measures following the operative treatment of children with SCHFX

April 7

Trauma I

14:20–15:40

OP28/14:47–14:52

Pulseless supracondylar humerus fracture with anterior interosseous nerve or median nerve injury: an absolute indication for open reduction?

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Level-3

Upper and lower extremity trauma

Introduction Management of the pulseless supracondylar humerus fracture remains controversial. In particular, the combination of pulseless supracondylar humerus fracture and anterior interosseous nerve (AIN) or median nerve injury may have increased overall risk. The purpose of this study was to assess the necessity for open versus closed surgical management of pulseless supracondylar humerus fractures with concomitant anterior interosseous nerve (AIN) or median nerve injury in children.

Materials and methods A retrospective review was performed at three pediatric trauma hospitals on all children age 5–15 who sustained a Gartland type III or type IV supracondylar humerus fracture with the combination of absent distal palpable pulses and AIN or median nerve injury between 2000 and 2014. In addition to choice of treatment, details regarding preoperative and postoperative examination findings, follow-up course, and outcome were also recorded.

Results 76 patients with displaced Gartland type III or type IV supracondylar humerus fractures presented with the combination of absent distal pulses and AIN or median nerve injury and met the inclusion criteria. 21 of 76 (27.6 %) cases underwent open reduction with antecubital fossa exploration (OR) versus 55 (72.4 %) that were treated with closed reduction and percutaneous fixation (CR). Indications for open reduction included concern for artery entrapment (n = 11), inadequate closed reduction (n = 9), and concern for nerve entrapment (n = 6). The risk of compartment syndrome was higher in open cases (5/20, 25.0 %) than closed cases (1/55, 1.8 %) (p = 0.001). The incidence of reoperation was also higher with open cases (4/20, 20 %) than closed cases (2/55, 3.6 %) (p = 0.021). Open reduction was also significantly associated with increased time to surgery (18.7 h ± 31.1 vs 9.0 h ± 4.8, p = 0.026) and length of hospitalization (4.0 days ± 4.2 vs 2.0 days ± 1.6, p = 0.004) compared to closed reduction. Overall, all but 6 of 76, (7.9 %) patients ultimately had complete resolution of preoperative nerve palsy with no significant difference in rate of clinical nerve recovery between the treatment groups (20/21 [95.2 %] in OR, 50/55 [90.9 %] in CR) (p = 0.531).

Conclusion Outcomes following open and closed surgical management of pulseless grade III or IV supracondylar humerus fracture with AIN or median nerve injury are ultimately both favorable and may suggest that open reduction is not always necessary.

Significance New evidence demonstrates treatment of some paediatric pulseless supracondylar humerus fractures with AIN or median

nerve injuries may be accomplished via closed rather than open reduction—in many cases, potentially decreasing hospital times and costs.

April 7

Trauma I

14:20–15:40

OP29/14:52–14:57

Supracondylar humeral fractures: frequency of bicolumnar and extra-capsular lateral entry pin fixation

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Level-4

Upper and lower extremity trauma

Introduction The purpose of this study is to evaluate the quality of type III supracondylar humerus lateral entry pin fixation constructs at a level 1 academic trauma hospital by assessing whether medial and lateral column fixation was obtained and whether the starting point is extra-capsular.

Materials and methods This is a retrospective review of type III supracondylar humerus fractures percutaneously fixed with lateral-entry pins January 2013–June 2015. Fluoroscopic images were used to create a longitudinal line bisecting the humerus and a transverse line in the plane of the fracture. If there was at least one lateral-entry pin crossing through the proximal lateral quadrant into the far cortex and another crossing through the distal medial quadrant into the far cortex then bicolumnar fixation was achieved. Also, if the starting point of the pins was on the lateral side and above the mid-waist of the capitellum on the AP and within the cortical outlines of the “hourglass” on the lateral it was considered extra-capsular.

Results 111 type III supracondylar humerus fractures with all lateral-entry pin constructs were evaluated. Sixty-one (55.0 %) achieved bicolumnar fixation and 50 (45.0 %) were fixed using what appeared to be extra-capsular pin entry sites. However, only 27 (24.3 %) of the lateral entry pins were both bicolumnar and extra-capsular.

Conclusion There are a high proportion of type III supracondylar humerus fractures that do not achieve bicolumnar lateral-entry pin fixation, which may result in a less biomechanically stable construct. Also, a high proportion of supracondylar humerus fractures are being fixed with what appear to be intra-capsular pin entry sites. Currently, the relevance of intra vs extra-capsular starting sites have not been determined.

Significance Lateral entry pinning of supracondylar humerus fractures is one of the most frequent paediatric orthopaedic procedures performed. Greater divergence of the lateral entry pins crossing the fracture site improves stability, and pins that have an intra-capsular starting point theoretically are at increased risk of intra-articular infection.

April 7

Trauma I

14:20–15:40

OP30/15:10–15:15**Comparison of real-time sonography assisted fracture reduction (safr) versus conventional radiography control reduction in children with displaced forearm fractures**Pavel Kotlarsky¹, Rostislav Novak¹, Oren Feldman¹, Mark Eidelman¹¹Rambam Healthcare Campus, Haifa, Israel**Level-2****Upper and lower extremity trauma**

Introduction Forearm fractures in children and adolescents are very common. Many are displaced and require reduction. Radiography is essential for evaluation of the fracture and the reduction. However it is not always available, and performed after reduction and casting. This may lead to multiple reduction attempts and unsatisfying final results. Ultrasonography is widely available, allows visualization of cortical disruption and therefore, can provide real-time information regarding the quality of reduction. The purpose of this study was to compare real-time sonography assisted fracture reduction with conventional radiography control reduction in children with displaced forearm fractures.

Materials and methods We compared two groups of patients with displaced distal forearm fractures—one treated with real-time SaFR, and another one treated with the conventional method of reduction without real-time image guidance. Only patients with severely displaced distal forearm fractures were included. In all patients fracture reduction was performed in the emergency department under sedation. In patients treated with SaFR, ultrasonography was performed before casting in two planes—dorsal and lateral and if necessary additional manipulation was immediately performed. All fractures were examined with conventional radiography after cast application.

Results 80 patients with displaced distal forearm fractures were included; 30 treated with SaFR and 50 treated with the conventional method of reduction. Mean age was 9 years (range 3–13 years) in the SaFR group and 10 years (range 3–14) in the conventional treatment group. None of the patients in the SaFR group required remanipulation. In the conventional treatment group 8 % (4 out of 50) of patients underwent additional sedation, cast removal and repeated manipulation, due to residual fracture malalignment. All patients were treated conservatively without surgery.

Conclusion SaFR is a reliable and accurate method of correction of displaced forearm fractures in children.

Significance Based on our experience SaFR seems to be superior compared to conventional methods of reduction.

April 7

Trauma I

14:20–15:40

OP31/15:15–15:20**Risk factors for complications in open forearm fractures in the paediatric population**Robert Wimberly¹, Adam Hines², Marilyn Elliott³, Daniel Sucato³, Anthony Riccio³¹Texas Scottish Rite Hospital for Children, Dallas, USA; ²Tripler Army Medical Center, Tripler AMC, USA; ³Texas Scottish Rite Hospital, Dallas, USA**Level-3****Upper and lower extremity trauma**

Introduction Infection and re-fracture are well-known complications following open paediatric forearm fractures. The purpose of this paper is to determine the incidence of these complications and to identify predictors for their occurrence specifically analyzing factors related to the patient, injury pattern, and treatment following the surgical management of paediatric open forearm fractures.

Materials and methods This is an IRB-approved retrospective review of a consecutive series of patients who had an open forearm fracture treated at a single-institution paediatric level 1 trauma center from 2007 to 2013. A medical record review and radiographic analysis was performed for each patient.

Results There were 262 patients, 207 boys and 55 girls, at an average age of 9.7 years. The Gustillo-Anderson classification was type 1 in 219 (83.5 %), type 2 in 39 (14.1 %) and type 3 in 4 (1.5 %) patients. All patients had an irrigation and debridement in the operating room. The overall incidence of infection was 3.4 % (9 patients). The only predictor for developing infection were patients who were noted to have a contaminated wound at the initial debridement (21 vs. 2.2 %, $p = 0.002$) There were no differences seen with regard to timing of antibiotics ($p = 0.87$), time to formal debridement ($p = 0.20$), Type 1 versus Type 2 or 3 open fractures (3.4 vs 5.0 %, $p = 0.64$), 24 vs. 48 h of post-operative IV antibiotics (5.2 vs 3.5 %, $p = 0.53$), or when comparing diaphyseal, distal, and Monteggia fracture patterns (3.6 vs. 2.9 % vs. 5.9 %, $p = 0.81$) or when comparing buried or exposed intramedullary implants (3.5 vs. 4.2 %, $p > 0.99$). The overall refracture rate was 2.3 % (6 patients) and did not correlate with the type of open wound type ($p > 0.99$) or fracture pattern (0.4973), although 5 of the 6 re-fractures were in diaphyseal injuries. 28 (10.7 %) patients returned to the operating room for additional treatment; 21 of which were for removal of implants after healing.

Conclusion The incidence of infection following open both bone forearm fractures in children is 3.4 % and correlates primarily with the contamination seen at the time of the initial debridement.

Significance Careful evaluation of the degree of contamination at the time of the initial debridement should direct surgeons to more aggressive and repeated debridement to reduce the risk of infection.

April 7Trauma I
14:20–15:40**OP32/15:20–15:25****Treatment of long finger hyperextension injuries in children participating in ball game activities. the development of a clinical decision guide**Christina Steiger¹, Aron Grazioli², Júlia Armenter Duran², Victor Dubois Ferriere², Dimitri Ceroni²¹Hôpitaux Universitaires de Genève, Genève, Switzerland; ²Hôpitaux Univ. de Genève, Genève, Switzerland**Level-2****Upper and lower extremity trauma****Introduction** Hyperextension injuries of the long fingers are common in the paediatric population. However, exact guidelines regarding their diagnosis and treatment do not exist. The objective of this 5-year prospective study was to develop a clinical decision guide for the diagnosis and treatment of these injuries which improves diagnostic accuracy while reducing unnecessary and cost-intensive investigations.**Materials and methods** Three-hundred consecutive patients under 16 years of age were included in the study. Patients were eligible for study participation when presenting with acute long finger hyperextension injuries acquired during ball game activities. To establish high and low-risk parameters for severe finger injury, standardized clinical examinations and finger radiographs were conducted. Four standardized clinical variables (location of pain, swelling and bruising, stability and mobility) were assessed and recorded in medical charts by emergency physicians before radiography. Standard finger radiographs were inspected by a board-certified paediatric radiologist and by a senior paediatric orthopedic surgeon in order to determine the exact lesion. All bony lesions present on a radiograph were compiled and their risk to cause late complications was analyzed. Furthermore the predictive value of the clinical examination in the identification of low risk injuries was assessed.**Results** Sixty-seven per cent of children consulting for a finger trauma due to hyperextension did not have any fractures. No child with a low risk clinical examination (no instability and only moderate restriction of mobility) of the injured finger had a subsequent high-risk diagnosis (relevant intra-articular fracture, instability). Clinical high-risk diagnoses was revealed in only 11 significant fractures.**Conclusion** The present study shows that in the majority of cases treatment decisions after hyperextension finger injuries could be based on clinical evaluation alone. Using the developed clinical decision guide the likelihood of missing significant high-risk lesions is expected to be very low and the majority of radiographs currently undertaken could be avoided. Once the method is fully validated clinicians will be able to apply it without endangering patient health, substantially reduce treatment costs and improve patient flow in the emergency department.**Significance** Level II prospective study.**April 7**Trauma I
14:20–15:40**OP33/15:35–15:44****Tibial spine fracture versus anterior cruciate ligament injury in children: a comparison of association injuries**Francisco Fernandez¹, Thomas Wirth¹, Oliver Eberhardt¹¹Olgahospital, Stuttgart, Germany**Level-3****Upper and lower extremity trauma****Introduction** Tibial spine fractures (TSF) and anterior cruciate ligament injury (ACLI) in childhood are severe and rare injuries to the knee. In the literature no prospective comparative data of the respective associated injuries is found. This research presents a prospective review of clinical records and operative reports to characterize the incidence of concomitant injuries in tibial spine fractures and anterior cruciate ligament injury.**Materials and methods** A total of 203 children with TSF or ACLI were treated surgically over a period of 10 years. The average age of children with TSF was 10.4 years, and in ACLI 12.6 years. The type I-TSF (according to the Myers and McKeever classification) were excluded because of conservative treatment in all cases. All children who were operated on were included. 98 type II or type III-TSF and 103 ACLI were analyzed. The basis for the study were clinical reports, imaging results and operative findings.**Results** In 31 % of children with TSF and 63 % of the ACLI-group associated injuries were found intraoperatively. Associated injuries were: in patients with TSF meniscal entrapment (14 %), meniscal tears (7 %), lesions of the medial ligament (6 %), and chondral injuries (4 %); in patients with ACLI meniscal tears (40 %), lesions of the medial ligament (16 %), partial lesions of the posterior cruciate ligament (3 %), chondral injury (4 %). Coincident medial and lateral meniscal tears occurred in 2 children. Meniscal surgery was necessary in 5 cases of the TSF-group and in 35 cases of the ACLI-group.**Conclusion** Concomitant injuries showed significant differences according to number and severity. While in tibial spine fractures entrapped ligaments were most frequent, meniscal tears, lesions of the medial ligament or chondral injuries were rare. By comparison, severe meniscal tears (up to bilateral lesions) are common in the ACLI group. Their treatment is more complex. Additionally, partial ruptures of the posterior cruciate ligaments occur, which are not found in the TSF group.

April 7

Trauma I

14:20–15:40

OP34/15:44–15:45**Compartment syndrome in infants and toddlers**Alexander Broom¹, Alexandre Arkader², Alex Gornitzky³, John Flynn³, Paul Choi²¹Children's Hospital Los Angeles, Los Angeles, USA; ²Children's Hospital Los Angeles, Los Angeles, USA; ³CHOP, Philadelphia, USA**Level-4****Upper and lower extremity trauma**

Introduction Acute compartment syndrome is a serious orthopaedic emergency and can affect children and adults. We studied the cause, diagnosis, treatment and outcome of acute compartment syndrome in infants and toddlers younger than 3 years old.

Materials and methods Eighteen patients younger than 3 years were identified with acute compartment syndrome from two large paediatric trauma centers over a fifteen-year period. All children underwent fasciotomies. The mechanism of injury, time of injury, time to diagnosis, compartment pressures, time to fasciotomy, and outcome at the time of the latest follow-up were recorded.

Results Nine (50 %) of eighteen patients developed compartment syndrome secondary to trauma; five (of 18, 28 %) due to infection; and four (of 18, 22 %) due to intravenous infiltration. The average time from injury or hospital admission to fasciotomy was 34.5 h (range 2.9–136.3 h). In general, the functional outcome was excellent at the time of the latest follow-up with sixteen (of 18, 89 %) patients having excellent outcome. No cases of Volkmann's ischemia were noted at time of fasciotomy—even when performed as late as 5 days after injury.

Conclusion Compared to the general paediatric population, the diagnosis of compartment syndrome in infants and toddlers may be further delayed—beyond 24 h after injury. The diagnosis of compartment syndrome in this younger population is an extreme challenge, and heightened awareness is needed. Trauma induced fractures appear to be the most common cause of compartment syndrome in infants and toddler. However, one should be suspicious of compartment syndrome in the setting of infection, IV infiltration, and non-accidental trauma.

Significance Despite delays in diagnosis and time to treatment, the present study shows that the outcomes in infants and toddlers remain favorable even when fasciotomy is performed 48–72 h after injury.

April 7

Tumors; Infection

16:15–17:29

OP35/16:15–16:20**A comparative study of the treatment of simple bone cysts of the humerus: open curettage and bone grafting with or without instrumentation or intramedullary nailing**Bulent Erol¹, Tolga Onay¹, Mert Osman Topkar¹, Abbas Tokyay¹, Ahmet Nadir Aydemir¹¹Marmara University Hospital, Istanbul, Turkey**Level-3****Tumours**

Introduction There is no standard approach to the treatment of simple bone cysts (SBCs). None of the conventional and new techniques demonstrate a significant advantage over the others. Functional and radiographic outcomes, in addition to complications and re-operation rates of open curettage and grafting without instrumentation or with intramedullary nailing in the treatment of humeral SBCs were compared.

Materials and methods Between 2007 and 2013, 37 children [25 male, 12 female; the mean age 9.5 years (range 3–17 years)] who had a SBC of the humerus were treated with curettage and grafting without instrumentation (Group 1, 21 patients) or with intramedullary nailing (Group 2, 16 patients). The pathological fracture rate was high in both groups (Group 1, 85.7 %; Group 2, 87.5 %). The success of these techniques was compared in terms of functional and radiographic outcomes, in addition to complications and re-operation rates (for complication, fracture union, cyst healing).

Results The follow-up time ranged from 26 to 85 months. The mean last follow-up Musculoskeletal Tumor Society (MSTS) functional scores for Group 1 and 2 were 28.9 and 29.5. A shorter average time period was required for complete functional recovery (7.5 versus 9.5 weeks) and fracture union (7 versus 9 weeks) in Group 2 compared to Group 1. Group 2 patients also had a higher complete or significant partial radiographic healing rate (100 % versus 76.1 %). The recurrences (2/21 patients; 9.5 %) were occurred within 1 year in Group 1. The complication and re-operation rates were 19/14.2 % and 25/6.25 % for Group 1 and 2.

Conclusion Even though, perfect functional results were possible only with open curettage and grafting, internal fixation and continuous decompression with elastic intramedullary nails provided a shorter functional recovery and fracture union time, in addition to higher radiographic healing rates.

Significance The combination of open mechanical destruction of the cyst membrane and continuous intramedullary decompression of the cyst cavity by elastic nails provides an effective option in the management of SBCs.

April 7

Tumors; Infection 16:15–17:29

OP36/16:20–16:25

Internal fixation improves outcomes for unicameral bone cysts of the proximal femur in children

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Level-3

Tumours

Introduction There is little data to guide the treatment of unicameral bone cysts (UBC) of the proximal femur. Treatment methods include corticosteroid injection as well as curettage and bone grafting, with or without internal fixation. Our purpose was to analyze the treatment of proximal femoral UBCs and compare the outcomes of those treated with or without internal fixation.

Materials and methods An IRB approved, retrospective review of 23 patients treated for UBC of the proximal femur at a single institution between 1997 and 2014 was performed. Medical records and radiographs were reviewed to identify patient and lesion characteristics, as well as treatment specifics, tumour recurrence, and pathologic fracture. Seventy-eight percent of patients were male and had a mean age of 12 years (range 5–24 years) with an average follow-up of 62 months (range 6–438 months).

Results Tumours were located in the femoral head in 8 patients, intertrochanteric region in 8 patients, and subtrochanteric region in 7 patients. Eight patients presented with a pathologic fracture. Initial treatment included serial steroid injection (n = 1), curettage and bone grafting (n = 6), internal fixation (n = 4), and curettage plus internal fixation (n = 12). Mean time to radiographic healing following treatment was 10 months (range 2–20 months) and return to full activity was 5 months (range, 6–20 months). Multiple procedures were required for 8 (35 %) patients prior to radiographic evidence of healing, and 4 (17 %) patients sustained a post-intervention fracture. Patients younger than 10 years old, those who presented without a fracture, and those whose treatment did not include internal fixation, had a statistically significant increased risk of recurrence requiring additional treatment (p < 0.05). At one year, Kaplan–Meier survival free of subsequent treatment was improved in patients treated with internal fixation compared to those without (Log-rank p = 0.01).

Conclusion Significant reduction in recurrence was observed in patients who were treated with internal fixation at the time of their index UBC procedure.

Significance Internal fixation should strongly be considered when treating UBC's of the proximal femur.

April 7

Tumors; Infection
16:15–17:29

OP37/16:25–16:30

A surgical treatment protocol for proximal femoral benign bone lesions in children and recommended surgical procedures. a retrospective analysis of 62 patients

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Level-4

Tumours

Introduction The proximal femur is one of the most common locations for benign bone lesions in children and adolescents. Surgical intervention frequently is required to manage these lesions. We retrospectively analyzed the long-term clinical, functional, and radiological results of 62 children treated surgically for bone cysts and NOFs of the proximal femur, and aimed to develop a treatment strategy with recommended surgical procedures.

Materials and methods Sixty-two children with benign bone lesions of the proximal femur were surgically treated between 2005 and 2013. The median age of patients (38 M/24F) at surgery was 9 years (range, 5–17 years). Histopathological diagnoses were simple bone cysts (31), aneurysmal bone cysts (27), and non-ossifying fibromas (4). All lesions were symptomatic, and the majority were associated with actual micro-fractures (20; 32.25 %) or displaced fractures (28; 45.2 %). Surgical treatment was determined due to 4 criteria including patient's skeletal maturity, localization and initial diagnosis of the lesion, and the amount of bone loss in the femoral neck and lateral proximal femur. The surgical procedures consisted of biopsy, curettage, bone grafting and, when required, internal fixation. The median follow-up was 45 months (range, 25–89 months).

Results 2Complete clinical recovery was achieved in 90.3 % of patients between 5 to 8 months postoperatively. Full weight-bearing and mobilization, without pain and limping was possible. The median preoperative and postoperative last follow-up Musculoskeletal Tumor Society (MSTS) scores were 13.3 % (range, 10–23.3 %) and 96.6 % (range 90–100 %), respectively (p < 0.0001). The pathological fractures were healed at an average of 10 weeks (range 8–12 weeks). All lesions radiographically responded well to treatment, and 92 % demonstrated complete or significant partial healing between 5 to 7 months that was maintained throughout follow-up. There were 6 (9.7 %) early or late complications, including superficial wound infection (1), skin necrosis (1), mild varus malunion of the proximal femur (2), shortening of the femoral neck (1), and re-fracture (1). Two patients (3.2 %) required re-operation for complications.

Conclusion This treatment protocol, based upon retrospective review of a large series, provided effective treatment options for different types of lesions in this particular region, with good local tumor control and excellent long-term functional and radiological results.

Significance This protocol can be used as a guideline in the management of pathological fractures for benign lesions of the proximal femur, which can be a challenge in children.

April 7

Tumors; Infection
16:15–17:29

OP38/16:40–16:45**MRI evaluation of ewing's tumours. radiological and anatomical correlation**

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Level-3**Tumours**

Introduction The goal of surgery in Ewing's tumour is to remove the tumour by passing through healthy tissue, while preserving maximum function. Therefore surgical planning is important. Several studies have shown the benefits of MRI in determining the regional extension of the tumour. Current guidelines recommend that surgical planning is based upon pre-chemotherapy MRI. However, there is a controversy whether pre or post chemo MRI enables the best planning. The goal was to determine which investigation provides the best surgical planning.

Materials and methods This was a single center retrospective study. 50 Ewing tumours were treated between 2005 and 2015 in our institution. 24 cases involved long bones. 2 cases were excluded because MRI was not interpretable. 22 Ewing tumours of limbs were eventually included: 7 femurs, 5 tibia, 5 fibula, 4 humerus, 1 ulna. The average age was 17 years. MRI analysis was performed on three sequences (T1, T1 gadolinium, T2 Fat sat or Stir). MRI before chemotherapy and after chemotherapy were analyzed by 2 radiologists. The distance of the limit of the tumour from the bone extremity on MRI (proximal and distal joint limits) was compared with the histology of the resection specimen. Statistical analysis was performed with the software MedCalc.

Results The inter and intra observer reproducibility were excellent (correlation coefficients between 0.97 and 0.99). Tumour margins were significantly different between the MRI pre and post chemotherapy for all MRI sequences studied ($p < 0.005$). Correlation between MRI pre chemotherapy and histology was 0.96 (T1), 0.91 (STIR), 0.94 (T1 gadolinium). Correlation between MRI post chemotherapy and histology was excellent 0.99 for the 3 sequences.

Conclusion Post chemotherapy MRI provided a more accurate assessment of the limits of Ewing's tumour. Surgical planning can therefore be based on post chemotherapy MRI. Surgical cuts can be only 1–2 cm away from the limits as seen on MRI. This is of major concern in children especially with metaphyseal tumours locations where accurate planning helps to preserve the joint or the growth plate.

April 7

Tumors; Infection
16:15–17:29

OP39/16:45–16:50**Functional outcomes of biological reconstruction after wide resection for malignant tumor of the proximal humerus in children: clavícula pro humero versus arthrodesis**

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Level-4**Tumours**

Introduction The reconstruction of the proximal humerus in children must be stable, durable and biological such as: arthrodesis and Clavícula Pro Humero (CPH). We purpose a comparison of the functional outcomes and complications of these two techniques.

Materials and methods Seven CPH and 12 arthrodesis after sarcoma resection of the proximal humerus in children from 8 to 19 years were included. For obtaining a fusion, 16 vascularized fibular autograft were used (CPH = 6, arthrodesis = 10) or a Masquelet induced membrane procedure (CPH = 1, arthrodesis = 2). Postoperative immobilization was 3 weeks in the CPH group using an arm sling and 3 months in the Arthrodesis group using a shoulder cast in abduction position. The active range of motion and the functional scores (MSTS-ULRS and TESS) were assessed for the last follow-up (CPH = 2.6 years, arthrodesis = 7.2 years).

Results The average range of motion in abduction, external rotation (ER), internal rotation (IR) and flexion were in each group 64° vs 42°, 12° vs -7°, 86° vs 73° and 66° vs 51°. The MSTS-ULRS and TESS scores were 22 vs 16 and 83 % vs 76 % respectively. ER and MSTS-ULRS score were significantly better in "CPH" group. There was no significant difference in time to bone healing between both groups. Fourteen complications in the CPH group including 5 distal clavicle non unions and 26 complications in Arthrodesis group including 3 non unions of the distal junction, 3 cases of swinging arm and 3 graft necrosis were listed.

Conclusion Biological reconstructions has the advantage of keeping bone mass in children. Arthrodesis and CPH are two effective techniques. CPH would get a better external rotation and a functional gain without loss of internal rotation. The non union of the distal clavicular junction is common. The CPH is a simple technique of reconstruction of the proximal humerus in children without restrictive immobilization. When the resection involved the shoulder fixators, both CPH and

arthrodesis can be used with a potential functional gain in the CPH procedure.

Significance After wide resection of the shoulder, CPH reconstruction provides a good functional outcome, associated with a relative simple procedure, and with a better rate of bone union in comparison with arthrodesis.

April 7

Tumors; Infection
16:15–17:29

OP40/16:50–16:55

Function and quality of life in adolescents undergoing resection of a malignant bone tumor of the lower limb and reconstruction by arthroplasty with a megaprosthesis

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Level-4

Tumours

Introduction Modular megaprotheses are one of the most common methods of reconstruction after segmental resection of the long bones in the lower extremities, with variable outcomes and failure rates reported in the literature. The purpose of our study is evaluate the survival, functional status and overall satisfaction of adolescents undergoing resection of malignant bone tumors of the lower limb and reconstruction with non-expandable arthroplasty with megaprosthesis. **Materials and methods** We performed a retrospective cohort study of the patients undergoing resection of malignant bone tumor of the lower limb and reconstruction with non-expandable megaprosthesis, in our institution, in the period 1994–2014. Data was collected from the medical records, regarding patients' demographics, duration and modalities of treatment, complications and need for additional surgeries. Standing full-length X-Rays of the lower limbs were used for measuring the final limb length discrepancy and the Musculoskeletal Tumor Society Scale (MSTS) and KidScreen 10 questionnaire were applied for functional assessment.

Results We included 20 patients in this study, 10 males and 10 females, with average age of 14.2 ± 3.3 years at diagnosis. The predominant tumor type was osteosarcoma (77 %) and the main location was the distal femur (45 %). The majority of patients presented in Enneking stage IIB (77 %). Overall chemotherapy treatment was undertaken for 12.7 ± 7.7 months. For reconstruction, an arthroplasty of the hip was used in 16 cases and a knee arthroplasty in 4 cases. Two patients died, yet retaining their implants. The Follow-up time for the living patients was 84.4 ± 68.2 months. There were complications in 10 patients (45 %): 6 cases (27 %) required further surgery. Two patients lost their arthroplasty due to infection. The final limb length discrepancy was $6.6 \text{ mm} \pm 5.8$. Age at the functional assessment of the patients was 21.4 ± 5.8 years. The MSTS score was 22.5 ± 4.9 and the Kidscreen-10 average score was 75.8 %.

Conclusion The treatment of malignant bone tumors by resection and reconstruction with arthroplasty with non-expandable megaprosthesis involves a high rate of complications, but allows good longevity of the reconstruction and reasonable functional outcomes. In spite of

some physical limitations, the majority of patients in our institution have a good quality of life.

Significance This study allows us to understand the function and quality of life in adolescents undergoing resection of a malignant bone tumor of the lower limb and reconstruction by arthroplasty with a megaprosthesis.

April 7

Tumors; Infection
16:15–17:29

OP41/17:05–17:10

Risk factors of longer hospital stays in paediatric bone and joint infections in France

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Level-2

Musculoskeletal infections

Introduction Paediatric Bone and Joint Infections (PBJI), even if rare (22/100,000 in France in 2008), can cause growth disturbance and joint sequelae. Recent published studies suggest that a short intravenous treatment (2–5 days) could be effective, allowing a fast discharge, especially because PBJI are mainly discharged home (93 % in France in 2008). The objective of this study was to analyse the factors associated with hospital stays longer than 5 days (> 5 days) in PBJI, using 2013 French National Hospital Discharge Database (NHDD).

Materials and methods Hospital discharges of children <15 years (y) with haematogenous PBJI were selected using a validated NHDD algorithm based on specific diagnosis and surgical procedure codes. Descriptive analyses were conducted to evaluate the French incidence of PBJI. Patient and hospital characteristics (type of stay and hospital) were analysed in order to identify risk factors of a stay greater than 5 days using uni- then multivariate logistic regression modelling. Interactions could exist and will be tested to confirm the preliminary results exposed in this abstract.

Results PBJI were identified in 2,717 patients. The national incidence was 22/100,000, mainly in males (26/100,000) and in 1 year old children (80/100,000). Septic arthritis represented 50 % of cases, osteomyelitis 46 % and spondylo-discitis 4 %. Twenty-eight percent of patients had a micro-organism coded (*Staphylococci* 50 %) and 4 % had at least one comorbidity. The mean hospital length of stay (LOS) was 7.3 days, costing €5,075 per stay. Half of PBJI patients (49 %) had hospital LOS >5 days. No difference on rehospitalisation was observed between short and long PBJI stays. Patient factors associated with longer stays were being an infant (<1 year), having a bacterium coded (4.7 [3.0–7.3]) and having a sickle cell disease (6.8 [2.8–16.6]). As compared to septic arthritis, having a spondylo-discitis (OR [95 %CI] = 2.2 [1.4–3.4]) was associated with longer stays, whereas no difference was observed with osteomyelitis (0.9

[0.8–1.1]). On the contrary, viral infections were associated with less LOS >5 days (0.6 [0.4–0.9]), probably corresponding to reactive arthritis. Hospital factors associated with longer stays were hospitalisation in a General Hospital as compared to a Teaching Hospital (1.6 [1.4–1.9]).

Conclusion This national study showed the unchanging PBJI incidence in France. However, half of the hospital stays were longer than expected, with regarding to recent scientific evidence in favour of shorter intravenous treatment regimen. An publicity effort must be provided to improve knowledge and widespread use of short treatment regimen.

April 7

Tumors; Infection
16:15–17:29

OP42/17:10–17:15

The changing bacteriological epidemiology of osteoarticular infections in children

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Level-2

Musculoskeletal infections

Introduction Over the last decade, the development and extent use of molecular diagnostic methods in osteoarticular infections (OAI) has changed their bacteriological epidemiology in children. The aim of this study was to report the most frequently isolated pathogens in bone and joint infections in different age groups of the paediatric population.

Materials and methods Children aged between 0 and 15 years admitted to our institution between January 2007 and December 2014 for suspected OAI were enrolled in this retrospective study (199 cases). Age, gender, clinical signs, duration of symptoms, bone or joint involved, imaging studies, and laboratory data, including bacterial investigations were collected for analysis.

Results Identification of the microorganism was possible for 62.3 % of the infected children (124 cases). Classical isolation methods yielded pathogen identification in bone biopsy specimens, joint fluids or disk samples in 47 cases on a total of 162 exams carried out (29.0 %). Pathogens were recovered from blood cultures in 38 cases in a total of 160 exams carried out (23.8 %). Detection and identification of osteoarticular pathogens in blood, bone biopsy specimens, joint fluids or disk samples was made possible by using molecular probes in 75 additional cases. The most commonly identified causative pathogens for OAI in our review were *K. kingae* (33.2 %), *MSSA* (23.6 %), *S. pyogenes* (2 %), *B. burdorferi* (1.5 %), *S. agalactiae* (1 %), and *H. influenzae* (1 %). In 5.5 % of cases, *K. kingae* was highly suspected to be the pathogen considering the result of oropharyngeal PCR assay and the biological evaluation, and in 9.5 % of cases it was retrospectively suspected considering specific clinical and biological criteria, with unavailable oropharyngeal PCR. When considering only the results of positive bacteriology specimens, *K. kingae* was responsible for 53.2 % of OAI and *MSSA* for 37.9 %.

Conclusion The present study has demonstrated a change in the epidemiology of children with osteoarticular infection. Contrary to

what is commonly observed, *Staphylococcus aureus* is no longer the leading causative pathogen of osteoarticular infection in children. Use of appropriate PCR assays has demonstrated that *K. kingae* is currently the major bacterial cause of pediatric OAI, especially in children less than 4 year-old.

Significance As classic cultures of blood, bone aspirates, or joint fluid usually fail to isolate the causative pathogen, it is recommended that PCR should be implemented in the routine microbiological investigations as it provides better diagnostic evidence.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP43/08:00–08:05

Abduction bracing versus natural history in hip dysplasia: multicenter randomized controlled trial

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Level-1

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Stable hip dysplasia is treated with abduction bracing till a normal bony roof angle on ultrasound or acetabular index on pelvis X-rays is adequate for the child's age. Little is known about the natural history. This Multicenter Randomized Controlled Trial was performed to study the outcome of treatment with abduction bracing versus no treatment in dysplastic hips without instability.

Materials and methods Children between 3 and 4 months of age with stable but dysplastic hips on ultrasound (Graf type IIB and IIC) of 5 participating hospitals were randomized to either Pavlik harness treatment group (59 patients) or no treatment group (53 patients). Patients with more severe Graf types or clinical instability and those who were previously treated were excluded from this study. At 6 and 12 weeks intervals, the ultrasound was repeated in all patients. As a standard of care, patients underwent a pelvis X-ray at the age of 9 months and after walking age. Residual dysplasia was assessed by measuring the bony roof angle according to Graf classification on ultrasound and acetabular index according to Tönnis classification on pelvis X-rays. One senior pediatric radiologist read all images.

