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**Abstracts**

## Abstracts

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2 S	<b>FM01–FM142</b>	Freie Mitteilungen
40 S	<b>P01–P98</b>	Posters

## Index of first authors

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66 S

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## Impressum

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\*FM01

### Is serial radiographic evaluation of patients with a 1-part proximal humerus fracture necessary at routine follow-up time points?

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**Introduction:** 1-part proximal humerus fractures are generally treated nonoperatively. These patients undergo often serial radiographic evaluations at routine intervals to verify maintenance of fracture stability. The aim of this study was to determine whether serial radiographic evaluation of patients with a 1-part proximal humerus fracture changes the clinical course of treatment.

**Methods:** Subjects treated between January 2014 and December 2016 with a proximal humerus fracture were evaluated prospectively. Patients treated nonoperatively with a nonpathological 1-part fracture and routine radiographic evaluation at initial emergency admission and at each subsequent follow-up appointment at 1 week, 6 weeks, 3 months and 1 year, were included. Patients with concomitant lesions or dementia were excluded. Fracture stability, as determined by the Neer criteria, and corresponding treatment changes were evaluated at each time point.

**Results:** Of the 137 patients treated for a 1-part fracture, 107 met the inclusion criteria. Eight patients had a concomitant lesion and 1 had dementia, resulting in a study population of 98 subjects (mean age of 57 years). Fracture location involved the greater tuberosity in 74 patients and the surgical neck in 73, of which 49 had a combined type. 95% remained stable with fracture consolidation at latest at 1 year follow-up. Five patients had a secondary fracture displacement (5%), of which 2 underwent a reversed prosthesis procedure, 2 underwent an open or closed reduction and internal fixation, and 1 was further treated nonoperatively. Of the 4 patients with a fracture displacement at the surgical neck level, 2 had a comminuted fracture pattern of the calcar, and 2 were secondary to a trauma event. A comminuted fracture pattern at the greater tuberosity led to a secondary displacement of a fragment in 1 patient.

**Conclusion:** The majority of nonoperatively treated 1-part proximal humerus fractures remain stable. Radiographic evaluation at routine time points seems to expose the patient to unnecessary radiation. A patient-specific approach based on specific fracture patterns and compliance to the treatment protocol seems to be more appropriate.

FM02

### Superior fragment dislocation influences the surgical indication in greater tuberosity fractures more than posterior dislocation – analysis of a 104 patients cohort

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**Introduction:** Isolated GT fractures account for ~20% of the proximal humeral fractures. There is a paucity of knowledge with respect to the dislocation pattern and clear thresholds when to perform surgery after isolated GT fractures. However, incorrect treatment can lead to persistent pain and relevant impairment. For this reason, there is a need to evaluate GT fractures in an extensive cohort. The aim was to analyse the cohort characteristics and fracture pattern in patients with isolated fractures of the greater tuberosity (GT).

**Methods:** We performed a retrospective analysis in 104 patients (42 male, 62 female, mean age 47 years) with isolated GT fractures treated in our clinic (2012–2017). All available data and images (X-Ray, CT, MRI) were analysed. Fracture dislocation was assessed using the distance of dislocation (DA) and the angle until the GT impinges with the acromion (Omega). The main direction of fragment dislocation, the morphology of the fracture and whether the fracture was associated with glenohumeral dislocation was assessed.

**Results:** 17/104 patients underwent surgery based on the circle criteria. 37 Patients had a combined injury involving a dislocation and GT fracture. The mean DA was 6 mm (1–21 mm) and mean Omega 64° (29–117°). Patients treated with surgery showed significant higher DAs compared to conservative treatment (10 mm versus 6 mm,  $p > 0.001$ ), but did not differ in the Omega angle ( $p = 0.8$ ). Patients undergoing surgery showed a more frequent superior dislocation (82%), while patients treated conservatively prevalently had a posterior (47%) or minimal (25%) dislocation. Multifragmentary injuries were present in 32% of all patients (conservative: 29%, surgery: 47%,  $p = 0.16$ ).

**Conclusion:** Besides an increased fragment dislocation distance, patients in our surgery cohort present more often with superior fragment dislocation. With the common x-ray analysis, posterior

fragment dislocation and surgical indication may be underestimated. Comprehensive analysis of injury type is important for clinical decision making and further investigation.

FM03

### Is plain x-ray enough to quantify distance and direction of fractures of the greater tubercle?

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**Background:** There is no standardized and reproducible method to quantify the displacement of GT fragments in ap x-rays. Novel radiographic parameters have been presented to quantify the displacement of the GT fragments. Since these parameters have not been validated, we performed an intermodal analysis between x-ray- and CT-measures. The aim of this study was validation of different ap x-ray measurements, with which the greater tubercle (GT) fracture dislocation can be quantified.

**Methods:** In 32 patients, GT fracture dislocation was evaluated on ap x-rays using the fragment dislocation-distance perpendicular to the humeral axis (DA) and -distance from the rotational center of the head (DR). Furthermore, two proposed impingement angles – the angle between the GT fragment and axis of the humerus (Omega1) and angle between the GT fragment and lateral acromion (Omega2) were measured. In the CT scans, the actual three-dimensional distance and direction of the GT fracture dislocation was assessed. To validate the x-ray measures, comparison of the x-ray- with the CT-values were calculated using correlation analysis.

**Results:** The three-dimensional length of the dislocation measured in CT scans showed no correlation with the DA ( $r = 0.04$ ,  $p = 0.82$ ) or DR ( $r = 0.06$ ,  $p = 0.72$ ) respectively. Reduction to one-dimension revealed for both DA and DR moderate correlation in superior-, but not in medial- or in posterior- direction. The three-dimensional direction of the fragment dislocation showed slightly better correlation with Omega1 ( $r = 0.52$ ,  $p = 0.002$ ) compared to Omega2 ( $r = 0.45$ ,  $p = 0.010$ ). In ap x-rays, no measurement reliably represents the dislocation vector of a posteromedially dislocated GT fragment.

**Conclusion:** Ap x-rays qualify only for evaluation of a limited amount of GT fractures. DA and DR are a good representation of fragment dislocation in superior direction but may underestimate posteromedial dislocation. Omega values may give a semiquantitative information about the direction of the fragment.

\*FM04

### Major joint injuries, interventions and late sequels in male top handball players compared to age-matched reference group

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**Introduction:** Top handball players expose their body to serious stress and risk of injuries that could leave long term sequels. Since handball is a throwing sport shoulder and elbow injuries are expected most often. The aim of the study is to reveal if male top handball players suffered more musculoskeletal injuries during their active career than a reference age-matched male population. Furthermore, we compared the number of operations, late sequels of reported injuries and long term persisting pain in locomotory system of the two groups.

**Methods:** We included in the study former top professional handball players that reached the level of playing in the Swiss National Team. Top athletes that were active in the Swiss National Handball League between 1970 and 1985 answered a questionnaire about former injuries, operations and their present health status specifically asking for sequels in the major joints. A total of 34 top athletes were compared to 58 age matched male volunteers that could have performed recreational sports, but none of them was top-athlete.

**Results:** The handball group was on average 58.4 years old (range 52–68 y), the control group did not differ significantly (mean age 58.7 y, range 53–69 y). The handball players reported on average 284 games for their clubs in the Swiss National League and 91 games for the Swiss National Team. The incidence of shoulder injuries (0.08 athletes, 0.10 controls), the number of interventions, sequels or present shoulder pain was not statistically different between the groups. Regarding elbow injuries, athletes had more interventions (3/34 vs. 0/58, Fisher test  $p = 0.47$ ), but difference in present pain or late sequels did not reach statistical significance. For knee injuries we saw no significant difference in incidence (0.27 vs. 0.17), number of interventions, sequels or persisting knee pain. The most interesting

results were found regarding foot and ankle. There was a significantly higher incidence for injuries (0.5 vs. 0.03,  $p < 0.001$ ) and interventions (0.5 vs. 0.09,  $p < 0.001$ ) but no statistical difference for sequels and persisting pain. Overall health status was estimated identical (athletes mean 85.9%, controls 85.8%).

**Conclusions:** Top handball players did not suffer from more shoulder or knee injuries than the control age-matched population. The elbow is more at risk in those top athletes, but sequels appear to be less serious. The most distinctive difference can be seen regarding foot and ankle injuries.

\*FM05

#### Which lateral clavicle fractures can be treated by an arthroscopic assisted endobutton procedure? An analysis of risk factors

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**Introduction:** Arthroscopic assisted treatment of lateral clavicle fractures with CC stabilization gain popularity over the last years. Several studies show favorable results with this technique. There is little evidence which types of lateral clavicular fractures are suitable for arthroscopic assisted treatment with an endobutton device. The primary aim of this study was to evaluate the clinical and radiological outcome of an arthroscopic assisted treatment of acute lateral clavicle fractures with an endobutton device and to specify which fracture type is best addressed with this method. The secondary outcome was to evaluate potential risk factors for complications.

**Methods:** Retrospective single center review of 20 unstable lateral clavicle fractures treated with an arthroscopic assisted CC-stabilization technique between September 2012 and August 2016. The endobutton device used were either a DogBone- or TightRope-Button (Arthrex, USA). Data pertaining to demographics and postoperative complications were collected. Fractures were classified according to the Neer-Classification and time to radiological union and secondary loss of reposition were analyzed. The functional outcome was evaluated with Constant- and DASH-Scores, VAS and SSV.

**Results:** Between September 2012 and August 2016, 217 patients with clavicle fractures were operated at our clinic. 28 of those were lateral clavicle fractures. 20 were treated with the above mentioned method with an average age of 45 year (male: female ratio 14:6). In those cases with a follow up at least twelve months (12–50) were bony healing was observed the DASH-Score was on average 2.0 (0–9.82). The Constant-Score had an average of 81.8 (range, 68–93) points and the average difference to the collateral side was 4.1 points (range, 0–15) in the same group. No infections or coracoid fractures have been reported. Six patients developed a nonunion of which two needed revision.

**Discussion:** Our results show that arthroscopic assisted CC stabilization with an endobutton technique allows good functional results by adult patients of all ages. Very lateral unstable clavicle fractures seem to be especially suitable for this surgical technique. The high number of delayed unions however warrants further analysis and future research should focus on this topic. Analysis of risk factors showed that early mechanical stress, a lateral clavicular fragment bigger than 3 cm and a time delay to surgery could be risk factors for these nonunions.

FM06

#### Periarticular and glenoid morphology of the scapula differs in patients with Hill-Sachs lesions: a controlled statistical shape modeling study

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**Introduction:** Patients with large Hill-Sachs lesions are difficult to treat within the greater anterior shoulder instability population. Previous research has associated glenoid morphology differences with anterior shoulder instability. Statistical shape modeling (SSM) is a powerful

tool to compare complex morphology without idealizing underlying geometry, and can identify unknown morphologic differences of the scapula. The aim of this study was to quantify and compare periarticular and glenoid morphology of the scapula between subjects with Hill-Sachs lesions and control subjects using SSM.

**Methods:** Computerized tomography (CT) scans of 41 control scapulae and 54 scapulae of patients with Hill-Sachs lesions were three-dimensionally reconstructed. SSM identified the modes of variation in the scapulae of both groups. These modes were then quantified in relation to the glenoid center (offset measures) or longitudinal glenoid center-plane (angles) in both groups. Glenoid bone loss was determined by measurement of the missing circular segment of the best-fit glenoid circle.

**Results:** As compared to controls, the pathologic group had a more superior and medial offset of the coracoid tip ( $23 \pm 5$  mm vs.  $30 \pm 4$  mm and  $19 \pm 3$  mm vs.  $16 \pm 4$  mm, respectively;  $p < 0.001$ ) with a posteriorly rotated coracoid pillar and a posterior-inferiorly rotated scapular spine pillar ( $135^\circ \pm 8^\circ$  vs.  $141^\circ \pm 7^\circ$  and  $60^\circ \pm 6^\circ$  vs.  $65^\circ \pm 8^\circ$ , respectively;  $p \leq 0.001$ ). This resulted in a more anteriorly angulated coracoid process ( $26^\circ \pm 5^\circ$  vs.  $29^\circ \pm 6^\circ$ ;  $p = 0.002$ ) and a more horizontal orientation of the coracoacromial arch ( $79^\circ \pm 7^\circ$  vs.  $87^\circ \pm 7^\circ$ ;  $p < 0.001$ ) for the unstable shoulders. Compared with the control subjects, the glenoid of the pathologic group had an increased estimated height-width ratio ( $1.40 \pm 0.09$  vs.  $1.44 \pm 0.10$ ;  $p = 0.018$ ), and was flatter in the anterior-posterior direction (radius of curvature:  $65 \pm 69$  mm vs.  $135 \pm 207$  mm;  $p < 0.001$ ). No difference in glenoid version was found ( $-1^\circ \pm 3^\circ$  vs.  $-2^\circ \pm 4^\circ$ ;  $p = 0.112$ ). Mean glenoid bone loss was  $13.5 \pm 7\%$  for the pathologic shoulders.

**Conclusion:** Differences in glenoid morphology, as well as previously unknown shape variations of the coracoid and acromion were identified in this cohort of patients with Hill-Sachs lesions. Further biomechanical and prognostic studies are warranted to investigate whether these shape variations, specifically those of the acromion and coracoid, are predictors of shoulder instability.

FM07

#### Long-term results of the open Latarjet procedure for recurrent anterior shoulder instability in patients older than 40 years

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**Introduction:** Age older than 40 years at surgery is known to be an independent risk factor for outcome after the Latarjet procedure. So far, no long-term results about the Latarjet procedure in elderly are available. It was the purpose to analyze long-term results of the open Latarjet procedure for recurrent anterior shoulder instability in patients older 40 years.

**Methods:** Thirty-two patients (33 shoulders) with a mean age of 49 (range, 40–66) years were evaluated at a mean of 11.3 (range, 8–16) years after open Latarjet procedure for recurrent anterior shoulder instability. Eleven patients (33%) underwent previous soft-tissue based stabilisation surgery and four (12%) received a concomitant supraspinatus repair. Clinical and radiographic (with CT-scan) long-term results were assessed.

**Results:** At final follow-up, the relative preoperative Constant score and SSV had improved from 80% to 89% ( $p = 0.003$ ) and from 60 to 90 points ( $p < 0.001$ ). The postoperative total Rowe score averaged at 92 (range, 55–100) points and 30 patients (96%) rated their final overall results as good or excellent. Seven patients (22%) underwent joint preserving surgery and one (3%) underwent reverse total shoulder arthroplasty for severe dislocation arthropathy and shoulder dysfunction. There was one redislocation (3%) and apprehension persisted in seven patients (22%), which was associated with too medial (>4 mm) graft positioning ( $p = 0.005$ ). Postoperative dislocation arthropathy according to Samilson was severe in 14 patients (44%) and progressed  $\geq 2$  grades from preoperatively in 17 patients (41%). Progression of dislocation arthropathy was associated with too lateral (>1 mm) graft positioning ( $p = 0.023$ ) and correlated with older age at surgery ( $r = 0.650$ ;  $p < 0.001$ ).

**Conclusion:** The open Latarjet procedure for recurrent anterior shoulder instability in patients older than 40 years is associated with good functional outcome and stability. In contrast, it is associated with a substantial rate of dislocation arthropathy and progression of arthropathy correlates with lateral graft positioning and older age at surgery.



FM08

### Arthroscopic repair of isolated subscapularis tears: clinical outcome and structural integrity at a minimum of 4.5 and a mean of 8.6 years of follow-up

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**Introduction:** Open or arthroscopic subscapularis tendon repair improves subjective and objective shoulder function in the short term. Longer term follow-up after rotator cuff repair, however, shows increasing failure rates with increased follow-up time. It was the purpose of this study to determine whether arthroscopic repair of isolated subscapularis tears result in sustained clinical and structural success after no less than 4.5 years.

**Method:** A database review was conducted to identify patients who had undergone an arthroscopic repair of an isolated subscapularis tear between August 2003 and December 2012 to be reviewed with a minimal follow-up of 55 months. Patients with complete clinical documentation and pre-operative MRI were contacted for a clinical and imaging follow-up including visual analogue assessment of pain, Subjective Shoulder Value (SSV), scoring according to Constant (rCS), and measurement of active and passive ranges of motion. Imaging consisted of native MRI of the shoulder. For patients who had MRI and complete review between 24 and 48 months a subgroup analysis was performed to document deterioration between early to mid-term follow-up.

**Results:** 25 patients (12 female, 13 male) were available for final clinical and radiological examination at a mean follow-up of 8.6 years (range 4.6 to 13.9). Ranges of active motion were preserved with a mean 154 degrees of flexion, external rotation of 58 degrees of external and internal rotation to the scapula in 19 cases, to the thoracic vertebral body 12 in 4 cases and in two cases until bellline. Internal rotation significantly improved from preoperative to last follow-up ( $p < 0.001$ ). The average SSV significantly improved from 41.2% preoperatively to 90.7% at final follow-up ( $p < 0.001$ ). The average rCS significantly improved from 69% preoperatively to 92% at final follow-up ( $p < 0.001$ ). Interestingly range of internal rotation, SSV and rCS showed a significant improvement between early to last follow-up in the subgroup analysis. MRI evaluation showed a rerupture rate of 4% (1/25).

**Conclusions:** Arthroscopic repair of isolated subscapularis tears yields good to excellent clinical results and a high healing rate with durable structural integrity. After the operation, the shoulder function seems to improve rather than to deteriorate from short- to mid-term follow-up.

FM09

### Biomechanical comparison of three anchors for rotator cuff repair in standardized physiological and osteoporotic bone – introducing 1000 loading cycles

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**Introduction:** Previous biomechanical studies only used single-pull-destructive tests in line with the anchor and are limited by a great variability of cadaver bone mineral density. Therefore we provided a more physiologic setting, testing different anchor constructs: titanium, bioresorbable and all-suture anchors (TwinFix<sup>®</sup> Ti 4.5 mm (Smith&Nephew), Healix<sup>®</sup> BR 4.5 mm (DePuySynthes Mitek) and Iconix 2.3 mm (Stryker), in standardized physiological and osteoporotic bone specimen. We hypothesized that the anchors would show comparable failure properties in physiologic bone but the all-suture construct would fail earlier in osteoporotic bone.

**Methods:** 60 standardized artificial bone specimen (AO-Project MT\_2004\_EXT-01) were used for biomechanical testing- 30 “physiological” and 30 “osteoporotic” specimen with 10 bone-anchor constructs in each group. The particular advantage is the homogenous bone density, thus providing the most reliable and significant testing conditions. Using custom-built steel clamps, the anchors were placed in 45° slope as during surgery when inserted into the humeral head. Testing was performed using a servohydraulic testing machine at a sample rate of 50 Hz. Cyclic loading for 1000 cycles and Load-to-failure (LTF) testing was performed until the construct failed.

**Results:** Cyclic loading revealed a significant higher displacement after 1000 cycles for the Healix (3.7 ± 1.5 mm) as compared to the Twinfix (2.2 ± 0.9 mm;  $p = 0.001$ ) and to the Iconix anchor (2.3 ± 1.4 mm;  $p = 0.005$ ). No significant differences were found neither between

Iconix and Twinfix, nor with regard to bone density. In the physiological group, the highest LTF was found for the Iconix (632.9 ± 96.8 N) significantly higher than for the other two anchors (TwinFix 497.1 ± 50.5 N and Healix 322.4 ± 31.4 N,  $p < 0.0001$ ). The TwinFix anchor showed a higher LTF than the Healix anchor ( $p < 0.0001$ ).

In the osteoporotic group, the Iconix again showed a higher LTF compared to the Healix anchor (500.9 ± 50.6 N vs. 315.1 ± 11.3 N,  $p < 0.0001$ ) but was not significantly higher compared to the TwinFix anchor [467.4 ± 39.4 N,  $p = 0.17$ ]. As expected, the anchors showed a higher LTF in physiological compared to osteoporotic bone (484.2 N vs. 427.8 N,  $p < 0.0001$ ).

**Conclusions:** Interestingly, the all-suture Iconix anchor outperformed the other anchors in physiological bone. It was also the strongest anchor in osteoporotic bone but only significant compared to the Healix. Currently, all-suture anchors are not yet indicated in osteoporotic bone.

FM10

### Glenoid and acromial morphology is significantly correlated to direction of shoulder instability

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**Introduction:** The influence of the acromion morphology on glenohumeral stability in the anterior posterior plane is not known. It was the purpose to find a possible relationship between the size and position of the posterolateral acromion (posterior acromial coverage; PAC) a tendency to either anterior or posterior shoulder instability.

**Methods:** Between 2010 and 2017, patients with a diagnosis of unidirectional posterior instability were age and gender matched to a cohort of patients with a diagnosis of unidirectional anterior instability. Two blinded observers undertook measurements on radiographs and CT scans. The measurements included glenoid version, posterior acromial tilt, PAC in relation to the glenoid, and critical shoulder angle (CSA).

**Results:** Eighty-two patients were enrolled with 41 in each group. A significant mean difference was seen between posterior instability and anterior instability groups for glenoid retroversion  $-4.21^\circ$  (CI  $-5.70$  to  $-2.72$ ), posterior acromial tilt  $-8.26^\circ$  (CI  $-4.27$  to  $-12.25$ ), PAC 11.51 mm (CI 8.45 to 14.56) and CSA 2.15° (CI 0.09 to 4.20). Regression analysis showed glenoid version ( $p = 0.002$ ), then PAC ( $p = 0.006$ ), followed by posterior acromial tilt ( $p = 0.047$ ) to be the factors that significantly influenced the model.

**Conclusion:** This is the first report showing a significant difference in the morphology of the glenoid and acromion in patients treated for posterior instability compared to patients with anterior instability. Patients with unidirectional posterior instability are more likely to have increased glenoid retroversion with an acromion that is higher and flatter in relation to the center of the glenoid. These findings may lead to a better pathophysiological understanding and possibly new treatment options.

FM11

### Does the lever arm ratio of the rotator cuff and the deltoid play a role in pseudoparalytic shoulders?

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**Introduction:** Tear pattern and tendon involvement are risk factors for the development of a pseudoparalytic shoulder. However, some patients have similar tendon involvement but significantly different active forward flexion. In these cases it remains unclear why some patients suffer from pseudoparalysis and others with the same tear pattern show good active ROM. Moment arms and force vectors of the RC and the deltoid muscle play an important role in the muscular equilibrium to stabilize the glenohumeral joint. The goal of the present study was to investigate the role of the moment arms of the rotator cuff (RC) and the deltoid muscle in the presence or absence of pseudoparalysis in shoulders with massive RC tears.

**Methods:** Biomechanical and clinical analyses were conducted calculating different moment arm ratios of the RC and the deltoid muscle using a computer rigid body model and a retrospective radiographic investigation of two cohorts with and without pseudoparalysis and massive RC tears. Idealized lever arms were represented by two spheres concentric to the joints centre of rotation either spanning to the humeral head or deltoid origin of the acromion. The effects of different lever arm ratios on RC muscle forces and

glenohumeral stability was calculated. Individual ratios of the RC / deltoid moment arms on antero-posterior radiographs using the newly introduced Shoulder Abduction Moment (SAM) Index was compared between the pseudoparalytic and nonpseudoparalytic patients.

**Results:** Linear decrease of RC activity and improved glenohumeral stability (+14%) was found in model simulations for lever arm ratios with larger diameters of the humeral head which also were consequently beneficial for the (remaining) RC. Clinical investigation of the lever arm ratio showed significant risk of having pseudoparalysis in patients with massive tears and a SAM Index <0.77 (OR = 11).

**Discussion:** Different lever arm ratios representing individual biomechanical characteristics of the bony shoulder morphology have an impact on the presence or absence of pseudoparalysis in shoulders with massive RC tears. The computer rigid body model fed with clinical parameters was able to show a linear correlation between lever arm ratios acting on the glenohumeral joint and instability. The newly introduced and easy to measure radiographic parameter called SAM Index is associated with the presence or absence of pseudoparalysis.

FM12

### Long-term outcome of pectoralis major transfer for the treatment of irreparable sub-scapularis tears: an update 20 years postoperatively

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**Introduction:** Irreparable subscapularis tears are associated with painful shoulder dysfunction. A reliable treatment option is the PMT. However, there are no long-term results of more than 10 years available. It was the purpose to analyze long-term results after pectoralis major transfer (PMT) for an irreparable subscapularis tear.

**Methods:** Twenty-eight patients underwent thirty consecutive PMTs. After a mean of 20 (range, 18–21) years, twenty-one patients (70%) with a mean age of 74 (range, 59–87) years were clinically and radiographically assessed. The long-term results were compared with preoperative findings and with previously published short-term results.

**Results:** At final follow-up, the absolute and relative preoperative Constant scores had improved from 45 (range, 20–74) to 68 (range, 46–83) points ( $p < 0.001$ ); and from 50% (range, 22–80%) to 81% (range, 58–95%;  $p < 0.001$ ), respectively. Significant improvement was also seen in mean SSV (20% to 72%;  $p < 0.001$ ) and all patients rated their final overall results as good or excellent. Improvement of active forward flexion (127° to 139°), abduction (115° to 135°) and internal rotation did not reach statistical significance ( $p > 0.05$ ). Although statistically significant, compared active internal and external rotation did not deteriorate substantially (from 8 to 6 Constant score points;  $p = 0.015$  and from 50° to 37°;  $p = 0.004$ ) from the thirty-two months to the final follow-up. At final follow-up, a rupture of the PMT was sonographically identified in 2 patients (12%). One patient (5%) underwent reverse total shoulder arthroplasty and two patients (12%) showed radiographic evidence of cuff tear arthropathy (Hamada stages 4 or 5), both with the sonographically identified rupture of the PMT.

**Conclusion:** Pectoralis major transfer for an irreparable subscapularis tear leads to significant subjective and objective improvement over 20 years of follow-up. It is associated with a low rate of salvage reverse total shoulder arthroplasty. If the transfer fails, cuff tear arthropathy may develop.

FM13

### Acromion roof in patients with osteoarthritis and rotator cuff tears – multiplanar analysis with computertomography

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**Introduction:** There is evidence for differences of scapular shape between shoulders with rotator cuff tears (RCT) and osteoarthritis (OA). But which bony part of the acromion really differs, is still unknown. The Aim of this study was to three-dimensionally analyze orientation and shape of the acromion in patients with RCT and concentric OA (COA).

**Methods:** CT scans of 70 shoulders with degenerative RCT and 54 shoulders with COA undergoing primary shoulder arthroplasty were analyzed. The two groups were compared in relation of 1) shape of the acromion, 2) its orientation in space and 3) the antero-posterior glenoid coverage in relation to the scapular plane.

**Results:** 1.) Lateral acromion roof: Acromial area and lateral acromial roof extension is larger in patients with RCT than in COA ( $p < 0.00$ ). Significant differences of the lateral extension of the acromion margin were limited to the anterior two-thirds. 2.) Acromial roof orientation. The acromion in RCT is on average 10° more “externally rotated” (axial plane:  $p < 0.00$ ), 5° steeper (sagittal plane:  $p = 0.02$ ) and on average 3° more tilted down-ward (coronal plane:  $p = 0.01$ ) than in COA.

3.) Glenoid coverage: With regard to the scapular plane, on average, the anterior glenoid is 4.5° less ( $p = 0.02$ ) and the posterior glenoid 8° more covered ( $p < 0.00$ ) in RCT than in COA but the overall glenoid coverage ( $p = n.s.$ ) is similar in both groups.

**Conclusion:** A more externally rotated (axial plane), steeper (sagittal plane) and more down-ward tilted (coronal plane) acromion is more frequent in patients with RCT than COA. Based on our results, lateral acromioplasty should probably be performed only in the anterior two-thirds with protection of the posterior part.