Results After randomization, the treatment groups were fully comparable for all important predictors of outcome. The average increase in alpha angle in the Pavlik group over 6 weeks was 3.6°. In the non-treatment group this was 3°. At 6 weeks there was no difference in treatment effect: Pavlik group mean angle 58.8° ± 5.5°, non-treatment group 58° ± 5.2°, mean difference -1.39° (95 % CI -3.46, 0.67), p-value 0.18. At 12 weeks, values were 60.5° ± 3.8°, 60° ± 5.6° respectively, mean difference -1.0° (95 % CI -2.92, 0.91), p-value 0.30. Analysis of secondary outcomes showed no treatment differences at 9 months of age (p = 0.82) and at latest follow-up (p = 0.35) in Tönnis classification for residual dysplasia.

Conclusion The natural history of hips with stable dysplasia (Graf type IIB and IIC) showed a similar development and improvement as did the treated hips. The Pavlik harness did not improve overall outcome and both groups showed similar rates of normalization and residual dysplasia. This study indicates that these hips should not be treated, but follow-up is necessary to identify those hips that will fail to improve spontaneously.

Significance With time most Graf IIB and IIC dysplastic hips will resolve without treatment. Further research is needed to identify the hips that will fail to improve.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP44/08:05–08:10

Modified dunn procedure for slipped capital femoral epiphysis, 151 consecutive cases: the role of femoral head perfusion monitoring and post-operative bonescan

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Level-2

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction The 'Modified Dunn Procedure' via surgical hip dislocation for moderate to severe stable and unstable SCFE remains controversial. We present our experience of 151 consecutive cases (2008–2015), initially without and later with intra-operative monitoring of the femoral head perfusion using an ICP Pressure Probe (Codman®) and the correlation of intra-operative monitoring and post-operative SPECT-CT-Bonescan with femoral head collapse.

Materials and methods The operative technique is designed to preserve the femoral head blood-supply. From April 2011, the femoral head perfusion was monitored intermittently throughout the operation until after capsular closure. To avoid any tension on the supero-lateral capsular flap that is connected with the retinacular vessel, we modified the capsulotomy and repair. 150/151 patients had a post-operative 3-Phase-Bonescan with Pin-hole at day 5–7 and from 2011 a SPECT-CT. There were 96/151 stable [mean posterior sloping angle (PSA): 61 (35–90)] and 55/151 unstable slips [mean PSA 66 (35–90)]. Monitoring and/or SPECT-CT/Bonescan were correlated with radiological collapse in 75/151 cases with a minimum 18 months follow-up [mean 2.4 (1.6–4.3) years].

Results Prior to monitoring 21 % of stable slips (4/19) were non-viable on post-operative Bonescan. However since monitoring and modified capsulotomy all stable slips (77/77) were viable on post-operative SPECT-CT-Bonescan and 76/77 cases pulsatile on intra-operative monitoring. The one case with no intra-operative pulse (chronic, osteopenic, severe slip PSA 85) later collapsed. In the unstable group prior to monitoring 33 % (5/15) cases were non-viable post-operatively, this remained unchanged since monitoring with 33 % (13/40) non-viable cases. Pulsatile monitoring had a positive predictive value (PPV) of 100 % for no collapse in stable and 75 % in unstable slips. A viable SPECT-CT-Bonescan had a 98 % PPV in stable and 93 % PPV in unstable SCFE. Pulsatile intra-operative monitoring combined with a

viable SPECT-CT-Bonescan had a 100 % PPV for no collapse in both stable and unstable SCFE. Varying degrees of collapse occurred in 13/14 non-viable SPECT-CT/Bonescan cases despite Bisphosphonate-treatment and non-weight-bearing.

Conclusion Our results with monitoring and modified capsulotomy are encouraging for stable SCFE, where intra-operative monitoring (100 % PPV) may be sufficient alone to assess femoral head vascularity. In unstable SCFE we recommend a post-operative SPECT-CT-Bonescan to complement monitoring (100 % combined PPV). Further research into anabolic treatment strategies is required to stimulate bone healing and improve the currently high collapse rate of non-viable cases.

Significance Intra-operative monitoring and our modified capsulotomy increase the safety of this complex procedure and a SPECT-CT-Bonescan can help optimise the post-operative management particularly in unstable SCFE.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP45/08:10–08:15

Continued growth after fixation of slipped capital femoral epiphysis

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Level-2

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction In treatment of Slipped Capital Femoral Epiphysis (SCFE) in Scandinavia a smooth Hansson pin or short threaded screw is used to allow for further growth which is considered to be able to prevent the development of impingement.

Materials and methods Sixteen participants with unilateral SCFE, nine girls and seven boys with a median age of 12.0 years (range 8.4–15.7 years) were included. The slipped hip was fixed with a Hansson pin, and the other, non-slipped, hip was prophylactically pinned. No reduction was performed. At the time of surgery, tantalum markers were installed bilaterally on each side of the growth plate through the canal drilled for the pin. Patients were examined by use of Radiostereometric analysis (RSA) postoperatively and at 3, 6 and 12 months. RSA measures skeletal movements with high resolution using tantalum markers and roentgen rays. The position of the epiphysis in relation to the metaphysis was calculated

Results At 12 months the epiphysis moved caudal with a median of 0.16 mm and posterior 2.28 mm on the slipped side in comparison to 2.28 mm cranial and 0.91 mm posterior on the non-slipped side, $p = 0.003$ and $p = 0.030$ respectively. Both slipped and non-slipped epiphysis moved medial, 1.52 and 1.74 mm respectively (n.s.). Marked variation of the movement of the epiphysis was noted especially on the slipped side.

Conclusion We were able to measure a movement of the epiphysis in relation to the metaphysis after fixation with a smooth pin for SCFE on the slip side and on the prophylactically fixed non-slip side. This suggests that growth is continued after using the smooth Hansson pin. The RSA method can be used for further studies for the understanding of remodeling after "growth-sparing" fixation of SCFE.

Significance We consider a fixation for SCFE that prevents further slip but allows for continued growth with possible remodeling ideal. With the “growth-sparing” fixation technique the risk of femoral acetabular impingement and the development of early osteoarthritis can be reduced, which is the long-term goal in the treatment of SCFE.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP46/08:15–08:20

Radiographic evaluation of growth and remodeling of the proximal femur after treatment of slipped capital femoral epiphysis with threaded versus smooth pins

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Level-3

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction In-situ fixation with a single cannulated screw is the standard of care for slipped capital femoral epiphysis (SCFE). However, alternative implants have been recommended. Smooth pins or modified smooth screws are believed to prevent the epiphysis from further slip while permitting further growth of the proximal femur. In this study, we evaluated femoral growth, CAM deformity and remodeling potential of the active physis after treatment for SCFE. We also compared the impact of threaded and smooth non-threaded implants.

Materials and methods We reviewed the medical files of 43 patients (29 male, 14 female; mean age, 12.1 years) with SCFE treated in our Institution. All patients sustained idiopathic SCFE treated with in situ pinning; 23 patients were treated with a single cannulated screw and 20 with two smooth pins. Bilateral slips or patients who underwent prophylactic pinning were not included in this study. AP and frog-leg radiographs of the pelvis were reviewed for each patient at initial presentation, postoperatively, at physeal closure and after implant removal. Slip severity was assessed with Southwick’s angle. The longitudinal growth of the proximal femur was evaluated using the femoral neck length, the caput-collum-diaphyseal (CCD) angle and the articulo-trochanteric distance (ATD). CAM deformity was assessed using the anterior offset α -angle and the head–neck offset ratio (HNOR). An α -angle over 42 degrees and a HNOR below +0.17 was considered suggestive of CAM deformity.

Results Most of the patients presented moderate ($n = 17$) or mild ($n = 22$) SCFE. After pinning, mean CCD angle was 138 degrees, which was decreased to 133° by the time of implant removal. Likewise, femoral neck and ATD did not present any differences within or between the two groups. After pinning, mean α -angle was 66° and mean HNOR –0.03. At the time of implant removal, α -angle was reduced at 52 degrees ($p < 0.001$) and HNOR improved at +0.039 ($p < 0.001$). Similarly, there were no significant differences between the two groups in terms of α -angle or HNOR improvement.

Conclusion Our data does not suggest that smooth pins allow further longitudinal growth of the proximal femur. Femoral head-neck junction deformity was remarkably improved by means of remodeling until the fusion of the physis. However, residual CAM deformity is not definitely avoided after in situ pinning, even in moderate or mild SCFE.

Significance In our study, the use of smooth or threaded implants did not influence the outcome. Therefore, a single cannulated screw remains preferable when treating SCFE, considering its lower complication rates.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP47/08:33–08:38

Does late hip dysplasia occur after normal screening in breech babies?

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Level-2

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Recent publications have raised concern regarding the occurrence of late dysplasia after normal screening in breech babies. One such paper states a late dysplasia incidence of 29 %. This finding is in contrast with other published work which suggests breech presentation is predictive of spontaneous stabilization of the unstable neonatal hip. We therefore decided to identify the rate of late dysplasia after normal screening in our patient cohort and also to investigate the use of prophylactic abduction diaper usage.

Materials and methods During the study period of December 2012 to June 2014, breech presentation babies referred to the selective screening program at University Hospital Southampton were identified. 90 babies were prospectively enrolled into the study and randomized to either the observational arm or prophylactic treatment with the Healthy Hip Diaper (HALO, Minnetonka, MN). All babies had a normal initial clinical examination and ultrasound. Regular follow-up including clinical and ultrasound examination was undertaken culminating in pelvic xrays performed at 13 ± 1 months. 68 % of patients elected against prophylactic treatment, 28 % opted for prophylactic treatment meaning a total of 44 % of babies proceed against their initial randomization. 75 % of recruited babies completed follow-up and were included in the analysis. Dysplasia was defined as an acetabular index (AI) $>2SD$ from the mean gender, age and side specific values.

Results The overall rate of radiographic dysplasia at 13 months was 7.4 %. The rate was 5 % in the treatment group and 8.3 % in the observational group. This was not statistically significant. Two patients required intervention, one requiring capsulorraphy with acetabuloplasty and the other requiring an arthrogram. Overall compliance with the abduction device was low.

Conclusion We conclude that late radiographic dysplasia does occur after normal clinical and ultrasound screening in breech babies, although not to the same extent as recently published data. We cannot recommend prophylactic abduction devices for all breech babies. Consideration must be given to further clinical and radiographic

follow-up for hip dysplasia when the risk factor of breech presentation is present.

Significance We demonstrated that there is an incidence of late acetabular dysplasia following normal ultrasound screening in breech births, however in our series this was far less than recently published data.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP48/08:38–08:43

The transverse acetabular plane and version following dega like osteotomy in treatment of DDH

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Level-4

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Redirectional osteotomies or acetabuloplasties are used in the treatment of DDH to correct dysplasia and improve coverage. Salter's osteotomy creates retroversion of the acetabulum and may predispose to impingement. This study was to quantify transverse plane cover and acetabular version after Dega like acetabuloplasty.

Materials and methods 44 children (47 hips), with mean age of 2.5 years (1.3–6.3) were surgically treated for DDH. Routine post op CT scans following open reduction and Dega acetabuloplasty were analysed. Acetabular version, depth of the acetabulum, and total acetabular index (TAI), anterior acetabular index (AAI) and posterior acetabular index (PAI) were measured. In 41 cases the contralateral hip was normal, therefore was used as control group. Unpaired t test was used for statistical analysis.

Results All operated hips maintained acetabular anteversion with mean anteversion angle(AAA) of 17.6° (SD 5.5°). Anteversion in the control group was 13.3° (SD 5.0°) p value = 0.0002. The average depth of acetabulum was similar 5.1 mm (SD 0.2 mm) and 5.9 mm (SD 0.3 mm) for DDH and control group respectively, p = 0.132. The mean TAI was 126.8° (SD 10.9°) for DDH group and 128.4° (SD 7.8°) for control group, p = 0.423. The mean AAI was 71.8° (SD 6.8°) for DDH group and 67.4° (SD 7.2°) for control group, p = 0.0046. The mean PAI was 54.9° (SD 9.5°) for DDH group and 61.0° (SD 5.8°) for control group, p = 0.007.

Conclusion A Dega type acetabuloplasty corrects the transverse plane dysplasia of DDH and maintains the acetabulum in its anteverted position. Anterior and posterior transverse plane indices of the abnormal hip are improved with maintenance of anteversion.

Significance Dega like acetabuloplasties may prevent the late complications associated with Salter's osteotomy.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP49/08:43–08:48

Patterns of type II osteonecrosis after treatment of developmental dysplasia of the hip

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Level-4

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Osteonecrosis (ON) or growth disturbance (GD) secondary to treatment of developmental dysplasia of the hip (DDH) represents a spectrum of involvement, from temporary irregular ossification leading to normal development, to significant deformity resulting in early degenerative arthritis. There have been a number of attempts to classify ON in relation to DDH. Although each have their merits, all have poor inter-rater reliability and may have little clinical relevance.

Materials and methods We attempt to define 'Type II' ON, which seems to represent a true physeal GD and leads to deformity of adjacent portions of the femoral head and neck. This is often viewed as the most disabling form of ON and may lead to early arthritis of the hip. This study reviews 56 patients with Type II ON who have been managed at The Hospital for Sick Children between 1991 and 2014. Following clinical and radiographic review, we measured neck length, neck shaft and the neck physeal angles and recorded the shape of the physis. An attempt was made to classify objectively the shape of the proximal femur and to correlate this with clinical outcome.

Results Patients were initially treated with either closed reduction, anterior open, or medial open reduction at an average age of 20.9 (2.7–188.4) months. Almost 40 % of patients required further surgery such as open reduction, femoral osteotomy or pelvic osteotomy. Of the 37 patients managed under the age of 12 months, 37.8 % (14 patients) required secondary surgery, for those 19 patients over the age of 12 months at initial procedure, 42 % (8) required at least one episode of further surgery. The average follow-up from time of the initial procedure to most recent follow-up is 114.5 (0.4–207.4) months. Radiographically three distinct patterns of involvement were identified; a long medial neck, a mixed picture with some overgrowth medially but undergrowth on the lateral neck, and thirdly a short lateral neck, often with an uncovered medial beak.

Conclusion By correlating radiographic findings with clinical symptoms we aim to better understand 'Type II' ON after treatment for DDH in an attempt to plan intervention more appropriately.

Significance It is hoped that by recognising these sub-groups we will be able to predict which patients with 'Type II' ON are likely to require secondary surgery, and what the expected prognosis is for each pattern of deformity.

April 8Hip/DDH/LCP/SCFE
08:00–10:00**OP50/08:48–08:53****Association between presence of ossific nucleus and decreased risk of avascular necrosis in open and closed hip reductions in the treatment of DDH: a meta-analysis of cohort and case control studies**Cynthia Chen¹, Shevaun Doyle¹, Daniel Green¹, Roger Widmann¹, John Blanco¹, David Scher¹, Ernest Sink¹, Emily Dodwell¹¹Hospital for Special Surgery, New York, USA**Level-2****Hip/DDH/Legg-Calvé-Perthes/SCFE**

Introduction Concern for an increased risk of avascular necrosis with an absent ossific nucleus has led some surgeons to delay open or closed reduction until the ossific nucleus has appeared on X-ray or ultrasound. A previous meta-analysis reported no association between presence of the ossific nucleus and decreased risk of avascular necrosis. With a recent increase in publications on this topic, with more than double the number of manuscripts available for inclusion, revisiting this topic is warranted. The aim of this meta-analysis was to review systematically and analyze the best clinical evidence regarding the ossific nucleus and its role as a protective factor for development of avascular necrosis in the treatment of developmental dysplasia of the hip.

Materials and methods A systematic literature search was performed for studies reporting avascular necrosis outcomes after open and closed reductions for developmental dysplasia of the hip that investigated the pre-operative presence of the ossific nucleus. Data on study design, patient characteristics, and risk estimates were extracted. Studies were graded for quality using the Newcastle Ottawa scale. Pooled effect estimates were calculated using a fixed effects model. A sub-analysis was performed for high grade (grade >1) AVN. Meta regression was performed based on study quality.

Results Fourteen observational studies (ten retrospective, four prospective) were included. Initial analysis of both low and high grade avascular necrosis (I-IV) included 104 cases of avascular necrosis in 513 hips with an ossific nucleus present before reduction, and 94 cases of avascular necrosis in 353 hips without an ossific nucleus before reduction. The presence of the ossific nucleus was associated with a 40 % decrease in avascular necrosis (OR = 0.6 95 % CI 0.41–0.88). However, when considering only avascular necrosis > grade 1, no significant effect was found (OR = 0.8 95 % CI 0.47–1.24).

Conclusion Unlike previous reports, there is an association between presence of the ossific nucleus and decreased rates of avascular necrosis when considering all types of avascular necrosis in both higher and lower quality studies. There was no association between the presence of the ossific nucleus and decreased rates of higher grade avascular necrosis.

Significance Presence of the ossific nucleus may be associated with decreased rates of low grade avascular necrosis, but not more serious forms of avascular necrosis. Further research is necessary to understand the pathophysiology of avascular necrosis in the treatment of

developmental dysplasia of the hip, before adopting delayed treatment methods for open and closed reductions of developmental dysplasia of the hip.

April 8Hip/DDH/LCP/SCFE
08:00–10:00**OP51/09:06–09:11****Periacetabular osteotomy through a minimally invasive approach: radiological correction and complication profile**Balakumar Balasubramanian¹, Beth Pincher², S Abouel-Enin², Caroline M Blackey², Sanjeev Madan³

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

Introduction Periacetabular osteotomy (PAO) has previously been shown to be a safe and effective treatment for severe hip dysplasia. More recently a minimally invasive approach has been described by Soballe et al. in an attempt to reduce complications while still achieving effective acetabular re-orientation. In this study we report the radiological corrections achieved and complication profile of PAO procedures undertaken through the minimally invasive approach.

Materials and methods 106 PAOs were performed in 103 patients, by the senior author, using a minimally invasive approach from 2007 to 2015. Pre- and post-operative radiographs were reviewed and the degree of acetabular re-orientation was analysed. Case notes were examined retrospectively to identify haemoglobin levels and any reported complications.

Results 73 female and 30 male patients underwent PAO procedures at a mean age of 25 years. All patients had minimum 10 months of follow-up. Pre-operatively the average centre edge angle measured -1.6° with the vertical centre edge angle reading -0.2° . Post-operative radiographs confirmed correction of these values to 28.9° and 31.0° respectively. Sharp's angle was also improved from a mean value of 49.5° to 33.7° . On review of the Tönnis angle this had also been corrected from an average of 24.1° to 8.6° . The average drop in haemoglobin was calculated as 39 g/L with around 50 % of the patients requiring a peri-operative blood transfusion. 5 patients reported lateral cutaneous nerve hypoesthesia and 4 had problematic screws. 2 patients underwent washouts as treatment for haematoma and infection. 3 patients had delayed union of the pubic osteotomy and a further patient reported asymptomatic osteotomy non-union.

Conclusion The minimally invasive approach allows for accurate re-orientation of the acetabulum whilst minimising tissue damage. Our results show successful radiographic correction of the severely dysplastic hip with an acceptable complication profile when compared to previous studies evaluating the traditional approach.

Significance This study shows that minimally invasive approach has favourable outcomes and that it is feasible to achieve adequate correction with less morbidity.

April 8Hip/DDH/LCP/SCFE
08:00–10:00**OP52/09:11–09:16****Seventy patients with total hip replacements before the age of twenty**Vera Halvorsen¹, Masako Tsukanaka², Lars Nordsletten², Ingvild O Engesaeter³, Lars B Engesaeter³, Anne Marie Fenstad³, Stephan M Röhrli²¹Orthopaedic Department, Oslo University Hospital, Oslo, Norway; ²Dept of Orthopaedics, OUS, Oslo, Norway; ³NAR, Bergen, Norway**Level-2****Hip/DDH/Legg-Calvé-Perthes/SCFE****Introduction** The aim of this study was a long-time follow-up of patients under the age of twenty with total hip replacements (THR).**Materials and methods** Seventy out of 81 eligible patients younger than 20 years when reported to The Norwegian Arthroplasty Register 1987-2010 were clinically evaluated. Eighty patients (94 hips) underwent radiographic examinations. Self reported health parameters were assembled.**Results** The average clinical follow-up was 12 (2–26) years, almost the same as radiographic follow-up. The average age at surgery was 17 (11–20) years. Approximately one-third of the patients had inflammatory disease and more than one-third had arthritis due to pediatric hip diseases. The majority of the patients were working or studying at follow-up, only a minority received disability pension. There were 24 different types of cups and 17 different types of stems used. Eighty-nine percent of the cups were uncemented and 95 % of the stems. The ten-year survival of the THR was 70 %. At follow-up 25 % of the patients had experienced revision(s). After the first revision the new ten-year survival for any component was 62 %. Seven hips had 3 or more revisions, one patient experienced 7. There were fewer revisions after 1998. At follow-up Harris Hip Score (HHS) was 83 (15-100) and physical activity score according to UCLA was 6.5. The EQ-5D VAS was 75 with no difference between patients with or without previous revisions. EQ-5D scores concerning anxiety and depression showed lower scores for women compared to the normal population. SF-36 scores showed lower performance for women than for men on some parameters, but relatively good scores compared to the normal population and other patients with a history of surgical interventions. Radiological examinations showed osteolysis around 19 % of the cups and 62 % of the stems. Some radiographs showed worrying signs of loosening even if HHS were high.**Conclusion** Although the youngest patients with total hip replacements have a high revision rate, most of them are not on disability pension and they perform relatively well clinically according to HHS, UCLA, EQ-5D and SF-36. HHS was high at follow-up even if there were worrying signs of osteolysis and loosening on radiographic examinations.**Significance** Level III.**April 8**Hip/DDH/LCP/SCFE
08:00–10:00**OP53/09:16–09:21****Predicting the need for a less invasive pelvic osteotomy: a radiographic evaluation of 100 paediatric hips**Shahril Shaarani¹, Jamie Dowling², Damian McCormack²¹Department of Trauma & Orthopaedic Surgery, Children's University Hospital Temple Street, Dublin, Ireland; ²Children's University Hospital, Dublin, Ireland**Level-3****Hip/DDH/Legg-Calvé-Perthes/SCFE****Introduction** The spherical acetabulum is an essential prerequisite for normal development of the young hip. The radiographic criteria to define hip dysplasia vary with age, from neonate to adult. However hip sphericity measurement should always be valid. We propose a radiological tool to calculate the probability of a less invasive pelvic osteotomy in the residual dysplastic hip.**Materials and methods** We retrospectively reviewed the radiographs of 100 hips of children from 2009 onwards, treated previously with either closed or open reduction for dislocated hips. Subsequent radiographs were assessed for: (1)first circular area based on a circle placed lateral to the tear-drop (acetabular floor) and acetabular roof; C1(cm2) (2)second circular area based on a circle concentrically positioned over C1 and overlapping the superolateral corner (SL) of the acetabulum; C2(cm2) (3)the diameter of both circles; d1 and d2 respectively(cm) (4)the angle created by the sector of C1 bisected by Perkin's line; γ angle (5)acetabular index (AI) (6)superior hip joint space SL-C1 distance; SC(mm) (7)difference in surface area of C2&C1; C3(cm2) (8)area of the circular segment covered by the acetabular roof; A(cm2). All measurements were taken as an average of 3 subsequent measurements to prevent type 1 error. Patients' demographics and subsequent surgeries were documented. The data were analysed with student t-test for continuous data using SPSS version 20 (SPSS Inc, Chicago, Illinois). $P \leq 0.5$ is significant. A probability plot was tabulated to ascertain a threshold for the values required for surgery.**Results** Among the 100 hips, the mean age of patients was 29 months (range 11-78 months, SD 20). Pelvic osteotomy was required in 39 hips. Student t-test demonstrates that superior hip joint space (SC) and difference in spherical concentricity (C3) are positive predictors of surgical intervention ($p = 0.04$ and $p = 0.12$ respectively). However the acetabular index (AI) and the area of the circular segment covered by the acetabular roof (A) are not predictors of surgical intervention ($p = 0.64$ and $p = 0.37$ respectively). A C3 surface area of more than 3.1 cm² and a SC distance of more than 2.1 mm can predict a future pelvic osteotomy procedure.**Conclusion** The lack of acetabular sphericity assessment is simple and reflects poor lateral acetabular development, which the acetabular index may not reflect. We propose a radiological tool to calculate the probability of a less invasive pelvic osteotomy in the residual dysplastic hip, which can be used on antero-posterior pelvis lateral hip radiographs.

Significance This study provides an alternative radiological tool to predict the need for a less invasive pelvic osteotomy.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP54/09:21–09:26

Characteristics in treatment of the hip of patients with down syndrome

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Level-3

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction The treatment of hip instability in patients with Down syndrome is challenging. We performed different pelvic osteotomies and corrections at the proximal femur for this indication. This retrospective study was conducted to evaluate the clinical and radiological outcome of each intervention.

Materials and methods All in all, 166 patients with Down syndrome were treated at Olgahospital Stuttgart in the observation period. Problems related to the hip joint were diagnosed in 63 of those patients. Only patients who underwent surgery were included in this study. The charts and x-rays of those 31 patients were evaluated with respect to the following parameters: Incidence of the hip problem, concomitant diseases, temporal progress, kind of operation method and date, duration of stay in the hospital, after-care, follow-on surgery related to complications, AC-angle, CE-angle, ACM-angle, CCD-angle, index of migration according to Reimers, classification of Bauer and Kerschbauer and general morphology of the femoral head. The group was compared with an age-matched group of 21 patients with hip dysplasia. Those patients underwent similar operations in the same year.

Results In the Morbus Down group, we performed surgery for preservation of the hip in 49 hips. This included 13 osteotomies according to Chiari, 11 triple osteotomies according to Tönnis, 10 corrections by femoral varus derotation osteotomy, 8 pelvic osteotomies according to Pemberton, 5 pelvic osteotomies according to Salter and 2 open reductions of the hip. With respect to the timing of surgery, we detected three peaks of age. There was no difference in the course of the disease and quantity of complications between groups. Satisfactory results concerning clinical and radiological outcome were achieved predominantly by complete redirection acetabular osteotomies. Half of patients, who were solely treated by femoral varus derotation osteotomy, needed follow-on-surgery in form of pelvic osteotomy. Comparison of preoperative and postoperative range of motion of the hip joint between groups detected capsular insufficiency, increased ligamentous laxity and muscular hypotonia in patients with Down syndrome. Comparison of pelvic radiographs demonstrated significant improvement concerning measured angles in both groups. Preoperative values with respect to AC-

angle and CE-angle demonstrated were lower in hip dysplasia group ($p < 0.01$); whereas values for ACM-angle were comparable between groups.

Conclusion Hypermobility and secondary dislocation of the hip joint is a common problem in patients with Down syndrome, which often requires surgical intervention at an early stage.

Significance According to our data and clinical results we suggest a complete redirection acetabular osteotomy in combination with capsular plication for treatment of this challenging condition.

April 8

Hip/DDH/LCP/SCFE
08:00–10:00

OP55/09:39–09:44

Intermediate to long-term results following femoral neck lengthening (Morscher Osteotomy)

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Level-4

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Femoral neck lengthening and transfer of the greater trochanter were introduced by E.Morscher as treatment for patients with Coxa Breva and overgrowth of the greater trochanter. In this study we evaluated intermediate and long term results of this operation.

Materials and methods We reviewed clinical and radiographic results of 16 patients (18 hips) that were treated by the Morscher osteotomy. 10 patients had Perthes disease, 3 had DDH, and 3 had Avascular Necrosis of the hip (2 post-septic and 1 post-traumatic). The mean age at the time of surgery was 15.4 years, with mean follow-up of 13.6 years (range 2–21 years). All patients were evaluated clinically by means of the Harris Hip Score (HHS), before and after surgery.

Results Pre-operative clinical examination revealed that all patients had a limp and a positive Trendelenburg test. Average Harris Hip Score was 76.7 (range 60–88). Post-operatively, the Trendelenburg test was negative in 12 hips, positive in 4 hips and improved in 2 hips. Post-operative average HHS was 95.1 (range 88–100). Radiographic examination showed incongruent hips in 3 patients with progression of osteoarthritis. 2 hips required THR 20 years after the operation. Leg length discrepancy was reduced in all patients (mean 15 mm). Overall Patient satisfaction level was good–excellent in 11 patients, fair in 3 and bad in 2 patients. Post-operative complications included blade migration (1 patient) and wire breakage (2 patients).

Conclusion The Morscher osteotomy can be effective for the treatment of patients with Coxa Breva and overgrowth of the greater trochanter with positive Trendelenburg test and mild leg length discrepancy. A congruent hip joint is a prerequisite for the success of the operation.

Significance Morscher osteotomy is an effective treatment method for patients with Coxa Breva and overgrowth of the greater trochanter.

April 8Hip/DDH/LCP/SCFE
08:00–10:00**OP56/09:44–09:49****Modified Waldenstrom classification less than II-B associated with better surgical results in severe Legg-Calve-Perthes disease**Charles T Mehlman¹, Ayesha Yahya², Junichi Tamai², Emily A Eisman², Alvin H Crawford²¹Cincinnati Children's Hospital Medical Center, Cincinnati, USA;²Cincinnati Children's Hospital, Cincinnati, USA**Level-3****Hip/DDH/Legg-Calvé-Perthes/SCFE****Introduction** The purpose of this study was to analyze the impact of disease stage (as measured by the modified Waldenstrom classification) on surgical outcomes in severe Legg-Calve-Perthes disease.**Materials and methods** Seventy-seven patients with severe Legg-Calve-Perthes disease (100 % with stiffness, 75 % hinge abduction) underwent a staged containment protocol (medial release with Petrie casting, followed by Salter osteotomy and/or shelf acetabuloplasty) and were retrospectively reviewed. Our primary outcome variable was Stulberg classification which was subdivided into <Stulberg II and >Stulberg III. Potential predictor variables that we analyzed included modified Waldenstrom classification, patient age, gender, and lateral extrusion. Univariate (Fisher exact test) and multivariate statistical analysis (logistic regression) was performed.**Results** There were 47 pts (33 male, 14 female) in the <II-B group with an average age at surgery of 7.1 years (range 3.4–10.6), while there were 30 patients in the >II-B group (26 male, 4 female) with an average age at surgery of 8.1 (range 3.8 to 11.9). Univariate analysis revealed a significantly ($p = 0.019$) higher rate of Stulberg <II (68 % 32/47) in the modified Waldenstrom <II-B group as compared to >II-B (40 % 12/30). Multivariate analysis of potential predictor variables (modified Waldenstrom, age at surgery, lateral extrusion, and gender) revealed that modified Waldenstrom ($p = 0.019$) and gender ($p = 0.021$) were significant.**Conclusion** In this cohort of patients with severe Legg-Calve-Perthes disease sub-group analysis revealed significantly better results (Stulberg I & II) in patients with modified Waldenstrom <II-B.**Significance** In patients with severe Legg-Calve-Perthes disease it appears to be advantageous to operate early. These findings are consistent with those previously reported by Ben Joseph.**April 8**Hip/DDH/LCP/SCFE
08:00–10:00**OP57/09:49–09:54****Management of avascular necrosis of the femoral head in children with sickle cell disease. Results of non-operative and operative treatments at skeletal maturity**Cindy Mallet¹, Alexandre Abitan², Christophe Vidal¹, Keyvan Mazda¹, Brice Ilhareborde¹¹Robert Debré hospital, Paris, France; ²Robert Debré Hospital, Paris, France**Level-3****Hip/DDH/Legg-Calvé-Perthes/SCFE****Introduction** Avascular necrosis of the femoral head (ANFH) is a frequent orthopedic complication in patients with sickle cell disease. In children, this entity is quite similar to Legg-Calve-Perthes (LCP) disease with potential revascularization. Functional or surgical treatments aim to restore proper hip containment to prevent joint arthritis. Literature only reports results of total hip replacement as a salvage procedure. This is the first study reporting long-term results at skeletal maturity of functional or surgical treatment for ANFH due to sickle cell disease in children.**Materials and methods** All patients with ANFH due to sickle cell disease were retrospectively reviewed. Two groups were analyzed depending on the treatment (Group 1: functional treatment, group 2: surgical treatment). Functional treatment consisted in skin traction in case of hip contracture, and non-weight bearing. In case of subluxation of the femoral head with reimers migration index >30 %, surgical treatment was performed including intertrochanteric femoral varus osteotomy (FVO) and/or triple pelvic osteotomy or shelf procedure depending of the spherical congruity of the hip. ANFH was defined using Catteral and lateral pillar Herring classifications at initial evaluation. Outcome was assessed at skeletal maturity, on pain and function using Harris Hip Score (HHS) and radiographically on Stulberg classification. Hip range of motion was compared initially and at latest follow-up in the 2 groups. Total hip arthroplasty (THA) and Stulberg 4–5 were considered as a failure.**Results** Twenty-five hips in 18 patients were analyzed with a mean 7.5 (± 3.4) years follow-up. Mean age at diagnosis was 11.4 (± 2.9) years. Thirteen patients (52 %) underwent surgical treatment: 10 intertrochanteric OFV associated with triple pelvic osteotomy in 1 case and shelf procedure in 2 cases, 2 triple pelvic osteotomy alone, and 1 shelf procedure alone. In group 1, 10 hips (84 %) were classified Catteral 1 and 2 and Herring A. In group 2, 11 hips (85 %) were classified Catteral 3 and 4, and 10 hips (77 %) were Herring B. At latest follow-up, mean HHS was good (81 ± 10) and no statistical difference was found in hip ROM and in HHS between the 2 groups. However, 3 (25 %) hips in group 1 and 5 (38 %) in group 2 were classified Stulberg 4 and 5. One hip (8 %) in group 1 and 2 (15 %) in group 2 underwent THA.**Conclusion** In more severe hips with extensive physeal involvement (Herring B-C and Catteral 3–4), surgical treatment should be attempted with satisfactory hip ROM and function. Nevertheless, osteoarthritis may occur in nearly 40 % of those operated hips.**Significance** Conservative treatments for ANFH in sickle cell children led to good functional results.**April 8**Spine
10:30–12:30**OP58/10:30–10:35****Low pelvic incidence is associated with proximal junctional kyphosis in patients treated with growing rods**Christopher N. Carender¹, William Z. Morris¹, Connie Poe-Kochert¹, George H. Thompson¹, Jochen P. Son-Hing¹, Raymond W. Liu¹¹Case Western Reserve University, Cleveland, OH, USA

Level-3**Spine**

Introduction Growing rods have been demonstrated to correct spinal deformity in early onset scoliosis (EOS) while allowing for spinal growth. There has been little investigation into the potential effects, if any, of abnormal pelvic incidence (PI), and on complications, especially proximal junctional kyphosis (PJK). The goals of this study were to investigate whether PI remains constant during growing rod treatment and to report the effects of PI, if any, on complications during treatment.

Materials and methods We reviewed clinical and surgical data from our prospectively collected pediatric orthopedic spine database. Forty-eight patients had at least one lateral radiograph throughout the course of treatment containing the femoral heads and sacral endplate, and a minimum follow up of 2 years. Clinical failures, defined as rod fracture, pedicle screw pullout, hook dislodgement, and hook erosion, were collected prospectively. Radiographs were retrospectively measured for PI and the development of PJK.