FM14

### Anterior Latissimus Dorsi Transfer (ALDT) for irreparable subscapularis lesion: safety assessment and midterm results in a series of 16 patients

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**Background:** An isolated, irreparable subscapularis lesion may severely affect shoulder function. In the absence of cuff arthroplasty a myotendinous transfer may be indicated. Little is known about the ability of the latissimus dorsi to substitute the subscapularis unit. The aim of the study is to assess ALDT for 1) complications related to the intervention and 2) its clinical and radiological outcome.

**Methods:** Prospective cohort study of 16 consecutive patients (mean age 58 years, range 46–71) treated with a transfer of the latissimus dorsi to the lesser tuberosity of the humerus. Supraspinatus or supra-infraspinatus tendons were reinserted simultaneously in 7 and 4 patients. All patients had an irreparable subscapularis lesion but mild arthropathy (Hamada  $\leq 2$ ). Complications related to the intervention and clinical and radiological outcome were assessed up to a mean follow-up of 30 months (range 24–55).

**Results:** One patient had postoperative hypo-aesthesia in the axillary nerve region, with spontaneous recovery. Two patients had rupture of the ALDT and underwent reverse shoulder arthroplasty. Active range of motion increased, with internal rotation from lumbosacral to L3 and forward elevation from 119° to 155° ( $P < 0.05$ ); external rotation was maintained. The adjusted Constant Shoulder Score and subjective shoulder value increased from 60% to 80% and 50% to 80%, respectively ( $P < 0.01$ ). Pain level decreased from 5.4/10 to 1.5/10 points on the visual analog scale ( $P < 0.05$ ). Progressive arthropathy was present in three patients (19%) with 1, 2 and 3 stages according to the Hamada classification in one patient each.

**Conclusion:** ALDT is a safe procedure, with complication rates comparable to those after other musculotendinous transfers around the shoulder joint. Subscapularis dysfunction may be addressed without limiting external rotation. Long-term follow-up is needed to prove the effect of ALDT on progressive eccentric arthropathy.

FM15

### Arthroscopic stabilization for posterolateral elbow instability – clinical results

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**Objectives:** Posterolateral Rotational Instability (PLRI) is an important problem in elbow surgery, especially since it is frequently misinterpreted as lateral epicondylitis. Current surgical treatment consists of ligament reconstruction with a tendon graft. This requires open surgery and graft harvest with all associated risks and potential complications. The objective of this study was to prospectively follow 10 patients undergoing arthroscopic elbow stabilization with suture anchors instead of tendon graft ligament reconstruction.

**Methods:** 10 patients with clinical signs and MR-findings of PLRI were included in this study after having given informed consent. Elbow arthroscopy was performed and PLRI II–III° confirmed. The elbow was stabilized by reattaching the lateral ulnar collateral ligament and extensor tendons with suture anchors. Endpoints were VAS pain (0–10), ROM, the Mayo Elbow Performance Score (MEPS) and the Andrews Carson Score (ACS).

**Results:** The mean age was 44 years (95% CI 35–53), 60% male. 4 patients had a history of trauma, all others had been treated for lateral epicondylitis with an average of 2.2 (95% CI 1–4) corticosteroid injections and physiotherapy. There were statistically significant and clinically relevant improvements in all endpoints with a reduction in pain by 5.4 pts (95% CI 4.6–6.3) and improvement in MEPS by 37.2 pts (95% CI 28–47) and ACS by 59 pts (95% CI 50–68). There was no significant reduction in extension ( $-1^\circ$ , 95% CI  $-2.9$ – $-3.8$ ) or flexion ( $-1.7^\circ$ , 95% CI  $-0.6$ – $-4.0$ ). There were no complications, one patient did report occasional tenderness to touch over the knots.

**Conclusions:** Arthroscopic stabilization provided a statistically significant and clinically relevant improvement in this prospective cohort of patients with  $^{\circ}$ I– $^{\circ}$ III PLRI.

FM16

### Is there a place for radiocapitellar arthroplasty? – A consecutive case series with 2–6 years follow-up

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**Introduction:** The literature on RCA is sparse. This study presents the largest single surgeon experience on RCA with special interest on indications, outcome and complications.

**Methods:** Between 2010 and 2015, a total of 16 elbows in 15 consecutive patients were treated with RCA. The data were prospectively collected including preoperative and yearly functional elbow assessment (Mayo Elbow Performance Score; MEPS) and radiographic examinations. The radiographs were assessed for progression of ulnohumeral arthritis, position and loosening of the implant. Furthermore, complications and revisions were analysed.

**Results:** Four men and 11 women (mean age 51.9 years, range 32 to 65) were included in this study. The mean follow-up was 3.4 years (range 2–6 years). The indications were posttraumatic (n = 11) and primary radiohumeral osteoarthritis (n = 5). A mean of 1.4 surgeries (range 0–5) had been performed in these patients before the RCA was implanted. The mean MEPS significantly improved from preoperative to the final follow-up (45.9 to 85 points;  $p < 0.01$ ). The arc of motion improved from  $106^\circ$  to  $117^\circ$  ( $p = 0.06$ ). Radiographic ulnohumeral degeneration progressed in 40% but was not symptomatic at the final follow-up. Five elbows required subsequent surgery. Revision of a loose radial head component was necessary in three (19%) patients. After revision, the final outcome was improved but was still significantly worse compared to patients without revision.

**Discussion:** Our patient group included relatively young and active patients with severe restrictions in their activities of daily life due to elbow pain. The overall outcome of patients was good to excellent but less positive in patients that needed a revision. Loosening of the radial head component was a problem in this series and improved fixation technique may be indicated.

FM17

### Anconeus interposition arthroplasty as salvage procedure for advanced radiocapitellar arthropathy: a case series

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**Introduction:** Advanced arthropathy of the radiocapitellar joint leaves very limited surgical options, in particular in younger patients. We report a series of 7 cases were treated with an anconeus interposition arthroplasty in this complex situation.

**Methods:** 7 Patients have been treated with an anconeus interposition arthroplasty in our institution between 2013 and 2017. Indications, preoperative function and radiographical changes were summarized. The Mayo Elbow Performance Score (MEPS) was used to report clinical changes until final follow-up. Minimum follow-up was set at 18 months (18–40 months) after the procedure.

**Results:** The mean age of the patients was 48 years (44–70 years) at the time of the operation. All patients were suffering of a posttraumatic condition. In two cases ongoing pain following a radius head replacement was leading to the anconeus interposition. All patients had previous surgical interventions at the level of the affected elbow (1–4 surgeries). Pain and function showed an increase of the MEPS from a mean of 42 points (40–45 points) preoperatively to 80 points (70–85 points) postoperatively. None of the patients had to be revised surgically until final follow-up. All patients stated that they would undergo the same procedure again.

**Conclusion:** In this very limited number of patients the anconeus interposition arthroplasty offered a clear benefit for the patients regarding pain level and function. In selected patients this procedure may present a joint-saving option with a low complication rate.

FM18

### Odontoid fractures: a retrospective single center study

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**Introduction:** Odontoid fractures are associated with a high rate of morbidity and mortality and make up 15% of all spine fractures in the adult population. These fractures have a bimodal distribution occurring as the result of high-velocity accidents in the young and from simple falls in the elderly. Long-term studies have improved the understanding of these injuries and helped to optimize patient specific treatment algorithms. It was the aim of this study to retrospectively analyze our experience of morbidity, mortality and complication rate according to treatment method.

**Methods:** We retrospectively reviewed all odontoid fractures treated at our department between January 2004 and December 2014. Pathological and chronic fractures were excluded. Classification was performed according to Anderson and D'Alonzo and according to Grauer for Type II fractures. We analysed our study population looking into treatment methods and complications.

**Results:** 88 patients were included (50 male and 38 female). Mean age was 73 years. We observed 71 Anderson Type II fractures and 17 Type III fractures. None of the fractures was classified as Type I. 61 patients with Type II fractures were operated, in the Type III group 2 patients needed surgery. 52 patients were treated with anterior screw fixation, 11 had dorsal atlanto-axial fusion. Conservative treatment was performed in a Halo-vest (n = 25). 9 patients (14%) from the operative group needed revision surgery whereas 2 patients (8%) from the conservative group had secondary surgery for instability. Most frequent complications were infection (n = 9), dysphagia (n = 7), instability (n = 5) and postoperative neurological impairment (n = 5). 13 patients (15%) died within the first 8 weeks after trauma.

**Conclusion:** Complication rate after odontoid fractures is relatively high regardless of treatment method. This is mostly due to elevated patient age and comorbidities. Our study population reflects the classical fracture distribution already described in previous publications. Anterior screw fixation remains the treatment of choice for most of Type II fractures. C1/2 fusion provides good results as a revision procedure with few complications. Conservative treatment in a Halo-vest leads to good outcome with fewer complications in selected cases.

FM19

### Augmented reality based navigation increases precision of pedicle screw insertion

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**Introduction:** Insertion of pedicle screws can lack accuracy without any sort of navigation. Current navigation techniques are too timeconsuming or expensive. The novel technology of overlaying a hologram to the reality (mixed or augmented reality) could potentially introduce a innovative way of navigation.

**Methods:** Eighty lumbar sawbone vertebrae were embedded with different angulations in agar-based gel. 160 pedicles were randomized into two groups, either free-hand (FH) or the augmented reality (AR) group. A 3D model of the vertebral body was uploaded to the Microsoft HoloLens. Four surgeons (two experts, two beginners) had each to predrill the screw holes of 20 pedicles either FH or with AR technique by manually overlaying the virtual 3D model onto the sawbone vertebra. CT images were obtained to quantify the precision of pedicle hole drilling.

**Results:** The mean minimal axis/pedicle wall distance for the for experts was 4.8 mm (STD 1.0) with the FH technique vs. 5.0 mm (STD 1.4) with AR ( $p = 0.389$ ). For the novice, the FH technique showed 3.4 mm (STD 1.8) vs. 4.2 mm (STD 1.8) for AR ( $p = 0.044$ ), meaning a significantly better centering of the axis of the predrilled hole within the pedicle for novices but not for experts with AR. Calculated perforation for 6mm screws occurred in 2 of FH and 3 of AR guided screws with no significant differences in the expert surgeons. However, 18 and 7 screws would be perforating pedicles with FH and AR respectively ( $p = 0.006$ ) in novice surgeons.

**Conclusion:** Overlay of the hologram vertebra onto the reality (augmented reality) increases accuracy of pedicle screw placement compared to the free hand technique. The technique of augmented reality has the potential to be a novel very intuitive, simple and cost-effective way of navigation in spinal surgery.

FM20

### Augmented reality based navigation increases precision of Sacral-Alar-Iliac screw insertion

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**Introduction:** Sacral-Alar-Iliac (SAI) screws are increasingly used for pelvic fixation. Their insertion is surgically challenging without any sort of navigation. We investigated whether overlaying a hologram to the reality (augmented reality) could potentially introduce an innovative way of navigation and increase screw placement accuracy.

**Methods:** The left and right side of forty pelvic models (sawbone) was randomized into two groups, either free-hand (FH) or the augmented reality (AR) guided screw insertion. A 3D model of the pelvis, including optimized 3D screw trajectories, was uploaded to the Microsoft HoloLens. Two surgeons had each to predrill the screw holes of 20 SAI screws either FH or with AR technique by overlaying the virtual 3D model onto the pelvic sawbone model. CT images were obtained to quantify the precision of the drilled screw holes.

**Results:** Perforation of the bone occurred in more than half of the drill trajectories with the FH technique with 24 perforations while only 1 perforation was observed with AR guided technique ( $p < 0.05$ ). Calculated perforation for a 9 mm screw occurred in 17 of FH and 4 of AR guided technique ( $p < 0.05$ ).

**Conclusion:** Overlay of a 3D hologram with the ideal screw trajectory markers onto the real sawbone pelvis model (augmented reality) increases accuracy of screw hole placement compared to the free hand technique very significantly. Augmented reality based navigation has the potential to be a novel, accurate and cost-effective technique in spinal surgery.

FM21

### Cement augmented percutaneous iliosacral screws prevent screw loosening in the treatment of patients with fragility fractures of the pelvis

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**Objectives:** Osteoporosis rates are increasing over the last years and therefore is the incidence of fragility fractures of the pelvis (FFP). The importance of early mobilisation with full weight bearing in elderly patients is shifting from traditional conservative treatment towards operative stabilisation of FFP with minimal invasive techniques. However, concerns regarding the holding power of osteosynthetic materials in osteoporotic bone may influence treatment decision. Cadaveric studies have shown that augmentation of screws with bone cement provides a better hold in osteoporotic bone. The aim of this study was to analyse the incidence of screw loosening in augmented versus non-augmented percutaneous iliosacral screws in FFP.

**Methods:** We treated the first patient with augmented percutaneous cannulated and fenestrated screws at the beginning of 2017, therefore we retrospectively analysed all consecutive patients with FFP who were treated operatively from the start of 2017. One group of patients was treated with percutaneous iliosacral cannulated screws (7.3 mm cannulated screw, DePuy Synthes) without cement augmentation and the other group was treated with percutaneous iliosacral cannulated fenestrated screws (7.5 mm ISG Schraube, Medid) and cement augmentation (TraumaCem V±, DePuy Synthes). All patients were allowed weight bearing as tolerated postoperatively. Basic patient characteristics, radiological findings and mobility levels were collected and statistically analysed.

**Results and Conclusion:** Seven patients with FFP were treated without augmentation and 20 patients were treated with augmentation. The average age of the groups was 79 years (range 50–98) and 78 years (range 62–87), respectively ( $p > 0.05$ ). A total of 15 iliosacral screws were placed without augmentation and 31 iliosacral screws were augmented. In the group without screw augmentation loosening was seen in 2 patients (3 screws) while in the augmentation group no screw loosening was detected ( $p = 0,030$ ). Cement augmentation of iliosacral screws in patients with FFP results in significant less screw loosening. Using in-screw cement augmentation may help reducing complications and secondary surgery following iliosacral screw fixation in this frail patient population.

### Predictive risk factors for proximal junctional failure in thoracolumbar fusions

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**Introduction:** The purpose of the study is to identify risk factors for junctional breakdown (JBD) in a series of 12 patients who underwent thoraco-sacral fusions for variable degenerative indications. A new software is tested to locate the level with maximal bending moment on full standing EOS images.

**Methods:** 12 patients presenting JBD after lumbo-sacral, thoraco-sacral, or thoraco-pelvic fixations were included in the study. Preop EOS images were analyzed and compared with the first postop EOS showing JBD. Parameters analyzed were: Spinopelvic parameters [Pelvic Incidence (PI), Pelvic Tilt (PT), Sacral Slope (SS), Sagittal Vertical Axis (SVA), Spinosacral Angle (SSA), Lumbar Lordosis (LL), and Thoracic Kyphosis (TK)], Proximal Junctional Angle (PJA), Odontoid-Hip axis Angle (ODHA), C7 slope and CIA (Cervical Inclination Angle). Global Lordosis (GLL), Lower Lordosis (LLL), Upper Lordosis (ULL) and TK were also measured from T1 to the true inflection point, to the lumbar apex and to S1. The software used, allowed to estimate the location of the level with maximal bending moment (Mmax) before and after JBD.

**Results:** All patients except one had a JBD located between T10 and L1, diagnosed at average follow-up of 18.58 months. JBD was a fracture in six patients, severe adjacent disc degeneration in the remaining. Average PI was 52°. PT and SS were not statistically modified after JBD versus preop ( $p > 0.05$ ). Average PJA was 34.5°. GLL, ULL, anatomical L4-S1 lordosis, and TK were increased ( $p < 0.05$ ) after JBD. LLL was not increased ( $p = 0.6$ ). SVA, SSA, ODHA, and C7 slope were not modified ( $p > 0.05$ ). CIA average value decreased by 7.5% after JBD. T1–T5 alignment was correlated to C7 slope before ( $R2 = 0.77075$ ) and after JBD ( $R2 = 0.85409$ ). Ten out of twelve JBD occurred at or one level away from preop Mmax location.

**Conclusion:** Harmonious distribution of lumbar (GLL, ULL, LLL) and thoracic curves (TK, T1–T5 segment) is necessary in spinal fusions in order to avoid overstress. In this study, all patients had an excessive ULL causing a posterior shift and increased bending moment at the end of the construct, leading to JBD. It should be avoided stopping fusion constructs at the level of Mmax, to avoid overstress. The software model used could predict the location of JBD, however, further research is needed to validate the method.

\*FM22

\*FM23

### Dynamic lumbar stabilization: promises in theory not kept in clinical practice

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Dynamic lumbar stabilization is a debated subject: Whilst there seems sound biomechanical reasoning, there is little in form of evidence based clinical results. Yet as recently as April 2017 there was a review stating that the principle of load sharing between disc and facet joint has been shown as plausible in pedicle based systems in Level II 2 EBM studies. From our results presented here, we like to question this statement.

**Methods:** Patients with back and leg pain Level above VAS 6/10 who failed an intensive conservative treatment for three months were considered eligible for this study. MRI inclusion criteria were Disc protrusion and -degeneration Pfirrmann Grade 3, stenosis Schizas C in two or three levels. Facet arthrosis up to grade 2 Fujiwara. No frontal or sagittal plane deformity on standing x-ray. No instability according to AAOS criteria on Flexion/Extension x-ray. Surgery was performed by the senior author using a bilateral Wiltse approach, Decompression with removal of maximum one third of the facet joint. The Spine shape<sup>®</sup> system with a medium rod was used in all patients. Results were independently assessed using ODI, VAS back- and leg pain at 3, 6, 12 and 24 months. Normal standing and Flex/Ex x-rays were taken at 6 months, 24 months. In case of an unsatisfactory result an MRI was taken.

**Results:** All patients had a significant reduction of leg pain, five reported on going back pain for one year, three continued beyond this time point. One reported new leg pain at two years. In one of the back pain patients screw loosening was observed at one year. Two patients were revised to a fusion at two years. Meaningful difference in leg and back pain and return to work was achieved in only 6 patients. A "rebalancing" of the spine in standing position was not achieved at two years, rather there seemed a significant loss of lordosis.



**Conclusion:** The results presented here are observational retrospective data from a small group of patients with a common indication and pathology clearly described. In this small selected group there is no evidence that this type of system is superior than widely published results for decompression or fusion. Furthermore, like published elsewhere for Dynesis<sup>®</sup>, the disc deteriorates despite the dynamic fixation. We question the need for further evidence based studies as results for any such dynamic pedicle based systems are unlikely to be better than either decompression or fusion due to their inherent biomechanics.

FM24

### Diurnal changes of the intervertebral discs of the entire spine: the influence of weightlifting

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**Introduction:** Few studies have reported on the diurnal change of the intervertebral discs (IVDs), but it remains unknown if this is also true for the entire spine, and whether weightlifting influences these changes. This study opted to clarify these uncertainties.

**Methods:** This prospective study investigated two groups of healthy volunteers, weightlifters (WL) and non-weightlifters (NWL) between 2015–2017 who underwent magnetic resonance imaging (MRI) of the entire spine in the morning and evening. The inclusion criteria for both groups were as follows: weightlifters (WL) were required to have participated in weightlifting  $\geq 4$  times per week for  $\geq 5$  years, while non-weightlifters (NWL) were limited to a maximum of  $< 2$  times per week for  $\geq 5$  years. WL were then requested to perform a heavy weightlifting of the entire body with specified exercises in-between imaging, while NWL were asked to refrain from any heavy activity. Images were acquired on a 3 Tesla MRI-Scanner and quantitative measurements were conducted on sagittal (IVDs of the entire spine) planes using regions of interest on T2 mapped images. The chi-squared, Wilcoxon rank sum, Wilcoxon signed rank tests, and linear regression (adjusting for age and sex) were used.

**Results:** Twenty-five individuals were analyzed (WL:  $n = 12$  vs NWL:  $n = 13$ ). The median age was 28 (interquartile range [IQR 26–30]) years and there were 10 [40%] females (no differences between groups [ $p = 0.400$  and  $p = 0.513$ ]). The median of the measured T2 values within the IVD significantly decreased throughout the day (216.4 [IQR 194.4–241.3] milliseconds [ms] to 193.3 [IQR 179.9–212.7] ms,  $p < 0.001$ ). The decrease of the T2 values in the IVD was found in the cervical, thoracic, and lumbar spine ( $p < 0.001$  each). There were no differences between the two groups in the morning and throughout the day ( $p = 0.913$  and  $p = 0.786$ ). These findings remained with linear regression analysis.

**Conclusions:** The IVDs are affected by diurnal changes with substantially lower T2 values in the evenings compared to the morning values. As another novel finding, these results are found for the entire spine, are similar for WL and NWL, and, surprisingly, are not influenced by heavy weightlifting.

FM25

### Vertebral body lavage reduces the risk of drop in blood pressure following vertebral body augmentation with PMMA

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**Introduction:** Vertebral body lavage (VBL) prior to percutaneous cement augmentation procedures for acute osteoporotic vertebral compression fractures (VCF) has been demonstrated to reduce the amount of fatty bone marrow displaced into the circulation in animal models, thereby potentially decreasing the risk for cardiovascular complications. However, no clinical trial has confirmed these findings in humans. We therefore asked whether VBL affects (1) systemic blood pressure, (2) heart rate, and (3) oxygen saturation in patients undergoing percutaneous cement augmentation procedures for acute VCF.

**Methods:** In a retrospective comparative study, 145 consecutive patients undergoing percutaneous cement augmentation procedures for acute VCF (mean age  $74 \pm 12$  (42–96) years; 70% female; 475 levels treated) were included. Patients undergoing vertebral body lavage prior to cement application were allocated to the 'lavage group' ( $n = 61$  patients; 203 spinal levels treated), and patients without prior VBL to the 'control group' ( $n = 84$  patients, 271 spinal levels treated). Mean arterial blood pressure (MAP), heart rate, and oxygen saturation were monitored immediately prior and three minutes after cement injection. Logistic regression analysis was performed with  $\Delta$ MAP  $\geq 10$  mm Hg before and after cement injection as the dependent variable and demographic, radiographic and procedural factors as independent variables.

**Results:** MAP decreased by mean  $3 \pm 7.3$  (range, 0–30; [confidence interval, 0.5–6.7]) mm Hg before and after cement injection in the 'lavage group' and  $9 \pm 10.5$  (range, –3 to 35; [CI, 7–11]) mm Hg in the control group ( $p < 0.001$ ). There were no differences in terms of heart rate and oxygen saturation before and after cement application either within the groups or between the two groups. Multivariate logistic regression analyses revealed VBL as the only factor influencing MAP (adjusted odds ratio: 3.49,  $p = 0.03$ ).

**Conclusion:** VBL leads to decreased drop in blood pressure after percutaneous cement augmentation procedure. This effect is likely the result of a decreased amount of fatty bone marrow displaced into the circulation thereby reducing the risk of pulmonary fat embolism.

FM26

### Different outcomes (median REPP's) for single-level vs. multi-level stenosis of the lumbar spine? A prospective bicentric study

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**Introduction:** Lumbar spine surgery in spinal stenosis is known to reduce pain, neurological symptoms and impairment. The outcome varies from patients without complaints to patients with even more complaints. The relative effect per patient (REPP) is a method to calculate the outcome individually (REPP = (complaints before treatment – complaints after treatment)/complaints before treatment). REPP 1 is the best result for a patient without complaints, 0 = unchanged, a negative score more complaints. In this prospective outcome study the outcome was calculated as REPP's. The patients were stratified in single-level vs. multi-level stenosis, and for the single-level with stabilization vs. without stabilization. The primary aim was to measure the median REPP's for both groups and the secondary aim to compare the outcome without stabilization/with stabilization for single-level pathology.

**Methods:** Included were the patients consecutively treated for spinal stenosis in two spine centers. Inclusion criteria were lumbar spinal stenosis Excluded were the patients with cognitive impairment, infection, neoplasia and unwilling to participate. Each center collected the patient information about the affected segments and the sociodemographic data. The PROM used was the NASS questionnaire (North American Spine Society, lumbar element) in a digitalized version on a touch screen computer. The data were collected preoperatively, and a year postoperatively.

**Results:** 257 patients could be included operated between 1.1.2003 and 31.12.2007; 90 patients with single-level, 167 with multi-level stenosis. The average age in the single-level group was 79.8 years, 58% women, in the multi-level group average age was 85.4 years, 58.7% women. The normalized NASS score to 100 decreased in the single-level group from preop 63.2 (SD 14.9) to 28.7 (SD 22.2). The median REPP was 0.501 (only decompression 0.58, decompression and fusion 0.44). In the multi-level group the NASS score decreased from preop 61.0 (SD 16.5) to 34.3 (SD 22.6). The median REPP was 0.254.

**Conclusion:** The 1 year outcome differs clearly for the patients with single-level vs. multi-level stenosis. The median REPP for single-level (0.501) is nearly double of those with multi-level stenosis (0.254); for single level: only decompression 0.58, decompression and fusion 0.44. The extent of stenosis seems to play an important role for the outcome.

FM27

### When does isolated posterior fusion fail in fractures of the spine?

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**Introduction:** Traumatic injuries of the spine do occur commonly. Besides fractures of the vertebral body, the intervertebral discs (IVD) are frequently also involved and injured. Up to date there is a paucity of knowledge how to determine the necessity of additional ventral fusion in fracture situation. The purpose of the study is to establish a score with several parameters for better and sharp patient selection to determine a successful surgical treatment plan.

**Method:** We developed the score after copious literature review. Our score is based on 6 parameters, each aspect favours either a conservative (negative values) or a surgical (positive values) approach. The amount of all aspects indicates the exigency of additional ventral interbody fusion. • There is less load on IVD in a rigid spine (above Th10, DISH, Bechterew = -3) than in a mobile spine (+1). • Young Patients (<50 = +1 // >50 = -1) and • greater deformity (Kyphosis >30%, Collaps >50% = +1) do have a higher risk for deformity after posterior fusion (Hoppe S et al Global Spine J 2017). • If the IVD is degenerated pre-trauma we do expect less progression. Depending on Pfirrmann (Spine 1976) or Watanabe (Am J Roentgenol 2007) or Benneker (Eur Spine J 2005) Score – existing degeneration (-2) or minor degeneration (+1) influence the score. • Dudli S et al. (Eur Spine J 2015) showed a rapid progressive degeneration of endplates in burst fractures. Therefore the integrity (-1) or injury (+1) of the endplate affect the score. • The integrity of the annulus fibrosus (AF) plays a crucial role in fracture healing. If a AF disruption or hernia is present in MRI (+1), there is a higher risk for sequestration into the fracture and therefore non-union. An intact AF (-2) seems to be beneficial for non-surgical approach.

**Results:** We will present our preliminary results of our retrospective analysis of patients treated in our institution during the past five years.

**Conclusion:** The disc-injury-score shall be an instrument to help determine whether additional ventral interbody fusion in fracture situation is necessary.

FM28

### The influence of lumbar disc- and facet joint degeneration on spinal kinematics

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**Introduction:** The effect of the amount of degeneration of facet joints or the lumbar intervertebral disc on the motion range of lumbar segments is not sufficiently elaborated. Further, the differences of range of motion (ROM) between varying degrees of degeneration and a fusion are not yet understood. We aimed to investigate the influence of disc- and facet joint degeneration on ROM at individual lumbar segments.

**Materials and methods:** The ROM of lumbar spinal segments was quantified using flexion/extension radiographs of 81 patients prior to spinal fusion. The grade of degeneration of facet joints (n = 356) and discs (n = 397) was documented in MRI and CT-Scans. One way ANOVA test was performed to test whether segmental ROM depends on the specific grade of degeneration of the according level. Group differences were subsequently analyzed with a Bonferroni corrected multiple comparison test.

**Results:** The grade of disc degeneration was significantly related to changes in ROM (p <0.01) whereas no association was observed with the amount of degeneration of the facet joints. More specifically, Disc degeneration Pfirrmann grade 5 was associated with a significant decrease in motion (p <0.01), while grade 2 to 4 did not exhibit significantly differences in ROM, however. Further, no significant differences in ROM were present between severe disc degeneration grade 5 and spinal fusion (p = 0.36).