Results The mean age at initial treatment was 6.9 years (range 2.8–10.8 years), with 35 females and 13 males. The mean length of follow up was 8.1 years (range 2.0–22.1 years). No statistical change in PI was observed throughout this study ($p = 0.655$). The total number of failures was 52, with a mean of 2.0 ± 1.5 failures (range, 1–8 failures) in 26 patients. The development of any failure as well as the total number of failures was associated with younger age at initial treatment ($p < 0.0005$ for both). Development of PJK was associated with younger age at initial treatment ($p = 0.030$), female gender ($p = 0.002$), and lower mean pelvic incidence ($p = 0.042$).

Conclusion Pelvic incidence remains constant throughout growth and the course of treatment with growing rods. Low PI was associated with increased PJK. When using growing rods in EOS patients with decreased PI, increased attention should be paid to sagittal plane balance in an attempt to avoid PJK.

Significance To our knowledge, this study is the first to identify low PI as being associated with development of postoperative spinal pathology. Further investigation into the consequences of low pelvic incidence is warranted.

April 8

Spine
10:30–12:30

OP59/10:35–10:40**The outcomes of spinal fusion for cervical kyphosis in children with neurofibromatosis**

Ilkka Helenius¹, Paul Sponseller², Thierry Odent³, William MacKenzie⁴, John Dormans⁵, Jahangir Asghar⁶, Daniel Hedequist⁷, Jonathan Phillips⁸

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Level-3**Spine**

Introduction Cervical kyphosis is typical of neurofibromatosis type I (NF1). Surgical stabilization may be difficult because of vertebral dysplasia resulting in thinning of posterior elements, elongation of pedicles, and erosion of vertebral bodies. Outcomes of cervical spinal fusion in these children are not well described. We aimed to (1) characterize clinical presentation and (2) report outcomes of posterior-only vs. anteroposterior cervical fusion in children with NF1.

Materials and methods A multicenter study identified nineteen children (mean age at surgery, 11 years; range, 2 to 17.9 years) with NF1 who underwent surgery from 2000 through 2014 for cervical kyphosis. Sixteen had dystrophic changes and twelve dural ectasia. Seven underwent preoperative halo traction (mean, 23 days; range, 6 to 65 days). Patients underwent posterior ($n = 6$) or antero-posterior ($n = 13$) surgery. Eighteen received spinal instrumentation, and one was not instrumented. Mean follow-up was 4 years (range, 1–10 years) and fifteen of the sixteen patients with dystrophic changes had a minimum 2-year follow-up. Twelve patients were immobilized with a halo body jacket for a mean of 67 days (range 45–180 days).

Results Fourteen children presented with neck pain, nine with head tilt, six with previous cervical laminectomy, and four with neurologic deficits. Two patients showed spontaneous dislocation of the mid-cervical spine without neurologic deficit. Mean preoperative cervical kyphosis was 77° (range 38° – 110°). Nine had scoliosis (mean major curve, 48° , range 14° – 78°). Preoperative halo traction reduced mean kyphosis by 42 %. At final follow-up, all spinal fusions showed union and cervical kyphosis averaged 18° (range, -25° to 58° ; mean correction, 78 %; $p < 0.001$). Cervical kyphosis correction was significantly better in the antero-posterior (82 %) than in the posterior only (54 %) fusion group ($p = 0.046$). Vertebral dysplasia and erosion continued in all sixteen patients with dysplasia preoperatively. Complications occurred in eleven (58 %) patients, including five new neurologic deficits and five cases of junctional kyphosis. Seven (37 %) patients required revision surgery. Junctional kyphosis was more common in children with five or fewer levels fused ($p = 0.046$).

Conclusion Erosion of vertebral bodies continued during follow-up in all patients presenting with dysplastic changes preoperatively. There were no non-unions in either group, but more than half of children experienced a complication, and approximately one-third required revision. Fusion should include at least six levels to prevent junctional kyphosis.

Significance The cervical spine should be screened in all children with NF1. The risk of complications is high in children undergoing spinal fusion for cervical kyphosis.

April 8

Spine
10:30–12:30

OP60/10:40–10:45**Intraoperative spinal cord monitoring in children under 4 years old: peculiarities and performances**

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Level-3**Spine**

Introduction There are few data in the literature concerning intraoperative monitoring (IOM) in children with congenital spinal deformities, operated under the age of 4 years old. IOM in this population is challenging. Firstly, a spinal cord lesion would be particularly catastrophic at this age. Secondly, there is no alternative to neurophysiologic IOM. Most of these young patients are indeed unable to cooperate with a wake-up test. Thirdly, IOM presents particularities in such young patients due to the immaturity of their sensory-motor pathways. The purpose of this study was to investigate IOM peculiarities and performances in this challenging population.

Materials and methods This study was retrospective and monocentric. 78 IOM in child under 4 years old were extracted from a whole database of 1020 IOM performed between 2004 and 2015. There were 39 females, 39 males (age ranges: 3–47 months; mean 29.3 months). There were 68 hemivertebra: 10 thoracic (above T10), 40 thoracolumbar (T10–L2), 18 lumbosacral; 4 congenital dislocated spine, 5 polymalformative scoliosis and 1 cerebral palsy (63 index surgeries, 15 revision procedures and 11 double-approach surgeries). IOM was performed using somatosensory evoked potentials (SSEP), neurogenic mixed evoked potentials (NMEP) and D-waves. Uniformly total intravenous anesthesia was practiced.

Results IOM specificity was 96 % and sensitivity was 86 % (67 true negatives, 6 true positives, 3 false positives, 1 false negative). The latter corresponded to a 21-month child with a congenital dislocated spine, who showed no clear SSEP alert but had postoperative paraparesis. One patient was characterized by unreliable baseline IOM data. IOM was difficult in 10/77 cases, being unilateral because of a planned fibular graft harvest. Cortical SSEP were present in 75/77 cases. NMEP were present in 26/26 cases. D waves were present in only 4/10 cases. Representative true positive alerts are presented.

Conclusion IOM in children under 4 years old presents specific challenges. As motor evoked potentials (MEP), D waves were difficult to obtain in this population. Positioning an epidural electrode above the T8 spinal level allowed IOM to be performed combining SSEP and NMEP, non-specific for motor pathways. However, NMEP were characterized by higher signal-to-noise ratio than SSEP and were thus easier to monitor. **Significance** As far as possible, IOM should be multimodal. MEP and D-waves could be very difficult to obtain in such young children. Because of the immaturity of central sensory-motor pathways, it is useful in this population to perform IOM that “by-passes” the brain, performing NMEP and epidural SSEP.

April 8Spine
10:30–12:30**OP61/10:45–10:50****Upper foundations implanted cephalad to upper end vertebrae of kyphosis decreases post-operative proximal junctional angle**Ron El-Hawary¹, Ozren Kubat², John Heflin³, Nadim Joukhadar⁴, Mohamad Yasin¹, Anna McClung⁵, Tara Flynn⁶, David Skaggs⁷¹IWK Health Centre, Halifax, Canada; ²Clinical Hospital Centre Zagreb, Zagreb, Croatia; ³Shriners Hospital Utah, Salt Lake City, USA; ⁴Dalhousie University, Halifax, Canada; ⁵Growing Spine Study Group, Dallas, USA; ⁶Children’s Spine Foundation, Philadelphia, Croatia; ⁷CHLA, Los Angeles, USA**Level-3****Spine**

Introduction Proximal Junctional Kyphosis (PJK) is a complication of distraction-based treatment for early onset scoliosis (EOS) and is diagnosed utilizing sagittal plane measurements of the proximal junctional angle (PJA). Two common definitions of PJA include PJA-1: Angle between the caudal endplate of the Upper Instrumented Vertebra (UIV) to the cephalad endplate 2 vertebrae above UIV, and PJA-2: Two levels below UIV to 2 levels above UIV. To identify a potential risk factor for the development of PJK during treatment of EOS, we hypothesize that choice of UIV will affect PJA. The purpose of this study was to compare the post-operative PJA in patients with UIV above, at the same level as, or below the upper end vertebrae of kyphosis (UEV).

Materials and methods Children with >2 year f/u treated with distraction based implants from 2 EOS registries were evaluated. Sagittal radiographs were analyzed to measure PJA at final f/u. Unpaired t-tests were used to compare mean PJA measurements amongst three groups: Those with the UIV above (Group 1), at the same level as (Group 2), or below (Group 3) the UEV.

Results We identified 295 children with EOS who were treated with distraction surgery (Age 5.8 years, Cobb angle 72 degrees, and kyphosis angle 50 degrees at implantation). Aetiologies included 56 congenital, 77 neuromuscular, 82 syndromic, 40 idiopathic, and 40 unknown etiology patients. N = 164 rib-based and n = 131 spine-based anchors. Group 1 (n = 88): Mean PJA-1 = 5.5 and PJA-2 = 14.2. Group 2 (n = 62): Mean PJA-A = 8.4 and PJA-B = 17.7. Group 3 (n = 145): Mean PJA-A = 8.0 and PJA-B = 18.2. Mean PJA-A of Group 1 was significantly less than that of Group 2 (p = 0.02), Group 3 (p = 0.03) and Group 2/Group 3 combined (p = 0.01). Mean PJA-B of Group 1 was also significantly less than Group 3 (p = 0.04) and Group 2/Group 3 combined (p = 0.03). Comparison of Group 1 and Group 2 PJA-2 was approaching significance (p = 0.08).

Conclusion For patients undergoing growth-friendly surgery, those who had UIV above the UEV had significantly lower PJAs than those who had UIV at or below the UEV.

Significance This may decrease the risk of developing PJK after growth friendly surgery; however, the clinical significance of this finding is currently being studied.

April 8Spine
10:30–12:30**OP62/11:03–11:08****Comparison of weight percentile gain with growth-friendly constructs in early onset scoliosis (EOS)**Rachel Y Goldstein¹, Liam Harris², Lindsay Andras³, Paul Sponseller⁴, Charles Johnston⁵, John Emans⁶, David Skaggs³, Growing Spine Study Group⁷¹Children’s Orthopaedic Center, Los Angeles, USA; ²Children’s Hospital Los Angeles, Los Angeles, USA; ³Children’s Hospital Los Angeles, Los Angeles, USA; ⁴Texas Scottish Rite Hospital, Dallas, USA; ⁵Boston Children’s Hospital, Boston, USA; ⁶Growing Spine Foundation, Milwaukee, USA

Level-3**Spine**

Introduction Previous studies demonstrate significant increases in weight percentile following treatment of early onset scoliosis (EOS) with VEPTR and Growing Rods. Our objective is to compare the improvement in nutritional status seen in EOS patients following treatment with various growth friendly techniques, focusing on underweight patients (<20th weight percentile).

Materials and methods This is a retrospective review of patients treated surgically for EOS from a multicenter database. Patients were grouped by type of instrumentation: growing rods with spine anchors, growing rods with rib anchors, guided growth constructs, or VEPTR. Patients with index instrumentation at >10 years old and less than 2 year follow-up were excluded.

Results 287 patients met the inclusion criteria and aetiologies were as follows: congenital = 85; syndromic = 79; neuromuscular = 69; and idiopathic = 52. The average age of the patients at surgery was 5.41 years, with average follow-up of 5.79 years. Preoperatively, 55.4 % (162/287) were below the 20th percentile. Among this group, mean change in weight percentile was 10.5 % (range –16.72 to 88.71 %). Further, all implant groups increased in mean weight percentile at final follow-up. Change in weight percentile by implant type for the groups was as follows: growing rods with spinal anchors = 13.42 %, growing rods with rib anchors = 9.24 %, Guided Growth Constructs = 4.58 %, and VEPTR = 4.21 %. There were no significant differences in weight percentile change between the groups when subdivided by implant type ($p = 0.17$). There was no significant correlation between age at surgery, and change in weight percentile ($p = 0.09$). Idiopathic cases demonstrated the largest increase in weight percentile (mean = 15.90 %) compared to other aetiologies which were as follows: neuromuscular = 10.74 %, syndromic = 10.71 %, and congenital = 7.96 %, though the difference between groups was not statistically significant ($p = 0.58$).

Conclusion Overall, treatment of EOS with growth friendly constructs resulted in an increase in weight percentile. For underweight patients (< 20th percentile) there was no significant difference in change in weight percentile between the groups when subdivided by type of construct.

Significance This research offers evidence of comparative efficacy of multiple growth-friendly constructs for the surgical treatment of ICEOS in weight gain following surgery. Increased understanding of the long term benefits of different devices may lead to improved patient outcomes.

April 8Spine
10:30–12:30**OP63/11:08–11:13****Comparison of ponte osteotomies and three column osteotomies in the treatment of congenital spinal deformity**Paul Choi¹, Priscella Chan², Ted Sousa³, Lindsay Andras³, Elizabeth Joiner³, Vernon Tolo³, David Skaggs³¹Children's Orthopaedic Center, Los Angeles, USA; ²Children's Hospital Los Angeles, Los Angeles, USA; ³Children's Hospital Los Angeles, Los Angeles, USA**Level-3****Spine**

Introduction Congenital spinal deformity has traditionally been treated with 3 column osteotomies (hemivertebrectomy or vertebral column resection) to address rigid deformities. Alternatively, multiple ponte osteotomies may correct the deformity while minimizing risk.

Materials and methods A retrospective review of patients with congenital spinal deformity treated with posterior spinal fusion between 1996 and 2013 was undertaken. Patients treated with multiple ponte osteotomies (PONTE group) were compared to those managed with three column osteotomies (HV/VCR group). Patients who had prior instrumentation, isolated cervical deformity, growing spine instrumentation, or less than 2 year follow up were excluded. Deformity angular ratio (DAR), which is the curve magnitude divided by number of levels of the deformity, was calculated for each patient.

Results There were 48 patients (17 PONTE, 31 HV/VCR [28 HV, 3 VCR]). For the PONTE group, mean age at surgery was 14 years, and they had a mean of 4 pontes and an 11 level fusion. Their mean DAR was 12° and mean number of congenital anomalies was 1.8. The HV/VCR group had a mean age at surgery of 7 years and a 5 level fusion. The mean DAR for the HV/VCR group was 16° with mean number of congenital anomalies of 1.2. Patients had a mean of 55 % of the initial deformity correction in the HV/VCR group and 63 % in the PONTE group, but this difference was not significant ($p = 0.23$). There was one neurological deficit in the PONTE group which was managed with a stage procedure and the deficit resolved. In the HV/VCR group, there were two neurological deficits: one which resolved, and another resulting in complete permanent paralysis. Their revision rate was 38.7 % (12/31) in the HV/VCR group and 17.6 % (3/17) in the PONTE group ($p = 0.23$). Reasons for reoperation in the HV/VCR group include proximal junctional scoliosis and kyphosis (3/31, 9.7 %), hardware migration (3/31, 9.7 %), pseudoarthrosis (2/31, 6.5 %), wound dehiscence (1/31, 3.2 %), and wound drainage (1/31, 3.2 %). Reasons for reoperation in the PONTE group include proximal junctional kyphosis (1/17, 5.9 %), wound drainage (1/17, 5.9 %), and prominent hardware (1/17, 5.9 %).

Conclusion Patients with congenital spinal deformity and a mean DAR of 12° treated with multiple ponte osteotomies and long fusions had corrections comparable to the HV/VCR group.

Significance This study demonstrates that ponte osteotomies are an effective alternative to hemivertebrectomy or vertebral column resection to obtain and maintain correction.

April 8Spine
10:30–12:30**OP64/11:13–11:18****Growth of the thoracic spine re-visited: is the dimeglio data accurate?**Ozgun Dede¹, Gokhan Demirkiran², Kadir Buyukdogan², Z. Deniz Olgun³, Erhan Akpınar², Muharrem Yazici²¹University of Pittsburgh, Pittsburgh, PA, USA; ²Hacettepe University, Ankara, Turkey; ³University Orthopaedics, Hawthorne, NY, USA

Level-3**Spine**

Introduction The knowledge of growth in the thoracic spine and estimated final height are important guides in the treatment of early-onset spinal deformity and the decision for final fusion. The contemporary approach of early vs. late-onset scoliosis is based on the previously documented rapid growth during the first 5 years of life. Dimeglio's previous data indicated that growth of the thoracic spine is not linear, but consists of two fast growing phases: one during the first 5 years of life, and two during adolescence. Despite being often cited, this data has not been re-confirmed with later studies. This study aimed to identify the growth pattern and velocity of the thoracic spine during childhood.

Materials and methods Reformatted sagittal CT images of thoracic vertebrae were examined in children without spinal deformity. The image measured was that of the entire thoracic spine cut at the widest canal diameter. The length of the thoracic spine was measured from the postero-superior corner of the T1 body to the postero-inferior corner of the T12 body. Patients aged 0–2 years below the 3rd percentile according to World Health Organization growth charts and those aged 2–16 years below the 3rd percentile according to Centers for Disease Control and Prevention charts were excluded from the study.

Results 194 thoracic CT scans were included. The analysis of the data identified two break points in growth velocity; the first at the end of the 4th year of life and the other at the beginning of the 10th year (see Figure). Specifically, the growth rate between 0 and 4 years was 1.37 cm/year, 4–10 years 0.68 cm/year, 10–12 years 1.33 cm/year and 13–17 years 0.75 cm/year.

Conclusion According to our results, the thoracic spine in children demonstrates two major growth spurts. The initial growth spurt is between birth to the end of the 4th year and the second is between 10 and 13 years of age. Between 4 and 10 years there is a steady but slower increase in thoracic height.

Significance Although our findings support Dimeglio's data in general, the fastest growth velocity may be limited to a younger age group than was previously believed. This finding may help guide treatment decisions in EOS patients.

April 8Spine
10:30–12:30**OP65/11:18–11:23**

Gelatine matrix with human thrombin decreases blood loss in adolescents undergoing posterior spinal fusion for idiopathic scoliosis a randomized, multicenter, clinical trial

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Level-1**Spine**

Introduction Surgical treatment of adolescent idiopathic scoliosis can be associated with major intra-operative blood loss. Gelatine matrix with human thrombin has been widely used in these children, but no randomized clinical trials exist on its effectiveness in children undergoing major surgery.

Materials and methods A prospective, randomized comparison of gelatine matrix with human thrombin in addition to traditional surgical methods to address blood loss in adolescents undergoing posterior spinal fusion for idiopathic scoliosis was performed. The main outcome parameters included intraoperative blood loss and total blood loss (intraoperative and drain output). Patients were randomized to receive a minimum two and maximum four units of gelatine matrix with human thrombin (intervention, treatment group) in addition to traditional surgical haemostatic methods (bone wax, epidural packing, diathermy), which were solely used in the control group.

Results A total of sixty out of 90 eligible adolescents operated for idiopathic scoliosis using posterior pedicle screw instrumentation were enrolled and randomized into control (n = 30) and treatment groups (n = 30). The groups were similar at baseline with one exception: the control group had significantly less flexible main thoracic curves on bending radiographs than the treatment group (p = 0.033). Every operative hour increased the intraoperative blood loss by 356.9 ml (95 % confidence interval 273.4–440.4 ml, p < 0.001) and total blood loss by 430.5 ml (95 % confidence interval 342.9–518.0 ml, p < 0.001). After adjusting for number of pedicles instrumented and operative time using multiple linear regression analysis the intervention significantly decreased the intraoperative (–171 ml, 95 % confidence interval –320.1 to –22.2 ml, p = 0.025) and total blood loss (–177 ml, 95 % confidence interval –332.9 to –20.8 ml, p = 0.027). Haemoglobin decrease from a day before the operation to the second postoperative day was significantly smaller in the treatment group (–6 g/l, 95 % confidence interval –10.7 to –1.3, p = 0.013) as compared with the control group.

Conclusion The Use of gelatine matrix with human thrombin reduces both intra-operative blood loss and postoperative haemoglobin decrease in adolescents undergoing surgery for idiopathic scoliosis when added to traditional methods to address blood loss.

Significance Based on the current findings, the use of gelatine matrix with human thrombin seems to be indicated in adolescents undergoing posterior spinal fusion using pedicle screws for adolescent idiopathic scoliosis.

April 8Spine
10:30–12:30**OP66/11:36–11:41**

Spino-pelvic Sagittal alignment in children with cerebral palsy

Abir Massaad¹, Ayman Assi², Aren Joe Bizdikian², Fares Yared², Nour Khalil², Ziad Bakouny², Virginie Lafage³, Wafa Skalli⁴, Ismat Ghanem⁵

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Level-4**Spine**

Introduction Standing posture of children with Cerebral Palsy (CP) is usually altered by musculoskeletal deformities in the lower limbs with knee flexion being very common during standing. Head position is known to be essential when assessing sagittal alignment of the spine and pelvis [1]. To our knowledge, standing posture including the head and pelvis [1]. To our knowledge, standing posture including the head and pelvis [1]. To our knowledge, standing posture including the head and pelvis [1].

Materials and methods 39 spastic ambulant children with CP (8 hemiplegia, 31 diplegia, age: 10.4 ± 3.6 years), age-matched to 13 TD children, had undergone full-body EOS[®] biplanar X-rays. All children were asked to adopt the free standing position during X-ray examination. The following parameters were calculated: pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), sagittal vertical axis (SVA), CAM-HA (distance between the vertical line dropped from center of the auditory canals and the middle of hip axis), spino-sacral angle (SSA: angle formed by the sacral plate and the axis joining the center of the C7 vertebra to the midpoint of the sacral plate), T1 and T9-tilt and knee flexion (KF). Differences between groups were assessed for each parameter using Student's or Mann–Whitney's tests. Correlations between parameters were evaluated using Pearson's test. Significance level was set at 0.05.

Results Children with CP had a larger pelvic incidence compared to TD children (PI: $48^\circ \pm 8$ vs $41^\circ \pm 5$, $p = 0.005$). Both C7 and the head were shifted anteriorly in the CP group (SVA: $40 \text{ mm} \pm 40$ vs $-15 \text{ mm} \pm 23$; CAM-HA: $31 \text{ mm} \pm 40$ vs $-17 \text{ mm} \pm 24$, $p < 0.001$). Similar results were found for T1 and T9 (T1-tilt: $-1.9^\circ \pm 5$ vs $5^\circ \pm 2$; T9-tilt: $3^\circ \pm 5$ vs $9^\circ \pm 3$, $p < 0.001$). Children with CP had a high KF ($18^\circ \pm 14$ vs $3^\circ \pm 2$, $p < 0.001$). PI was found to be correlated with TK ($r = 0.56$, $p = 0.04$) and SSA ($r = 0.79$, $p = 0.001$) only in TD children. KF was correlated to SVA ($r = 0.45$, $p = 0.006$), CAM-HA ($r = 0.33$, $p = 0.049$) and LL ($r = -0.35$, $p = 0.037$) only in CP.

Conclusion While physiological correlations were found between PI and the spine in the sagittal plane, children with CP seem to have different strategies of posture by shifting forward their head and spine in order to compensate their increased knee flexion.

Significance This is the first study that assesses sagittal alignment, including the head position, in children with CP.

[1] Gangnet N. et al. (2003) Surg Radiol Anat.

April 8**Spine**

10:30–12:30

OP67/11:41–11:46

Do sublaminar polyester bands affect the outcomes of postoperative infections after adolescent idiopathic scoliosis surgery?

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Level-3**Spine**

Introduction The incidence of surgical site infections (SSI) after adolescent idiopathic scoliosis (AIS) surgery ranges from 0.5 to 7 %. There is currently a return of interest in hybrid constructs, combining lumbar pedicle screws and thoracic sublaminar bands, but some authors have raised concerns about the risk of SSI and the difficulty of bacterial eradication. The goal of this study was, therefore, to assess the outcomes of SSI after AIS surgery using sublaminar bands.

Materials and methods 524 consecutive patients operated for AIS using sublaminar bands between June 2006 and June 2014 were included. SSI cases were identified and analyzed retrospectively. Radiological and functional outcomes were evaluated at follow-up using EOS imaging and SRS 30 scores, and compared to a control group

Results The overall SSI rate was 5.3 %, with a majority of monomicrobial (86 %) infections occurring in the first 6 weeks postoperative (93 %). The most frequent pathogens were skin bacteria (*Staphylococcus aureus* and *Propionibacterium acnes*) with a community profile. Patients were treated successfully with surgical debridement without implants removal, combined with 6 weeks of antibiotic therapy. However, 25 % of patients required more than 1 surgical debridement. Instrumentation removal was performed in the 2 cases with late SSI, and performed uneventfully. Radiological and functional outcomes at follow-up were not affected by the occurrence of SSI.

Conclusion Sublaminar bands are not associated to a higher risk of infection. However, the SSI rate in the current study stands in the upper range of the literature, and other preventive strategies should be considered. In the case of early infection, bands removal is not necessary to obtain pathogen eradication, but the sublaminar implants can be pulled out safely in case of late SSI. The occurrence of SSI does not alter the outcomes at follow-up.

Significance The use of sublaminar bands in AIS did not increase SSI rate.

April 8**Spine**

10:30–12:30

OP68/11:46–11:51

Conservative treatment in adolescent idiopathic scoliosis with curves over 40°: is the measurement of the Cobb angle the only parameter to be considered?

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Level-2**Spine**

Introduction The recent literature has shown positive results in bracing patients with idiopathic scoliosis above 40° that refused

surgery. However, no one has investigated whether other parameters are able to affect the results. The aim of this study was to evaluate the effectiveness of the brace in idiopathic scoliosis with curves above 40° and to assess whether the magnitude of the curve in Cobb angle is the only parameter for the indication to surgical or conservative treatment.

Materials and methods This is a prospective study based on ongoing database including 1238 patients with idiopathic scoliosis. The study including idiopathic scoliosis with 40° or more, Risser 0–4, with no surgical intervention. 160 patients fulfilled the inclusion criteria. Of these, 104 patients has a definite outcome, 28 abandoned treatment and 28 are currently under treatment. The minimum duration of follow-up was 24 months. X-rays was used to obtain Cobb angle and torsion of the apical vertebra (Perdriolle's method). Three outcomes were distinguished in agreement with SRS criteria: curve correction, curve stabilization and curve progression. We have divided the sample in subgroup according to Risser (0–2; 3–4), to rotation (<20; >25) and to Cobb angle (<45°; >45°). The Kruskal–Wallis and Spearman Rank Correlation tests have been used as statistical tests.

Results The results from our study showed that the 104 patients with a definite outcome Cobb mean value was 47 degrees \pm 5.37 SD at beginning and 34.18 \pm 8.45 SD at follow-up. Perdriolle was 20.2 \pm 5.49 SD at beginning and 16.76 \pm 7.04 at follow-up. Curve correction was accomplished in 81 patients (77.8 %), whereas a curve stabilization was obtained in 15 patients (14.4 %), 9 patients (8.6 %) have a curve progression and 16 (15.4 %) where recommended for surgery. The subgroups with rotation <20 showed a correction/stabilization in 98.1 % and surgery referral in 1.8 % while in subgroups with rotation >25 a correction/stabilization was achieved in 69.4 % but surgery referral in 60.8 %. The subgroups with risser 0–2 showed a correction/stabilization in 92.6 % and surgery referral in 10.3 % while in subgroups with risser 3–4 a correction/stabilization was achieved in 91.6 % but surgery referral in 25 %.

Conclusion The results suggest that an adequate conservative treatment must be definitely considered in the treatment of scoliotic curves in patients who refuse surgery, in particular if the rotation is less than 20 and Risser is between 0 and 2, the results will be better.
Significance

April 8

Spine
10:30–12:30

OP69/11:51–11:56

Curve reduction in patients younger than 10 years of age treated with elongation, derotation and flexion casting technique performed uneder general anesthesia and neuromuscular bloking drugs

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Level-3

Spine

Introduction Juvenile scoliosis, among different types of spinal deformity, still remains a challenge for orthopedic surgeons. Elongation, derotation, flexion (EDF) casting technique is a custom-made

thoracolumbar cast based on a three dimensional correction concept. The primary objective of the present study was to measure changes on plain radiographs of patients younger than 10 years of age with scoliosis treated with EDF casting technique. The second aim was to evaluate the effectiveness of the EDF plaster technique performed under general anesthesia (GA) and neuro-muscular blocking drugs, i.e. curare.

Materials and methods A retrospective comparative case series study was performed of forty-four skeletally immature patients. The inclusion criteria were: diagnosis of scoliosi with onset between 4 and 10 years, ambulatory patients, curve magnitude (Cobb angle) over 30° and documented progression (curve progression was assessed on two consecutive radiographs taken at 6-month interval and was defined as an increase greater than 6°), and no prior treatment for scoliosis. Three patient groups were selected. Group 1: EDF cast applied with patients awaken and no anesthesia; Group 2: EDF cast applied under GA without neuromuscular blocking drugs; Group 3: EDF cast applied under GA with neuromuscular blocking drugs. All the patients were treated with two serial EDF casts applied 2 months and a half months apart. All measurements were taken from the radiographic exams. Cobb's angle; Mehta's angle and Nash and Moe grade of rotation were assessed before and after applying the cast. Thirty-four (77.3 %) patients were followed-up at least 24 months after removal of last EDF cast.

Results Eighteen patients (3 males, 15 females) were included in Group 1, 12 (2 males, 10 females) in Group 2 and 14 (5 males, 9 females) in Group 3. The Groups were comparable at baseline ($p > 0.05$). Serial EDF casting was more effective at initial curve reduction and in preventing curve progression when applied under GA with neuromuscular blocking drugs ($p < 0.001$ and $p < 0.03$, respectively). Metha's angle and Nash and Moe score improved significantly in all groups of patients. During follow-up period, six patients required surgery in Group 1 (6/18; 33.3 %), 3 patients required surgery in Group 2 (3/12; 25 %) and 2 patients required surgery in Group 3 (2/14; 15 %).

Conclusion EDF casting is a safe technique that can positively influence the natural evolution of scoliosis in patients younger than 10 years of age by reducing and slowing curve progression in both frontal (Cobb's angle) and transverse plane (rib vertebral angle difference and apical vertebral rotation degree).

Significance EDF casting achieves better correction when applied under GA. Adding neuromuscular blocking drugs improves correction during EDF cast treatment and reduces curve progression at 24 months follow-up.

April 8

Spine
10:30–12:30

OP70/12:09–12:14

High-grade lumbosacral spondylolisthesis in childhood and adolescent: results of non-instrumented circumferential fusion

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Level-4**Spine**

Introduction The treatment of high-grade lumbosacral spondylolisthesis remains controversial. The aim of this study is to present the long term results of the non instrumented circumferential fusion in a population of children and adolescence presenting L5-S1 High-grade lumbosacral spondylolisthesis (>50 %).

Materials and methods A total of 44 cases of high-grade lumbosacral spondylolisthesis (III, IV or ptosis), treated between 1993 and 2011, have been retrospectively reviewed. Preoperatively, the patients have been prepared by bipolar traction and suspension in hyperlordosis, during a 9 days period, followed by a non-instrumented circumferential arthrodesis (posterolateral L4-S1 using iliac bone graft by Wiltse's approach and anterior L5-S1 using tibial bone graft by retroperitoneal approach). A plaster cast applied in hyperlordosis, for a 4 months period ensured the bone consolidation. Results have been determined by both radiological and clinical evaluations and through 2 "quality of life" questionnaires (Oswestry and SRS-30) before the surgery, post-operatively (<12 months after) and at the last follow up.

Results The patients' mean age at surgery was 14.1 years. The average follow up was 10 years. At last follow up, the mean Oswestry score was at 3.5 and the SRS30 at 4.4. The average pelvic incidence was 77°. The pelvic incidence, the L5 incidence and the L4 incidence have progressed during the growth. The pelvic parameters have been poorly modified. The correction of the lumbosacral kyphosis was 10° and the intervertebral slippage by 25 % in average. The lumbar lordosis reduced by 5 %. Six neurologic complications, out of which 4 recovered, have been observed. Half of them were sphincter disorders while the other half represented motor and/or sensitive disorders, that all resolved spontaneously. Three complications linked to the consolidation required a further surgery. At last follow up 75 % of patients had a normal life.

Conclusion The non-instrumented circumferential fusion provides very good functional outcomes, a satisfactory and stable over time correction of the spino-pelvic parameters with few complications, especially neurological.

April 8

10:30–12:30

Spine

OP71/12:14–12:19

Accelerated discharge protocol for posterior spinal fusion (PSF) Patients with adolescent idiopathic scoliosis (AIS) decreases hospital post-operative charges 22 %

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Level-4**Spine**

Introduction Charges for PSF for AIS can range from \$77,362 to \$152,637. Implants (22 %), inpatient and intensive care unit bed costs (22 %), and operating room costs (9.9 %) are the top three contributing factors. Length of stay following PSF for AIS averages

5.2–6.5 days. The purpose of this study was to determine if implementing an accelerated protocol could decrease our average hospital stay and what impact this had on postoperative pain management.

Materials and methods Our tertiary pediatric medical center implemented an accelerated discharge protocol following PSF for AIS in June of 2013, with multidisciplinary collaboration of nursing, physical therapy, pain management and surgical team. This is a retrospective review of all consecutive patients undergoing PSF for AIS before (June 1, 2008–May 31, 2013 = traditional protocol) and after (June 1, 2013–October 22, 2014 = accelerated protocol) .

Results There were 194 patients in the traditional pathway and 90 patients in the accelerated pathway. No significant differences in age at surgery, sex, or number of levels fused were present between the groups. Patients managed under the accelerated discharge had an average hospital stay of 3.7 days compared to 5.02 days for the traditional discharge ($p < 0.001$). There was no difference in reported pain between patients in the accelerated protocol or the traditional protocol for POD1 (3.40 vs. 3.23, $p = 0.4332$). However, patients in the accelerated protocol reported slightly more pain compared to the traditional protocol for pain on day of discharge (3.19 vs. 2.46, $p = 0.0010$). There was no increased incidence of wound complications between the two groups (7/194 vs. 3/90, $p = 0.91$) or readmission (3/194 vs. 4/90, $p = 0.213$). Hospital charges for post-operative care were significantly less in the accelerated discharge group than in the traditional group (\$18,360 vs. \$23,640, $p < 0.0001$). This corresponded to a 22 % (\$5280/\$23,640) decrease in postoperative hospital charges.

Conclusion Reducing length of stay to 3 days following posterior spinal fusion for adolescent idiopathic scoliosis reduces post-operative charges by 22 % without increasing post-operative complications.

Significance Accelerated discharge following PSF for AIS did not increase risk to the patients and did produce significant post-operative savings.

April 8

Poster presentations

11:00–12:14

OP72/11:00–11:03

Analysis of pelvic fracture pattern and overall orthopaedic injury burden in children sustaining pelvic fractures based on skeletal maturity

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

Introduction Pediatric pelvic fractures are rare injuries and result from high-energy mechanisms. With the intention of examining the effects of advancing skeletal maturity on pelvic and extremity fracture patterns, we performed a retrospective study to review pelvic fracture patterns and concomitant orthopaedic injuries in children who have an open triradiate cartilage (TRO), compared to children in which the triradiate cartilage was closed (TRC). We hypothesize that based on the patency of the triradiate cartilage; these injuries will differ, ultimately leading to a difference in management.