**Conclusions:** While the degree of facet joint degeneration seems not significantly associated with limitations in spinal motion, severe lumbar disc degeneration limits segmental motion, nearly equal to spinal fusion.

FM29

### Nose to back: compatibility of nasal chondrocytes in a degenerative disc environment

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Low back pain affects more than 600 million people globally, and intervertebral disc (IVD) degeneration is the most common cause of specific low back pain. Degenerative disc disease is evoked by an imbalance of the anabolic and catabolic processes in resident cells leading to loss of extracellular matrix. Treatments dedicated to restoring IVD homeostasis are greatly in demand, one of which is cell therapy. In recent years, nasal chondrocytes (NCs), have gained a reputation for cartilage tissue regeneration. To assess whether NCs can be considered as an autologous cell source for cell therapy of disc degeneration, we compared the response of NCs to those of mesenchymal stromal cells (MSCs) and articular chondrocytes (ACs), two cells sources presently used in phase two clinical trials for the treatment of DDD. To implement conditions mimicking the milieu of degenerated IVD in vitro, cells were cultured in low glucose media (1 gr/L) in hypoxia (2% O<sub>2</sub>) for 28 days. The media was additionally adjusted to pH 6.8 and/or supplemented with proinflammatory cytokines TNF $\alpha$ , IL1 $\beta$ , and IL6 as is found in the degenerated disc. Furthermore, cells underwent chondrogenic instructional priming due to the addition of TGF $\beta$ 1 for the first seven days of culture. Analysis of histology, immunohistochemistry, biochemistry and quantitative rPCR demonstrated that even though MSCs could be chondrogenically primed, harsh environmental conditions and donor variability play a crucial role in their successful survival and chondrogenesis. ACs were sensitive to priming in that they could accumulate glycosaminoglycans (GAG), however, lack the ability to synthesize Collagen type II (Col2). Commendably, primed NCs produce ECM rich in both GAG and Col2 in all nonacidic conditions. Even though an acidic environment reduces its GAG production the same as ACs, the supplementation of the inflammatory cytokines affect the NCs to a lower extent compared to ACs. Our data indicate that NCs are more resident to harsher environments than ACs or MSCs upon chondrogenic priming. These findings encourage the assessment that employing NCs in a cell therapy treatment of degenerative disc disease could promote new matrix production in the disc, which could inhibit or delay further disc height loss if not even lead to disc height gain.

FM30

### Augmented reality guided lumbar facet joint injections

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**Introduction:** Augmented reality is not a new concept but evolves rapidly due to the fast-developing technology and has a huge potential in medicine. We opted to proof the feasibility of augmented reality guided interventions using HoloLens in a phantom study. The purpose of our study was to assess feasibility and accuracy of augmented reality-guided lumbar facet joint injections. This could potentially reduce radiation dose to the patient, but also to the performing radiologist.

**Methods:** A spine phantom completely embedded in hardened opaque agar with three ring markers was built. A 3D model of the phantom was uploaded to an augmented reality headset (Microsoft HoloLens). Two radiologists, independently performed twenty augmented reality-guided and 20 CT-guided facet joint injections each: for each augmented reality-guided injection, the hologram was manually aligned with the phantom container using the ring markers. The radiologists targeted the virtual facet joint and tried to place the needle tip in the holographic joint space. CT was performed after each needle placement to document final needle tip position. Time needed from grabbing the needle to final needle placement was measured for each simulated injection. An independent radiologist rated images of all needle placements in a randomized order blinded to modality (augmented reality vs. CT) and performer as: perfect, acceptable, incorrect, unsafe. Accuracy and time to place needles were compared between augmented reality-guided and CT-guided facet joint injections.

**Results:** In total, 39/40 (97.5%) of augmented reality-guided needle placements were either perfect or acceptable compared to 40/40 (100%) CT-guided needle placements (P = .5). One augmented reality-guided injection missed the facet joint space by 2 mm. No unsafe needle placements occurred. Time to final needle placement

was substantially faster with augmented reality guidance (mean  $14 \pm 6$  s vs.  $39 \pm 15$  s,  $P < .001$  for both readers).

**Conclusions:** Augmented reality-guided facet joint injections are safe and accurate in an experimental setting. Augmented reality may allow facet joint injections faster, without radiation exposure to the performing radiologist, and with potentially less radiation for patients. Ongoing research is currently solving technical limitations such as the time-consuming processing, manual alignment and misregistration during patient movement.

FM31

### Excellent patient-rated outcomes after atlantoaxial (C1/2) fusion: results of a >10-year-long prospective evaluation

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**Introduction:** Various surgical techniques have been introduced for C1/2 fusion, the most common being Magerl's transarticular screw fixation or Harms' direct instrumentation. Common indications include degenerative osteoarthritis (OA) or rheumatoid arthritis (RA). Only few, small studies have evaluated outcomes after C1/2 fusion. We investigated patient-rated outcome in a large series of consecutive patients undergoing isolated C1/2 fusion.

**Methods:** We analysed prospectively collected data (2005–2016) from our Spine outcomes database, collected within the framework of EUROSPINE's Spine Tango Registry. It included 126 patients (34 (27%) men, 92 (73%) women; mean (SD) age  $67 \pm 19$  y) who had undergone first-time isolated C1/2 fusion (61% Magerl, 39% Harms) at least 1 y ago for OA (83 (66%)), RA (20 (16%)), fracture (15 (12%)) or other (8 (6%)). Patients completed the multidimensional Core Outcome Measures Index (COMI; 0–10) and reported on global treatment outcome, satisfaction with care, self-rated complications and reoperations.

**Results:** After 12 mo, mean COMI scores ( $N = 119/126$  (94%)) showed a significant reduction from baseline:  $6.9 \pm 2.4$  to  $2.7 \pm 2.4$  ( $p < 0.0001$ ). OA patients showed a slightly but significantly greater reduction in COMI than RA ( $p < 0.049$ ), owing largely to a worse baseline status. Overall, 76% patients achieved a  $\geq 2.2$ -point reduction in COMI (i.e., the MCIC), and 86% reported a good global outcome (op helped/helped a lot). 91% patients were satisfied/very satisfied with their care. Self-reported complications were declared by 16% patients and further surgery, by 2%. Results were consistent at 2y FU.

**Conclusion:** In this large series with almost complete follow-up, C1/2 fusion showed exceptionally good results. Despite the complexity of the intervention, outcomes were comparable with or surpassed those in our registry for simple procedures such as ACDF and lumbar discectomy. In light of these findings, reservations about the procedure should be reviewed.

\*FM32

### Analysis of radiological accuracy and clinical differences among different methods of cervico-thoracic posterior fixation

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**Objective:** The aim of this study was to compare the accuracy of posterior subaxial cervico-thoracic fixation using three different techniques: intraoperative computed tomography (iCT) scanner-guided navigation, three-dimensional (3D) C-arm based spinal navigation and fluoroscopy based posterior stabilization.

**Background:** Surgical techniques for posterior fixation of cervico-thoracic pathologies are challenged by the great variation in pedicle dimension and angulations as well as the risky neurovascular anatomy. Intraoperative computed tomography navigation promises improved accuracy of spinal navigation with the benefit of increased visualization of a pedicle's trajectory. However, it remains a debate how useful iCT imaging is for posterior pedicle screw implantation in the subaxial cervico-thoracic spine.

**Methods:** A total of 167 screws were implanted in 19 patients with cervico-thoracic instability who underwent posterior fixation. 86 screws were inserted with the use of the iCT based spinal navigation (group A), 56 screws were implanted using the 3D C-arm navigation system (group B), while 28 screws were inserted under the guidance of fluoroscopy (group C). Screw positions were evaluated using postoperative CT scans according to the Neo et al (cervical) and

Gertzbein and Robbins (thoracic) classifications. The assessment of the screw placement was retrospectively done by an independent observer. Accurate positioning was defined then as screws that were correctly placed completely within the pedicle as well as screws with a breach of less than 2 mm.

**Results:** Intraoperative computed tomography based navigation has permitted a more accurate intraoperative evaluation of the implanted screws. With the use of the iCT, the intraoperative accuracy rate has reached 58.13% while with the 3D C-arm navigation, 30.18%. In cervico-thoracic posterior stabilizations done with the aid of fluoroscopy, the intraoperative accuracy was not determined and only a final accuracy rate was measured. With both navigated modalities, the immediate correction of misplaced screws was feasible and a final accuracy rate of 59.30% was obtained with the use of iCT vs. 30.18% with the 3D C-arm and 25% with fluoroscopy.

**Conclusion:** In subaxial cervico-thoracic posterior fixation, the use of iCT-based spinal navigation has demonstrated significantly higher accuracy rates than with the C-arm-based spinal navigation or fluoroscopy-based systems.

\*FM33

### Anterior extreme short fusion for correction of thoracolumbar/ lumbar scoliosis using support lever fulcrum effect

*Andrea Frey*

**Introduction:** Anterior scoliosis correction is a powerful alternative to dorsal scoliosis correction allowing for shorter fusion distance. Decrease in lordosis however might be a consequence with anterior scoliosis correction for thoracolumbar and lumbar curves. We aimed to investigate whether support lever (fulcrum) effect enforces scoliosis correction in anterior extreme short fusion and preserves lumbar lordosis in thoracolumbar/ lumbar scoliosis. The fulcrum effect occurs due to intercorporeal interposition of a rib graft anteriorly and the concave side of the scoliotic curve.

**Methods:** Ten consecutive patients with Lenke 5 and 6 idiopathic adolescent scoliosis treated by anterior extreme short fusion using fulcrum effect were assessed radiographically to find the amount of correction in the coronal plain and to quantify the changes in deformity in the sagittal plain.

**Results:** With only a mean of 4 fused segments, the scoliotic curves improved 74% from a mean of  $56^\circ$  (SD 7) preoperatively to  $14^\circ$  (SD 8) immediately postoperatively, and remained mostly unchanged with  $18^\circ$  (SD 10) at 6 weeks. The apical vertebral translation had a mean of 48 mm (SD 12) preoperatively, 13 mm (SD 10) postoperatively and 5 mm (SD 6) 6 weeks postoperatively. The coronal spinal balance as measured by C7 offset did not change relevantly from 25 mm (SD 4) preoperatively to 23 mm (SD 4) at 6 weeks following surgery. Regarding the sagittal spine profile the thoracic kyphosis, as measured from T1–T12, did not differentiate greatly – from a mean of  $39^\circ$  (SD 10) to  $36^\circ$  (SD 7) 6 weeks postoperatively. The preoperative mean lumbar lordosis, measured from L1–S1, did not decrease significantly from  $56^\circ$  (SD 9) to  $51^\circ$  (SD 7) at 6 weeks postoperatively.

**Conclusion:** The potential decrease in lordosis associated with anterior scoliosis correction for thoracolumbar and lumbar curves can be addressed with the aforementioned surgical method of support lever (fulcrum) effect.

FM34

### Patient's attitude towards the use of electronic aids for the surgical informed consent: a multicenter survey with 209 participants

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**Introduction:** The informed consent (IC) is an essential and statutory process before a surgical intervention. Traditionally the IC is conducted with a written form accompanied by the surgeons' explanation.

Although this method shows good patient satisfaction, the patient's knowledge of the important facts about the operation already some hours after the IC is described as poor. And although studies have shown that the use of electronic aids (EA), like films or computer-animations, during the IC can increase patient's knowledge significantly, its use is not widely spread even these days. The goal of the present study was to determine how the surgical IC is conducted these days and if EA are used on a routine base. Likewise it should be investigated what is the patient's attitude toward the use of EA for the IC and if EA should be applied during the IC process.

**Methods:** A survey (paper questionnaire) relating to patient's attitude and contentment with the current IC process and in particular concerning the use of EA was distributed in 5 different Swiss public hospitals to the patients of the orthopaedic departments during the postoperative hospitalisation.

**Results:** 209 patient interviews (51% female) could be included into the study of which 38% were older than 60 yrs. In 97% the patients indicated that an IC has taken place and in 72% it was with the performing surgeon. 85% of the patients think that it should be the surgeon himself who should do the IC. In 78% the IC has been done with a written protocol, which was signed by the patient and in only 6% EA were used. More than 60% of the patients indicated that EA would be "very or rather useful" during the IC and three-fourths of the patients think that the personal role of the doctor during the IC is nevertheless "very or rather important".

**Conclusion:** The assumption was confirmed that EA for the IC are not used routinely even today although patient's knowledge would be increased significantly. Remarkably in one third of the cases the IC seems to be delegated. Likewise it could be shown that the majority of the patients suppose EA for the IC as very helpful if it would be available. Hence it can be concluded that EA for the IC should be more available so that surgeons can apply it to improve the surgical IC, but the person role of the surgeon seems to be crucial.

FM35

#### Surgeon's opinion about the use of electronic aids for the informed consent process: a survey with nearly 600 participants

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**Introduction:** The informed consent (IC) is an essential and statutory process before a surgical intervention. Traditionally the IC is conducted with a written form accompanied by the surgeons' explanation.

Although this method shows good patient satisfaction, the patient's knowledge of the important facts about the operation already some hours after the IC is described as poor. And although studies have shown that the use of electronic aids (EA) during the IC can increase patient's knowledge significantly, its use is not widely spread amongst surgeons even these days. The goal of the present study was to determine how the surgical IC is conducted these days, if EA are used on a routine base and what is the surgeon's opinion about it.

**Methods:** An online survey about the status quo of the current IC process and in particular concerning the use of EA was sent to the members of the national associations of the orthopaedic and general surgeons in Switzerland.

**Results:** 591 surgeons (86% male) participated the survey of which two-thirds work as independent surgeons in the private clinic or as senior consultants in public hospitals. 82% of the surgeons estimate their own knowledge of the legal aspects of the IC as "high". Almost all the surgeons conduct the IC at the time of consultation in the outpatient clinic and in 87% of the cases with a written document, which is signed by the patient. 80% of surgeons do not use EA during the IC. Most of the surgeons (88%) perceive the IC is an important educational preoperative aspect of the doctor-patient relationship, and only 12% perceive it as a "necessary evil". Two-thirds of the surgeons think that EA such as films or computer animations would be "very or rather helpful" during the IC. Almost 40% of the surgeons remark that the main reason why EA are not more often used during IC is due to the lack of availability of EA. Another 30% of the surgeons think that it is because of the fact that no one so far was thinking in this direction while the residual 30% of the doctors think that these are the costs or legal issues.

**Conclusion:** The assumption was confirmed that EA for the IC are not used routinely even today although patient's knowledge would be increased significantly. Likewise it could be shown that the majority of the surgeons suppose EA for the IC as very helpful if it would be available. Hence it can be concluded that EA for the IC should be more available so that surgeons can apply it to improve the surgical IC.

#### Swiss Orthopaedics minimal dataset: first report of reliability and validity

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**Introduction:** The Swiss Orthopaedics minimal dataset (SOMD) was launched five years ago as a standardized, generic and patient-reported outcome questionnaire. It consists of ten variables (location of disease, pain within the past four weeks, limitations at work/sports/sleep/autonomy, subjective body part value, employment status, work disability, and household support). This is the first report about its reliability and validity.

**Methods:** Two retrospective observational studies using two cohort samples were conducted. The test-retest sample (n = 60) consists of data from three retirement homes (2013), while the test sample (n = 14,180) consists of data from an University Hospital (2014–2017). In the test-retest sample, the same questionnaire was completed twice, at day 0 and 7. In the test sample, only the first questionnaire was considered (to avoid duplicates) and only those were considered that completed the SOMD and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) of the hip within 14 days (to minimize recall bias). Reliability (test-retest and internal consistency), construct validity for the parameter of pain, and return rates were analyzed.

**Results:** The test-retest sample showed high test-retest reliability for all tested separate variables of the SOMD (ICC = 0.96–1.00; Cronbach's alpha 0.92; n = 53 [n = 7 (12%): lost to follow up]). The test sample also had a very high internal consistency reliability (Cronbach's alpha 0.80 [combined value for all ten variables]; n = 12,190 [n = 1,990 {14%}: excluded [e.g. duplicates]] and high construct validity for pain (correlation between SOMD pain and WOMAC pain: rho = 0.62; n = 302). The return rate of the SOMD was 43% in 2016 and 31% in 2017 in a University Hospital setting.

**Conclusions:** This is the first report about the SOMD, documenting a relatively high reliability (test-retest and internal consistency), acceptable validity for the parameter pain and moderate practicability. The analysis serves as a backbone of a structured modification of an improved version of the SOMD.

FM37

#### Siris QR – quality registry data in 30 seconds

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**Introduction:** In 2012 the Swiss implant registry for knees & hips was introduced. 2 pathways for data entry were made available to the individual surgeon, one based on a standard paper form derived from structures introduced with the IDES (International Documentation & Evaluation System) for hips in 1984, the other being an online portal linked directly to the Siris database. IDES paper forms had just recently been replaced by specific iPad apps at this point which made it clear, that we would not return to the just abandoned pathway. In an initial approach, ways were sought to directly derive all information from the inhouse clinical information system and transmit this data electronically. While the goal was successfully achieved, the resulting structure was hard-coded within the system. When Siris then changed the data requirements in 2015 a repeat effort of the same magnitude was out of question.

**Objectives:** The new challenge was to find a way of optimizing data quality for Siris while making the task as simple as possible for the individual surgeon.

**Methods:** The new data requirements were broken down to the individual data points and mapped towards information available from within the existing system. Instead of exporting information in form of tables as in the initial approach 2012, all available data points were integrated into a structured QR code, allowing for data to be missing without creating an error. In parallel a specific iOS app (Siris QR) was developed to read this QR information now included in the regular OR schedule and present it in a Siris compliant structure. From this point, all the surgeon needed to do was to scan the specific code, complement the missing fields and upload the full data set via wlan.

**Results:** Siris QR has been in constant use since August 1, 2015 at Schulthess Clinic with some improvements and minor updates over time. By the end of 2017 the 5000 mark for Siris QR documented operations was reached. Time to document an individual operation lies between 20 & 30 seconds, with data fully plausibilized while being input. The app has been accepted & released in the Apple AppStore and can be used freely by any interested party in Switzerland. What a new user requires is a one-time setup of the QR code and upload pathway, typically a single day's work for the IT department.

\*FM38

### Application and measurement properties of EQ-5D to measure quality of life in patients with upper extremity orthopaedic disorders. A systematic literature review

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**Introduction:** The most widely used instrument to measure quality of life (QoL) is the EuroQol EQ-5D. However, its use in assessing upper extremity condition-related QoL as well as its measurement properties remain largely undefined. The objective of this systematic literature review was to provide an overview of the application of EQ-5D in patients with upper extremity disorders and analyse its measurement properties.

**Methods:** We searched in Medline, EMBASE, Cochrane and Scopus for clinical studies investigating orthopaedic patients with surgical interventions of the upper extremity, where the EQ-5D was used as an outcome measure. Quantitative QoL data and data describing the use of the EQ-5D were extracted. Furthermore, EQ-5D measurement properties, as assessed by validation studies, and the quality of those validation studies were graded according to the COSMIN guidelines.

**Results:** Twenty-three studies were included in the review. The majority (19 studies) investigated patients with an intervention at the shoulder. QoL was the primary outcome in 15 studies, and in 5 studies, the EQ-5D was used for cost-utility analyses. EQ-5D index scores in non-trauma patients generally improved postoperatively, whereas trauma patients did not regain their recalled pre-injury QoL levels. The EQ-5D measurement properties were reported in three articles, two on proximal humeral fracture and one on carpal tunnel syndrome. Positive ratings were seen for construct validity with correlations  $\geq 0.7$  with the Short Form (SF)-12 or SF-6D health surveys. Test-retest reliability was also high with intraclass correlation coefficients  $\geq 0.77$ , and responsiveness was intermediate (standardised response means: 0.5–0.9). However, ceiling effects were identified with 16–48% of the patients achieving the highest score. The methodological quality of the three validation studies ranged from fair to good.

**Conclusion:** The EQ-5D is increasingly used in patients with upper extremity disorders. For trauma patients, QoL does not seem to return to pre-injury levels, yet the use of the EQ-5D as an instrument to document QoL by recall in these patients remains to be evaluated. The few available studies reporting the measurement properties indicate good reliability and validity with moderate responsiveness. Further research is required, especially to assess the responsiveness of the EQ-5D in patients with upper extremity and hand conditions.

\*FM39

### Is arthroscopic rotator cuff repair cost effective? A prospective Swiss health-economic study

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**Introduction:** Knowledge about the costs and benefit of orthopaedic surgery in a real world setting is needed for orthopaedic surgeons as well as insurance and health service systems. Little is known about the impact of common orthopaedic upper extremity procedures on the quality of life and costs in Switzerland. Therefore, we conducted a study to examine the influence of arthroscopic rotator cuff repair (aRCR) on the quality of life and costs from the Swiss health system perspective.

**Methods:** Patients indicated for aRCR were included in a prospective study. Quality of life (EQ-5D-5L) and shoulder function were assessed one year before (control data) and up to two years after surgery. Their relationship was explored by regression analysis. Quality of life was expressed as a EQ-5D index based on a scale of 0 (dead) to 1 (perfect health). Sixteen major Swiss insurance companies provided direct medical cost data for both the 1-year pre- (pre-OP) and 2-year post-surgery (post-OP) time points. Indirect costs (loss of productivity) were assessed using the work productivity and activity impairment questionnaire. The health economic analysis was performed from a societal perspective including total costs (i.e. direct medical costs plus productivity losses). Total costs to gain an extra quality adjusted life-year (QALY) were estimated by calculating the incremental cost-effectiveness ratio (ICER) for all patients and stratified by rotator cuff tear severity.

**Results:** We examined a total of 153 patients (mean age 56.9 years; 63% male) who underwent aRCR operation. The mean EQ-5D index improved over time from 0.71 (pre-OP) to 0.93 (1 year post-OP) and 0.96 (2 years post-OP), and was significantly associated with shoulder function improvement ( $p < 0.001$ ). Mean total costs increased from

7,887 Swiss Francs (CHF) (pre-OP) to 19,583 CHF (1 year post-OP), then decreased below the pre-OP level in the second year after surgery (4,355 CHF). The ICER for aRCR was 22,426 CHF per QALY gained (95% CI: 12,027–32,824 CHF/QALY) until two years post-OP compared to the pre-OP control period. Patients with complete tears of two or more tendons had a lower ICER (15,315 CHF/QALY) compared to those with partial tears or tears on only one tendon (27,278 CHF/QALY).

**Conclusion:** Arthroscopic RCR shows a cost-utility ratio clearly below the often suggested US\$ 100,000/QALY threshold. This ratio seems even more favourable in patients with more severe rotator cuff tears.

FM40

### Potential effects of minimal volume standards on mortality after primary total knee and hip replacement and after operative treatment of femoral neck fractures

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**Introduction:** Minimal case volume standards (MVS) are currently discussed for defined surgical procedures. Orthopaedic surgery is also in focus, especially prosthetic joint replacement procedures. There are no methods described so far, which would allow a numeric (objective) definition of MVS thresholds based on an objective quality standard. The aim of this analysis was to find if mortality after primary knee replacement (TKR), primary hip replacement (THR), and femoral neck fractures (FN) could be used to objectively define MVS.

**Methods:** We used hospital discharge open access data published by Swiss Federal Statistical Office for the period from 2010 to 2015. We analysed the mortality data for TKR, THR and FN (the latest procedure restricted to patients older than 60 y). For each procedure, we determined the total number of cases as well as risk-adjusted mortality rates per year and per hospital/unit in Switzerland. Cumulative mortality has been calculated stepwise from lowest to highest possible threshold and presented graphically. A simulation has been performed in order to estimate number of potentially saved lives (PSL), should the MVS be implemented.

**Results:** For THR the total number of patients was 83,247 over 6 years. Highest pooled mortality ratio was 0.0014 for low volume hospitals, and 0.0009 for high volume hospitals. For TKR we found in the total of 43,392 patients highest mortality for low volume hospitals 0.0007, whereas the highest mortality in high volume hospitals was 0.0009. There were 29,047 cases of FN reported over 6 years, and the maximal mortality in the low and high volume hospitals was almost equal (0.0517 and 0.0487 respectively). Thresholds below 20 cases / unit did not prove any positive values for PSL.

**Conclusions:** Minimum case volume thresholds analysed by stepwise pooling of mortality data are not supporting thresholds between 10 and 20 operations/year, as requested from authorities for KTP or HTP. The effect on mortality (based on calculation from data 2010–2015) is unneglectable (TKR) or even paradox (FN). Further analysis using other quality indicators is necessary find an objective and effective MVS threshold.

FM41

### A novel approach for the approximation of the humeral head retrotorsion based on bilateral three-dimensional registration of the bicipital groove

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**Introduction:** The accurate restoration of the pre-morbid anatomy of the proximal humerus is a key for the success of reconstructive surgeries of the proximal humerus. The bicipital groove has been proposed thereby as a landmark for the prediction of the humeral head retrotorsion. We hypothesize that a novel method based on bilateral registration of the bicipital groove yields an accurate approximation of the pre-morbid anatomy of the proximal humerus.

**Methods:** Three-dimensional triangular surface models were created from computed tomographic data of 100-paired humeri (50 cadavers). Humeral segments of the distal humerus and of the humeral shaft of predefined length were defined. A surface registration algorithm was applied to superimpose the models to the mirrored contralateral humeral model based on the defined segments. We evaluated the 3D proximal humeral contralateral registration (3D-p-HCR) errors, defined as the difference in 3D rotation of the humeral head between both superimposed models. As a reference method we used the landmark-based retrotorsion (LBR) error to measure the intra-individual differences in retrotorsion with a landmark-based 3D method.



**Results:** The average 3D-p-HCR error using the proximal humeral shaft (bicipital groove) segment for the registration was 2.8° (SD 1.5°; range, 0.6° to 7.4°). The average LBR error of the reference method was 6.4° (SD 5.9°; range, 0.5° to 24.0°).

**Conclusion:** Bilateral registration of the proximal humeral shaft is a reliable method to approximate the pre-morbid anatomy of the proximal humerus.

FM42

#### Assessing heterochronic parabiosis effects on osteo-articular loss of homeostasis in murine models

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**Introduction:** Tissue homeostasis is ensured by self-repair mechanisms of the specialized cells constituting the tissue and their replacements through differentiation of tissue specific adult stem cells. During ageing and its related diseases including cognitive impairment, sarcopenia or heart hypertrophy, this equilibrium is gradually lost. Recent evidence showed that shared circulation between old and young animals could revert these age-induced tissue homeostasis impairment. Here we assess the impact of such heterochronic parabiosis approaches on the age-driven osteoporosis (OP) and age-driven osteoarthritis (aOA) or collagen induced osteoarthritis (cIOA) in murine models.

**Methods:** Conjoined couples of 4 and 18 months old male C56Black6 mice were surgically created by skin incision at the flank, suturing the corresponding limbs and the abdominal wall to increase stability and the surface for vascularization. Either two young (y-y) or two old (o-o) (=> isochronic parabiosis), or one old and one young (o-y or y-o) (=> heterochronic parabiosis) were coupled. Successful shared circulation was verified by Evans Blue injection in one of the two mice. In some young animals, collagenase was injected twice intraarticular into the knee joint to induce osteoarthritis. All animals were analyzed for bone morphometric parameters with uCT and histological for OARSI grading of joint cartilage degeneration. In total 21 couples were analyzed.

**Results:** Old blood circulation mildly increases the onset of collagenase-induced OA in young animals (OARSI score y-y: 4.7 vs y-o: 7.7, p <0.05). In contrast, young blood circulation could increase in old animals the mineral density of long bones (BV/TV o-y 9.3% vs o-o 6.7%, p <0.05) and articular sub-chondral bones (BV/TV o-y 75.7% vs o-o 67.7%, p <0.05). No impact on age-driven osteoarthritis was detected through OARSI score evaluation.