Materials and methods Using a trauma database, we retrospectively reviewed all patients less than 18 years of age with pelvic fractures presenting to a level 1 trauma center during a 14 year period. Radiographs and CT scans were reviewed. Pelvic injuries were classified using the modified Torode classification. Epidemiologic data included age, race, gender time of presentation, mechanism of injury, Glasgow Coma Scale (GCS), Injury Severity Score (ISS), Abbreviated Injury Score (AIS), and need for surgical orthopedic intervention. Orthopaedic injuries were also independently extracted and classified.

Results 178 patients met the inclusion criteria, 60 TRO and 118 TRC. The average age for the TRO and TRC groups was 8.3 and 16.3, respectively. The mortality rates were 0 % (TRO) and 5.9 % (TRC). There were no statistically significant relationships between the GCS, ISS, and AIS between groups. The most common mechanism of injury in the TRO group was a vehicle striking a pedestrian compared to a motor vehicle accident in the TRC group ($p < 0.05$ for both). All children in both groups (100 %) suffered extremity injuries. TRC patients were more likely to have hip dislocations ($p < 0.01$), acetabular fractures ($p < 0.05$), sacral fractures (0.05), and Torode type IV fractures ($p < 0.01$). They were also more likely to require operative orthopaedic management for their pelvic and extremity fractures, independently ($p < 0.05$). TRO patients were more likely to sustain pelvic rami fractures ($p < 0.05$) and have Torode type IIIa fractures ($p < 0.01$).

Conclusion We suggest that children with open triradiate cartilage are a unique subset of patients and should be distinguished from patients with a closed triradiate cartilage. Patients with a closed triradiate cartilage should be treated similar to adults as they share a similar mechanism of injury, mortality rate, and need for operative fixation.

Significance This is the only study to our knowledge to report and compare pelvic fracture patterns and concomitant injuries between patients who are skeletally immature and mature.

April 8

Poster presentations
11:00–12:14

OP73/11:03–11:06

Cast immobilisation of paediatric fractures: what happens to the skin?

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Level-2

Basic science

Introduction Cast immobilisation remains the mainstay of treatment for several paediatric fractures, yet causes skin irritation and discomfort. This study aims to evaluate skin changes following cast immobilisation.

Materials and methods Patients with a fracture amenable for treatment in a fiberglass short-arm or short-leg cast were recruited. Skin parameters assessed before cast application included: (1) Transepidermal water loss (TEWL), (2) Stratum corneum (SC) hydration, (3) Hair density, Presence of (4) abnormal pigmentation, (5) abrasion/ulceration, (6) rash. These were obtained for the dorsal and volar surfaces of the casted limb and repeated for the non-casted limb. Participants also provided weekly recordings on the extent of itching,

odour and sweatiness experienced. Upon cast removal, the same parameters were obtained, and skin swabs were taken from both casted and non-casted limbs for comparison.

Results 60 patients completed the study. TEWL increased by 0.67 g/m² h (95 % CI: 0.07, 1.41; $p = 0.08$) and 2.75 g/m² h (95 % CI: 1.65, 3.85; $p = 0.00$) for the dorsal and volar surfaces respectively after casting. SC hydration increased by 4.58 units (95 % CI 1.43, 7.73; $p = 0.01$) and 10.3 units (95 % CI 5.38, 15.2; $p = 0.00$) for the dorsal and volar surfaces respectively after casting. There is no significant difference between changes in hair density of the casted limb, 0.64 (95 % CI -0.318, 1.59; $p = 0.19$) and the non-casted limb, 0.58 (95 % CI 0.15, 1.02; $p = 0.10$). None developed pigmentation or ulcerations. 1 patient had abrasion due to a pen cap inside the cast. 3 developed erythema—2 had it prior, and 1 has eczema. 14 patients had a higher quantity of skin flora on the casted limb, and a pathogen (Enterobacteriaceae) was found on 1 of the casted limbs. Among patients with 3 weeks' cast duration, the extent of odour increased across the 3 weeks by 0.85 (95 % CI 0.35, 1.35; $p = 0.00$), and the extent of sweatiness increased from week 1 to week 2 by 0.27 (95 % CI 0.003, 0.54; $p = 0.05$). Methods cited to combat discomfort include blowing cool air, use of talcum powder, perfume, air-conditioner, and scratching with an object placed into the cast.

Conclusion Paediatric skin barrier function declines after cast immobilisation, with possible maceration accounting for increased SC hydration. Hypertrichosis was not observed. Itching remains a problem throughout casting, with odour and sweatiness becoming more bothersome with increased casting duration.

Significance This is a novel study documenting the effects of cast immobilisation on paediatric skin, including objective measures of skin function.

April 8

Poster presentations
11:00–12:14

OP74/11:06–11:09

Posttraumatic tibiofibular synostosis after treatment of distal tibiofibular fractures in children

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Level-2

Upper and lower extremity trauma

Introduction Posttraumatic pediatric distal tibiofibular synostosis is a rare complication following fracture. The purpose of this retrospective case series, from 3 institutions, was to evaluate the incidence and pattern of posttraumatic distal tibiofibular synostosis in children.

Materials and methods Of the 604 pediatric distal tibiofibular fractures reviewed, twenty patients (3.3 %) with synostosis after treatment of distal tibiofibular fractures were identified at three tertiary referral centers. There were twelve boys and eight girls, with a mean age of 8.4 ± 2.0 years (range 3.7–11.5 years) at the time of injury. Medical records were reviewed, and serial radiographs were analyzed to determine fracture configuration, pattern of synostosis, and changes in the relative positions of the proximal and distal tibial and fibular physes and in ankle alignment.

Results The time from the occurrence of the fracture until the recognition of the synostosis ranged from 2 to 6 months (mean, 2.8 months). The most common fracture configuration was oblique

tibial fracture combined with a comminuted fibular fracture. There were twelve focal types and eight extensive types. The proximal tibiofibular distance was decreased in thirteen cases. Proximal migration of the distal fibular physis developed in all cases. Five patients had ankle valgus of 10° or greater with moderate or severe distal fibular shortening. Eight of 20 patients were symptomatic after synostosis; the remainder were asymptomatic.

Conclusion We identified two patterns of synostosis after the treatment of pediatric distal tibiofibular fracture: focal and extensive. The focal type was more prevalent than the diffuse/extensive type. The diffuse type was more likely to occur due to high-energy injury.

Significance When a tibiofibular synostosis develops, it creates growth abnormalities that warrant observation and potential treatment, as it may cause progressive deformity or ankle pain.

April 8

Poster presentations
11:00–12:14

OP75/11:16–11:19

Interobserver and intraobserver variability with the IHDI (International Hip Dysplasia Institute) classification: a comparison between different levels of expertise

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Level-2

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Diagnosis and treatment of DDH requires an easy and reliable classification system allowing best possible agreement among examiners. The recently developed IHDI (International Hip Dysplasia Institute) Classification stages DDH without requiring the presence of the ossific nucleus as previous classifications did. However, in order to expand its use, it must show intraobserver and interobserver reliability for all levels of expertise (experts and trainees). The aim of this study is to show that IHDI classification is a highly reliable comparison tool in DDH patients regardless of the examiners level of training.

Materials and methods On two separate occasions, two pediatric orthopedic surgeons and two senior orthopedic surgery residents independently classified 70 hip X-rays with variable degrees of DDH severity. All hips were first visit patients. Hips were classified according to the published IHDI recommendations. To assess the IHDI Classification degree of interobserver and intraobserver variability, we calculated Interclass Correlation Coefficients (ICC).

Results All CCIs, both intra- and inter-observer were above 0.90. Mean intra-observer CCI for the right hip was 0.984 and 0.987 for the left hip. Inter-observer CCIs were also all above 0.90, indicating almost perfect agreement no matter what level of expertise the examiner had.

Conclusion Agreement between and within observers for the IHDI Classification is very high.

Significance The IHDI classification is a reliable tool in the assessment of DDH, with almost perfect agreement independent of level of expertise of examiners.

April 8

Poster presentations
11:00–12:14

OP76/11:19–11:22

Posterior sloping angle as a predictor of bilaterality in slipped capital femoral epiphysis

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Level-3

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction Patients presenting with unilateral slipped capital femoral epiphysis (SCFE) are at risk of developing a subsequent contralateral epiphysis slip. Prophylactic pinning of the unaffected hip may prevent a potential contralateral slip, but it is an invasive procedure. Decision analysis models that support close surveillance of the other hip versus prophylactic pinning remain controversial. Lately, morphometric parameters such as the posterior sloping angle (PSA) of the unaffected femoral epiphysis are examined in order to help in decision-making. In this study we attempted to evaluate the utility of PSA to predict a potential contralateral slip when measured on plain frog-leg radiographs of the pelvis. Additionally, we assessed the inter-observer reliability and intra-observer reproducibility of this radiologic index.

Materials and methods We retrospectively reviewed the medical files of two groups of patients with SCFE treated in our institution from 2000 to 2010. 15 patients (9 male, 6 female; mean age, 11.6 years) sustained bilateral SCFEs and constituted the study group. 15 patients (8 male, 7 female; mean age, 12.2 years) with unilateral SCFE were randomly assigned to the control group. The period between the two slips in the study group was found to be 13.9 months (range, 6–29 months). No patient presented with simultaneous bilateral hip involvement. The PSA of the unaffected hip was evaluated in the initial frog-leg radiograph by two different observers on two different occasions.

Results The patients that developed bilateral SCFE presented with an increased PSA of the femoral epiphysis on the initial radiograph compared with the patients that sustained a unilateral SCFE. The mean PSA was $M = 17.8^\circ$, $SD = \pm 5.5^\circ$ in the study group and $M = 9.4^\circ$, $SD = \pm 3.2^\circ$ in the control group ($p < 0.001$). Both inter-observer reliability and intra-observer reproducibility demonstrated good ($K = +0.68$) and excellent ($K = +0.79$) agreement respectively.

Conclusion The results of this study suggest that PSA is a valid and reproducible radiologic index when measured on plain frog-leg radiographs. This angle may predict a subsequent contralateral slip and assist in decision-making. The unaffected hip with a PSA of more than 12.3° should be treated with caution because of the high possibility of a subsequent contralateral slip. These patients may be candidates for prophylactic pinning.

Significance Prophylactic pinning of the unaffected hip in SCFE is a controversial procedure. Calculation of the PSA is a promising way to predict which patients are sufficiently high risk to justify this invasive treatment.

April 8Poster presentations
11:00–12:14**OP77/11:27–11:30****Radiographic analysis of the pediatric hip with hereditary multiple exostoses**Maria Pilar Duque Orozco¹, Oussama Abousamra¹, Kenneth Rogers¹, Mihir Thacker¹¹Nemours/AIDHC, Wilmington, DE, USA**Level-4****Tumours****Introduction** This study aimed to report the radiographic presentation of involved hips in children with HME. This included radiographic hip measurements, the location of the osteochondromas location and their relationship with hip subluxation.**Materials and methods** Radiographs (AP pelvis) of children with HME, between 2003 and 2014, were reviewed retrospectively. Only patients who were skeletally immature at the first visit were included. One radiograph per patient per year was reviewed. Radiographs were examined for the presence of osteochondromas and their locations. Different parameters were evaluated: Femoral neck-shaft angle, Reimer's migration percentage (MP), Sharp acetabular angle, Wiberg's angle, femoral head-neck ratio (coronal plane) and Shenton's line. All measured radiographs were divided into three age groups: ≤ 8 years, > 8 and < 13 years and ≥ 13 years. Differences of the measured parameters with age were evaluated. Radiographs of children with a minimum 2 year follow up were identified and changes of osteochondromas' presence over time were recorded. Children with hip subluxation were identified and any relationship with osteochondromas locations was recorded.**Results** A total of 51 children (102 hips) with HME were identified. In all locations, there was an overall increase of the occurrence of osteochondromas in the older age groups. However, in the medial femoral neck, a significantly less numbers of osteochondromas were found after 13 years of age ($p = 0.018$). Thirty-six children had a minimum follow up of 2 years (mean age at first visit 8.5 years and mean age at last visit 13.1 years). In these children, an increased occurrence of lesions was found in medial femoral neck and ischium ($p < 0.05$) between the first and the last visits. There was a significant decrease in MP with age. There was also a significant increase in Sharp and Wiberg's angles in the older patients. Hips with broken Shenton's line decreased in number with age ($p 0.028$). Hip subluxation was encountered in 63 hips. Ninety percent had a unilateral subluxation. No specific location of osteochondromas was found to have a relationship with subluxation.**Conclusion** In children with HME, radiographic hip parameters showed a trend to improve with age, mainly after 13 years of age. A new occurrence of osteochondromas in the older age group was noted.**Significance** Since radiographic hip measurements tend to improve with age, surgical treatment should be proposed cautiously and should primarily target persistent deformities in older patients.**April 8**Poster presentations
11:00–12:14**OP78/11:30–11:33****Paediatric polytrauma: analysis of mechanism, pattern and outcome in a United Kingdom Major Trauma Centre**Stohr Kuldeep¹, Gohar Abbas Naqvi¹, Gabriella Johansson², Andreas Rehm¹, Andrew Carrothers¹¹Cambridge University Hospital, Cambridge, United Kingdom;²Cambridge University, Cambridge, United Kingdom**Level-4****Upper and lower extremity trauma****Introduction** Paediatric trauma remains a major contributor to child morbidity and mortality. The major trauma centre network (TCN) is a new way of treating major trauma in the United Kingdom. It has improved outcomes in adult trauma. We explore the network's potential impact in paediatric polytrauma by independently analysing paediatric trauma data in a United Kingdom level I trauma centre and identifying the pattern of injuries, associated mechanisms and assessing the outcomes.**Materials and methods** This is a retrospective analysis of our hospital trauma database, which reviewed all cases of moderate to severe trauma in children aged < 16 years, over a period of 3 years (January 2012 to December 2014). Data reviewed, included demographics of patients, transfer information, day, month and time of presentation, mechanism and type of injury, systems involved, Glasgow Coma Scale (GCS), Abbreviated Injury Scale (AIS), Injury Severity Score (ISS) and Probability of Survival (PS) calculated from Glasgow Coma Scale (GCS) and ISS. Injuries were categorised according to seven body areas including head, face, thorax, abdomen, pelvis, spine and limbs. Different injury patterns were assessed in relations to age group, mechanism of injury and mortality rate.**Results** 213 patients were included with mean age of 7.8 ± 5.2 years. Vehicle related incidents (46 %) were the most common mode of injury and the median length of hospital stay was 5 days (IQR 4–10 days), with 52 % of patients having to stay in critical care for a median length of stay of 1 day (IQR 0–2 days).Most of the injuries occurred on roads (37 %) or at home (31.4 %) followed by public areas (14.6 %) and institutions (7.8 %). Road traffic accidents were the most common mechanism of injury over all (46 %) and also in the age groups 6–10 years and 11–16 years. Infants < 1 year old account for 13 % of emergency admissions and suspected non accidental injury (NAI) and fall from low height were the 2 main mechanisms involved. All suspected NAIs presented with either head injury or asphyxia-related brain injury. Three cases of hanging were also reported, two of them were most likely accidental while playing alone and one was suspected self harm. The most common injury was a head injury (87, 54.7 %) followed by limb injuries (68, 42.7 %) The overall mortality rate for head injuries was 8.7 % and was the only injury that was fatal in isolation in 2 cases.

Pelvic fracture was the least common injury 15 (7 %) and all but one were associated with injuries in other body regions. 14 out of 213 patients died with average mortality rate of 6.6 %. The average ISS was 19 ± 10 . Pearson's (r) shows a positive correlation of ISS with length of stay in hospital and in critical care.

Conclusion Mechanism, severity and pattern of paediatric trauma, show significant variation according to age groups. A multi disciplinary team approach is imperative with management in specialist centres to optimize their care and eventual functional recovery. Head injury remained the most common injury with significant mortality in all ages. Rib fractures and pelvic fractures should be considered a marker for the severity of injury and should alert doctors to look for other associated injuries.

Significance As trauma networks begin to be adopted globally our data has relevance to other urban/rural areas similar to our own. We also explore the role of damage control orthopaedics principles in the context of paediatric trauma management.

April 8

Poster presentations
11:00–12:14

OP79/11:33–11:36

Pediatric septic arthritis and osteomyelitis in the USA: A KID database analysis

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Level-2

Musculoskeletal infections

Introduction Previous studies have reported increasing rates of osteomyelitis over time, and decreasing rates of septic arthritis. The primary goal of the current study was to determine if the incidence rates of osteomyelitis, septic arthritis and combined infections have changed over time, and how they compare to previously reported rates. Secondary aims were to determine mean in-hospital costs and length of stay, and assess how these have changed over time.

Materials and methods The Kids' Inpatient Database (KID), containing a U.S. national sample of pediatric hospital records from 2000, 2003, 2006, 2009, and 2012, was used to determine yearly counts of osteomyelitis, septic arthritis and combined infections in children 18 and younger. US census data estimates from the National Center for Health Statistics were used to calculate yearly incidence rates, mean costs, and length of stay. Due to skewed data, the log mean length of stay and costs were calculated and compared over time.

Results From 2000 to 2012, the incidence of osteomyelitis increased from 8.1 to 9.0 per 100,000; decreased in septic arthritis from 4.9 to 3.7 per 100,000; and increased in the combined infections from 0.9 to 1.4 per 100,000. Length of stay in 2000 was 8.7 days for osteomyelitis, 6.7 for septic arthritis and 11.0 for combined infections. Mean in-hospital costs in 2000 were \$24,742 for osteomyelitis, \$17,624 for septic arthritis and \$30,047 for combined infections. Length of stay decreased for septic arthritis and mean costs increased significantly for all infections over the study period. Mean hospital costs in 2000 were \$24,742 for osteomyelitis, \$17,624 for septic arthritis and \$30,047 for combined infections. Costs more than doubled over the study period for all infection types ($p < 0.001$).

Conclusion Our findings concur with previous reports; the incidence rate of septic arthritis alone has decreased over time, while rates of osteomyelitis alone and combined infections have increased. Rates reported here are lower than those reported in other series, although the current series is limited only to infections treated in-hospital and does not include cases that may have been treated on an out-patient basis.

Significance Osteomyelitis and combined infections may be increasing with time due to improved diagnostics such as MRI, making it easier to identify subtle disease. Length of stay has decreased over time, potentially related to shorter IV antibiotic regimens. Despite shorter length of stay, costs have increased over time in the USA.

April 8

Poster presentations
11:00–12:14

OP80/11:43–11:46

Plantar pressure and balance ability in obese children

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Level-2

Foot and ankle

Introduction Overweight and obese children often experience problems in gait and posture. Pedobarography has been implemented to examine the effect of excessive body weight on foot morphology and biomechanics (McGraw et al. 2000). However, it is not yet clear to what extent mechanisms that contribute to the ability to balance (proprioception, vision, vestibular system) are influenced by differences in body composition in children. This study was designed to examine the effect of excessive weight on the biomechanical and morphological parameters of children's feet during static balance tasks. The aim of the study was to examine the differences in plantar pressure and balance ability between children with normal and increased body fat.

Materials and methods Thirty-six children (13 girls) were divided depending on their body fat percentage, as estimated by the Jackson and Pollock equation adjusted for age and sex. The overweight-obese (OG) and the control group (CG) were 11.0 ± 2.6 and 10.1 ± 2.7 years old, had 21.2 ± 8.0 % and 11.6 ± 6.3 % body fat, and 25.5 ± 4.0 and 17.6 ± 1.6 kg/m² BMI, respectively. Static balance was assessed on one or two feet, with eyes open or closed, while standing on a foot scanner (EPS, Loran engineering, Bologna, Italy) as still as possible. The star excursion balance and functional reach test were assessed as field tests. The level of significance was set at 0.05.

Results OG had significantly lower medial arch index and larger contact surface than the CG indicating a pes planus. The difference was more prominent when standing on both feet. Variability of the center of pressure on the anterior-posterior and mediolateral axis did not demonstrate any significant differences between the two groups in any of the examined conditions (open/closed eyes vs. standing on left/right/both feet). The star excursion balance tests revealed a significant higher performance in the CG compared to the OG.

Conclusion This study gives evidence that children with excess body fat have a permanent deformation of the foot arch. The absence of differences when standing on one foot indicates a ceiling effect in arch flexibility of OG, whereas CG have the ability to become flatter feet. The lack of differences in balance parameters between the two groups when using instrumented analysis in contrast to the significant lower performance in the star excursion balance test indicates that some measures might not be sensitive enough to capture some properties of balance. Lastly, although there is evidence that proprioception is inferior in obese adults (Gardner et al. 1983) our results did not verify this hypothesis in children. This indicates that the loss of proprioception might be a process which gradually appears in later stages of maturity.

Significance Long-term studies with objective means and specific clinical tests could assist in assessing foot function in obese children.

April 8

Poster presentations
11:00–12:14

OP81/11:46–11:49

Clubfoot achilles tenotomy: percutaneous approach versus needle technique, outcomes at 2 years

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Level-1

Club-foot

Introduction Residual equinus after conservative clubfoot treatment is associated with a high rate of surgical procedures. Achilles tenotomy (AT) is performed to correct the equinus and prevents the rate of future surgeries. AT is usually performed between 6 weeks and walking age. Different techniques are reported (open and percutaneous) with the aim of being less invasive. Since 2011, a needle technique has been developed in our institution. The aim of the study was to report the results of this technique in comparison to a percutaneous approach.

Materials and methods This prospective study included 108 patients with CF followed between 2008 and 2013. All patients were treated by the physiotherapy method and AT were performed at walking age. Two groups were compared: the percutaneous group (PCG) (57 patients between January 2008 and October 2011) and the needle group (NG) (51 patients between November 2011 and November 2013). The needle tenotomy is performed using an 18-gauge needle, which is introduced distally to proximally in three points in the middle of the tendon. A tendon hemisection is performed with the needle tip and started with a medial section, then a lateral and finished with a medial section in order to perform a Z-lengthening. Results were analyzed pre- and postoperatively. Ankle dorsiflexion (ADF) was measured physically with a goniometer. Lateral tibio-calcaneal angle (LTCA) was measured on radiographs with the foot and ankle in maximal dorsiflexion. Comparison between the two groups was performed using a Student T-test. **Results** Both groups were similar in age, gender, severity of initial deformity and etiologies. Results are reported as follows for the NG and PCG groups respectively, with no statistical difference. Mean preoperative ADF was -22.7° and -22° and mean LTCA was 108.4° and 112° . At a mean follow-up of 2.0 years, mean ADF was 10.3° and 10.0° and mean LTCA was 77.1° and 81° . No iatrogenic injuries such

as sural artery section/aneurysm or neurological deficiencies of the tibialis posterior nerve have been reported.

Conclusion Needle AT is as efficient as the percutaneous technique with similar 2-years outcomes for ADF. LTCA tends to be more corrected in the NG group. With the needle technique, scars were not visible, which is important in the future of the growing child.

Significance Currently, less invasive techniques need to be developed and must take into account the aesthetic appearance by growing. The needle tenotomy is proved to be a valuable technique in that sense.

April 8

Poster presentations
11:00–12:14

OP82/11:49–11:52

Reliability and validity of Edinburgh visual gait score as an evaluation tool for children with cerebral palsy

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¹Nemours/AIDHC, Wilmington, DE, USA

Level-4

Neuromuscular/Cerebral Palsy/AMC/MMC

Introduction This study aimed to evaluate the interobserver and intraobserver reliability and the validity of Edinburgh Visual Gait Score (EVGS) based on the experience at our institution.

Materials and methods Thirty children with cerebral palsy (CP) were included. One gait video per patient was reviewed. Children were at different levels of the Gross Motor Function Classification System (GMFCS). Ten children were at GMFCS I, ten at GMFCS II and ten at GMFCS III. All children had a three dimensional gait analysis at the same visit when the video was recorded. Seven observers reviewed the same thirty videos separately using EVGS. Three observers (one senior orthopaedic surgeon and two physical therapists) had high level of experience in gait analysis, two observers (two orthopaedic surgeons) had medium level of experience and the last two observers (two orthopaedic fellows) had no previous experience in gait analysis. None of the seven observers had a previous experience using EVGS. Interobserver reliability was calculated using percentage of complete agreement and kappa values. Reliability was also calculated within each group of observers based on their level of experience. The two least experienced observers reviewed the videos at two different time points, 3 months apart. Intraobserver reliability was calculated using percentage of agreement. Validity was evaluated by comparing the observations with three dimensional gait analysis data. Percentage of agreement was calculated as well.

Results Percentage of agreement between all observers for the 17 items of EVGS ranged between 90 % and 60 %. Foot initial contact was the most reliable item with agreement of 90 % (Kappa 0.85). Pelvis obliquity in mid stance was the least reliable items (Kappa 0.18). Percentage of agreement in the highly experienced group was 79 %, in medium level group was 74 % and in the least experienced group was 67 %. Intraobserver reliability showed agreement between 92 and 64 % for all items. Again, foot initial contact was the most reliable. Comparison with the gait analysis data was performed for all items except clearance in swing (not available in the gait analysis data); Percentage of agreement for the other 16 items was 65 %.

Conclusion In gait assessment for children with CP, EVGS was reliable across different levels of experience; however, higher

reliability was recorded for the more experienced observers. It was a valid method when compared to the standard gait analysis.

Significance EVGS is a useful tool in gait evaluation in children with CP; it is reliable when used by clinicians with different levels of experience.

April 8

Poster presentations

11:00–12:14

OP83/11:59–12:02

Three years' experience with the Fassier–Duval telescopic rod in children with osteogenesis imperfecta

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Level-4

Other

Introduction Bisphosphonate treatment has changed the natural course for children with Osteogenesis Imperfecta (OI) which still often requires supplementary orthopaedic treatment (1,3). In our former practice the older technique was used with smooth non-telescoping stainless-steel rods for realignment and fracture treatment of long-bone deformity in children with diminished bone quality. A telescoping rod has the advantage of “growing” with the child's own natural growth which hypothetically should reduce the number of operative procedures needed. The Fassier–Duval telescoping rod (FD-rod) has the advantage of a single entry point over the traditional telescoping rods such as the Sheffield or the Bailey-Dubow rods (2). The aim of this study was to evaluate the outcome of the use of FD-rods.

Materials and methods We report the first 18 (consecutive) children with fragile bones receiving 36 FD-rods during June 2011–March 2014. The age of the children was 1.7–16.1 years (mean 7.3 years). In total 29 surgeries were performed by one surgeon at Astrid Lindgren Children's Hospital at Karolinska University Hospital in Stockholm, Sweden. The follow-up time was 0.4–2.8 years, (mean 1.1 years). Diagnosis and indication for operation was registered, complication rate was registered, evaluation of mobility was performed with the nine-graded Wilson mobility scale (1 = independent walker in all surroundings–9 = no mobility) and presence of pain was recorded before and 3 months after surgery.

Results Seventeen children were diagnosed with OI and one child with Osteopetrosis (OP). Among children with OI, six were classified with OI type I, seven with type III and four children with type IV. Fifteen children with OI were receiving intravenous Pamidronate treatment. The indication for insertion of the FD rod was realignment of long-bone deformity in 25 out of 36 rods (70 %) and in 11 out of 36 (30 %), the rod was inserted due to acute fracture. Thirty-five out of 36 rods were inserted in the lower extremity; 22 in femur and 13 in tibia. Only one rod was inserted in the humerus. Evaluation of Wilson Mobility Scale displayed improved mobility 3 months after the insertion of FD rods, from a median value of 6 (percentile 25th–75th:2–8) to 2 (percentile 25th–75th:2–6) ($p = 0.027$). Pain was reported by 16 children before surgery. Three months after surgery four children indicated presence of pain. The complication rate was six out of 36 rods (17 %). The reoperation rate was three out of 36 rods (8 %) rods; one revision surgery for

deep infection (in femur) and one child was re-operated on twice for impingement of the male rod (in tibia) in the knee joint. The second rod with impingement of the male rod (in tibia) in the knee joint resolved spontaneously with growth.

Conclusion In our experience the technique of using FD-rods is demanding but has a reasonably fast learning curve and the short term results are very promising. The vast majority of the children and parents were very satisfied due to the children's fast ambulatory improvement, fast postoperative recovery and the relatively low complication and re-operation rate.

Significance Reducing the number of operations is important for the children's development and quality of life, and can also provide substantial health economic advantages.

April 8

Poster presentations

11:00–12:14

OP84/12:02–12:05

Do males and females get different jobs within pediatric orthopedics? A comparison from the POSNA needs assessment survey

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Level-2

Multicentre and innovative studies

Introduction Over the past decades more females have entered surgical specialties. However, little research exists regarding how a surgeon's gender impacts their practice. This study evaluates if gender differences exist within pediatric orthopaedic surgeons regarding practice types, on-call responsibilities, surgical volume, reasons for job choice, working with fellows/residents, and mentorship.

Materials and methods The 2015 Needs Assessment Survey consisting of 99 questions was sent to the POSNA membership. For the purposes of this survey, responses were analyzed by gender (a self-reported designation on the survey). Chi squared testing assessed for statistical significance.

Results A total of 530 surveys were returned (43.2 % response rate). There were 422 males (79.6 %) and 108 females (20.4 %). There was a statistically significant difference in the practice types males and females joined ($p < 0.013$). Males were more likely to become hospital or university employees, and go into solo practice compared to females that tended to join non-affiliated, multi-specialty or pediatric orthopaedic group practices. Additionally, there was a significant difference in reported number of surgical cases per week (25.6 % of males reporting performing >7 surgeries per week vs only 9.8 % of females $p < 0.004$) and number of surgical hours per week (53.5 % males reporting 10+ hours surgery per week vs only 31.9 % females $p < 0.00001$). There was also a significant difference in the percentage of males planning on retiring in the next five years compared to females ($p < 0.022$). There was no difference in the amount of call, percentage working with residents or fellows, number of times one has changed practices, or mentorship available to new partners. In addition there was little difference in regards to reasons for one's

job selection as both genders rated quality of partners and an interesting practice as the two key factors when choosing a job.

Conclusion While male and female surgeons choose a job based on similar characteristics, there are significant gender differences in practice models and surgical volumes reported. A greater percentage of males are going to reduce their workload or retire in the next 5 years, which may further increase the percentage of female surgeons in the workforce.

Significance At this point, gender differences have not been studied for surgeons in pediatric specialties. However, given that we have identified gender differences in pediatric orthopedics, future work is required to fully understand the differences and their effect on the workforce. This study will serve as a benchmark for the future studies addressing these issues.

April 8

Poster presentations
11:00–12:14

OP85/12:05–12:08

Is improvement of treatment of Osgood-Schlatter disease possible? Efficiency of the platelet rich plasma therapy

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Level-3

Upper and lower extremity trauma

Introduction Prolotherapy is a well known method for stimulating healing: platelet-rich plasma (PRP) is an especially effective treatment. PRP was developed in the 1970s and first used in Italy in 1987 in a case involving open heart surgery. It has since been applied to many medical fields: cosmetic surgery, dentistry, sports medicine, pain management, injury of joints, tendons and nerves, fractures, pseudarthrosis and Osgood Schlatter disease. Osgood-Schlatter disease (OSD) is one of the common causes of knee pain in adolescents undertaking sports. The diagnosis is based on clinical signs, changes visible on ultrasonographic views and on X-ray images. OSD treatment is long and may last from 2 to 3 years. Pharmacological treatment with NSAIDs and rehabilitation do not significantly influence the length of treatment, therefore the Platelet-Rich Plasma (PRP) may be used to improve the results and accelerate the recovery. PRP injections were previously used to enhance bone healing in distraction osteogenesis, to improve fracture healing and to treat enthesopathies.

Materials and methods We introduced PRP injections for the treatment of OSD in 2012. The PRP was injected into the tibial tuberosity under C-arm control. We applied PRP to 29 children (25 boys and 4 girls). In the course of the disease the symptoms in these patients were severe, and the previous treatment was ineffective. The patients underwent ultrasound and X-ray examination before and after the administration of PRP. Follow-up varied from the 2–24 months. The correlations between clinical findings, ultrasound and radiographic view before and after PRP administration were analyzed.

Results The average age at time of PRP injection was 12.3 years in girls and 13.5 years in boys. OSD patients who underwent PRP treatment were satisfied with results. The knee pain and swelling

disappeared within 2 weeks after the PRP application and after 1 month symptoms were completely absent in most of the patients (>93 %). Radiographic imaging indicated visible remodeling of tibial tuberosity within 1–2 months of PRP administration. After 2 months patients were able return to active participation in sport. Only two patients needed additional surgery.

Conclusion 1. Platelet Rich Plasma (PRP) is an effective treatment of painful OSD in teenagers. 2. PRP facilitates a prompt return to physical activity

Significance PRP injections are an effective treatment for Osgood Schlatter disease facilitating the relief of pain and return to sporting activity.

April 8

Limb reconstructions II
14:20–15:42

OP86/14:25–14:30

Hemiepiphyodesis using staples and physeal screws for guided correction of angular deformity of the lower leg

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Level-3

Upper and lower extremity reconstructions

Introduction The purpose of this study was to evaluate the efficacy of staples and physeal screws for angular correction of lower leg deformity, and to evaluate the completeness of deformity correction by the end of the period predicted.

Materials and methods We retrospectively reviewed 103 episodes of hemiepiphysiodesis for angular deformity in 43 patients from 2004 to 2013: 37 physes in 14 patients with percutaneous transphyseal screw placement (Group 1), and 66 physes in 29 patients with hemiepiphysal stapling (Group 2). All patients were followed up to skeletal maturity. Angular deformity correction evaluated by measuring the mechanical lateral femoral angle and the medial proximal tibial angle. The growth remaining of femur and tibia was determined by using the Green-Anderson graph and the multiplier method of Paley et al. The age for recommended hemiepiphysiodesis was estimated by calculating the correctable angle as 360° (remaining growth, cm)/ 2π (width of physis, cm). Physeal behavior after metal removal was categorized: stationary (angular changes within $\pm 3^\circ$), rebound (more than 3° recurrence of the deformity), and arrested (more than 3° deformity in a direction opposite from the original deformity). Complications requiring additional surgery were noted.

Results The amount of coronal deformity of the lower limb was improved from its preoperative state and there was no significant difference between the 2 groups in the rate of correction. In all cases, deformity was corrected to an acceptable amount. The mean actual correction period was longer than the calculated one in both groups. Physeal behavior after metal removal were all stationary in Group I, but there were cases of 8 rebound and 9 of worsening in Group II. Additional surgery was required in 4 cases: 1 for screw malposition in Group 1, and 1 each for staple extrusion, overcorrection and infection plus physeal injury in Group 2.

Conclusion With respect to the rate of correction, the percutaneous transphyseal screw is as effective as staples in hemiepiphysiodesis for

guided correction of angular deformity. However this surgery should be performed a few months earlier than the calculated time when the patient is near skeletal maturity. Percutaneous screws appear to offer more advantages and fewer complications than stapling

Significance Several factors may cause the correction period to be longer than the expected. These are the error in calculating the correctable angle, variation among patients in screws or staples location, individual difference in growth among patients, and uncertainty in determining the best time for metal removal.