**Conclusion:** We demonstrate to our knowledge for the first time the effect of heterochronic circulation on bone and cartilage phenotype. Altogether these findings set experimental basis for identifying potential pro- and anti-geronic factors in osteo-articular disease.

FM43

#### Genipin-coated sutures – viable delivery of a collagen crosslinking agent to improve suture pullout in degenerated tendon

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**Introduction:** The suture-tendon interface is often the weakest link in tendon-to-tendon or tendon-to-bone repair. Genipin is an exogenous collagen crosslink agent derived from the gardenia fruit that can enhance suture pullout strength. This study evaluated whether sutures precoated with genipin can provide higher suture pullout strength in healthy and degenerated tendons and investigated the extent and distribution of genipin-induced crosslinking.

**Methods:** Single-stitch suture pullout tests were performed ex vivo 24 hours after suturing on 25 bovine superficial digital flexor tendons. Using a matched-pair design, one group of 12 tendons were cut in proximal and distal halves and randomized to treatment (genipin-coated suture; n = 12) and control groups (normal suture; n = 12). To simulate a degenerative tendon condition, a second group of 13 tendons were injected with 0.2 mL of collagenase D (8 mg/mL). After 24 hours of incubation, tendons were cut in proximal and distal halves and randomized to treatment (n = 13) and control groups (n = 13). Additionally, fluorescence was measured to determine the degree of crosslinking and to microscopy was employed to characterize its distribution pattern.

**Results:** In healthy tendon pairs, the median maximum pullout force was 42 N (range, 24–73 N) with genipin-coated sutures compared to 29 N (range, 13–48 N) in the control group (p = 0.003). In degenerated tendons median maximum pullout force was 16 N (range, 9–36 N) with genipin-coated sutures compared to 13 N (range, 5–28 N) with control sutures (p = 0.034), no differences in work to failure or stiffness were observed. Fluorescence was higher in tendons treated with genipin-coated sutures compared to the control group, while a higher number of genipin-induced crosslinks was observed in the treated healthy compared with the degenerated tendons (–3.18, CI 95% 0.97–5.34, p = 0.006).

**Conclusion:** Genipin-coated sutures improved pullout resistance of a simple in healthy and degenerated tendons in an ex vivo animal model. A genipin-coated suture represents a potential delivery vehicle for exogenous crosslink agent to augment suture retention properties.

\*FM44

#### Altered chemokine receptor expression on peripheral T cells in osteoarthritis patients

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**Introduction:** Osteoarthritis (OA) is a condition affecting millions of patients around the world, causing pain and disability and often resulting in joint replacement surgery. The aetiology of OA has long been attributed to mechanical wear mainly due to the increased prevalence of OA in load bearing joints among older patients. However, recent studies reveal a complex molecular disease causality in which inflammation, nutritional deficit and angiogenesis lead to the destruction of the joint structure. The aim of this study was to examine chemokine receptor expression in peripheral blood and bone marrow of OA patients in order to map the inflammatory mechanisms behind OA.

**Methods:** Seven OA patients scheduled for hip arthroplasty and nine healthy controls were included in the study. Peripheral blood was taken from both groups. Additionally, in the OA group, bone marrow was removed from the proximal femur during hip replacement surgery. The expression of 18 chemokine receptors on CD4 and CD8 T-cells from both blood and bone marrow was then studied using flow cytometry.

**Results:** We found a significantly increased fraction of CCR2 expressing CD4 and CD8 T cell in patient peripheral blood compared to both patient bone marrow and healthy controls. Additionally, we found a significantly diminished fraction of CXCR3 (Th1) expressing T-cells and a significantly increased fraction of CCR4 (Th2) expressing T-cells in peripheral blood from OA patients. Generally, peripheral patient blood showed a more CD8-like, mature phenotype compared with a naïve, T-helper phenotype in bone marrow and control blood.

**Conclusion:** Through analysis of chemokine receptor expression, we found that the peripheral blood of OA patients has a specific immune profile, most strikingly characterised by CCR2 overexpression. This points to migration of effector immune cells from bone marrow to blood as a part in OA disease progression, and also offers the possibility of targeting CCR2 to diminish pain and inflammation in OA patients.

\*FM45

#### Health-related quality of life after fractures of the lateral third of the clavicle in children and adolescents

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**Introduction:** The health-related quality of life after pediatric fractures of the lateral third of the clavicle is unknown. We examined (1) the health-related quality of life of patients who sustained a fracture of the lateral third of the clavicle in childhood of a large regional pediatric trauma center, (2) if the health-related quality of life was associated with the age at the time of the injury, and (3) if fracture and dislocation patterns were associated with health-related quality of life.

**Methods:** We were able to identify 69 patients (21 girls and 48 boys) who sustained a fracture of the lateral third of the clavicle from January 2004 to June 2015. These patients were asked to fill in a questionnaire that included the Quick version of the DASH (Disability of Arm, Shoulder, and Hand) (primary outcome) and the Peds-QL (Pediatric Quality of Life Inventory). Until July 2017 we were able to get a response of 56 of these patients, resulting in a follow-up of 81%.

**Results:** Treatment was conservative in all cases but one. After a mean follow-up of 6.5 years (range 1 to 13.2 years) the mean

Quick-DASH was 1.3 (SD 4.4) at a scale of 0–100, with lower values representing better quality of life. The mean physical function score of the Peds-QL was 97.8 (SD 4.4) and the mean psychosocial function score was 91.8 (SD 10.7), both at a scale of 0–100, with higher values representing better quality of life. There was no statistically significant association of age at the time of injury on the primary outcome Quick-DASH. There were no statistically significant associations between fracture or dislocation patterns with regard to health-related quality of life.

**Conclusions:** Conservative treatment fracture of lateral clavicle fractures in children and adolescents is associated with excellent health related quality of life as measured with the disease-specific Quick-DASH and the non disease-specific Peds-QL at a mean follow up of 6.5 (range 1 to 13.2) years. There was no effect of age at the time of injury and we were unable to identify associations to commonly analyzed risk factors, such as dislocation patterns. Since the conservative treatment of this type of fracture in children and adolescents is associated with such a good health related quality of life, it is unlikely that these results could be further improved by surgical interventions.

FM46

### Are there factors influencing health related quality of life in midshaft clavicle fractures of children and adolescents

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**Introduction:** Midshaft clavicle fractures are one of the most common fractures in children and adolescents. Although the standard for the treatment of closed clavicle fractures was traditionally conservative treatment, over the past years there is an increasing number of clavicle fractures treated with a surgery. In pediatric traumatology, this trend is less noticeable, but also in the younger age group, especially in adolescents, the amount of operated patients is increasing. The literature gives us few information about long-term results after midshaft clavicle fractures in infancy, particularly there are few publications with investigation of large study populations of this common injury. The goal of our investigation is to investigate the health related quality of life of children and adolescents treated for a midshaft clavicle fracture in a large trauma center. Is it possible to identify factors that are associated with a poor long-term result?

**Material and Methods:** We identified a total of 785 patients with a clavicle fracture treated conservatively or surgically in our institution between 01.01.2004 and 31.06.2015. Exclusion criteria were fractures of the medial or lateral third of the clavicle, patients older than 16 years, inability to fill in the questionnaire because of language deficiencies, neurologic or metabolic disorders and birth trauma. We included 632 patients with a midshaft clavicle fracture. All patients received a questionnaire with the established Quick DASH score and Peds-QL score.

**Results:** At 6.3 years after trauma, we have follow-up completed in 81% (512 patients). 99% are treated conservatively. 1% (6 patients) were operated (ESIN: 4; ExFix: 1; Plate:1) The Peds QL in the study group was 96.31 (±7.83), there is no statistically significant difference in results related to age, gender or initial dislocation of the fracture. The Quick DASH was about 2.3 (±5.2). There is no statistically significant difference in the results related to the initial dislocation of the fracture. There are no clinically relevant differences related to age or gender.

**Conclusion:** We found good to excellent clinical result in nearly all of our patients despite their age at accident, gender or initial dislocation with mainly nonoperative treatment. Our results show a high health related quality of life in our study population. There are no factors identified associated with a poor outcome. We cannot support the trend towards more operative treatments in children and adolescents.

\*FM47

### Health-related quality of life after paediatric supracondylar fractures of the humerus

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**Introduction:** There is limited literature regarding the health-related quality of life (HrQoL) after pediatric supracondylar fractures of the humerus. We examined the HrQoL of children who sustained such fractures and who were treated in a large regional pediatric trauma center, and if the HrQoL was associated with the Pediatric Comprehensive AO Classification.

**Methods:** Until 11/2017 we were able to follow up on 770 patients (392 girls, 378 boys) who sustained a supracondylar fracture of the humerus from 01/2004 to 04/2017. They were asked to fill in a questionnaire that included the Quick-DASH (Disability of Arm, Shoulder, and Hand) (primary outcome) and the Peds-QL (Pediatric Quality of Life Inventory). Fractures were classified radiologically according to the Pediatric Comprehensive AO Classification.

**Results:** 330 children (mean age 5.5 years) sustained an AO type I injury, 142 (6.0 years) a type II, 143 (6.5 years) a type III, and 155 children (6.9 years) an AO type IV supracondylar humerus fracture. All children with a type I fracture were treated non-operatively. One child with a type II fracture, 133 children with a type III, and 141 children with a type IV fracture underwent closed reduction and percutaneous pinning and received a cast immobilization. Ten children with a type III and 13 with a type IV fracture underwent closed reduction facilitated by a radial external fixateur and one percutaneous K-wire. There were no open reductions. After a mean follow-up of 6.3 years there the mean Quick-DASH was 2.0 (SD 5.2) at a scale of 0–100 for the type I fractures, with lower values representing better HrQoL (type II: 2.8, SD 10.8; type III: 3.3, SD 8.1; type IV: 1.8, SD 4.5). The mean function score of the PedsQL for the type I fractures was 97.4 (SD 8.0) at a scale of 0–100, with higher values representing better HrQoL (type II: 97.4, SD 9.5; type III: 96.1, SD 9.2; type IV: 97.4, SD 6.5).

**Conclusions:** In this cohort of 770 patients in which we applied the validated disease-specific Quick-DASH and the non-disease specific PedsQL as outcome measures, there was equally good mid- and long-term HrQoL when closed reduction and percutaneous pinning or the application of a radial external fixateur in AO type III and IV supracondylar humerus fractures was compared to AO type I and II fractures, which were treated non-operatively. As such, this treatment algorithm, without the need for open reduction, appears to be successful in terms of HrQoL for these children.

FM48

### Fractures in a pediatric urban population in Switzerland – epidemiology and review of literature

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**Introduction:** The total number of consultations in 2016 for pediatric emergencies at our hospital was 35,644, of them 5,227 were for traumatic injuries. This represents 15% of the consults and is therefore a major public health challenge. The diagnosis and first treatment are mostly done by pediatric residents working at the emergency department. The aim of this paper was to analyse and compare the prevalence and type of pediatric fractures and their etiologies in an urban population in Switzerland with previous published data in the literature.

**Method:** In order to provide a better quality of care and resident training at the pediatric emergency unit of our hospital, the residents were asked to fill in a simple document for all x-ray prescribed during their shift with: type of injury, diagnosis and proposed treatment. All inscriptions were controlled by an attendant of pediatric orthopedic surgery the next morning at the daily board, where all radiographies of the previous 24 hours were reviewed and discussed. All fractures were recorded for one year with special regard to age, sex, type of injury, diagnosis and treatment.

**Results:** (preliminary results after 8 months 12.05.2017 to 11.01.2018). After eight months, we recorded 654 fractures. Mean age was 9 years and 6 months (7m – 17yr 9m). The male to female ratio was 1.3 (57.3% were boys). 456 fractures were seen at the upper extremity (70%), 142 at the lower extremity (22%) and 56 at the axial skeleton (spine, pelvis and clavicle) (8%). Concerning the upper extremity 215 fractures affected the right side (47%). The most implicated bone was the radius (176 fractures), with only five fractures affecting the growth plate at the distal radius (Salter Harris II), followed by the phalanx (158 fractures) that were mostly due to a hyperextension trauma (50 times). For the lower extremity, there were 81 right-sided fractures (57%). The tibia was the bone that sustained the most fractures (39 fractures) with 20 fractures affecting the diaphysis, followed by phalangeal fractures of the toes. The most encountered sport activity leading to lower extremity fractures was soccer (27 times).

**Conclusion:** Our intermediary results seem to be similar according to previous published data concerning the type of encountered fractures in a pediatric population and confirm the importance of pediatric resident training in taking care of pediatric fractures at the emergency care unit.

FM49

### Health-related quality of life and foot-function after clubfeet treatment using Ponseti casting followed by z-lengthening of the Achilles tendon and limited posterior release

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**Introduction:** Over the last decades, the Ponseti method has become the state of the art for clubfeet treatment. We modified the Ponseti method at our institution to decrease the splinting duration compared to the recommendation of Ponseti's original method. Our objective was to analyse the clinical and functional outcome as well as the recurrence rate after modification of the Ponseti technique.

**Methods:** Six to eight padded long leg Soft Cast TM3 were applied until the desired position of the foot was achieved. Our modification of this technique included an open z lengthening of the Achilles tendon followed by capsulotomy of the ankle and subtalar joint to remove fibrotic tissue and release the soft tissue structures until the ankle and subtalar joint was well aligned. In some cases, temporary K-wire fixation of the talo-navicular or ankle joint was necessary for 6 weeks postoperatively. A Ponseti Brace or a unilateral brace was applied for 2 years. We assessed the health-related quality of life using the PedsQL questionnaire and we looked for the functional outcome with the Disease Specific Instrument (DSI).

**Results:** Sufficient data of 107 patients (77 girls, 30 boys, 156 clubfeet) with idiopathic clubfoot treated in our hospital from January 1994 to January 2015 could be obtained. The affected side was 49 bilateral, 33 right, 25 left clubfeet, respectively. The initial treatment started at a mean age of 10.1 days. At a mean follow-up of 9.6 years, 81% of patients answered our questionnaires. The mean DSI was  $74.3 \pm 18.2$ , the mean overall PedsQL was  $87.3 \pm 13.0$  (PedsQL function: mean:  $88.7 \pm 16.3$ ; PedsQL social: mean  $88.3 \pm 13.1$ ). The relapse rate was 22.7%, and 20.5% necessitated surgery.