April 8

Limb reconstructions
II 14:20–15:42

OP87/14:30–14:35

Guided growth in children using 8-plates for length leg discrepancy and/or angular deformity. Review of ninety-six plates in 32 children

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Level-4

Upper and lower extremity reconstructions

Introduction Angular deformity and length leg discrepancy are common pathologies in childhood treated by techniques of guided growth using the eight-plate device. Objective: to evaluate the influence of variables like age, gender, medical conditions or orthopaedic diagnosis in dependent variables like speed and degree of correction, rebound effect, clinical evolution and complications.

Materials and methods Retrospective study was undertaken on patients treated between 2006 and 2014 in our hospital using the 8-plate device for correction of leg length discrepancy and/or angular deformity. We analyzed the influence of variables described above.

Results Thirty-two patients (24 male and 8 female, mean age 11 years, range 2–17) and 96 plates with a follow up of 19 months (range 3–42 months) were analyzed. Nineteen patients had a leg length discrepancy (15 male and 4 female, average age 12.7 years, range 2–16 years) and were treated with epiphysiodesis around the knee. Mean initial discrepancy was 31.94 mm (11 mm/75 mm) and final was 18.94 mm (10 mm/34 mm). The average correction rate was 0.54 mm/month (0.1 mm/3.21 mm), being lower in patients with higher skeletal maturation. Eleven patients with genu valgus (8 male and 3 female, average age 8.93 years, range 2–17) were treated with medial hemiepiphysiodesis of the femur, tibia or both. Before the treatment, mean Femoral Angle (mL DFA) was 86.850 (820/960) and mean Tibial Angle (mMPTA) was 91.50 (700/1060). At follow up, mean mL DFA was 88.310 (780/950) and mean mMPTA was 91.310 (830/1000). Six patients with genu varum (4 male and 2 female, average age 11.3 years, range 7–17) were treated with lateral hemiepiphysiodesis of the tibia, femur or both. Before the treatment, mean mL DFA was 91.20 (86/1020) and mean mMPTA was 82.440 (600/1080). At follow up, mean mL DFA was 87.90 (820/1040) and mean mMPTA was 80.40 (690/900). The average correction rate for angular deformity was 0.27/month (0.02/0.92) for mL DFA and 0.71/month (0.04–1.36) for mMPTA. We observed lower correction rate in patients with mucopolysaccharidosis and Blount disease. The average hospital stay was 2.85 days (1–11 days). There was one screw breakage and four superficial bound infections. No deep

infection or physal screw problems were observed in our series. Three patients with leg length discrepancy and two with genu varus showed no improvement.

Conclusion The 8-plate device is effective in the treatment of length leg discrepancies and angular deformities. It shows a good rate of correction and has few complications. Several variables influence the results.

Significance This paper provides an understanding of the effectiveness and rate of correction using guided growth for angular and longitudinal deformities of the lower limbs in children.

April 8

Limb reconstructions II
14:20–15:42

OP88/14:35–14:40

Is the eight-plate an absolutely successful choice in treating angular deformities of the lower limbs in paediatric patients?

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Level-4

Upper and lower extremity reconstructions

Introduction Temporary Hemiepiphysiodesis using Eight-plate is a technique that has gained popularity among surgeon for correction of angular deformities of the lower limbs in children carrying the advantages of a minimally invasive technique and the monitored guidance of the angular deformity correction with a lower risk of complications known to be related to other devices like screws and staples.

Materials and methods We retrospectively studied the results and complications in 60 limbs angular deformities in 42 children, 27 males 64 % and 15 females 36 %, treated by gradual guided correction using eight-plate from 2012 to 2015. Evaluation of the results included documenting number of patients reached full targeted correction, under corrected and overcorrected deformities, and prevalence of hardware failure.

Results Out of the 60 treated lower limbs 49 limbs reached the targeted correction in 6 to 12 months with mean correction time of 10 months. Complications reported included 10 limbs (16.7 %) of hardware breakage. 3 limbs (5 %) had superficial infection treated by antibiotics and one required surgical debridement and secondary sutures. 2 limbs (3.3 %) had skin irritation because of prominent screw tip projecting subcutaneously on the opposite side of the bone, 7 limbs in 4 patients were overcorrected due to missed follow-up and 4 limbs in 4 patients were under corrected.

Conclusion Eight-plate guided gradual correction of lower limb angular deformities comes at the top of the most reliable devices for such a purpose. There are certain precautions to be taken to avoid reported complications before placing the full trust in it. Recommended measures include proper placing and length of the cannulated screws used, meticulous calculation of the expected correction potential considering different physal closure timing among different racial groups related ages of puberty and finally the weight of the patient.

Significance Discussing the different complications seen with eight-plate guided angular deformities correction in the lower limbs in childhood.

April 8

Limb reconstructions
II 14:20–15:42

OP89/14:53–14:58

Limb lengthening after internal hemipelvectomy with the Fitbone®-System

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Level-4

Upper and lower extremity reconstructions

Introduction Internal hemipelvectomy after resection of malignant bone tumors of the pelvis is one option accepting a shortening of the leg which may be aggravated by the growth of the contralateral side in case of children, so that at maturity a huge limb length discrepancy results. The method of callous distraction offers the potential of bone growth of high biological quality. Using fully implantable distraction nails (Fitbone), lengthening can be controlled by wireless by an external control unit and the risk of infection is minimal. In cases of internal hemipelvectomy with or without arthroplasty, the neo-acetabulum is set under high load with an unknown risk of subluxation or even luxation if lengthening of the femur is performed. Would it be an option to use a fully implantable distraction nail also under these circumstances? Which perspective can be expected?

Materials and methods In 5 patients (2 male, 3 female) mean age 16.8 years, limb lengthening was performed with a fully implantable system (Fitbone) after resection of a malignant bone tumor of the pelvis which was treated by an internal hemipelvectomy. In all cases the lengthening nail was implanted retrograde through the knee joint. The osteotomy was performed about 9 cm proximal of the knee joint level. In 2 cases another distraction nail was implanted in the tibia and lengthening was performed simultaneously.

Results The mean lengthening gain was 10.5 cm (femur 8 cm, tibia 3,6 cm). The mean follow up was 28 months (12–42) after finishing lengthening. No technical complication occurred. In all cases bone formation was circular and sufficient. The position of the hip joint/prosthesis and the functional use remained unchanged.

Conclusion From our experiences limb lengthening of the femur and tibia with fully implantable distraction nails (Fitbone) seems to be suitable and effective even after internal hemipelvectomy with or without arthroplasty, if the hip was able to carry full load for at least 2 years. Using a fully implantable system exercises can be done without restrictions to prevent contractures, stiffness and subluxation of the adjacent joints.

Significance Lengthening of the tibia and especially lengthening of the femur with a fully implantable system seems to be a favourable option even after internal hemipelvectomy.

April 8

Limb reconstructions II
14:20–15:42

OP90/14:58–15:03

Limb lengthening and deformity correction of congenital and acquired deformities in children using the Taylor spatial frame

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Level-1

Upper and lower extremity reconstructions

Introduction The Taylor Spatial Frame (TSF) is a circular external fixator, where the rings are attached to separate bone segments by (half-)pins and connected by 6 oblique, telescopic struts, creating a hexapod. By varying the strut lengths the relative orientation of the rings and bone segments is changed and can correct uniplanar or multiplanar deformities, including axial length and rotation in addition to pathological angulation and translation between segments. There are few reports in the literature about the use of TSF in children. Hence, the aim of this retrospective investigation was to evaluate and present our results from the use of TSF in congenital and acquired deformities in children.

Materials and methods During the period October 2000 to May 2014, we mounted 127 frames (76 tibiae, 51 femora) in 116 children (57 males, 59 females; mean age 13, range 4–18 years). Follow-up after frame removal was at least 12 months and 32 months in average. Eighty-five TSF were applied for congenital (Group I) and 42 for acquired deformities (Group II). Six procedures were done only to correct axial deformities without lengthening, 19 procedures included pure lengthening without any axial correction, while 56 frames were used to correct biplanar and 46 frames to correct triplanar deformities, all including lengthening. Mean lengthening for all frames was 38 mm (7–80) mm. Other deformity parameters included mainly: valgus 11 (5–35)°, varus 16 (5–35)°, procurvatum 12 (5–25)° and external rotation 17 (10–40)°. Clinical and radiographic evaluation of all deformity parameters were done before surgery. Frames with specific strut lengths were built preoperatively according to the deformity parameters, limb size and the planned mounting parameters (“total residual” mode).

Results Deformity parameters were corrected to satisfaction in all but 3 patients, who needed further surgery for deformity correction. In 30 procedures 1 or 2 additional “total residual” adjustments were necessary for fully correction of the deformities. Mean lengthening index was 2.3 (0.8–20) months/cm in Group I and 2.3 (0.8–13) months/cm in Group II. In Group I 9 patients (all tibia lengthenings) received autologous bone grafting to provide consolidation. Three patients sustained a fracture during treatment and were operated with extension of the frame, while 4 patients fractured in the callotasis zone after frame removal. In Group II 2 patients had to be operated for possible compartment syndrome, whereas 1 of these had muscle necrosis in the anterior compartment. One patient developed arthritis in the knee

after two femoral lengthenings (14 cm). No fractures or other major complications were observed in Group II. Minor complications like superficial skin infections were observed in both groups.

Significance The current retrospective analysis of 127 cases of limb lengthening and deformity correction analysis a large number of patients, both totally and in subgroups based on the patient's diagnosis. Therefore important information can be gained by this study.

April 8

Limb reconstructions II
14:20–15:42

OP91/15:10–15:15

Congenital agenesis of the anterior cruciate ligament: a retrospective review of 14 knees treated by surgical reconstruction with a 7 years follow up

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Level-4

Upper and lower extremity reconstructions

Introduction Congenital agenesis of cruciate ligament (ACL) is a rare condition with a prevalence of 0.017/1000 live births and probably underestimated. This agenesis can be isolated but is often associated with diverse malformations. The few series reported in the literature have been limited to sporadic cases and the treatment is still discussed. We report a series of 14 cases of cruciate deficient knees in 11 patients treated by ligamentoplasty for an unstable knee.

Materials and methods Patients with open physes were treated by physal sparing reconstruction (PSR) of anterior cruciate ligament (Clocheville technique) and patient with closed physes were treated by the bone-tendon-bone (BTB) technique. Patients were evaluated at 45 days, 1 year and at last follow up by clinical evaluation, Xrays, MRI and IKDC questionnaire.

Results 14 knees (11 patients) were included. There were 7 boys and 4 girls with a mean age of 11.2 years (2.5–17). 5 patients presented isolated agenesis of the ACL (1 bilateral) and 6 presented associated malformations (2 fibular hemimelia, 1 short femur, 1 short tibia, 1 Multiple epiphyseal dysplasia and 1 connective tissue disorder (bilateral)). Physical examination revealed major anterior laxity in all cases. MRI and arthroscopy confirmed the diagnosis in all cases. 3 patients presented hypoplasia of posterior cruciate ligament and 6 patients presented meniscal malformations or lesions. 12 knees were treated by PSR techniques and 2 by BTB techniques. Notch-plasty was always associated with the reconstruction. Mean follow up was 7.1 years. 3 patients required surgical revision: 1 for cyclop's syndrome, 1 for stiffness and 1 for traumatic graft rupture. 10 of 11 patients have a good clinical and IKDC result at the last follow up without instability.

Conclusion The Physal sparing reconstruction of the anterior cruciate ligament for open physes and BTB technique for closed physes have good clinical and functional evolution at 7 years follow up. We recommend surgical management of congenital agenesis of the cruciate ligament in symptomatic patients to prevent degenerative lesions and avoid any functional limitation.

Significance This study is the largest series of surgical treatment of congenital agenesis of the cruciate ligament. Surgical management has a good clinical and functional outcome and can prevent degenerative lesions.

April 8

Limb reconstructions II
14:20–15:42

OP92/15:15–15:20

Quengel casting for the management of pediatric knee flexion contractures: a 26-year single institution experience

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Level-4

Upper and lower extremity reconstructions

Introduction Quengel casting was introduced in 1922 for non-surgical treatment of knee flexion contractures (KFC) associated with haemophilic arthropathy. It consists of an extension-desubluxation hinge fixed to a cast allowing for gradual correction of a flexion deformity while preventing posterior tibial subluxation. The purpose of this study is to report one center's experience with this technique for the treatment of pediatric KFC.

Materials and methods A retrospective review was conducted at a tertiary pediatric orthopaedic institution over a 26-year period. All patients with KFC treated with Quengel casting were included. Demographic data, associated medical conditions, adjunctive soft tissue releases, complications, and the need for late surgical intervention were recorded. Tibio-femoral angle measurements in maximal extension were recorded at initiation and termination of casting, 1-year follow up, and final follow-up. Success was defined as no symptomatic recurrence of KFC or need for subsequent surgery.

Results 18 patients (26 knees) were treated for KFC with Quengel casting. Underlying causes of the KFC included cerebral palsy, arthrogryposis, congenital flexion contracture, and pterygium syndrome among others. Average age at initiation of casting was 8.1 years with average follow-up of 59.9 months. 15 knees (58 %) underwent posterior soft tissue releases prior to casting. An average of 1.5 casts per knee were applied over an average of 23.9 days. Average KFC prior to casting was 52.0° (range 15°–100°) which improved to 5.96° (range 0°–40°) at cast removal ($p < 0.00001$). Superficial skin irritation was noted in 2/25 knees (8 %). No skin ulcerations or neurologic injuries occurred.

16 patients (22 knees) had 1-year follow-up or failed prior to 1 year. Of these, 11 knees (50 %) had a successful outcome. Residual KFC of those treated successfully was 6.8° (range 0°–30°) at 1 year and 8.2° (range 0°–30°) at final follow-up, averaging 71.4 months ($p = 0.81$). Of the 11 knees deemed failures, all had recurrence of deformity within 1 year of casting. Average KFC in this cohort prior to further intervention was 49.5° (range 15°–100°). Surgical release prior to application of the Quengel cast did not improve the chances for success ($p = 0.09$).

Conclusion Quengel casting with or without adjunctive soft tissue releases can improve pediatric KFC by an average of 46° with minimal complications. Though 50 % of treated patients will demonstrate significant recurrence or need later surgery, the majority of those treated successfully have durable results at intermediate term follow-up.

Significance Quengel casting is a safe and effective non-surgical treatment option for children with KFC.

April 8

Limb reconstructions II
14:20–15:42

OP93/15:20–15:25

Quality of Life (QoL) after hemiepiphyodesis for knee axial deviations: a child-dedicated questionnaire

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Level-2

Upper and lower extremity reconstructions

Introduction Guided growth is a routine method in the surgical treatment of most frequent lower limb axial deformities, which mainly occur around the knee. The Aim of this study was to evaluate retrospectively the quality of life (QoL) of the operated children using a dedicated questionnaire.

Materials and methods Between May 2006 and January 2012, 37 patients (28 Male, 9 Female), (65 limbs; femur = 37, tibia = 30), with an age range between 5 years and 6 months and 15 years and 3 months, affected by idiopathic axial deviations (IAD) (n = 42) or pathologic axial deviations (PAD) (n = 22), were treated with hemiepiphyodesis according to Stevens' surgical technique using "eight-plate" (Orthofix®). The deformities were valgus (n = 43; 35 M, 8 F) and varus (n = 22; 16 Male, 6 Female). The syndromes associated with PAD were: Mucopolysaccharidosis (n = 11), Rickets (n = 3), Ellis van Creveld (n = 2), Multiple exostosis (n = 2), Neurofibromatosis (n = 2) and Cleido-cranial Dysplasia (n = 2). The surgical technique was a distal, medial (n = 35) femoral hemiepiphyodesis, or a proximal, medial (n = 8) or lateral (n = 20) tibial hemiepiphyodesis. The average age at surgery was 11 years and 8 months; patients with PAD were treated earlier (9 years and 8 months) than patients with IAD (12 years and 9 months). The analysis of the results of the surgical technique, comprised of a Post-Operative Questionnaire (23 child-dedicated questions regarding the post-operative period) with a maximum score of 100 and a validated score Pedi-IKDC (International Knee Documentation Committee) on functionality of the knee during daily activities and sports, with a maximum score of 100. The two questionnaires were submitted with a Computer Assisted Telephonic Interview (CATI).

Results Of 37 patients, 33 answered. The Post-Operative Questionnaire showed a quick and complete knee function recovery after surgery (2 weeks in 63 %, 3 weeks in 75 %). Sport activity was started in 67 % of patients by the end of the first month. After 4 days, 51.5 % of patients were back to school. The average score was 83.088 (SD \pm 10.7; min 53.7–max 98.1). The average score with patients with IAD was 85.85 (SD \pm 9.98), while in patients with PAD it was 81.21 (SD \pm 11.42). There was no statistically significant difference between the two groups (p = 0.223). The average score of the Pedi-IKDC Questionnaire was 79.83 %. The average score of patients with IAD was 82.72 % and

75.90 % in patients with PAD. There was no statistically significant difference between the two groups (p = 0.156). Eighty-eight percent of the children was satisfied of the procedure.

Conclusion Our results highlight the effectiveness and low invasiveness of the surgical treatment of lower limb axial deformities, both in IAD and in PAD, with a guided growth technique.

Significance Guided growth surgical technique determines a quicker recovery to normal daily activities and sports and is a subjectively well accepted procedure by children.

April 8

Limb reconstructions II
14:20–15:42

OP94/15:25–15:30

Stabilization surgery for habitual dislocation of the patella in children: clinical and radiological outcomes

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Level-4

Upper and lower extremity reconstructions

Introduction Many procedures undertaken for the unstable patella have been reported with varying results, but those for habitual dislocation of the patella in children are rare except single procedures reported as case reports. This study aims to present the clinical and radiological outcomes of our surgical technique.

Materials and methods We retrospectively reviewed a consecutive series of patients treated with our patella stabilization procedure from December 2000 to October 2014. Twenty-nine patients (39 knees, 15 boys and 14 girls) constituted the study population. The mean age at surgery was 8.8 years (range 3.4–14.9). In all cases, we performed lateral retinacular release, medial capsular plication, vastus medialis obliquus advancement and vastus lateralis recession with or without transfer to the border of rectus femoris and vastus medialis. In 23 cases, reconstruction of the medial patello-femoral ligament (MPFL) using the iliotibial band (n = 22) or semitendinosus tendon (n = 1) was performed concomitantly with the aforementioned procedures. Clinical outcomes based on the Lysholm functional score and changes in radiological parameters were investigated.

Results The Lysholm score increased from 71.7 ± 13.3 before surgery to 86.1 ± 9.0 (p < 0.001) at a mean of 3.6 year-follow-up (range, 1–11.5 years). The patello-femoral angle significantly improved from $-27^\circ \pm 28$ to $13^\circ \pm 14$ (p < 0.001). The congruence angle ($72^\circ \pm 29$ vs $25^\circ \pm 23$) and sulcus angle ($147^\circ \pm 18$ vs $135^\circ \pm 20$) also significantly improved (p < 0.001 and p < 0.001, respectively). The patellar height ratio (Caton-Deschamps method) did not change significantly (1.28 ± 0.66 vs 1.30 ± 0.43 , p = 0.394). Re-dislocation of the patella developed in five knees (5/39, 12.8 %), of which four occurred in the knees that were treated without reconstruction of the MPFL. These knees were treated successfully by subsequent surgery including the MPFL reconstruction procedure.

Conclusion Our reconstruction procedure was effective in improving clinical and radiological parameters in children with habitual

dislocation of the patella. Addition of the MPFL reconstruction using the iliotibial band appeared to reduce re-dislocation rate in the cases where intraoperative stability of the patella was not sure even after completion of the other procedures.

Significance Our patellar stabilization technique addresses thick and short lateral quadriceps, which is believed to be one of the main pathologic changes in habitual patella dislocation, and utilizes the iliotibial band as a graft material for MPFL repair without notable donor-site morbidity.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP95/14:20–14:25

Reconstruction with expandable endoprosthesis: a good alternative in the treatment of malignant bone tumors of the lower limb in children

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Level-4

Tumours

Introduction The optimal method of reconstruction after a lower limb tumor resection in children remains controversial. This study evaluates the results of resection of malignant tumors of the lower limb in children and reconstruction with a mechanical expandable endoprosthesis.

Materials and methods We present a retrospective study of patients undergoing surgical treatment of a lower limb malignant bone tumor and reconstruction with an Expandable Prosthesis. Clinical data was collected from Medical Records: demographic characteristics of patients, characteristics of the tumor, affected segments, type of implant and complications. Functional assessment was performed using the Musculoskeletal Tumor Society Score (MSTS) and Kidscreen-10 Questionnaire.

Results Of the 14 patients who underwent surgical treatment of a malignant lower limb bone tumor and reconstruction with an expandable endoprosthesis, 8 were males and 6 were females, and aged 10.91 ± 1.98 years. The tumor was located in the distal femur in 9 patients, proximal femur in 1 patients and proximal tibia in 4 patients. 12 patients were staged Enneking IIB and 2 patients were Enneking III. Regarding complications: there were 2 cases of deep infection, requiring salvage treatment with a femorotibial arthrodesis; 2 implant failures which required revision to a total knee megaprosthesis; 2 cases of aseptic loosening endoprosthesis, that required revision, but maintaining an expandable endoprosthesis. With a mean follow-up of 8 years and 6 months (minimum 3 years and maximum of 15 years), each patient underwent 4.4 ± 2.2 surgeries, mostly for periodical mechanical lengthening of the endoprosthesis. At the end of follow-up, patients presented a limb length discrepancy of 3.8 ± 2.1 cm. We did not perform any amputation in this group and 13 patients remain alive. The MSTS score was 17.4 ± 6.8 and Kidscreen-10 score 72.7 ± 14.3 %.

Conclusion Reconstruction with an expandable endoprosthesis after tumor resection of the lower limbs in children allows preservation of limbs with good function, although final limb length discrepancy may still be a concern. Although we did not have any amputation due to infection, the multiple lengthening procedures that must be performed put the patient at risk for this situation, which is limb-threatening.

Significance Reconstruction with an expandable endoprosthesis is a good alternative in the treatment of malignant bone tumors of the lower limb in children, yielding good functional results. However, careful attention must be paid to management of limb length discrepancy and infection risk due to multiple procedures.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP96/14:25–14:30

Orthopaedic outcomes of intercalary biological reconstructions for lower extremity bone sarcomas in children

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Level-3

Tumours

Introduction Standard treatment for primary malignant bone tumors of lower extremity include chemotherapy and wide tumor resection. The majority of patients are candidates for limb salvage and reconstructive procedures. Some of them are also suitable for retaining natural joints adjacent to the tumor.

Materials and methods Retrospective evaluation based on clinical and radiographic MSTS and ISOLS criteria and comparison of orthopedic results in a cohort of patients. There were two subgroups treated with allograft reconstructions supplemented by biologic augmentation and long locking plates fixation versus allograft alone reconstructions with less stable fixation methods. Mann–Whitney U test was used to assess differences between the variables with p value <0.05 considered statistically significant.

Results Ten children (5 boys, 5 girls) aged 12.5 years (range 8–16) were treated for primary malignant tumors of distal femur (6), proximal tibia (3) and distal tibia (1). All underwent joint sparing resections with intercalary reconstructions including massive allograft alone (4), vascularized fibula transplant alone (1) or in combination of both (4), autologous tibia pro femur transplant (1). Follow up was 5.9 years (range 1–15). All children are alive and disease free. One local recurrence required amputation at the mid-femur level and prosthetic fitting with good functional outcome. All remaining walk functionally outdoors and gained good or excellent results in MSTS score: 24.2 (range 23–28) on average. ISOLS allograft/host fusion scoring revealed 7 excellent, and 3 good results. Average time to achieve bony fusion was 14,8 months (range 4–36) and 9,5 months (range 4–24) at diaphysis and epiphysis, respectively. Significantly faster fusion occurred in stable fixed, biologically aided reconstructions. Complications included one superficial wound infection, 7 allograft fractures in 6 children, non-union in 2, leg length discrepancy in 3 and all were solved with conservative or operative treatment without revisions of primary reconstructions.

Conclusion Joint preserving resections with biologic reconstructions remain a reliable and durable option for selected primary bone tumors in selected children. Better outcomes are obtained in reconstructions combining allografts with biological augmentation and stabilising bridging fixation. Complications, albeit frequent, are usually curable.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP97/14:30–14:35

Long term functional outcome and complications of using liquid nitrogen freezing for reconstruction of lower limb osteosarcoma in childrenAhmed Abdelaal¹, Norio Yamamoto¹, Katsuhiro Hayashi², Akihiko Takeuchi³, Shinji Miwa¹, **Ahmad Morsy**⁴, Yasser Assaghir⁴, Mohamed Alamelain⁴, Hiroyuki Tsuchiya⁵¹Kanazawa University Hospital, Kanazawa, Japan; ²Kanazawa University, ³Sohag University Hospital, Sohag, Egypt;**Level-4****Tumours****Introduction** Limb salvage has become the standard practice in the management of osteosarcoma. Limb salvage surgery represents a challenge in skeletally immature patients in whom further growth is anticipated. Several options are available for limb reconstruction in children, we report the long term results of using the freezing technique by liquid nitrogen for treatment of lower limb osteosarcoma in children using different reconstruction techniques.**Materials and methods** This study includes 24 children with lower limb osteosarcoma, the average age was 13 ± 3.2 years (6–18 years), and 10 were boys. The mean follow-up period was 87.3 ± 44.7 months (28–224 months). In 14 cases the lesion was in the femur, in ten patients it was in the tibia. Joint sparing and intercalary freezing was carried in out in 15 cases, while in five cases, osteoarticular freezing was performed, and a composite technique with a tumor prosthesis was performed in four cases.**Results** Ten patients remained disease-free, eleven patients lived with no evidence of disease, one was alive with the disease, and two patients died of the disease. Five- and ten-year rates of survival were 91.76 %. Graft five and ten years survival rates were 91.48 and 83.3 % respectively. Function on the Enneking scale was excellent in 19 patients (79.1 %), and good in three patient (12.5 %), fair in one (4.1 %), and poor in two patients (8.3 %), mean MSTS score was 25 ± 5.4 (6–30). Mean union time was 8.7 months \pm 2.1 (6–12 months). Mean MSTS score was higher among children who receive a joint sparing rather than a joint sacrificing resection; 27.2 versus 21.3. Complications were recurrence in three cases (12.5 %), all recurrences were from soft tissue, collapse of the osteoarticular graft occurred in two cases (8.3 %). Fracture of the graft occurred in two cases (8.3 %), nonunion occurred in three cases (12.5 %). Leg length discrepancy occurred in seven cases, with a mean difference of 21.8 ± 8.3 mm (7–31 mm). Lengthening was carried out in four cases and finally achieved equal leg length in three cases, shoe raises were sufficient for the rest.**Conclusion** Reconstruction by frozen bone autograft method is easy, effective, biological method of management. It is low-cost, with immediate mobilization of joints, possible cryo-immune effects, with excellent long term functional outcome and with fewer complications.**Significance** Reconstruction by frozen bone autograft for treatment of osteosarcoma is a good reconstructive choice in a child with lower limb osteosarcoma, with good response to chemotherapy, with non-osteolytic lesion. Best results could be obtained when the joint preservation is possible and intercalary freezing could be carried out.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP98/14:45–14:50

A survey of EPOS Members' views and practices regarding osteofibrous dysplasia: can we work towards a European directive?Anish P. Sanghrajka¹, Andreas Roposch²¹The Norfolk & Norwich University Hospitals, Norwich, United Kingdom; ²Great Ormond Street Hospital, London, United Kingdom**Level-4****Tumours****Introduction** Osteofibrous Dysplasia (OFD) and Adamantinoma (AD) are related lesions at opposite ends of a spectrum of disease; whether one progresses to the other remains controversial, and these beliefs could impact upon the management of OFD. The purpose of this study was to collect information about surgeons' views and practices with OFD, in order to evaluate whether there is consistency, and in which areas any variation exists.**Materials and methods** A modified Dillman method was the basis for design and distribution of an online survey, using an internet-based software package (SurveyMonkey, Palo Alto, USA). Survey domains included subspecialty interests, experience/views about the relationship between OFD/AD and a case vignette with radiographs. All active members of the European Paediatric Orthopaedic Society (EPOS) were invited to participate in the survey by email, with an individual link to a personal questionnaire. Up to two further reminders were sent to those who had not completed the questionnaire. Responses were analysed using a combination of descriptive and inferential statistical methods.**Results** A total of 181 people, from 34 countries, responded to the survey (response rate 69.3 %). 61 % of respondents reported concern that cases of OFD could transform to AD, but only 15 % reported direct experience of this phenomenon. 12 % of respondents believe that cases of OFD always require surgical treatment. The most popular modality of imaging investigation following a plain radiograph was Magnetic Resonance Imaging (MRI) (85 %). There was far greater variability with the use of computed tomography and bone scan (33 % and 26 % respectively). 43 % of respondents include a bone-biopsy for investigation of OFD, but 77 % would use it if they wanted actively to exclude AD. 65 % would manage the case of uncomplicated OFD in the questionnaire with observation alone. Non-surgical management was significantly more popular amongst surgeons without an oncology interest in comparison to those with this interest (56 % vs 72 %; $Z = 2.01$, $p = 0.04$). Curettage was the most popular surgical option, (52 %), with 26 % favouring marginal resection and 22 % wide excision; this did not differ significantly with oncology interest. During follow-up of OFD, 43.75 % reported using radiographs alone, whilst 53 % would use periodic MRI in addition.**Conclusion** A wide variation exists in the views and practices of EPOS members regarding OFD, encompassing investigation, management and its relationship to AD.**Significance** OFD requires further detailed, prospective long-term study to determine optimal management, in order to reduce the great variability that currently exists.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP99/14:50–14:55

Malignant peripheral nerve sheath tumors (MPNST) in pediatric NF I patients

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Level-2

Tumours

Introduction Although uncommon, MPNST can occur in the pediatric age group of NF I patients. It usually arises in the pre-existing plexiform neurofibroma site. The lesion is chemotherapy and radiation therapy resistant and complete surgical excision is the only known effective treatment. High mortality of this condition reported in the literature led us to review our experience with MPNST and formulate recommendations for management based on the results

Materials and methods Retrospective review of all pediatric patients diagnosed with MPNST in our institution was undertaken. Location, size, pre-existing lesions, potential delay in diagnosis, treatment afforded and outcome were recorded.

Results Seven patients fulfilled inclusion criteria. All had diagnosis of NF I and histologically proven diagnosis of MPNST. All live patients have at least 2 year follow up. All lesions arose in pre-existing neurofibromas. Four were in the pelvis, one in each cervical thoracic, popliteal area and the forearm. Three out of the pelvic lesions and the neck lesion had a delay in diagnosis and all these died of their disease. One pelvic patient and the two limb-site patients had complete wide resections and are long term survivors. In all patients MRI demonstrated suspected malignant changes in the pre-existing neurofibromas. In one of the pelvic patients this was several months prior to the diagnosis.

Conclusion Early diagnosis before metastatic spread and ability to perform wide, clean margin surgical resection was the only criterium preventing fatal outcome. We recommend aggressive investigation of any enlarging lesion in the NF I patients and regular screening by MRI of known pelvic and brachial plexus neurofibromas

Significance Regular surveillance of children with NF I associated plexiform neurofibromas in pelvis or thoraco-cervical area (silent areas of the body) can potentially prevent a fatal outcome of this condition

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP100/15:02–15:07

Percutaneous myofasciotomy: a minimal invasive method to treat muscle shortening in CP children

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Level-4

Neuromuscular/Cerebral Palsy/AMC/MMC

Introduction To reduce spasticity and correct muscle shortening percutaneous muscle lengthening is a minimal invasive procedure in children with spastic cerebral palsy (CP). Muscle lengthening procedures nowadays are considered to be negative for muscle power. We aimed to investigate the effect of percutaneous intramuscular lengthening as a whole body procedure in children with CP for safe and accurate lengthening of short muscles and fascia with only little loss of power. Percutaneous muscle lengthening has not yet been evaluated on its impact on quality of life. In daily routine caregivers often report about treatment effects in daily living. With this study we tried to evaluate these effects especially after percutaneous muscle surgery in children with CP.

Materials and methods Over 1000 children with spastic CP (bilateral and unilateral) have been treated with percutaneous muscle lengthening in Schön Klinik München Harlaching. The muscle lengthening in this technique is done with a very tiny scalpel percutaneously. The effected muscles have to be carefully examined by very accurate palpation. Under general anaesthesia up to 25 muscles are released in the legs, arms, stomach, back and in the face. We measured pain after surgery with VAS, blood loss, time of surgery and time of recovery to the preoperative functional level. The Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD©) questionnaire measures caregivers' perspectives on the health status, comfort, wellbeing, and ease of care giving of children with severe developmental disabilities. It was developed to measure the effectiveness of interventions intended to improve or preserve these outcomes for children with severe disabilities, including non-ambulant children with severe cerebral palsy, and traumatic or other acquired brain injuries.

Results The mean age was 12.3 years (3–25 years). We operated on 1015 patient, 57 patients (2009), 181 (2010), 329 (2011) and 448 (2012). The number of muscles lengthened was 17. 1 (1–32). Lengthening's were performed bilaterally in 707 patient, unilaterally in 228 patients and only in the arms in 80 patients. VAS in mean was 3.4 (0-7), intra surgical blood loss 21 ml (1–37), time of surgery in mean 2 min per muscle and time for recovery markedly shorten than after open surgery (mean 1.5 days per muscle). Obviously hand function recovered easier than leg function. Gait velocity improved by a factor of 1.5 in GMFCS 3 patients. CPCHILD measurements improved +8.9 points (–2–+23) in GMFCS level 3-5 with the most improvement in GMFCS 3 (+11.2 (4–23)).

Conclusion Our own experience indicates that surgery needs less time, and there is less post-surgical pain. Recovery is shorter and the method gets very high acceptance by patients and parents. Necessary muscle lengthening in combination with hip reconstruction could be achieved more gently. Our midterm outcome indicates that there is a persistent corrective effect with improvement in individual function and significantly improved quality of life.

Significance We completely changed our regime of treatment since we have observed the great benefit of this method for our patients.

April 8Tumor/Neuromuscular/CP
14:20–15:45**OP101/15:07–15:12****Knee hyperextension in children with cerebral palsy: outcomes over a minimum of 5 year follow Up**Oussama Abousamra¹, Daveda Taylor¹, Chris Church¹, Maria Pilar Duque Orozco¹, Nancy Lennon¹, John Henley¹, **Julianne Sees¹**, Freeman Miller¹, Justin Connor¹¹Nemours/AIDHC, Wilmington, DE, USA**Level-3****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** This study aimed to evaluate the course of knee hyperextension (back-kneeing) in children with cerebral palsy (CP) over a minimum of 5 year follow up.**Materials and methods** 3D gait analysis records from 1990 to 2015 were reviewed for all children with CP who had: (1) knee hyperextension (defined as midstance minimum knee flexion below one standard deviation that of age matched typically developing children (smaller than -2 degrees) and (2) follow-up gait analysis that was at least 5 years later. Gait velocity, average knee flexion at initial contact, minimum knee flexion in midstance, maximum ankle dorsiflexion in midstance, knee flexion moments in midstance and pelvic forward tilt in stance were analyzed from the motion data. From the accompanying physical exams knee and ankle passive range of motion (PROM), the Gross Motor Function Classification System (GMFCS), and the Gross Motor Function Measure (GMFM) were collected. Surgeries performed on the extremities during follow up were also recorded.**Results** Knee hyperextension was identified in 308 knees, of which 97 had follow-up data greater than 5 years (mean 8 years). The mean age at the initial visit was 8 ± 3 years and the mean age at the follow-up visit was 16 ± 4 years. Between the tests plantar flexor lengthening (PFL) was performed on 40 % of the limbs, hamstring lengthening on 27 % and rectus transfer on 24 %. Overall, knee flexion and ankle dorsiflexion in midstance did increase (knee flexion: -10 to 6; ankle dorsiflexion: 6 to 11 $p < 0.0001$). However the functional data did not change (22 % were GMFCS I, 12 % GMFCS II, 39 % GMFCS III and 27 % GMFCS IV. Gait velocity was 65 ± 34 cm/s and GMFM was 25 ± 9), nor was there a change in muscle tone (90 % had a spastic gastrocnemius and 70 % had a spastic quadriceps femoris). At follow-up, 29 % of the knees were in hyperextension, 37 % were normal and 34 % were in excessive flexion ($>1SD$ above normal) in midstance. Similar changes were noted between children who had PFL and those who did not.**Conclusion** In this study, hyperextended knees showed increased flexion over 8 years. 2nd rocker dorsiflexion also increased. Children maintained their functional level at follow-up.**Significance** In children with CP, knee hyperextension generally decreases over time. All children had specific orthopaedic management to address their gait deviations. Plantar flexor lengthening is indicated in some cases and the role of multilevel surgery in the treatment of knee hyperextension needs to be further determined.**April 8**Tumor/Neuromuscular/CP
14:20–15:45**OP102/15:12–15:17****Psychometric evaluation of spinal assessments to screen for scoliosis in children with cerebral palsy**Elisabet Rodby-Bousquet¹, Måns Persson-Bunke², Tomasz Czuba³, Gunnar Hägglund²¹Centre for Clinical Research, Uppsala University, Vasteras, Sweden; ²Orthopaedics, Lund University, Lund, Sweden; ³RC Syd, Lund University, Lund, Sweden**Level-1****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** In cerebral palsy (CP) there is an increased risk of scoliosis. It is important to identify a progressive scoliosis early on, because the results of surgery depend on the magnitude of the curve. The Swedish follow-up program for cerebral palsy (CPUP) includes clinical examinations of the spine. The reliability and validity of the clinical assessment have not been evaluated. In this study we evaluate the interrater reliability of the clinical spinal assessment method used in CPUP and scoliometer measurement in children with CP, and we evaluate their validity compared to radiographic examination.**Materials and methods** Twenty-eight children (6–16 years) with CP in Gross Motor Function Classification System (GMFCS) levels II–V were included. Clinical spinal examinations and scoliometer measurements in the sitting position were performed by three independent examiners. The results were compared to the Cobb angle as determined by radiographic measurement. Interrater reliability was calculated using a weighted kappa score. Concurrent validity was analyzed using the Cobb angle as gold standard. Sensitivity, specificity, area under receiver operating characteristic curves (AUC) and likelihood ratios (LR) were calculated. Cut-off values for scoliosis were set to $\geq 20^\circ$ Cobb angle and $> 7^\circ$ scoliometer angle.**Results** There was an excellent interrater reliability for both clinical examination (kappa = 0.96) and scoliometer measurement (kappa = 0.86). The clinical examination showed a sensitivity of 75 % (95 % CI 19.4–99.4 %), specificity of 95.8 % (95 % CI 78.9–99.9 %) and an AUC of 0.85 (95 % CI 0.61–1.00). The positive LR was 18.0 and the negative LR was 0.3. The scoliometer measurement showed a sensitivity of 50.0 % (95 % CI 6.8–93.2 %), specificity of 91.7 % (95 % CI 73.0–99.9 %) and AUC of 0.71 (95 % CI 0.42–0.99). The positive LR was 6.0 and the negative LR was 0.5.**Conclusion** The psychometric evaluation of the clinical assessment showed an excellent interrater reliability and a high concurrent validity compared to the Cobb angle. The findings should be interpreted cautiously as research with larger samples may further quantify the psychometric properties. Clinical spinal examination seems appropriate as a screening tool to identify scoliosis in children with CP.**Significance** Active surveillance of children with CP should include spinal examination. To avoid excessive exposure to X-rays it is useful to have a clinical method with high psychometric properties to screen for scoliosis. The CPUP follow-up program is currently

implemented for children in Sweden, Norway, Denmark, Iceland, and Scotland.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP103/15:27–15:32

The treatment of crouch gait using distal femur extension osteotomy and patellar tendon shortening in cerebral palsy

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Level-3

Neuromuscular/Cerebral Palsy/AMC/MMC

Introduction The combination of distal femur extension osteotomy (DFEO) and patellar tendon shortening (PTS) has been frequently used as an option for the treatment of crouch gait in cerebral palsy (CP). The purpose of this study was to evaluate if patients who underwent DFEO and PTS had better outcome than those who received only DFEO.

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 the intervention. Seventy-six individuals were considered for this study and were divided into 2 groups: DFEO group (54 patients/88 lower limbs) and PTS + DFEO group (22 patients/42 lower limbs). Demographic data, static and dynamic knee extension and flexion were analyzed and the results compared among groups.

Results The age at surgery was 12.8 years in the DFEO group and 14.5 years in the PTS + DFEO group ($p = 0.093$). The mean follow-up time was 34.3 months in DFEO group and 33.1 in PTS + DFEO group. These results did not differ statistically. GMFCS distribution was similar in both groups and level III patients were more prevalent. The groups was also matched regarding clinical mean knee flexion ($p = 0.978$) and mean knee flexion in stance phase during gait ($p = 0.094$) before intervention. The mean knee flexion deformity on physical examination was reduced from 15.50 to 7.00 in the DFEO group ($p < 0.001$) and from 15.10 to 6.40 in the PTS + DFEO group ($p = 0.002$). During stance phase, knee flexion decreased from 46.00 to 30.70 in the DFEO group ($p < 0.001$) and from 52.30 to 29.50 in the PTS + DFEO group ($p < 0.001$). The improvement in knee extension on physical examination ($p = 0.584$) and during stance phase ($p = 0.181$) was similar between groups.

Conclusion In the present study, significant reduction of static and dynamic knee flexion was observed in both groups. The inclusion of PTS in the treatment plan was not related to additional improvement of knee extension.

Significance The use of PTS for the treatment of crouch gait may have a better indication after the growth spurt and for recurrent cases. The primary cases may be successfully addressed using DFEO for the correction of the knee flexion deformity.

April 8

Tumor/Neuromuscular/CP
14:20–15:45

OP104/15:32–15:37

Improvements in active elbow and wrist extension is maintained 10 years after upper limb surgery in cerebral palsy and stroke

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Level-4

Neuromuscular/Cerebral Palsy/AMC/MMC

Introduction Children with cerebral palsy (CP) may eventually develop a pronation and flexion deformity of the wrist and a flexion deformity of the elbow, further impairing the function of the already paretic limb. Many teenagers also complain about the appearance of the arm. We have previously shown that tendon transfer surgery and tendon lengthening improve the usefulness of the arm (AHA) when assessed 6-months after surgery. Whether these improvements are maintained many years after surgery is unknown. We therefore wanted to investigate whether short-term improvements in ROM, bimanual hand function (AHA) and self-rated perception of the arm/hand following upper limb surgery are maintained up to ten years.

Materials and methods Fifteen individuals with unilateral or bilateral spastic paresis ($n = 12$) were followed up 9 years (104 ± 14 , range 71–126 months) after surgery to the upper extremity. The mean age at initial surgery was 11 ± 3 years. Outcome measures were ROM, hand function (AHA, Zancolli and House classifications).

Results Elbow extension deficit (average $17.2^\circ \pm 12$) was present in 12 out of 15 children pre-OP. Biceps lengthening ($n = 9$) reduced the deficit (pre $23.7^\circ \pm 12$, post $13.3^\circ \pm 9$ and at follow-up $15.9^\circ \pm 10$, $p < 0.05$) and was maintained 9 years after surgery. In the children who did not have biceps surgery, a significant deterioration in active ROM was observed (pre $7.5^\circ \pm 10$, post $5^\circ \pm 10$ and follow-up $16.3^\circ \pm 10$, $p < 0.05$). Wrist extension, was improved to $>50^\circ$ when evaluated 6-months post-surgery and this was maintained at long-term follow-up (pre $-7.1^\circ \pm 51$, post $44.3^\circ \pm 21$ and follow-up $38.6^\circ \pm 38$, $p < 0.5$). Short-term improvements in the usefulness of the operated hand (AHA) deteriorated slightly in the long-term to the pre-OP level.

Conclusion Short-term improvements in active elbow and wrist extension are maintained 9 years after upper limb surgery in spastic paresis. However, the Assisting Hand Assessment (AHA) was unchanged, indicating that cerebral control of complex movements is the limiting factor for use.

Significance Hand surgery in CP improves the position of the hand and elbow and is retained for 10 years after surgery. The appearance of the hand is often appreciated, even though the hand is not used more.

April 8Neuromuscular/CP
16:15–17:30**OP105/16:15–16:20****Malignant progression of scoliosis after salvage hip surgery in patients with spastic cerebral palsy**Jin Ho Hwang¹, Joon Woo Han¹, Hyun Woo Kim¹, Dong Hoon Lee¹, Hoon Park²¹Severance Hospital, Seoul, Republic of Korea; ²Gangnam Severance Hospital, Seoul, Republic of Korea**Level-3****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** Painful hip dislocation is a common problem in spastic quadriplegic cerebral palsy, which often requires salvage hip surgery such as proximal femoral resection or proximal valgus osteotomy. We aimed to (1) investigate the progression of scoliosis after salvage hip surgery, (2) compare it with the ones of hip reconstructive cases, and (3) compare them with the natural history of scoliosis in spastic cerebral palsy.**Materials and methods** We evaluated a total of 86 patients with spastic quadriplegic cerebral palsy with painful hip dislocation or subluxation undergoing reconstructive hip surgery (n = 59, group A) or salvage hip surgery (n = 27, group B). Demographic variables for retrospective research included age at surgery, sex, total body involvement, bed-ridden status, preoperative Cobb angle and follow up period. Most of the patients were younger than 15 years old, bed-ridden, with a preoperative Cobb angle less than 40 degrees and with total body involvement. All patients had serial radiographs taken at least 3 times from preoperatively to about skeletal maturity postoperatively. We retrospectively reviewed and compared the serial changes of Cobb angle, kyphosis angle, lordosis angle, and pelvic obliquity between the two groups.**Results** Cobb angle progressed from 13.0 to 24.0 degrees in median in group A, whereas it progressed from 17.0 to 48.0 degrees in median in group B. The difference of Cobb angle between the initial and the final radiographs was greater in group B than in group A. The Cobb angle progressed more rapidly in group B than in group A with statistical significance. Differences of Kyphosis angle, lordosis angle between the initial and the final radiographs showed no significant differences between the two groups. The progression rate of pelvic obliquity was greater in group B than in group A with statistical significance. When compared to the known natural history of scoliosis with total body involvement, the progression rate of scoliosis in our study was within the range of natural history.**Conclusion** We aimed to compare the 3 groups, reconstruction group, salvation group and natural history group in respect to scoliosis progression. Values in both groups were all in the range of the natural course but it is important to remember that there is a 3.52 times difference between the two groups. Although salvage hip surgery helps in relieving pain of the dislocated hip, efforts should be made to reconstruct it as soon as possible to prevent rapid progression of the scoliosis.**Significance** This is the first paper to investigate the progression of scoliosis after salvage hip surgery and compare it with open reconstruction.**April 8**Neuromuscular/CP
16:15–17:30**OP106/16:20–16:25****Development of a stiff knee after crouch gait treatment in cerebral palsy: the role of patellar tendon shortening**Mauro C de Moraes Filho¹, Francesco Blumetti¹, Cátia Kawamura¹, Jaqueline Leite¹, Daniella Neves¹, Marcelo Fujino¹, José Augusto Lopes¹¹AACD, São Paulo, Brazil**Level-3****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** Patellar tendon shortening (PTS) and distal femur extension osteotomy (DFEO) have been routinely used for the treatment of crouch gait in cerebral palsy (CP). However, the impact of these procedures on knee flexion during swing phase has not been addressed so far. The purpose of this study was to analyze if PTS is related to the development of a stiff knee after crouch gait treatment in CP.**Materials and methods** A retrospective comparative study was conducted. 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: PTS (19 patients/34 lower limbs), DFEO (54 patients/88 lower limbs) and PTS + DFEO (22 patients/42 lower limbs). Demographic data, static and dynamic knee extension and flexion were analyzed and the results compared among groups.**Results** 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. All groups presented reduction of knee flexion deformity on clinical exam and improvement of knee extension during stance phase. Passive knee flexion on physical examination decreased 8.90 in the PTS group, 12.50 in the DFEO group and 21.90 in the PTS + DFEO group. The deterioration of passive knee flexion noted in the PTS + DFEO group was higher than in the PTS ($p = 0.004$) and DFEO ($p = 0.012$) groups. Peak knee flexion during swing phase was reduced in all groups after surgery. The amount of reduction was 11.60 in the PTS, 10.40 in the DFEO and 16.10 in the PTS + DFEO groups ($p = 0.149$). Finally, patients were divided according to GMFCS levels. We observed that GMFCS level II subjects of the DFEO group exhibited lower reduction (2.20) of knee flexion during swing phase than the PTS + DFEO group ($p = 0.002$).**Conclusion** The reduction of knee flexion during swing phase was observed in all groups after treatment. Patients with GMFCS level II who received PTS + DFEO presented a higher decrease in knee flexion during swing phase than those who underwent only a DFEO.**Significance** Stiff knee gait can occur after knee flexion deformity treatment in CP. There are no reports in the literature comparing the swing phase effects of different techniques for crouch gait correction.

April 8Neuromuscular/CP
16:15–17:30**OP107/16:25–16:30****Percutaneous hamstring lengthening surgery is as effective as open lengthening in children with cerebral palsy**Alexander Nazareth¹, Susan Rethlefsen², Ted Sousa², Nicole Mueske², Tishya Wren², Rachel Goldstein², Robert Kay²¹Children's Hospital Los Angeles, Los Angeles, USA; ²Children's Hospital LA, Los Angeles, USA**Level-3****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** The purpose of this study was to compare the results of open versus percutaneous hamstring lengthening on the kinematics in ambulatory children with Cerebral Palsy (CP).**Materials and methods** This retrospective cohort study included 68 ambulatory children with CP who underwent hamstring lengthening surgery (HSL) with both preoperative and postoperative gait analysis testing between 1997 and 2015. 49 subjects underwent open hamstring lengthening surgery (oHSL, mean age 8.4 ± 2.5 years) and 19 subjects underwent percutaneous hamstring lengthening surgery (pHSL, mean age 8.3 ± 2.2 years). Lower extremity three-dimensional kinematic data was collected while subjects walked at a self-selected speed. Outcome variables for operative limbs were compared within and between groups using t-tests, X2 tests and multiple regression analysis.**Results** Average time from surgery to post-operative gait testing was longer in oHSL group (32.1 vs. 20.3 months, $p = 0.013$). Age at the time of surgery, concomitant surgeries and distribution of Gross Motor Function Classification System (GMFCS) levels were similar between groups. Baseline range of motion, strength and kinematic variables did not differ between groups. Significant post-operative decreases in knee flexion at initial contact were seen for both oHSL (change: $12.7^\circ \pm 13.4^\circ$, $p < 0.0001$) and pHSL (change: $19.1^\circ \pm 13.1^\circ$, $p < 0.0001$) groups. Increased post-operative maximum knee extension in stance was found for both oHSL (change: $8.2^\circ \pm 16.8^\circ$, $p = 0.001$) and pHSL (change: $14.4^\circ \pm 16.5^\circ$, $p = 0.001$) groups. Mean pelvic tilt increased (anteriorly) after hamstring lengthening in both oHSL (change: $3.7^\circ \pm 7.4^\circ$, $p = 0.001$) and pHSL (change: $4.8^\circ \pm 7.2^\circ$, $p = 0.001$) groups. No significant differences between oHSL and pHSL were found when comparing post-operative changes in kinematic variables between groups. These results persisted after adjusting for the covariate, time from surgery to gait testing.**Conclusion** Percutaneous HSL is as effective as open HSL in improving stance phase knee kinematics during gait in children with CP.**Significance** Percutaneous HSL is a quick, minimally invasive procedure that results in equivalent improvement in gait kinematics to open lengthening. Percutaneous HSL is tolerated well by patients, and since it allows for rapid rehabilitation it may be preferable to the open procedure.**April 8**Neuromuscular/CP
16:15–17:30**OP108/16:30–16:35****Semitendinosus transfer extends the knee and prevents anterior pelvic tilt in spastic diplegia: a long term outcome study**Charlotte Frost¹, Jill Rodda², Kerr Graham², Paulo Selber²¹The University of Melbourne, Melbourne, Australia; ²The Royal Children's Hospital, Melbourne, Australia**Level-4****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** Children with spastic diplegia often walk with flexed knee gait. Traditional distal hamstrings lengthening has been shown to improve knee extension, however it concomitantly increases anterior pelvic tilt and lumbar lordosis. Semitendinosus transfer to the adductor tubercle is hypothesized to improve knee extension, and by preserving hip extensor function, prevent deterioration of the pelvic position. This study aims to determine the long term effects of semitendinosus transfer on knee extension and pelvic tilt. Three dimensional gait analysis were performed barefoot, with/without usual assistive devices. Indications for semitendinosus transfers: incomplete knee extension stance and knee fixed flexion $5\text{--}15^\circ$. Semitendinosus transfers were undertaken during single event multilevel surgery (SEMLS).**Materials and methods** Children <16 years old with diplegic cerebral palsy, Gross Motor Function Classification System (GMFCS) II or III, who had a semitendinosus transfer prior to 2010, had three-dimensional gait analysis (3DGA) pre-operative and >36 months postoperative. Exclusion criteria were hemiplegia, lateral hamstring lengthening, and previous selective dorsal rhizotomy.**Results** A total of fifteen children (30limbs) with a mean age at surgery of 9 years (6.6–12.9), satisfied the criteria. Average follow up was 58 months (42–94 months). Gait Profile Score (GPS) improved 15.9° pre to 11.4° post (mean difference 4.5° CI (Confidence Interval) $2.3\text{--}6.8^\circ$, almost 3× Minimally clinically important difference (MCID)), knee GVS improved 23.0° to 17.5° (mean difference 5.5° CI $1.4\text{--}9.7^\circ$), maximum knee extension in stance was 25.3° to 15.0° (mean difference 10.3° CI $3.3\text{--}17.4^\circ$), knee flexion initial contact 38.8° to 29.3° (mean difference 9.5° CI $5.9\text{--}13.1^\circ$). Maximum or mean anterior pelvic tilt (APT) did not significantly change: maximum tilt 17.9° to 18.5° (mean difference -0.7° , CI -6.1 to 4.7°) and mean 13.7° to 14.5° (mean difference -0.8° , CI -6.6 to 4.6°).**Conclusion** Semitendinosus transfer in the context of SEMLS improves knee extension during gait without compromising APT. This translates to an improved extension posture, which may prevent knee and back pain. Semitendinosus transfer is superior to traditional distal hamstring lengthening as it protects the position of the pelvis.**Significance** Semitendinosus transfer in patients with cerebral palsy does not lead to excessive anterior pelvic tilt in gait, yet is able to extend the knees in stance phase.

April 8Neuromuscular/CP
16:15–17:30**OP109/16:48–16:53****Knee deformities in children with down syndrome: a focus on knee malalignment**Maria Pilar Duque Orozco¹, Oussama Abousamra¹, Brian Po-Jung Chen¹, Kenneth Rogers¹, **Julianne Sees¹**, Freeman Miller¹¹Nemours/AIDHC, Wilmington, DE, USA**Level-4****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** This study aimed to report knee disorders in children with Down syndrome. The role of knee malalignment is described.**Materials and methods** Records of all children with Down syndrome were reviewed. Two groups were identified (with and without patello-femoral instability (PFI)). Radiographic measurements included: Mechanical lateral distal femoral angle (mLDFA), anatomical lateral distal femoral angle (aLDFA), joint line convergence angle (JLCA), medial proximal tibial angle (MPTA), angle of depression of the medial tibial plateau, distance of tibio-femoral lateral subluxation and distal femoral physis-joint angle. Radiographs at the time of PFI diagnosis were used for the PFI group. Last available radiographs were used for the group without PFI. Knees with PFI were divided into two subgroups based on their treatment (surgical or conservative). Preoperative radiographs were used for the surgical group and last available radiographs were used for the conservative. Clinical and radiographic data were compared. For the surgical group, clinical and radiographic data were compared between preoperative and last visits.**Results** Out of 581 children with Down syndrome seen at our institution between 2004 and 2014, 5 % (31 children: 22 females, 9 males) had PFI in 56 knees. Mean age at diagnosis was 8.7 ± 3.7 years. Of the remaining 550 children who did not have PFI, 75 children had weight bearing knee radiographs for 130 knees. Knees with PFI had significantly more valgus and a larger angle between the distal femoral physis and the joint line. Depression of the medial tibial plateau and lateral tibial translation were noted in knees with PFI.

Out of the 56 knees with PFI; 19 had grade 2 of PFI, 27 had grade 3, 5 had grade 4 and 5 had grade 5 (Dugdale classification). Ten knees had surgical (bony) valgus correction, 11 had soft tissue surgery to correct the PFI, 2 had combined procedures and 33 had conservative treatment. Preoperative mLDFA, aLDFA were smaller in knees with valgus correction than in knees with other procedures or conservative treatment. Grades of PFI improved in the knees with soft tissue surgery over a mean of 2.3 years postoperatively. This improvement was not noted in knees with valgus surgery.

Conclusion In children with Down syndrome, PFI was associated with coronal and rotational knee malalignment. The Valgus malalignment was corrected with bony surgery and PFI grades improved with soft tissue surgery.**Significance** Patello-femoral instability in Down syndrome is a multifactorial pathology. The anatomical deformities described in this study should be considered in the approach of knee disorders for children with Down syndrome.**April 8**Neuromuscular/CP
16:15–17:30**OP110/16:53–16:58****Long-term outcome of total hip arthroplasty in patients with cerebral palsy: a durable and effective means of pain relief and functional improvement****Anthony Stans¹**, Matthew Houdek¹, Chad Watts¹, Cody Wyles¹, Todd Milbrandt¹, Michael Taunton¹¹Mayo Clinic, Rochester, USA**Level-3****Neuromuscular/Cerebral Palsy/AMC/MMC****Introduction** Total hip arthroplasty (THA) has been used to provide pain relief in patients with Cerebral Palsy (CP). However, there is hesitation to employ this technique because of fears of dislocation and early failure. The purpose of this study was to review the outcome of total hip arthroplasty performed at our institution in patients with CP, and focus on the need for revision, reoperation and postoperative complications.**Materials and methods** Following IRB approval a review of an institutional total joint registry database, medical records and radiographs was performed. 41,349 patients underwent primary THA from 1970 to 2013 and 35 (0.08 %) THA's were performed in patients with CP. The cohort consisted of 64 % males, with a mean age of 52 years and BMI of 25.3 kg/m². The most common Gross Motor Function Classification Scale (GMFCS) level was 2 (n = 16) and all patients could walk with assistance prior to surgery. Harris Hip Scores (HHS) were calculated prior to surgery and at final follow-up. The mean follow-up was 7 years (range 2–25 years).

CP THA patients were then matched 1:2 for age and gender to a group of patients undergoing THA for OA over the same time period. Kaplan–Meier survival methods and Cox Proportional Hazard Analysis were used to compare groups, and estimate implant survival, reoperation, and postoperative complications.

Results The mean implant survival for primary THA in patients with CP was 89 % at 5 years, and 81 % at 25 years. There was no difference in implant survival in CP patients compared to OA patients, and no difference in implant survival based on GMFCS designation. Likewise, there was no increased risk of reoperation or postoperative complications between CP and OA groups. Specifically there was no increased risk of dislocation in patients with CP.Prior to surgery all patients had moderate or severe pain, and pain was significantly reduced postoperatively ($P < 0.0001$). The mean preoperative HHS was 37, which significantly improved to 77 ($P = 0.0001$) following surgery. Preoperatively 10 patients had a hip flexion contracture of ≥ 15 degrees and no patient had hip flexion contracture post-operatively ($P = 0.0008$).**Conclusion** THA provides patients with CP significant pain relief and functional improvement. Patients with CP should expect similar

outcome to those with a primary diagnosis of OA, and a diagnosis of CP should not discourage a surgeon from performing this procedure. **Significance** THA is a durable treatment option for patients with CP and hip pain, with a majority of patients retaining their implants over the course of their lives.

April 8

Neuromuscular/CP
16:15–17:30

OP111/16:58–17:03

Presentation of hip migration in CP: results at a mean of 5 years follow up with proximal femoral temporary epiphysiodesis

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Level-4

Hip/DDH/Legg-Calvé-Perthes/SCFE

Introduction The aim of this study is determine the efficacy of Proximal Femoral Temporary Epiphysiodesis (PFTE) on a 5 years follow up retrospective study, as a preventive method for hip migration in patients with CP

Materials and methods The medical records of 28 quadriplegic patients (GMFCS IV and V) treated bilaterally with temporary medial epiphysiorisis of the proximal femur using cannulated screws, were evaluated. Mean age at the time of surgery was .yrs. Clinical and radiological evaluation and surgery were performed by the senior author to reduce the inter-observer errors. Acetabular Index (AI), Neck Shaft Angle (NSA) and Reimer's Index (RI) were measured before surgery, at 6 and 12 months and than annually. Student t-test was used for the statistical analysis .

Results 2 of the 28 patients had isolated PFTE procedure, 4 had also simultaneous temporary anterior epiphysiodesis of the distal femur bilaterally and 22 had simultaneous soft tissue surgery. In the 5 years of follow-up we noticed a steady improvement of the values studied. Results: Right side: Δ NSA 12,92°, Δ AI 5,59°, Δ RI 6,96 %

Left side: Δ NSA 12,81°, Δ AI 6,37°, Δ RI 11,66 %

The average follow-up time was 3.4 years (range 1.4–5.6 years). No AVN, chondrolysis or any other bone problems were recorded; no case of infections were notified; the mean operation time was 60 min and free weight bearing allowed immediately after surgery. We had two cases of minor complications resolved with a replacement of the screw. At the 24 months, 3 patients needed bilateral botulinum soft tissue injection.

Conclusion Our results suggest that bilateral temporary epiphysiorisis of the medial plate of the proximal femur by cannulated screws reduce valgus deformity of the proximal femur with increased varus neck shaft angle, improvement in acetabular coverage and decrease RI, redirecting concentrically of the femoral head into the acetabular cavity.

Significance The Authors believe that this minimally invasive approach it is a valid method in preventing progressive hip dislocation in cerebral palsy children. It reduces the natural speed of hip dislocation and avoids the need to perform early more invasive procedures.

April 8

Neuromuscular/CP
16:15–17:30

OP112/17:12–17:17

The treatment of the progressive neuromuscular planovalgus foot deformity with a combined method

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Level-4

Neuromuscular/Cerebral Palsy/AMC/MMC

Introduction The implementation of the extra-articular subtalar arthrodesis for the treatment of neuromuscular foot deformities has been used in the past either as a Grice or Batchelor procedure, with several modifications concerning the type of the bone graft and the stabilization of the correction with or without internal fixation to alleviate some of the problems that have been reported. None proved free of drawbacks. Our purpose is to report our experience with the combination of these two techniques which gives great solidarity and less drawbacks.

Materials and methods Fifty-five patients (60 feet) with progressive neuromuscular planovalgus foot deformity underwent an extra-articular subtalar arthrodesis with the combined Batchelor-Grice procedure. All patients were ambulant. The mean age was 10.1 years (5–14) and the average follow-up was 10 years (5–17). The main preoperative complaints were deformity, skin irritation and discomfort underneath the talar head. A strut graft 7–8 cm long was obtained from the junction of the middle and proximal third of the fibula, and cut into two small unequal pieces. The longer peg (4–5 cm) is inserted into a channel drilled in an antero-superior to postero-inferior direction through the neck of the talus to the calcaneus crossing the sinus tarsi, with the hindfoot in the reduced position, and the small one is placed in the sinus tarsi as in a Grice technique. Assessment of the results was based on preoperative and postoperative clinical and radiological criteria. The former were the appearance of the feet, the hind foot varus/valgus position and local symptoms (skin pressure signs and pain). Evidence of graft fusion, measurement of the talo-calcaneal angle on lateral radiographs and the percentage of talar head uncoverage were the radiologic criteria taken in a weight-bearing position.

Results Foot appearance and mobility were improved, while preoperative complaints were reduced. All grafts were stable and fusion appeared solid in the corrected position. The mean preoperative lateral talo-calcaneal angle was reduced from 40.7° (30–64°) to 32.6° (30–48°) postoperatively. The talo-navicular joint returned to normal and full coverage (100 %) of the talar head was obtained in all the feet, compared with the mean preoperative uncoverage of 61 % (40–100 %). The gap at the graft donor site was bridged with new bone, without any upward migration of the lateral malleolus.

Conclusion Supplementary soft tissue operations, for restoration of the muscle imbalance and improvement of the foot function, may be required either before or concomitantly with the fusion in complex paralytic planovalgus foot deformities.

Significance The combined Batchelor-Grice subtalar extra-articular technique is easily performed and gives a greater assurance of solidarity than when either of the two procedures is used alone.

April 8Neuromuscular/CP
16:15–17:30**OP113/17:17–17:23****Scoliosis in down syndrome**Oussama Abousamra¹, Maria Pilar Duque Orozco¹, Kenneth Rogers¹,
Julianne Sees¹, Freeman Miller¹¹Nemours/AIDHC, Wilmington, DE, USA**Level-4****Neuromuscular/Cerebral Palsy/AMC/MMC**

Introduction Scoliosis has been reported in Down syndrome with a prevalence of 10 %. Cardiac surgery via a thoracotomy has been blamed for causing scoliosis in adolescents. The effect of bracing has been controversial and surgery has had a high rate of complications. However, the available reports covered a few decades of experience. In this study, the aim is to report our recent experience in scoliosis management. Treatment options and outcomes are reported as well.

Materials and methods Records of all children with Down syndrome, who were seen at our institution between 2004 and 2014, were reviewed. Scoliosis diagnosis was confirmed on radiographs with curves more than 10 degrees. Children with conditions other than Down syndrome, that might affect the spine, were not included. Curve levels, direction and magnitude were recorded. Risser stage, before brace application and at last visit, was recorded as well as curve progression in the brace. Preoperative, postoperative and last visit curve magnitudes, fusion levels and postop complications were also recorded. A comparison between children with and without scoliosis, in terms of their cardiac surgery history, was performed using Chi square test with a level of significance at 0.05.

Results Out of 581 children with Down syndrome, 62 children with scoliosis (18 boys and 44 girls) were identified. The mean age at diagnosis was 13.8 years (8–20.1 years). Double (S shaped) curve was the most common pattern (52 %). Mean curve magnitude at presentation was 31 degrees (13–66 degrees). Bracing was successful in 5 of 7 patients over a 24 months period. Ten children had posterior spinal fusion, using pedicle screws, with a mean follow up of 2.6 years (1–7.3 years). Average hospitalization was 5 days. One case of deep wound infection and one superficial infection were noted. No revisions was needed. No difference was found in the cardiac history between children with scoliosis and children who did not develop scoliosis ($p = 0.104$).

Conclusion Scoliosis is a common finding in children with Down syndrome. Screening is recommended before the deformity becomes clinically evident with large curves. Bracing can be tried for early detected cases, taking the compliance issue into consideration. Spinal fusion is a successful treatment with good results and low complication rate over the short term follow up.

Significance This study emphasizes the importance of scoliosis screening in Down syndrome. Recent advances in scoliosis surgery show promising results indicating that people with Down syndrome have been enjoying orthopaedic advances as well as advances in other medical fields.

April 8Trauma II
16:15–17:29**OP114/16:15–16:20****Changes in gait pattern in adolescents with recurrent patellar instability**Carlo Camathias¹, Rahel L. Meier², Elias Ammann², Erich Rutz³,
Reinald Brunner³, Patrick Vavken⁴¹University Children's Hospital Basel, Basel, Switzerland; ²Basel Medical School, Basel, Switzerland; ³University Children's Hospital, Basel, USA; ⁴Boston Children's Hospital, Boston, USA**Level-3****Upper and lower extremity trauma**

Introduction The essential static patellar stabilizer is a normal shaped trochlear groove. A dysplastic groove destabilizes the patella. The trochleaplasty approaches this underlying condition and reshapes the trochlea. However, all studies report on trochleaplasty either for revision cases or accompanied by different other interventions. The solitary effect of the trochleaplasty remains still unexplained. Objectives: To introduce the trochleaplasty as a stand-alone treatment for recurrent patella dislocation, and to compare its pre- to postoperative functional and clinical variables.

Materials and methods 88 knees (67 patients) with recurrent patellar dislocation (mean age 14.8 years \pm 2.8 SD) were compared to 54 healthy knees (27 individuals, 14.9 years \pm 2.4 SD), matched for age, sex, BMI. Kinematics of ankle, knee, hip and pelvis were captured using 3D-gait analysis (VICON, Plug-in-Gait). One cycle (100 %) consisted of 51 data-points. A mean of six trials were computed. Temporo-spatial variables were assessed. Durations and kinematics of the stance-phase, loading-response, mid-stance-phase, pre-swing, and swing-phase were calculated.

Results Only walking speed (-6.7 %) decreased as a temporo-spatial variable. The loading-response increased 0.02 s \pm 0.01SE (10.8 %) with dislocations (0.98 % of total gait, $P < 0.01$). The mid-stance-phase decreased equally ($P < 0.01$). Dislocation decreased knee flexion during the entire gait cycle ($P < 0.01$), with the minimal peak during mid-stance ($9.01^\circ \pm 7.23$ SD vs. $18.54^\circ \pm 6.72$ SD). Dislocation increased plantar-flexion during loading-response $4.10^\circ \pm 0.43$ SE ($P < 0.01$), afterward, the dorsal-extension decreased $3.19^\circ \pm 0.30$ SE, ($P < 0.01$). Dislocation decreased hip flexion during all phases ($P < 0.01$), maximal different during mid-stance with $7.46^\circ \pm 0.53$ SE. 80 % of all patients developed this gait pattern. Correlations between the knee flexion and either plantar-flexion and hip flexion were strong with $r = 0.75$ and $r = 0.61$ ($P < 0.01$), respectively.

Conclusion Recurrent patellar dislocations decrease the knee flexion during the loading-response and the mid-stance phase. A decreased hip flexion and increased plantar-flexion indicate a possible compensation mechanism.

Significance This study adds functional view on the complex of problems concerning patellar dislocation.

April 8Trauma II
16:15–17:29**OP115/16:20–16:25****Trochleaplasty as solitary treatment for recurrent patella dislocation results in good clinical outcome in adolescents**Carlo Camathias¹, Kathrin Studer², Erich Rutz², Patrick Vavken³¹University Children's Hospital Basel, Basel, Switzerland;²University Children's Hospital, Basel, Switzerland;³Boston Children's Hospital Bas, Basel, USA**Level-4****Upper and lower extremity trauma**

Introduction The essential static patellar stabilizer is a normal shaped trochlear groove. A dysplastic groove destabilizes the patella. The trochleaplasty approaches this underlying condition and reshapes the trochlea. However, all studies report on trochleaplasty either for revision cases or accompanied by different other interventions. The solitary effect of the trochleaplasty remains still unexplained. Purpose: To introduce the trochleaplasty as a stand-alone treatment for recurrent patella dislocation, and to compare its pre- to postoperative functional and clinical variables.

Materials and methods We carried out a trochleaplasty in 50 knees (27 right) in 44 patients (30 females, mean age 15.6 years \pm 2.0 SD). J-sign, and the apprehension test were assessed clinically, as well as a Kujala, and a Lysholm score. Patients were asked the "patient subjective assessment", the "activity level", and the overall satisfaction according to IKDC. Caton-Deschamps-ratio and the lateral condyle index (LCI) were measured. Pre-operative values were compared to the postoperative ones, using a paired Wilcoxon signed-rank test.

Results Kujala improved from pre-operative 71 points to post-operative 92 points ($p < 0.0001$). Lysholm rose from preoperative 71 points to post-operative 95 points ($p < 0.0001$). Patient subjective assessment increased at the final follow-up compared to pre-operative ($p < 0.0001$). Most patients enhanced their activity ($p < 0.0001$), in addition the overall satisfaction increased significantly post-operative ($p < 0.0001$). Pre-operative, J-sign was positive in 45 knees and apprehension test in 41 knees. Both markers disappeared post-operative in 39 and 33 knees, respectively, leaving six knees with a positive J-sign and eight knees with a positive apprehension test ($P < 0.0001$ for both values, Chi²-Test). One patella re-dislocated post-operatively after 38 months. An additional four patients required a single arthroscopic debridement of the knee to release adhesions.

Conclusion Trochleaplasty as a solitary treatment for recurrent patello-femoral dislocations results in good clinical outcomes. The Kujala and Lysholm scores, as well as the subjective IKDC questionnaires, the overall satisfaction and activity level increased compared to preoperative values.

Significance Recurrent patellofemoral dislocations are very common in adolescents. The trochleaplasty is one of the accepted concepts for treating instabilities. However, the procedure is mostly combined with other interventions or performed as a revision. The single effect of the trochleaplasty is obscured and difficult to understand.

April 8Trauma II
16:15–17:29**OP116/16:32–16:37****An audit and comparison of the management of paediatric supracondylar fractures across three UK centres**Robert Jordan¹, Edward Jenner², Daniel Westacott³, Stephen Cooke³¹University Hospitals Coventry & Warwickshire, Coventry, United Kingdom; ²Warwick Hospital, Warwick, United Kingdom;³University Hospitals Coventry, Coventry, United Kingdom**Level-4****Upper and lower extremity trauma**

Introduction Supracondylar fractures of the distal humerus are the most common elbow fractures in children. The injury can be associated with nerve injury, vascular compromise and malunion. The British Orthopaedic Society set clear standards for assessment and treatment of these fractures in their 2014 BOAST guidelines. The recent implementation of the regional trauma networks in the UK has seen centres categorised as either Major Trauma Centres, Trauma Units or local emergency centres. The authors audited and compared the performance against the BOAST guidelines at each type of centre. **Materials and methods** A retrospective audit was performed over a 12 month period at the major trauma centre and 3 years at the trauma unit and local emergency centres. Children under 16 years of age were included who required admission for a supracondylar fracture. Each set of case notes were audited against the 2014 BOAST guidelines which included documentation of a comprehensive neurovascular assessment on admission, timing of surgery and surgical technique. Performance at the three centres was compared.

Results The number of cases seen at the Major Trauma Centre, the Trauma Unit and local emergency unit were 31, 18 and 20 respectively. The majority were boys (77 %) and the mean age was 6.5 years (range 2–11). The documentation of a complete neurovascular assessment ranged from 9 to 39 % with the anterior interosseous nerve least commonly recorded. There was improved performance at the Major Trauma Centre. According to the guidelines appropriate timing of surgery varied from 67 to 92 % and was highest at the major trauma centre. Documentation of safe medial wire insertion and achieving bicortical fixation was achieved in the majority of cases but the size of wire used was documented in only 50 % of cases and often was smaller than the suggested 2 mm.

Conclusion The assessment of neurovascular injuries in this cohort of patients was poor across all centres. Possible reasons include poor documentation, lack of knowledge of anatomy and structures at risk. The Major Trauma Centre had better compliance.

Significance The assessment of paediatric supracondylar fractures in UK emergency departments is poor. Although the Major Trauma

Centre performed best against guidelines, all centres have significant improvements to make.

April 8

Trauma II
16:15–17:29

OP117/16:37–16:42

A comparison of ketamine sedation and general anaesthesia in the manipulation of paediatric forearm and wrist fractures

Robert Jordan¹, Daniel Westacott², Alex Aquilani², Edward Jenner³, Stephen Cooke²

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Level-4

Upper and lower extremity trauma

Introduction Paediatric forearm and wrist fractures are common injuries. If significantly displaced the child traditionally undergoes manipulation under general anaesthetic. However this practice has consequences for the patient and hospital in terms of hospital resources and social impact. The provision of ketamine sedation for reduction of these fractures has recently been introduced in the Emergency Department at our centre. Anecdotally this has provided an efficient service. This study aims to compare the outcomes of those children treated through this pathway when compared to cases reduced under general anaesthetic.

Materials and methods A retrospective analysis was undertaken, over a 12 month period, of all children who presented with an angulated or displaced distal radius or forearm fracture deemed to warrant manipulation. This group were divided into those manipulated under ketamine (group A) and under general anaesthetic (group B). Angulation and translation were recorded on admission, post-reduction and final follow up. The quality of cast was estimated using the Cast and Gap index. Further procedures, radiographic displacement and theatre time were also recorded.

Results 66 children were manipulated over the study period; 31 in group A and 35 in group B. In Group A 77 % were boys, the mean age was 8.9 years, 58 % were wrist fractures and the mean angulation at presentation was 28.5 %. In Group B 51 % were boys, the mean age was 8.6 years, 62.9 % were wrist fractures and the mean angulation was 27.6 %. An acceptable reduction was achieved in all but two patients (6.4 %) in Group A. The mean cast and gap index were higher in Group A, 0.77 versus 0.81 and 0.25 versus 0.23 respectively. Significant radiographic redisplacement was observed in 9.6 % in Group A and 14.3 % Group B, although only one patient in Group B had a further procedure. The mean time utilised in theatre for Group B was 50.8 min (range 26–80), 20 % had to wait over 48 h for theatre availability and 31 % were admitted overnight following the procedure.

Conclusion Manipulation of fractures under sedation can achieve an adequate reduction in the majority of cases. If reduced successfully the outcomes in terms of further procedures and radiographic redisplacement are comparable to general anaesthetic cases. Over the 1 year period this pathway potentially saved 26 h of theatre time and 10 overnight admissions.

Significance The effectiveness of ketamine versus general anaesthesia for reduction of paediatric forearm and wrist fractures seems to be equal with ketamine being advantageous in utilising less resources.

April 8

Trauma II
16:15–17:29

OP118/16:42–16:47

Hegemann disease and fishtail deformity revised: analysis of the world's largest clinical series

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Level-4

Upper and lower extremity trauma

Introduction Hegemann disease and fishtail deformity are growth disturbances in the physal plate of the humeral trochlea. The aims of our study are (1) to evaluate aetiology, (2) to provide diagnostic tools and (3) to provide a treatment algorithm.

Materials and methods From 2008 to date all patients diagnosed with either Hegemann disease or fishtail deformity in three large Dutch hospitals were prospectively followed in an observational cohort study. Data on demographics, clinical presentation, radiographic imaging and treatment were obtained. Plain radiographs were assessed for skeletal age according to Sauvegrain. Also, carrying angles and trochlear notch angles were determined. Statistical analysis was performed using SPSS.

Results A total of 22 cases was selected (20?, 2?, average age 16.5 years (range 8–52)), which is the world's largest series. In 20 patients (91 %) a traumatic condition of the elbow was reported, prior to presentation (either major or minor trauma). Decreased trochlear notch angle (<104°) was measured in 19 patients (86 %). Accelerated skeletal maturation of the affected elbow was seen in all patients with incomplete skeletal maturation at presentation. Surgery was performed in 11 patients (50 %) for symptomatic intra-articular loose bodies. During follow-up clinical complaints and elbow function improved, but did not return to normal.

Conclusion The main risk factor for both Hegemann disease and fishtail deformity is a traumatic elbow injury to an immature elbow. Accelerated skeletal maturation of the elbow, decreased trochlear notch angle and disturbance of osseous anatomy, are suggestive of a vascular etiology. Imaging studies support the hypothesis that both diseases are a continuum of the same process. Therefore we propose one (new) nomenclature for this pathologic process: Disturbance of the Ossification Center of the humeral Trochlea (DOCT).

Significance Information on incidence, etiology and clinical outcome are incompletely understood and the conditions might be easily overlooked. Nevertheless, these diseases lead to loss of function and pain in the majority of young patients interfering with daily activities.

April 8

Trauma II

16:15–17:29

OP119/16:47–16:52**Management of pediatric type I open fractures**

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

Introduction The management of pediatric Type I open fractures remains controversial. The aim of this study is to compare outcomes in non-operative and operative treatment and to identify complications related to both treatments.

Materials and methods A multi-center retrospective chart review was performed to identify all Type I open forearm, wrist and tibia fractures treated between 2001 and 2014 at four high volume paediatric centres. Patients who had multiple traumatic injuries, were immunocompromised, or who did not have final radiographs indicating healing were excluded. Non-operative management consisted of wound irrigation in the emergency department and antibiotic administration.

Results 224 patients met inclusion criteria. Mean age at admission was 10.0 years (range 2.3–18.3 years), with 161 (72 %) male and 63 (28 %) female patients. 175 fractures were treated operatively (78.1 %), 49 fractures were treated non-operatively (21.9 %). Cefazolin was the most commonly administered antibiotic (88 % of patients). There were 12 complications, 11 in the operative group (6.3 %) and one in the non-operative group (2.0 %) ($p = 0.246$). There were two infections; one in the operative group (0.5 %) and one in the non-operative group (0.6 %) with no significant difference between the groups ($p = 0.334$). In the operative group, there were three compartment syndromes requiring release (1.7 %), three malunions (1.7 %), and one each of delayed union, neuropraxia, and a stiff wrist requiring surgery. The incidence of malunion was significantly higher in fractures treated with operative debridement and casting alone, 2/35 (5.7 %), versus those treated operatively with an implant, 1/140 (0.7 %, $p = 0.041$). We otherwise did not find a significant difference in complications seen by fracture type or fixation.

Conclusion There was no significant difference in infection rate or complication rate in those treated operatively versus those treated non-operatively. There were, however, more complications associated with operative treatment including compartment syndrome and malunion. Malunions were most common in patients treated with operative debridement and casting.

Significance In the treatment of open fractures, consideration should be given to the similar safety profiles of operative and non-operative treatment. There are complications associated with both operative and non-operative treatment.

April 8

Trauma II

16:15–17:29

OP120/17:05–17:10**Incidence and outcome of avascular necrosis following lateral humeral condyle fracture in children**

Rachel Y Goldstein¹, Lior Shabtai², Alexis Rounds³, Alexandre Arkader³, Nina Lightdale³, **James Lee Pace**³

¹Children's Orthopaedic Center, Los Angeles, USA; ²Children's Hospital Los Angeles, Los Angeles, USA; ³Children's Hospital Los Angeles, Los Angeles, USA

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

Introduction Avascular necrosis (AVN) following lateral humeral condyle fracture is a known, but poorly understood complication. Fracture severity and delay in treatment have often been cited as risk factors. The purposes of this study are to report the incidence, outcomes, and potentially significant contributing factors leading to AVN following lateral condyle fractures.

Materials and methods A retrospective review of children diagnosed with a lateral condyle fracture between 2001 and 2014 at a level-1 tertiary paediatric center was designed. Information collected included demographic data, classification, time from injury to surgery, operative versus non-operative management, open versus closed reduction and type of fixation. For patients with AVN, elbow range of motion (ROM), pain and deformity were measured as well at last follow-up. AVN cases were diagnosed by X-ray.

Results 500 children were available for review. The incidence of AVN was 1.4 % (7/500), of which 2/178 (1.1 %) were type 2 fractures and 5/168 (3 %) type 3 fractures. There were 5/315 (1.6 %) boys and 2/185 (1 %) girls. The average age was 3.3 years for the AVN group compared to 5 years of the total group. All cases of AVN occurred after open reduction and percutaneous fixation (ORPP) ($p = 0.01$) as initial treatment. Type 3 fractures were associated with AVN ($p = 0.041$). After average follow-up of 59 weeks (range 24–150 weeks), all patients regained full ROM except one who had lack of 15° of full extension and 10° full flexion. One patient required manipulation under anesthesia and physiotherapy but at final follow-up had full ROM. 5 patients were asymptomatic while two patients had mild and inconsistent pain. No evidence of cubitus valgus or varus deformity was found in this group. No significant correlation was found between type of fixation, ($p = 0.24$), gender, ($p = 0.64$), age, ($p = 0.059$) and time from injury to surgery and AVN ($p = 0.91$). All patients were treated within 48 h of injury.

Conclusion AVN following lateral condyle fracture is an established, clinically relevant complication but appears to be rare with a rate of only 1.4 %. Type 3 fractures and treatment with open reduction are significantly associated with AVN. Progression of deformity related to AVN can occur after acute fracture treatment and continued follow-up is needed due to the young age of this group. Most cases have no pain and full ROM at last follow-up.

Significance The rate of AVN following lateral condyle fractures is 1.4 %. Open reduction is associated with AVN. Most cases do not have pain and a full range of motion at last follow-up.

April 8Trauma II
16:15–17:29**OP121/17:10–17:15****Comparison of percutaneous pin fixation in chronic and acute paediatric mallet fractures**Christine Ho¹, Manoj Reddy²¹Texas Scottish Rite Hospital–Children’s Medical Center, Dallas, USA; ²Texas A&M HSC College of Medic, Bryan, TX, USA**Level-3****Upper and lower extremity trauma****Introduction** In the paediatric population, mallet fractures are more common than soft tissue mallet fingers because of the relative weakness of the physis compared to the insertion of the terminal tendon. While multiple techniques have focused on surgical fixation of acute adult mallet fractures, none have focused on the paediatric population.**Materials and methods** This is a retrospective review of 59 pediatric mallet fractures treated with percutaneous wire fixation from 2007 through 2014; 43 were acute fractures and 16 were chronic (greater than 4 weeks from date of injury). The Surgical technique was identical for all fractures and consisted of using a percutaneous towel clip to lever the dorsal fragment into its anatomical bed, and then percutaneously transfixing the DIP joint in slight hyperextension using 2 percutaneous K-wires, one radial and one ulnar, from the dorsal epiphyseal fragment to the volar metaphyseal cortex. Pins were removed in the clinic at the 6 weeks from surgery and patients allowed to start range of motion exercises at that time. Clinical outcome was defined by the Crawford classification.**Results** The average age was 14.6 years (range, 11–18). Mean time from injury to surgery was 15.3 days in the acute group and 51.4 days in the chronic group. 8 patients did not have radiographs at time of final follow-up. Mean joint surface involvement was 50.6 % of the articular base with a mean of 2.11 mm of articular gap (acute fractures 1.93 mm, chronic fractures 2.58 mm, $p < 0.007$). Average pre-operative extensor lag was 25.1 degrees. Average operative time was 33 min for acute fractures and 39 min for chronic fractures. Mean length of follow-up was 73.8 days. At final follow-up, all patients healed with an articular gap of 0.16 mm in the acute group and 0.59 mm in the chronic group ($p = 0.49$) with no nonunions or volar subluxations. 8 of the 59 patients (5 acute, 3 chronic) achieved full extension with an average extensor lag of 1.1 deg for the entire cohort. No patient had greater than 10 degree extensor lag at final follow-up. All patients achieved active flexion of 90°. In the acute group, the Crawford classification was excellent in 87 % (33/38) and good in 13 % (5/38). In the chronic group, results were excellent in 77 % (10/13) and good in 23 % (3/13) ($p > 0.05$). There were no fair or poor outcomes in either group. A clinical dorsal bump was noted in 15 % of patients (16 % in the acute group, 13 % in the chronic group, $p > 0.05$). There were no infections, wire breakages, nail deformities, or unplanned returns to surgery.**Conclusion** This percutaneous surgical technique to treat pediatric mallet fractures achieves favorable clinical and radiographic results with minimal complications, even in chronic fractures.**Significance** To our knowledge, this is the first study to evaluate the outcomes of surgical treatment of paediatric mallet fractures. Results, even in chronic fractures, are better than reported for adult mallet fractures.**April 8**Trauma II
16:15–17:29**OP122/17:15–17:20****Variation in paediatric emergency resource utilization: paediatric orthopaedic trauma team composition**Charles T. Mehlman¹, Albert d’ Heurle²¹Cincinnati Children’s Hospital Medical Center, Cincinnati, USA; ²Cincinnati Children’s Hospital, Cincinnati, USA**Level-4****Upper and lower extremity trauma****Introduction** Since the Institute of Medicine’s publication of “To Err Is Human” report focused attention on increasing patient safety in surgical settings, the relationship between effective team functioning in the operating room (OR) and safe/successful surgery has been shown to be nearly irrefutable. The purpose of this study was to quantify the amount of variation in the surgical team composition for paediatric orthopaedic procedures.**Materials and methods** After IRB approval, a retrospective chart review was performed on 634 consecutive patients treated in the OR in 2012 for an orthopaedic injury. Data abstracted from the chart included patient age, gender, injury, procedure performed, OR room number and OR team member composition including staff surgeon, circulating nurse, scrub technician, operation start and stop time, and day of the week. After hours were considered to be from 5 PM to 7:30 AM during the work week and from 5 PM Friday to 7:30 AM Monday for the weekend. A high frequency team member was defined as performing 10 or more orthopaedic procedures during a one-year period.**Results** All patients sustained an orthopaedic injury requiring reduction (open versus closed) with possible internal fixation in the operating room. We identified 18 out of 69 circulating nurses and 21 of 51 scrub technicians who meet our definition of high frequency team members. The high frequency circulators logged an average of 26 cases (range: 10–79), and the high frequency surgical technicians logged an average of 25 cases (range 10–64). We found that a team composed of solely high frequency team members occurred in 400 (63 %) of orthopaedic trauma procedures. A significantly greater proportion of out of hour procedures were composed of low frequency team members than procedures performed during normal working hours ($p = 0.003$). For the 342 (54 %) procedures that were completed without any staff switches, none of the procedures performed after hours were composed of high frequency team members ($p < 0.001$).**Conclusion** This study found that 63 % of pediatric orthopedic trauma cases were composed of high frequency team members. However, the OR team was composed of low frequency team members more often during after hours procedures.**Significance** The relationship between effective team function and safety is well-established. Findings from this study bring awareness to the insufficiency of orthopaedic trauma experience among after hours surgical staff, which could have implications for team effectiveness and safety.

April 9Foot and ankle/Club-foot
08:00–09:20**OP123/08:00–08:05****Pressure pain threshold in children with flexible flatfoot**Vladimir Kenis¹, Alexey Baidurashvili², Andrey Sapogovskiy², Ruslan Khusainov²¹The Turner Institute for Children's Orthopardsics, Saint-Petersburg, Russian Federation; ²The Turner Institute, Saint-Petersburg, Russian Federation**Level-2****Foot and ankle**

Introduction A flexible flat foot generally thought of as a benign condition which does not need any special treatment. Pain is the main indication for therapeutic and surgical intervention in children with flexible flat feet. Nevertheless, there is no consensus regarding a critical pain which could specify indications for treatment. We suggest a relationship between individual pain sensitivity and complaints in children with flexible flatfoot.

The aim of the study was to assess correlation of complaints on pain and algometry data in children with flexible flatfoot.

Materials and methods From 135 children (7–11 years old) which were referred to our clinic with diagnosis "flat feet" two groups of consecutive patients were selected by one of the investigators. For group A (52 patients) inclusion criterion was complaints of the patient and/or parent of foot pain during last 3 months regardless severity and frequency. Children of group B (49 patients) were referred to our clinic by other physicians (mostly pediatricians) because of foot shape ("flatfootedness") or foot shape which was a concern to the parents, and the patients had no foot pain within last 3 months. Optic plantography was performed for confirmation of medial arch decrease. Children with any hindfoot rigidity, shortening of Achilles tendon, inflammation, history of trauma were excluded from the study (36 patients). Directly after this separation the patients were referred blindly to another investigator for pressure algometry. The data obtained were opened after finishing of the study. Statistical analysis was performed for foot parameters and algometry data in both groups.

Results We did not find any statistical significant difference for any foot parameters obtained by plantography in both groups. Pressure algometry revealed lower pressure pain threshold in group A compared to group B ($p < 0,05$) in the upper and lower extremities.

Conclusion Children with flexible flatfoot complaining of pain had lower pressure pain threshold compared to those who have no history of foot pain.

Significance Pain in children with flexible flatfoot is poorly understood and subjective factors such as individual sensitivity to pain stimuli should be taken into consideration especially when planning any intervention.

April 9Foot and ankle/Club-foot
08:00–09:20**OP124/08:05–08:10****Growth modification of juvenile hallux valgus in skeletally immature children**Ming-Hung Chiang¹, Ting-Ming Wang², Kuan-Wen Wu², Ken N. Kuo²¹1.National Taiwan University Hospital (NTUH) 2.Min-Sheng General Hospital, Taipei, Taiwan; ²NTUH, Taipei, Taiwan**Level-4****Foot and ankle**

Introduction Surgical treatment of symptomatic juvenile hallux valgus (JHV) has been associated with a high prevalence of recurrence of deformity. Lateral hemiepiphyodesis of the first metatarsal is an alternative treatment for skeletally immature children. The purpose of this study is to evaluate the efficacy of percutaneous epiphysiodesis using transphyseal screws (PETS) for correcting JHV.

Materials and methods We have been using cannulated headless screw for PETS of first metatarsal lateral physis in skeletally immature children with symptomatic JHV since 2013. Weight-bearing AP and lateral radiographs of the foot were retrieved before surgery and followed to the closure of the physis. In each radiograph, we measured the intermetatarsal angle (IMA), hallux valgus angle (HVA), proximal metatarsal articular angle (PMAA), the metatarsal length ratio (MLR), and the screw position.

Results Ten children with 20 feet were followed to the closure of the first metatarsal physis. The mean age at index procedure was 12.1 years (range, 10.8–13.7 years). The mean stage of calcaneal apophysis ossification was 4 (stage 3 = 1, stage 4 = 8, stage 5 = 1). Mean follow up following surgery was 1 year 4 months. The mean screw position at physis crossing was 0.26 (0 = the lateral border of the physis, 1 = the medial border of the physis). The mean improvement in the HVA was 2.3 degrees (95 %CI, -0.04 to 4.7 degrees; $P = 0.079$). The mean improvement in the IMA was 2.0 degrees (95 % CI 0.8–3.1 degrees; $p = 0.003$). The mean change in the metatarsal length ratio was 0.5 % (95 %CI, -1.1 % to 2.0 %, $p = 0.526$). The mean change of the sagittal alignment (LAT-PMAA) was 1.15 degrees downward (95 % CI, 2.9 to -0.6, $p = 0.183$). The correlation of the change of AP-PMAA and IMA was 0.466 ($p = 0.038$).

Conclusion PETS of the first metatarsal lateral physis using the cannulated headless screws can effectively change IMA in skeletally immature patients with JHV. The change of IMA was related to the change of AP-PMAA. There was a tendency for improvement of the HVA, but this was not statistically significant. The changes of the metatarsal length ratio or the sagittal alignment of the first metatarsal bone were insignificant.

Significance This is the first study demonstrating the efficacy of PETS for the treatment of JHV in the skeletally immature children. Our study shows that IMA can be corrected effectively, but less degree in HVA. This technique should be reserved for patients whose deformity is mainly the IMA with symptoms.

April 9Foot and ankle/Club-foot
08:00–09:20**OP125/08:10–08:15****Comparison of two methods of arthroereisis for the treatment of idiopathic flatfoot in children**Daniela Dibello¹, Valentina Di Carlo², Luca Odoni², Francesca Vittoria², Marco Carbone²¹Paediatric Orthopaedic Department Maternal and Child Health Hospital–IRCCS Burlo Garofolo, Trieste, Italy; ²IRCCS BURLO GAROFOLO, Trieste, Italy**Level-3****Foot and ankle****Introduction** The purpose of this study was to compare the results of the Castaman and Nogarin surgical methods for arthroereisis for the treatment of idiopathic flatfoot in children.**Materials and methods** This retrospective comparative study considered 200 children affected by idiopathic symptomatic flatfoot treated at the Paediatric Orthopaedic Department Children's Hospital of Trieste between January 2011 and December 2014. Of these, 100 children with 58 boys, 42 girls; 10 grade 2, 89 grade 3 and 1 grade 4 flatfoot. The Costa-Bertani angle was $\leq 130^\circ$ – 135° in 2 patients, between 130° and 135° and 140° in 91 patients, $\geq 140^\circ$ in 7 patients. The Kite angle was $<35^\circ$ in 2 patients, between 35° and 40° in 91 patients, and $>40^\circ$ in 7 patients. The patients were treated with the Nogarin method and 100 (61 boys, 39 girls; 8 grade 2, 85 grade 3 and 7 grade 4 flatfoot, Costa-Bertani angle $\leq 135^\circ$ in 10 patients, between 130° and 135° and 140° – 145° in 84 patients, $\geq 140^\circ$ in 6 patients and Kite angle $<35^\circ$ in 10 patients, between 35° and 40° in 84 patients, and $>40^\circ$ in 6 patients) were treated with the Castaman method. In all cases we used the clinical form Paediatric Flat Foot Proforma (p-FFP).**Results** Among the children treated with the Castaman screw, the results using clinical and radiographic angle findings were excellent in 55, good in 34, fair in 8, poor in 3. Among those treated with the Nogarin screw, the results were excellent in 51, good in 36, fair in 9, poor in 4. The anaesthesia technique, the time and technical difficulty of the procedure, as well as the recovery time and costs were comparable in the two groups. Complications were almost the same in the two groups. There were 2 screw loosening and 1 broken screw with the Castaman method, and 1 screw loosening, 2 broken screws and 1 infection with the Nogarin method. No statistically significant difference was found between the results of the Castaman and Nogarin methods ($p \geq 0.05$).**Conclusion** Given the lack of any significant difference between the results achieved with the two surgical methods, we believe both to be valid treatments for idiopathic flatfoot. The reason is that the correction is based on screw proprioceptive stimulation of the endosinotarsal fibers.**Significance** The literature describes many surgical techniques using different types of screw for arthroereisis to correct flatfoot: the authors compared two of them, the Castaman and Nogarin methods, but found no statistically significant difference in the results.**April 9**Foot and ankle/Club-foot
08:00–09:20**OP126/08:15–08:20****Epidemiology of clubfoot: a meta-analysis identifying modifiable risk factors**Cynthia Chen¹, John Blanco¹, Shevaun Doyle¹, Roger Widmann¹, David Scher¹, Ernest Sink¹, Emily Dodwell¹¹Hospital for Special Surgery, New York, USA**Level-3****Club-foot****Introduction** A combination of genetic and environmental risk factors have been reported as causes of clubfoot including amniocentesis, maternal smoking during pregnancy, summer conception, lower parity, parental age, and breech position in utero. The aim of this study was to conduct a meta-analysis to assess the best evidence of risk factors for the development of clubfoot.**Materials and methods** We performed a systematic literature search for studies that investigated risk factors for clubfoot. Data on study design, patient characteristics, and risk estimates were extracted. Pooled effect estimates were calculated using random and fixed effects models based on study heterogeneity.**Results** Twenty-one case-control studies and three cohort studies were included in this analysis. On the Newcastle-Ottawa Scale, eleven studies were of higher quality (≥ 7) and nine studies were of lower quality (< 7). Studies with a quality score below five were excluded. The initial analysis identified several significant modifiable risk factors associated with an increased risk of clubfoot including smoking (OR = 1.54 95 % CI 1.42–1.66), cesarean section (OR = 1.43 95 % CI 1.35–1.51), and single marital status (OR = 1.18 95 % CI 1.11–1.24). Non-modifiable factors that were significantly associated with increased risk of clubfoot included male sex, twin gestation, family history, and race. Diabetes and maternal education were not found to be associated with risk of clubfoot. The sub-analysis of high quality studies identified woman lacking prenatal care (OR = 1.5 95 % CI 1.21–1.87), maternal age < 20 (OR = 1.14 95 % CI 1.07–1.20), Medicaid insurance (OR = 1.28 95 % CI 1.09–1.28), and premature birth (OR = 3.66 95 % CI 3.31–4.06) as additional factors associated with clubfoot.**Conclusion** This meta-analysis identified several modifiable risk factors significant to the development of clubfoot. The most notable and clinically relevant risk factors include smoking and lack of pre-natal care.**Significance** To our knowledge this is the first meta-analysis assessing risk factors in clubfoot. A knowledge of modifiable risk factors such as smoking and pre-natal care may play an important role in counseling patients before and during pregnancy. Strategies aimed at reducing risk factors may aid in decreasing the incidence of infants born with clubfoot.

April 9Foot and ankle/Club-foot
08:00–09:20**OP127/08:33–08:38****The risk factors for surgical release in children with clubfoot treated by the ponseti method: utility of radiographic assessment**David Heinsch¹, Alice Moist², Jolecia Flounory³, Leslie Rhodes³, Derek Kelly⁴¹University of Pennsylvania, Philadelphia, PA, USA; ²University of Tennessee Health Science Center, Memphis, TN, USA; ³Le Bonheur Children's Hospital, Memphis, TN, USA; ⁴Campbell Clinic, Collierville, TN, USA**Level-2****Club-foot****Introduction** The Ponseti Method has become the gold standard for treatment of Congenital Talipes Equinovarus (CTEV). Despite the success of initial deformity correction with Ponseti Method, some feet still develop relapse or recurrence, and many require more extensive surgical intervention. The primary goal of our study is to identify factors that may predispose patients to failure leading to more extensive surgical intervention. Secondly, we aim to determine the role of clinical scoring and radiographs in predicting the need for surgical intervention.**Materials and methods** Seventy-eight patients with CTEV presented to a single institute between 1/1/2010 and 1/1/2013 and were enrolled into an IRB approved prospective study on the utility of clinical scores and radiographs in the diagnosis and monitoring of CTEV. Sixty-four patients (97 feet) met inclusion and exclusion criteria. Database information included demographic data, treatment details, Dimeglio and Pirani scores, and radiographic results at presentation, 6 months, and 12 months of age; as well as any recurrence and the need for more extensive surgical release.**Results** Average follow-up for this group was 32.4 months (range 18–60). Twenty-one patients (33 feet) (34 %) required surgical release by the completion of the follow up period. These patients were compared to the cohort of 47 patients (64 feet) (66 %) who did not require surgical correction for residual or recurrent clubfoot. The Dimeglio and Pirani clinical scores between these two groups were statistically significantly different at all time points (presentation, 6 months, and 12 months). Radiographic differences were found to be statistically different at 6 months for the AP and lateral talocalcaneal angle. There were no statistically significant radiographic differences at 12 months. Risk factors found to correlate with surgical failure included presenting Dimeglio and Pirani scores, number of casts needed to correct the initial club foot, and the need for repeat casting.**Conclusion** Children with CTEV who progress to require extensive surgical release following Ponseti casting present with significantly higher initial clinical scores, require more casts at initial treatment, and require more frequent recasting. Clinical scores at 6 months and AP-talo calcaneal radiograph at 6 months correlate with the need for surgical release.**Significance** Initial clinical clubfoot scores provide prognostic value regarding the likelihood of extensive surgical release. Radiographs are unnecessary for most children with CTEV <1 year old as they do not add diagnostic or prognostic value over clinical scores.**April 9**Foot and ankle/Club-foot
08:00–09:20**OP128/08:38–08:43****Midfoot joints compensate for the decreased dorsal extension of ankle joint following clubfoot correction**Chakravarthy U Dussa¹, Leonhard Doederlein¹, Harald Böhm¹¹Orthopaedische Kinderklinik, Aschau im Chiemgau, Germany**Level-2****Club-foot****Introduction** The commonest residual deformity following successful correction of clubfoot is reduced dorsal extension of the ankle joint. This may be due to several reasons. We undertook a study to see the effect of decreased dorsal extension in ankle on the foot.**Materials and methods** The data for the study was acquired from a prospective Gait laboratory database for clubfeet. All children underwent foot analysis using Oxford foot model to assess the kinematics and kinetics. Inclusion criteria were: clubfoot of idiopathic aetiology, post correction through surgery, hind foot eversion. Exclusion criteria were: neurogenic and syndromal clubfeet, hind foot inversion. In all 58 patients were identified who fulfilled the above criteria. The observed parameters were dorsal extension of the ankle joint, dorsal extension of the midfoot, supination of the forefoot, and various measurements of the Talus on X-rays. Statistical analysis was done to determine the significance of individual parameters.**Results** 48 Patients with 67 feet were included in the study. Of these, 19 patients had bilateral clubfoot. The compensatory mechanisms identified in the foot were increased dorsal mobility in the midfoot especially the increased dorsal extension in the midfoot joint and increased supination. Statistical analysis showed a strong correlation between decreased ankle joint dorsal extension and increased dorsiflexion of the midfoot joints. However no statistical significance was found between the decreased ankle joint dorsal extension and maximal supination of the foot in mid-stance and terminal stance phase. The measurements of bony landmarks identified the possible cause of decreased dorsal extension.**Conclusion** The effect of decreased ankle joint motion of the foot in clubfoot has not been so far studied in detail. Dorsal extension of the ankle joint is necessary for 2nd Rocker motion during gait. Absence of the 2nd Rocker leads to premature heel raise. This is to some extent compensated by premature heel raise. Increase in midfoot joint motion predominantly dorsal extension was found in all these patients.**Significance** This finding has 2 clinical implications:

1. Clinically measured passive dorsal extension of ankle joint is mostly the summation of dorsal extension in ankle and midfoot joints,
2. It is important to be aware of this compensation before one considers fusion the midfoot joints to correct a midfoot deformity. This may lead to increased loading (impingement) of ankle joint and pain.

April 9Foot and ankle/Club-foot
08:00–09:20**OP129/08:43–08:48****Serial casting for stiff clubfoot according to Ponseti: the timing of achillestendon tenotomy**Ismat Ghanem¹, Elie Saliba², Ayman Assi³¹Hotel-Dieu de France Hospital, University of Saint-Joseph, Beirut, Lebanon; ²Hotel-Dieu de France Hospital, Beirut, Lebanon; ³Faculty of Medicine USJ, Beirut, Lebanon**Level-4****Foot & ankle**

Introduction Ponseti method for congenital idiopathic clubfoot correction has traditionally included percutaneous Achilles tenotomy in more than 90 % of stiff cases. The latter is usually performed during the fourth to sixth cast application and has proven to be the key factor for success of nonoperative treatment. However, in some cases it may not be easy to palpate the tendon and perform the procedure percutaneously owing to the swelling produced by repeated casting and a mini-incision may be required. The aim of this paper was to evaluate the influence of early Achilles tenotomy during management of clubfoot using Ponseti method in neonates with Dimeglio type III and IV deformities.

Materials and methods Ninety neonates with 140 stiff clubfeet, according to Dimeglio, scheduled to undergo treatment by the Ponseti method were prospectively randomly assigned into 2 groups: 70 feet underwent the percutaneous tenotomy during the first casting session (early group EG) and 70 during the 6th casting session (late group LG). The procedure is performed in an outpatient clinic setting without any anesthesia other than local skin application of lidocaine spray. Achilles tendon is palpated and an 18 gauge needle is introduced through the skin along its medial border few millimeters above its distal insertion on the calcaneus. The tendon is cut from medial to lateral in 1–3 needle swipes while foot is held in forced dorsiflexion. Cast is then applied according to Ponseti. Patients were reviewed at an average follow-up of 7.4 years (5.2–10.8) and results were assessed using Ghanem-Seringe score. Technical difficulties, postoperative blood staining on cast and short/long term complications were recorded.

Results Results in the LG group were rated excellent, good, fair, and poor in 70, 18, 9 and 3 % of patients respectively and 82, 13, 4 and 1 % of patients respectively in the EG Group ($p = 0.05$). Flattening of the talar dome of mild to moderate severity was found in 16 % in LG and 4 % of EG ($p < 0.001$). Technical difficulties mainly those related to palpation of Achilles tendon and tenotomy “feeling” were encountered in 38 % in LG and 3 % in EG ($p < 0.0001$). Blood staining on cast was found in 13 % in LG and 3 % in EG ($p < 0.001$).

Conclusion Percutaneous Achilles tendon performed as early as the first casting session seems to give more excellent results than when performed during 6th casting session as described by Ponseti, with less short/long term complications. This may be explained by greater ease to palpate Achilles tendon and perform a clear cut and selective tenotomy on a virgin foot, and early decrease in compressive forces over talar dome during corrective maneuvers.

Significance Percutaneous Achilles tendon performed as early as the first casting session seem to give more excellent results than when performed during 6th casting session as described by Ponseti, with less short/long term complications.

April 9Foot and ankle/Club-foot
08:00–09:20**OP130/08:48–08:53****Treatment of flatfoot due to neuromuscular, connective tissue and degenerative causes by subtalar arthroereisis and talonavicular arthrodesis: indications, technique and outcomes**Roberto Schiavon¹, Federica Vittorelli², Andrea Micaglio², Marcella Veronese², Andrea Borgo³, Olaf Schmidt⁴, Monica Pfeifhofer⁴, Antonella Cersosimo⁵, Sandra Bertana⁵, Fabio Forni⁵¹Orthopaedics and Traumatology Unit, Vicenza General Hospital, Italy, Vicenza, Italy; ²Vicenza General Hospital, Vicenza, Italy; ³Padova University Hospital, Padova, Italy; ⁴Merano (Bz) General Hospital, Merano (BZ), Italy; ⁵IRCCS of Neuroscience Bologna, Bologna, Italy**Level-3****Foot & ankle**

Introduction Most cases of juvenile flat foot are idiopathic, asymptomatic, and require no specific treatment. However, some juvenile and teenage patients may develop a rigid flat foot, where the Chopart and the subtalar joints are partially subluxed and arthritic, thus causing pain and limitation of functional. Usually these abnormalities are due to neuromuscular or connective tissue diseases or dysmorphic syndromes. Pain is present primarily during weight bearing, and pressure lesions may develop at the level of the talar head and the navicular tubercle that protrudes inferomedially. These problems are more marked if patients wear AFO orthotics. The functional limitation is caused by an alteration of the propulsive lever. In the transverse plane, the sagittal lever is shortened, with the third rocker displaced proximally toward Chopart’s joint which is deformed and hypermobile. Forefoot abduction and leg external rotation result in further reduction of the sagittal lever. In the hindfoot, the frontal lever between the first two rockers is increased, thus worsening gait biomechanics. Furthermore, an associated hindfoot equinus deformity due to triceps surae contractures is frequently observed.

Materials and methods The purpose of the study is the clinical and radiological evaluation of the surgical correction of this flat foot deformity by reconstruction of the anatomic lever by way of the following procedures: (a) talonavicular reduction/arthrodesis; (b) subtalar reduction/arthroereisis; (c) triceps surae tendon release and other soft tissue procedures when required. The arthrodesis is performed by fixing one or two titanium hollow screws along the talar column. The arthroereisis is performed using the titanium CNF (Calcaneal Notch Filler) screw device, inserted laterally as a spacer into the subtalar joint. Sixty-three patients were evaluated retrospectively (42 male, 21 female, 97 feet in all), of ages between 6 and 19 years. These patients were treated between 2004 and 2015 for flat foot via the surgical techniques described above, with a median follow-up time of 22 months (range 4–71 months).

Results After surgery, the anatomic and radiologic correction was achieved in all cases treated. At the follow-up, almost all patients maintained an anatomic recovery of the foot and obtained a better function of the gait, as well as resolution of the pain. Results were graded optimal or good in 87 feet (89.7 %), acceptable in 5 feet (5.15 %), and unacceptable in 5 feet (5.15 %). We defined cases as unacceptable outcome if the patient required reoperation due to pain or poor functional outcome.

Conclusion To treat painful, rigid flat foot secondary to various etiologies in childhood, we consider this new surgical technique to be a valid alternative to other surgical methods.

April 9

Foot and ankle/Club-foot
08:00–09:20

OP131/09:06–09:11

A new clinical test in the diagnosis of calcaneo-navicular coalitions

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Level-3

Foot and ankle

Introduction Tarsal coalition is a congenital fusion of two or more tarsal bones which can lead to a progressive painful foot deformity. Radiological examinations including plain radiographs and CT-scans are necessary for diagnosis of tarsal coalitions. Nevertheless clinical investigation of foot mobility remains crucial in screening. The most common clinical tests of foot mobility are the tip-toe test, the Jack test and manual examination of passive eversion and inversion of the foot. These tests have moderate significance of sensitivity and specificity and can't differentiate a particular type of tarsal coalition. We introduced a new clinical test of manual examination of calcaneo-navicular mobility. We suggest the advantages of this test for clinical evaluation in calcaneo-navicular coalitions and assessed sensitivity, specificity and inter-rater reliability.

Materials and methods we evaluate 100 children (155 feet) with flatfeet. The Study group included children with confirmed calcaneo-navicular coalition (28 children, 45 feet), talo-calcaneal coalition (22 children, 30 feet) and without tarsal coalitions (50 children, 80 feet). The evaluation of clinical tests was graded: positive test—1 point, negative test—0. Statistical analysis included assessment of sensitivity and specificity of all previously described tests and inter-rater reliability assessment of new test (ICC [95 % CI]).

Results Sensitivity of tip-toe and Jack tests was 86.7 and 85.3 % respectively. Sensitivity of manual examination of passive eversion and inversion was 80 %. Specificity of tip-toe and Jack tests was 65 % and 63.8 %. Specificity of manual examination of passive eversion and inversion was 87.5 %. The manual examination of calcaneo-navicular mobility has 95.6 % sensitivity and 93.3 % specificity. The new clinical test can differentiate calcaneo-navicular coalition from other types of tarsal coalitions. Inter-rater reliability (ICC [95 % CI]) was 0.818.

Conclusion A new clinical test of calcaneo-navicular mobility demonstrate higher value of statistical significance against previously

described tests and can be used in clinical examination in children suspecting for tarsal coalitions.

Significance Clinical assessment of patients suspected for tarsal coalitions is first step of comprehensive diagnostics. The new test of calcaneo-navicular mobility can help with the diagnosis and avoid unnecessary radiographic investigation.

April 9

Foot and ankle/Club-foot
08:00–09:20

OP132/09:11–09:16

Are radiographs predictive of clinical outcomes in idiopathic clubfeet?

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Level-2

Foot & ankle

Introduction Non-operative treatment for idiopathic clubfeet is the standard. The purpose of this study is to determine if standing lateral radiographs of the involved successfully-treated foot taken at 18–24 months of age are predictive of late recurrences.

Materials and methods Inclusion criteria consisted of idiopathic clubfoot patient ≤ 3 months of age at presentation, Ponseti treatment resulting in a clinically plantigrade foot at 2 years of age, standing lateral radiograph of the involved foot taken at 18–24 months of age, and a minimum 4 year follow-up. The radiographs of the foot, measured by two trained practitioners, were assessed for the talocalcaneal angle (TaCA) and the tibio-calcaneal angle (TiCA). The average values of the two raters were used. Interobserver reliability was calculated using intraclass correlation coefficients (ICC).

215 patients with 318 clubfeet were evaluated. All were rated by Dimeglio classification before treatment. At follow-up, the average age was 7.5 years (range 4–13.3 years). Results at follow-up were rated as *good* (maintained plantigrade foot), *fair* (required limited surgery to return to plantigrade position), or *poor* (required posteromedial release). A nonparametric Kruskal-Willis test was used to determine significant differences of the TaCA and TiCA for three group comparisons, followed by Mann-Whitney test for two groups.

Results The ICCs were 0.97 (TaCA) and 0.98 (TiCA), demonstrating excellent agreement between raters. The talocalcaneal angles were statistically different between *good* clinical outcomes and *fair* outcomes (28° vs. 24°, $p < 0.01$), but there was no statistical difference between *good* vs. *poor*, or *fair* vs. *poor*. There was no statistical difference in the tibio-calcaneal angles among groups ($P = 0.14$).

Table 1 Clinical Results (with minimum of 4 years follow-up)

	Good	Fair	Poor
318 feet / 215 patients	236 feet (74 %)	64 feet (20 %)	18 feet (6 %)
	(112)		
unilateral, 103 bilateral)	Avg		
Dimeglio score Avg	Avg		
Dimeglio score			
Dimeglio score	12.6	13.8	14.7
Talocalcaneal angle	28 (range 0°-59°)	24 (range 2°-44°)	25 (range 11°- 51°)
Tibiocalcaneal angle	86 (range 41°- 117°)	89 (range 64°- 118°)	86 (range 57°- 99°)

Conclusion Most clubfeet that were clinically plantigrade at 2 years of age remained so, while one-fourth subsequently required some surgery for late recurrence. We found that measurements of TiCA and TaCA from standing lateral radiographs taken at 18–24 months of age were not helpful in identifying those who experienced late relapse requiring surgical intervention.

Significance Most clubfeet that were clinically plantigrade at 2 years of age remained so, while one-fourth subsequently required some surgery for late recurrence. We found that measurements of TiCA and TaCA from standing lateral radiographs taken at 18–24 months of age were not helpful in identifying those who experienced late relapse requiring surgical intervention.

April 9

Foot and ankle/Club-foot
08:00–09:20

OP133/09:16–09:21

The rotterdam foot classification: a classification system for medial polydactyly of the foot

Lisebette Burger¹, Steven Hovius¹, Bart Burger², Christianne van Nieuwenhoven¹

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Level-2

Foot & ankle

Introduction Medial polydactyly of the foot is a rare and diverse congenital anomaly. In order to plan and evaluate surgical treatment, classification of medial polydactyly is useful. Current classification systems are based on limited amount of anatomical characteristics of the foot and are lacking uniformity. The aim of this study is to develop a more useful and valid classification system for medial polydactyly.

Materials and methods Literature review and clinical experience of an experienced surgeon was used to determine classification categories. Between 1993 and 2014 all subjects with medial polydactyly with preoperative radiological and clinical photographs were identified in our hospital database. All affected feet were classified with the Rotterdam foot classification. Intrarater and interrater reliability were assessed between 5 different observers in 30 different feet with use of Cohen's Kappa (κ).

Results A classification system, describing duplication level, syndactylism, presence of a hypoplastic ray, and deviation of the hallux was developed. Seventy-three feet were classified with the Rotterdam Foot Classification. Seven different duplication levels were distinguished. Complete metatarsal duplication was most frequently seen (70 %). Eleven feet showed a broad hallux without external expression of duplication. Syndactyly in the first web was present in 28 feet, in the second web in 13 feet, and in 21 feet in both first and second web. Hypoplastic rays were seen in 75 % of the feet. Intrarater agreement for duplication, hypoplastic ray, syndactyly and deviation were respectively $\kappa = 0.79$, $\kappa = 0.75$, $\kappa = 0.59$ $\kappa = 0.78$. Interrater agreement for duplication, hypoplastic ray, syndactyly and deviation were respectively $\kappa = 0.72$, $\kappa = 0.54$, $\kappa = 0.48$ $\kappa = 0.64$.

Conclusion The proposed classification system contains four anatomic features of the foot. Classification of all categories show moderate to good reliability. The use of the Rotterdam classification for medial polydactyly improves type-specific description is useful in communication between clinicians and researchers. In the future, the classification may enhance evaluation of surgical treatment.

Significance The use of the Rotterdam classification for medial polydactyly improves type-specific description useful in communication between clinicians and researchers. In the future, the classification may enhance evaluation of surgical treatment.

April 9

Metabolic/Other
10:40–12:00

OP134/10:50–10:55

Epidemiology and assessment of carpal tunnel syndrome in mucopolysaccharidosis

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Level-3

Metabolic Diseases

Introduction The carpal tunnel syndrome (CTS) in the mucopolysaccharidosis (MPS) is known, but the actual prevalence as well as the discovery modes remain imprecise. We report a multi-center study of 196 patients with MPS and analyze the characteristics of CTS detected by comparing them to the literature in order to try to establish predictive signs and a support strategy for this complication

Materials and methods A retrospective study was conducted in five pediatric surgery centers. 196 patients were enrolled and followed for 4.6 years on average. They were 67 girls and 129 boys. 63 patients

had Hurler syndrome (MPS I), 13 Hurler–Scheie Scheie, 56 Hunter (MPS II), 35 with Morquio (MPS IV), 22 Maroteaux Lamy disease, 3 type II mucopolysaccharidosis, 3 mucopolysaccharidosis type 3 (MLIII), 1 deficiency hexosaminidase and 1 deficit Gamma sarcoglycanopathy kind LGMD 2C. A clinical examination for pain and sensory and motor disorders was performed at each visit. A reference electromyography (EMG) was performed at diagnosis of MPS and periodically thereafter, studying nerve conduction velocity (NCV), motor (NCVm) and sensory (NCVs) and measuring the motor latency (MDL) of the abductor pollicis brevis muscle on two hands.

Results A CTS was diagnosed in 81 patients (41.3 %). None of the 35 patients with MPS IV have presented with this pathology. The prevalence reached 62 % in the MPIS/IHS group. This was followed by the MPS VI group with a prevalence of 59.1 %, then the MPS Group I with 50.8 %, and finally the MPSII group with 45 %. Involvement was bilateral in 94 % of MPS I patients, 87.5 % of MPIS + H, 100 % of MPS VI patients and ML II and III. 136 patients presented orthopaedic symptoms motivating consultation in which 23 % for symptoms in hands. Sensory disorders were present in 48 % of cases, the motor symptoms in 37 % and pain in 63 % of cases. MDL was always pathological, while the motor and sensory NCV were less systematically disrupted.

Conclusion CTS in children can be related to MPS and can be a way of revealing the MPS. Clinical signs of CTS in MPS may be frustrated, so a systematic EMG must be performed during monitoring. The disruption of the MDL seems to be the most relevant criterion **Significance** CTS in children can be related to MPS and can be a way of revealing the MPS

April 9

Metabolic/Other
10:40–12:00

OP135/10:55–11:00

X-linked hypophosphataemic rickets: orthopaedic management of lower limb deformity

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Level-3

Metabolic Diseases

Introduction A significant proportion of patients with X-linked hypophosphataemic rickets (X-LHPR) demonstrate severe lower limb deformity despite optimal medical management. Orthopaedic management aims to restore limb alignment. This study evaluates the deformity in these patients and the evolution of orthopaedic management.

Materials and methods Since 1995, 59 patients with X-LHPR have been treated at our Institution. Standardised long leg radiographs were only available for 39 patients (18 male). 20 patients were considered clinically straight and had not been X-rayed. Traumacad™ Software was employed to measure peri-articular deformity in both operated and non-operated patients. Statistical analysis was performed using SPSS 23 (SPSS Inc., Chicago, Illinois, USA) for categorical and continuous data.

Results Of the 39 patients, 16 (41 %) have radiographically straight legs. 20 have undergone bilateral lower limb surgery for persistent deformity (Mechanical Axis \geq Zone 2) in the coronal plane. A further 3 patients (6 limbs) are awaiting surgery. Six patients (12 limbs, 14

segments) had osteotomies and internal fixation as primary intervention. Only one patient developed recurrent deformity. There were no major complications.

Fourteen patients underwent 15 episodes of 8 plate insertion (Orthofix, Verona) (28 limbs, 34 segments) had 8-plates (Orthofix, Verona) applied. 16 limbs were in valgus and 12 in varus. In 5 limbs correction is on-going. Neutral limb alignment (central Zone 1) was achieved in 16/23 (70 %) limbs: a further 5 improved but not fully and the remaining 2 limbs in 2 patients have required osteotomies in 3 limb segments for residual deformity. The mean rate of angular correction following 8-plate application was 0.3 and 0.7 degrees/month for the tibia and femur respectively. The mean age at 8-plate insertion was 10.3 years (4.8–14.75 years). Patients with more than 3 years of growth remaining responded significantly better than older patients (Fisher Exact Test, $p = 0.024$). Guided growth was more successful in correcting valgus deformity than varus deformity (Fisher Exact Test, $p = 0.04$) but the unsuccessful cases with varus deformity all developed their deformity in adolescence. In the younger patients, diaphyseal deformity corrected as the mechanical axis improved at the rate of 0.2 and 0.7 degrees/month for the tibial and femoral shafts. One limb was overcorrected at time of plate removal: this has not returned to normal. There have been no cases of recurrent deformity. Patients with corrected coronal plane alignment did not complain of significant residual torsional malalignment. Serum phosphate and alkaline phosphatase levels did not affect response to surgery or complication rate.

Conclusion Guided growth by means of 8-plates is a successful and minimally invasive method of addressing deformity in hypophosphataemic rickets. Surgery is best performed in patients with more than 3 years of growth remaining.

Significance If coronal plane deformity is corrected early in patients with good metabolic control, the need for osteotomy can be avoided.

April 9

Metabolic/Other
10:40–12:00

OP136/11:00–11:05

Musculoskeletal manifestations in mucopolysaccharidosis type I (Hurler syndrome) following hematopoietic stem cell transplantation

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Level-2

Metabolic Diseases

Introduction Haematopoietic stem cell transplantation (HSCT) is the treatment of choice in young patients with Hurler syndrome. Despite the improved life expectancy following HSCT, musculoskeletal manifestations are assumed to be progressive and remain as one of the most disabling factors. Treatment strategies for skeletal and orthopaedic symptoms are therefore getting more important. The study summarizes musculoskeletal manifestation in 19 Hurler patients following HSCT.

Materials and methods Data were obtained retrospectively. Patients' charts for physical examinations of the joint range of motion (JROM) of shoulders, elbows, hips and knees were reviewed. Radiographic evaluations of thorax, spine, pelvis and hands were performed. MRI scans of the craniocervical junction (CCJ) were analyzed to determine

odontoid hypoplasia and the prevalence of craniocervical stenosis (CCS).

Results Nineteen Hurler patients (10 females, 9 males) with an average age of 8.1 years (range 2.5–23.8) at the latest follow-up, who underwent allogeneic HSCT between 1991 and 2012, were assessed during an average follow-up period of 6.4 years (range 0.7–22.5). Seventeen patients achieved long-term engraftment with a donor chimerism >94 % (10 patients) or mixed chimerism between 16.7 % and 59.3 % (7 patients). Two patients developed graft failure during follow-up. The majority of patients showed a steady state or even improvements in JROM of knees (31 or 63 % respectively), hips (47 or 40 % respectively) and elbows (56 or 38 % respectively) leading to a full range of motion in 44–69 % of joints. In patients with graft failure progressive restrictions in JROM were noted. Assessments of CCJ by MRI scan showed stable or improved diameters and correction of odontoid hypoplasia during follow-up in most cases. However thoraco-lumbar kyphosis, genu valgum as well as hip dysplasia were progressive despite HSCT.

Conclusion HSCT improves long-term survival and cognitive development in Hurler patients. However the beneficial effects on musculoskeletal manifestations are limited. Frequent monitoring for skeletal complications and supportive therapies are essential to preserve motor function. Additionally novel therapeutic concepts (e.g. anti-inflammatory treatment) might improve the musculoskeletal outcome.

April 9

Metabolic/Other
10:40–12:00

OP137/11:05–11:10

Hip dysplasia in Prader-Willi syndrome

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¹CHU Toulouse, Toulouse, France

Level-3

Metabolic diseases

Introduction Prader-Willi syndrome (PWS) combines short stature, obesity, hypotonia, delayed acquisitions and abnormal behavior. Scoliosis is frequent and hip dysplasia is up to ten times more common than in the general population. However, there is no study about the evolution of hip dysplasia with growth. The aim of the study was to determine the incidence of hip dysplasia in PWS and its evolution during growth.

Materials and methods

This was a retrospective study in 70 PWS children (40 girls, 30 boys) mean age 9 years (1.5–18). 134 radiographs of the pelvis were analysed according to four age groups (1–3 years: 42) (4–6 years: 40) (7–13: 36) (14–18 years: 16). Results were compared to normal coxometry depending on the child's age as reported in the literature and Severin score. Longitudinal analysis until the end of growth was performed in 16 patients.

Results

Average walking age was 26 months. 1 patient required surgery (Salter osteotomy). All patients were treated with growth hormone. Before the age of 6 years the lateral centre edge angle was close to the lower limit of normal and increased with growth thereafter. The

acetabular index was close to the upper limit of normal before the age of 6, and then decreased to normal values thereafter. The neck shaft angle was close to the upper limit before the age of 6 and then decreased to normal values thereafter. According to Severin score, dysplasia was frequent before the age of 6 years, then improved thereafter. Except for one case operated for severe dysplasia, Severin score was ≥ 3 in 26 % of patients before the age of 4 years, in 21 % before 7, in 4 % before 14 and 0 % thereafter.

Conclusion Hip dysplasia is 10 times more frequent in PWS than in the general population. In the literature, prevalence varies from 10 to 22 %. It may be related to ligament laxity, muscle hypotonia and delayed acquisitions. Dysplasia subsides from the age of 6 years. This study confirms the high prevalence of hip dysplasia in PWS, but it occurs mainly in early life. In most cases hip dysplasia subsides without any treatment

April 9

Metabolic/Other
10:40–12:00

OP138/11:23–11:28

A quantitative method for radiologic assessment of skeletal maturity using the distal femur

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Level-3

Other

Introduction Current methods for estimating skeletal maturity have shown wide variability and generally involve significant complexity, limiting practical use and leading some to favour chronological age. Recently, it has been shown that 90 % of final adult height is a more accurate predictor of skeletal growth patterns as compared to peak height velocity. Using 90 % of ultimate height as a gold standard and applying this to the same historical collection used to establish the Greulich and Pyle atlas, we sought to develop a quick, quantitative, and reproducible method of estimating skeletal maturity.

Materials and methods Forty-two healthy children (26 girls, 16 boys) reached 90 % growth at an average age of 11.3 ± 0.9 years for girls and 13.2 ± 0.5 years for boys. Annual radiographs of the knee 3 years prior and 2 years following the 90 % mark were analyzed. A horizontal line was drawn along the distal femoral physis, and the distance from the tip of the central peak to this line was divided by the physeal width to obtain a standardized value. Measurements were tested for intraclass correlation coefficient in 24 radiographs by the two authors. Linear regression analysis was used to compare chronological age, Greulich and Pyle bone age, and chronological age combined with central peak standardized height.

Results The intraclass correlation coefficient was 0.944 for central peak height, giving excellent inter-rater reliability. Linear regression analysis showed an improvement in overall correlation between predicted age of 90 % growth and true age of 90 % growth when using a combination of chronological age and position of the central peak of the distal femur on radiographs when compared to either chronological age or Greulich and Pyle bone age in both girls and boys.

Conclusion 90 % of ultimate adult height has been shown to be a better predictor of true skeletal maturity when compared to peak height velocity, and its use at a new gold standard may allow for the development of improved skeletal maturity grading systems. Using regression analysis, we have found that using a combination of chronologic age and standardized distal femur central peak height provides better prediction of 90 % height as compared to using either chronological age or Greulich and Pyle bone age measurements.

Significance To our knowledge, central peak height represents the first purely quantitative parameter for estimating skeletal maturity, and offers a practical methodology which can potentially improve treatment when skeletal maturity is an important factor.

April 9

Metabolic/Other
10:40–12:00

OP139/11:28–11:33

A retrospective cohort study of 207 cases of osteochondritis dissecans of the knee: risk factors and outcomes associated with surgical treatment

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Level-3

Other

Introduction The aim of this study is to describe the clinical characteristics, image findings, and outcomes of patients with juvenile osteochondritis dissecans (JOCD) of the knee.

Materials and methods This is a retrospective cohort study of knee JOCD patients assessed by a single pediatric orthopaedic surgeon at a tertiary care center between 2005-2015. All diagnoses were confirmed by magnetic resonance imaging (MRI). Patients with patellar dislocations or osteochondral fractures were excluded. Demographic data, sports played, comorbidities, surgical procedures, and clinical data were extracted from charts. Images were analyzed to identify the location and size of lesions. Chi square or Fisher's exact tests were used to compare discrete variables, and Mann-Whitney U and Kruskal-Wallis tests to compare continuous variables between groups. P-values of <0.05 were considered significant.

Results The sample consisted of 180 patients (207 knees), 124 boys and 56 girls. The average age at diagnosis was 12.7 years (5.6-18.1). Asthma was the most frequently associated morbidity (13.3 %). The majority were active in sports (80.8 %), mainly soccer (36.7 %) and basketball (29.4 %). JOCD was present bilaterally in 27 patients (15 %), 14 knees had bifocal OCD (6.8 %), and only 1 patient had bifocal lesions in both knees. The most common location was the medial femoral condyle (56.3 %) followed by the lateral femoral condyle (23.1 %), trochlea (11.4 %), patella (9 %), and tibia (0.5 %). In the sagittal view, the most common location was the middle third of the condyles (48.7 %). Surgery was performed in 71 knees (34.2 %), with an average age at surgery of 14.1 years (9–17). Bilateral JOCD was present in 13 surgical patients (18.8 %), but only 3 patients had bilateral surgery. Two operative patients had bifocal JOCD (2.7 %) and surgery on both lesions. Location distribution did not differ between surgical and non-surgical lesions. The average normalized area of non-surgical JOCD lesions was 6.8 (0.1–18), whereas surgical lesions averaged a significantly higher area of 7.7 (0.5–17) ($p = 0.023$). Average BMI was

21.6 compared with 20.2 for surgical and non-surgical patients, respectively, significantly higher for those who underwent surgery ($p = 0.002$). Most common procedure was fixation with 1.6 mm bioabsorbable nails (62.5 %), using an average of 4 nails (1-9); the second most common procedure was drilling (40.3 %). Fixation was achieved arthroscopically in 76 % of the cases. Revision surgery was required in 10 knees (13.9 %). The most common revision procedures were arthroscopic debridement (80 %) and implant removal (30 %). Most surgical patients had postoperative MRIs (55 knees), with an average radiological follow-up of 14.5 months (range 2.1–55.4).

Conclusion JOCD occurs more frequently in young adolescent athletic boys, affecting the middle third of the medial femoral condyle. In our cohort, 34 % of the patients had surgery, where bigger lesions and higher BMI were risk factors for operative treatment. At short-term follow up, the success rate following surgery was 84 %.

Significance To our knowledge, this is the largest published cohort regarding JOCD. It allows us to gain further experience in this topic and draw conclusion regarding the presentation, natural history and risk factors for progression of this disease.

April 9

Metabolic/Other
10:40–12:00

OP140/11:33–11:38

Deformity correction and stabilisation of long bones in adolescents with metabolic bone disease using rigid intramedullary nailing

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Level-4

Metabolic diseases

Introduction Metabolic bone disease can cause recurrent fractures and secondary deformities. Such conditions are usually managed with growing rods at young ages. This can be converted to rigid nailing after skeletal maturity. The aim of the study was to review the effectiveness of rigid IM nailing in stabilisation and deformity correction of lower limb long bones in adolescence which to our knowledge has not been studied before.

Materials and methods Patients who qualify for the study from the department database were retrospectively reviewed with medical records and radiographs to look for indications, deformity correction, and number of osteotomies-if needed, bone healing, time to healing and the incidence of complications.

Between Aug 2010 and Mar 2015 fifteen patients (24 segments) had rigid IM nailing. Ten patients had Osteogenesis Imperfecta, four with McCune Albright syndrome and one with hypophosphatemic rickets. 22 femora and two tibiae were IM nailed. The mean age of the patients was 13.1 (9.6–16.75 years). Eleven out of 24 segments were previously rodded. Eight segments were for acute fractures. 13 bones had significant deformities requiring corrective osteotomies. One patient had previous fracture non union.

Results All patients were allowed to partial weight bear immediately after surgery and were fully mobile 6 weeks following surgery. Mean follow up was 24 months (3–51 months) post-operatively. All deformities were corrected. All fractures and osteotomies

radiologically united. Mean radiological union time was 5.5 months (6 weeks–11 months). Patients with acute fractures had mean radiological union time of 4 months. Patients who had osteotomies had a mean radiological union time of 7.1 months. The patient with previous non union had BMP at the time of operation and radiologically healed in 10 months. Two patients had persistent bisphosphonate osteotomy lines but were completely asymptomatic. One patient had a prominent distal locking screw requiring screw removal and one had a persistent Trendelenburg gait.

Conclusion Rigid intramedullary nailing is very effective in stabilisation and deformity correction of long bones in adolescent patients with brittle bone disease. The technique has a low complication rate. We recommend the use of this technique in paediatric limb reconstruction in metabolic bone conditions.

April 9

Metabolic/Other
10:40–12:00

OP141/11:38–11:42

Hip morphology in MPS 1-H patients

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Level-3

Metabolic diseases

Introduction MPS I is a disorder caused by the accumulation of glycosaminoglycans in all tissues. This results from a deficiency of the enzyme (alpha)-L-iduronidase. The main features of interest to the orthopaedic surgeon are hip dysplasia, thoraco-lumbar kyphosis, genu valgum and stiff hands. The acetabula fail to deepen, and there is a progressive subluxation of the hip joints. Patients with Hurler syndrome have received bone marrow transplantation since 1981, but still, as the patients mature, clinical and radiographic abnormalities of the hips develop. Life expectancy is increased, so the treatment of hip dysplasia is even more important.

Materials and methods Twenty-eight patients were treated in our interdisciplinary outpatient clinic. In eighteen children a plain radiological investigation of the hips was performed. All of these patients underwent bone marrow transplantation in younger age. Because of hip pain or worsening of ambulation, eight patients got an MRI of the hips. Plain radiographs and MRIs were assessed, acetabular angle of Sharp, Centre edge angle and the Reimer percentage of coverage of the head were measured. In the MRIs we differentiate between the cartilaginous and the bone coverage.

Results At the time of the investigation the children were at a mean age six years. All patients demonstrated the characteristic radiological signs of failure of ossification at the superolateral margin of the acetabulum and gradual distortion of the femoral head with medial thinning. The mean acetabular angle in the plain radiographs was 39.3 degrees, in the MRIs 39.1 degrees. The percentage of bony coverage in the plain radiographs was 69.4 %. This value was lower in the MRI with a wider range. The cartilaginous coverage of the femoral head was 67 %, this was more than in comparable data for healthy

children. All arthrographies showed a stable hip situation, but a failure of ossification of the lateral acetabulum.

Conclusion Our results establish that patients with MPS-1H have a much greater cartilaginous coverage than comparable healthy children. Radiography only, may lead to a misunderstanding of hip morphology. MRI measurements can identify the cartilaginous coverage and help in deciding this question. Our findings suggest that MRI in addition to radiographs should be performed if surgery is clinically or radiographically considered.

Significance This study has a high clinical significance. The data shown can help in the pre-operative decision making processes.

April 9

Metabolic/Other
10:40–12:00

OP142/11:42–11:47

Treatment of complex deformities in osteogenesis imperfecta with the Fassier–Duval telescopic intramedullary nail

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Level-4

Upper and lower extremity reconstructions

Introduction The following work had the purpose of reviewing the efficiency of the Fassier–Duval endo-medullary telescopic fixation system as a treatment for complex deformities on the lower extremities of patients with Osteogenesis Imperfecta, treated by the author from 2006 to 2014. 156 patients with osteogenesis imperfecta (OI) were identified. All deformities were in long bones were complex and angular. All of them were treated with osteotomies in order to align the mechanical axes of each segment. 258 long bones, 198 femurs and 90 tibias underwent surgery.

Materials and methods The stabilization was achieved with Fassier–Duval endo-medullary telescopic nails. On an average 4.4-year follow-up, 30 femurs and 10 tibias showed some complications. All of the patients have concomitantly received either pamidronate disodium or zoledronic acid treatments.

Results The age of the patients was between 18 months and 12 years, with an average age of 5.8 years. There were 66 females and 90 males. The average age of the patients at the time of the first implant was 5.6 years. 258 systems were implanted in 156 patients. The average follow-up time was 4.4 years (8 years to 1 year and 2 months). The number of osteotomies to achieve the alignment was 2, with 2 in each of the femur and tibia. 40 long bones, 30 femurs and 10 tibias showed complications. 6 femoral fractures with nail angulation, 10 femoral neck fractures, 10 dislocations of the threaded distal end in the distal femoral physis, 10 sinkings of the threaded proximal end of the femoral component in the femur, 6 dislocations of the threaded distal end in the distal tibial physes, and 4 sinkings of the threaded proximal end of the femoral component in tibias.

Conclusion The stabilization with Fassier–Duval system in patients with osteogenesis imperfecta shows itself to be a reasonable alternative for the boney biology that doesn't present the inconvenience of preventing osseous growth.

Significance Total number of podium presentations and poster sessions: 142.

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