**Conclusion:** This is one of the few studies analyzing the health-related quality of life after clubfoot treatment in idiopathic clubfeet. Our results were superior compared to the literature in terms of the PedsQL, and relapse rate, the DSI was slightly worse. With the modified Ponseti treatment, we are able to decrease the splinting time significantly, which comforts the therapy in idiopathic clubfoot treatment.

FM50

### Are growth-friendly techniques for early onset spinal deformities also spine friendly?

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**Background:** The treatment of patients with early onset scoliosis (EOS) remains challenging. Different growth sparing surgical techniques are available, with distraction-based systems representing the most important ones. The high complication rate of these techniques is well known and modern systems, such as magnetically controlled growing rods (MCGR) are trying to overcome this problem. In contrast, very little is known about potential problems at the time of conversion to definitive instrumented fusion at the end of spinal growth.

**Method:** We looked at the outcome of patients undergoing definitive posterior instrumented spinal fusion (PISF) after previous growth sparing surgical treatment for EOS. A staged procedure was chosen in case of previous surgical site infection and/or to address severe deformities with preoperative halo gravity traction.

**Results:** Between 06/2015 and 01/2018 7 patients underwent either direct or two-staged conversion from growth sparing techniques to definitive spinal fusion. 6 patients were treated with vertical expandable prosthetic titanium ribs (VEPTR) and 1 patient with growing rods for an average period of 10.3 years. 3 patients had single stage implant removal and definitive PISF, and 4 underwent a staged procedure with initial hardware removal and halo application with PISF after an average of 4 weeks of halo-gravity traction. Average deformity correction with definitive PISF was  $15^\circ$  for hyperkyphosis ( $106^\circ/91^\circ$ ) and  $14^\circ$  for scoliosis ( $74^\circ/60^\circ$ ). 3/7 (42%) of patients had early postoperative complications leading to unplanned return to the operating theatre in 2 patients.

**Discussion:** Although looking at a small number of patients who have been converted from growth sparing techniques to definitive instrumented spinal fusion the results are uninviting and the term growth friendly should be handled with care. We are faced with rigid deformities, altered vertebral anatomy, and poor bone quality allowing

for little correction at the time of definitive fusion. Modern motorized implants appear to reduce the complication rate compared to traditional distraction-based systems during the period of repetitive lengthening but are likely to lead to the same problems at the end of growth, supporting the demand for real growth and spine friendly solutions.

FM51

### Osteochondral flap fracture of the coronoid process with intra-articular olecranon fracture and lateral condyle fracture in a child: a case report

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**Background:** Osteochondral flap fractures of the coronoid process are very rare lesions described in pediatric patients. They can result from a spontaneous reduction of a posterior elbow dislocation. Its radiological diagnosis is often delayed. We describe a patient treated in our institution for a triad of elbow fractures, including the osteochondral flap.

**Case presentation:** A 6 year-old boy presented with a post-traumatic dislocation of the left elbow with spontaneous reduction. Initially, radiographs showed a nondisplaced lateral humeral condylar fracture (Milch 1). Follow-up radiographs at day-4 showed two intra-articular fragments. A CT scan was performed, a multifragmentary osteochondral flap of the coronoid process and an intra-articular olecranon laminar fracture were also diagnosed. Treatment consisted in open reduction and suture of the osteochondral flap fragments, percutaneous fixation of the lateral condyle fracture with two K-wires and conservative treatment of the olecranon laminar fracture due to its stability.

**Outcomes:** K-wires removal was performed after 4 weeks. The fractures healed without sequelae and complications at 18-month follow-up. After 6 months the patient showed restoration of complete range of motion.

**Discussion:** Due to the rarity of this fracture, in case of spontaneous reduction of posterior post-traumatic elbow luxation, we suggest strict radiologic follow-up to avoid delayed diagnosis, treatment and complications of the osteochondral flap fractures in children.

FM52

### Ten-year followup after prophylactic pinning of the contralateral and asymptomatic hip in unilateral slipped capital femoral epiphysis

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**Introduction:** Prophylactic pinning of the asymptomatic and contralateral hip in patients with unilateral SCFE still remains controversial. Understanding the long term outcome of the contralateral hip in unilateral SCFE is crucial in helping the decision making about prophylactic fixation. There is limited data about the mid-term and long-term clinical, functional and radiographic outcomes after prophylactic pinning. Therefore, we sought to determine the minimum 10-year clinical, functional and radiographic outcomes in terms of development of cam morphology and hip osteoarthritis following prophylactic pinning of contralateral asymptomatic hip in patients treated for unilateral Slipped Capital Femoral Epiphysis (SCFE).

**Methods:** Thirty-six patients (19 males and 17 females) with a mean of 12.8 years (standard deviation; stdev:  $\pm 1.5$ ) were followed for a mean follow of 12 years (range, 10 to 17 years) after prophylactic pinning. The medical records were retrospectively reviewed for demographics, hip motion and additional surgeries. Hip function and pain was assessed by the Harris hip scores and the Hip Disability and Osteoarthritis Outcome Score (HOOS). Most recent postoperative radiographs were evaluated for measurement of the alpha angle and minimum joint space width.

**Results:** Four out of the 36 (11%) patients underwent subsequent surgical treatment for femoroacetabular impingement (FAI). The mean Harris hip scores for the remaining 32 patients was  $97 \pm 5$ . Thirty-one patients (86%) had Harris hip scores equivalent to excellent function outcomes ( $>91$  points). The mean scores for the HOOS was  $94 \pm 8$ . At the most recent radiograph, the mean alpha angle was  $53^\circ \pm 8$  on the AP radiograph and  $49^\circ \pm 8$  on the lateral view. A total of 10 out of 36 patients (28%) developed a cam morphology at the femoral head-neck

junction. No patients had radiographic signs of osteoarthritis of the hip. The mean minimum joint space width was 4.1 mm ± 0.4.

**Discussion and conclusion:** At minimum 10-year follow up after prophylactic pinning of the contralateral hip the vast majority of the patients can expect an excellent functional hip-specific outcome. However, patients with unilateral SCFE should still be considered to be at risk of developing cam FAI in the contralateral normal hip despite prophylactic fixation. Our findings showed that prophylactic pinning does not guarantee a life time impingement and pain free hip in all patients.

FM53

### Functional evaluation of the lumbar spine in symptomatic pediatric spondylolysis with Axial Loaded Magnetic Resonance Imaging (AL-MRI)

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**Purpose:** Spondylolysis and spondylolysthesis are a common cause of lower back pain. In selected populations of young athletes this evidence can reach 47%. Our purpose was to functionally evaluate symptomatic pediatric patients with Axial Loaded MRI (AL-MRI).

**Materials and methods:** From September 2013 to March 2015 we studied 60 young Patients, aged from 10 to 18 (mean 15 y.o.). All the Patients referred low back pain (LBP); 7/12 had sporadically sciatic pain in L5 territory. In all we had a plain X-ray evaluation of the lumbar spine in which a spondylolysis was suspected or detected. A spondylolysthesis was present at X-Ray, in 10/12 Patients. All the Patients underwent AL-MRI on a 3T MR Unit (Philips Ingegna); All the examinations underwent a brief post-processing to obtain a cine-loop of the similar images (e.g. basic Sag T2 with AL Sag T2 images) in order to obtain "functional" Cine-AL/MRI images of the lumbar spine. The axial loading was obtained with the use of the "Axial Loader" (Mikai Manufacturing).

**Results:** All Patients could execute the examination; only in 3 cases we had limited motion artifacts. All referred the comparison / increment of their symptoms during axial loading. In all we could well identify the spondylolysis when present and could obtain an increment of the spondylolysthesis varying from 1 to 4 mm in 10/12 Patients. The whole procedure was 15 to 20 minutes longer of a standard examination at our Institution.

**Conclusions:** In this still limited group of Patients MRI and AL-MRI seem to be a good method for an anatomical and functional evaluation of the pediatric lumbar spine; in particular in spondylolysis and spondylolysthesis we could well study the dislocation of L5 body and directly and functionally evaluate the compression of L5 roots with cine AL-MRI. The examination is easy to perform and easily repeatable. If this data will be confirmed in more numerous series of Patients, since the absence of radiological exposition, this examination could become a reference one in the study of pediatric spondylolysis.

\*FM54

### Postoperative evolution and return to sport after anterior tibial eminence fracture in children. A retrospective monocentric study

*Laura Fillistorf, Dr Stéphane Tercier, Prof. Dr. Olivier Borens*

**Introduction:** Anterior tibial eminence fracture is the typical traumatic injury of the ACL in children between 8 and 14 years old who still are skeletally immature. It is precisely a fracture-avulsion of the insertion of the ACL, classified in 4 types described by Zaricznyj with a frequency of 3/100,000 children. The aim of this study is to assess the management of this fracture, from the surgical technique to the post-operative follow-up including the short- and medium-term complications in the pediatric unit of orthopedic and traumatic surgery (UPCOT) in the service of pediatric and adolescent surgery within the CHUV.

**Methodology:** All patients diagnosed with an anterior tibial eminence fracture in the UPCOT within the CHUV between 2008 and beginning of 2016 and meeting the inclusion criterias were included and responded to a subjective questionnaire assessing their knee function (pedi-IKDC). Our collective is made of 29 patients, 13 girls and 16 boys, aged between 5 and 13. According to the Zaricznyj classification, the collective is made of 2 fracture of type 1, 13 of type 2, 12 of type 3 and 2 of type 4. Three patients were treated conservatively and 26 surgically including 17 arthroscopy and 9 arthrotomy. A retrospective revue of the medical files and analyze of the questionnaire have been done.

**Results:** Associate lesions including meniscal and ligamentous lesions or osteochondral tibial plateau fractures are found in 48% of the cases. The patients treated with arthroscopy present in average a score of 93.8 at the pedi-IKDC whereas those treated with arthroscopy 92.5. There isn't any statistically significant difference between those two groups (p-value 0.67). Three patients presented with post-operative complication (10%): such as a case of non-union, one arthrofibrosis and one ACL tear. Six months after the surgery most of the patients were able to return to sport.

**Conclusion:** The results confirm that most of the patients with a fracture of the anterior tibial eminence and managed in our institution show a good if not an excellent evolution in medium-term, illustrating the quality and the adequacy of our actual management. This study corroborates the literature regarding the benefit of the surgical treatment by arthroscopy.

FM55

### Functional testing after anterior cruciate ligament reconstruction in the pediatric population

*Dr Barbara Kwiatkowski, Dr Stéphane Tercier, Sandrine Vaucher*

**Background:** There is an increase in the number of children and adolescents with an anterior cruciate ligament (ACL) lesion as well as the number of patients needing a surgical reconstruction. This population has a higher ACL reinjury rate (20–25%) than the adult population. In order to reduce this risk, different tests are used to evaluate the function of the knee and to determine if the patient is ready to start a reathletization program. In the literature, the single hop test is often the only used test.

**Purpose:** To evaluate the relevance of five quantitative functional tests used to determine if the patient is ready to start a reathletization program after ACL reconstruction.

**Study design:** Cohort study

**Methods:** Between 2015 and 2017, 55 patients underwent functional testing four to six months after their ACL reconstruction. We use the single hop for distance, the timed hop, the triple hop for distance and the cross-over hop for distance. Since 2016 the Y balance test has been added to the hop tests. The Limb Symmetry Index (LSI) were calculated for all tests: This is the performance of the operated leg compared to the healthy leg. According to the literature, the LSI cut-off was defined as 85%. The neuromuscular control and plyometric quality were evaluated as well.

**Results:** A total of 20 patients (36%) did not reach a LSI of 85%. All but one patient passed the Y balance test, but for the hop tests: as much as 22% did not pass the single hop test, 18% the timed hop, 16% the cross-over hop for distance and 13% the triple hop for distance. 15% of the patients passed the single hop tests but failed the other tests and 9% failed only the single hop test. No significant differences were seen between genders, dominant/non-dominant legs or with/without associated meniscal tear.

**Conclusions:** 36% of the patients did not pass the functional tests, thus they could not start the reathletization program. This underlines the importance of this type of evaluation to avoid a premature return to sport. The single hop test seemed to be the most severe test as a higher percentage of patients did not pass and the mean LSI score was the lowest. 15% of the patients having passed this test failed the others. We conclude that a sole test is inadequate. We will introduce a reproducible qualitative test to evaluate the biomechanical and neuromuscular recuperation. Thereby we will be able to correct any deficiency and guide the patient in a safer return to sport without secondary lesion.

FM56

### Fracture prevention with percutaneous aspiration and use of two different bioresorbable bone cements in treatment of simple bone cyst

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**Introduction:** Simple bone cyst (SBC) is common in children and adolescent with high risk of refracture and recurrence. The risk of fracture and the probability of spontaneous healing in SBC are mainly depending on the activity of the cyst and can be quantified with the Cyst-Index. Can we avoid pathological fracture with this treatment? Our study presents the comparison after treatment of SBC in the active stage with percutaneous aspiration with injection of two different bioresorbable bone cements and the results of the treatment.

**Methods:** From 2006 to 2017, 38 patients (range: 1–17, mean: 11.7 ± 4.3 years) were collected in 3 hospitals with at least 1 year follow up (range 12–48 months, mean: 40 ± 19.6 months). 21 patients (5 femora, 11 humeri, 5 calcanei) treated with ChronOS® Inject and 17 patients (7 femora, 8 humeri, 1 calcaneum, 1 fibula) treated with Cerament™ and Cerament G. At follow-up radiological healing (modified Neer classification), activity level, refracture rates, recurrence rates, resorption rates and complications were analysed.

**Results:** Patients with ChronOS® Inject system experienced 27 times treatments (2 refractures and 4 recurrence). All refractures happened in proximal femur. Patients with Cerament™ system experienced 20 times treatments (2 refractures and 1 recurrence). After 1.5 months, 95% returned to unrestricted activity. 4 recurrences (19%) occurred in ChronOS® Inject system, 1 recurrence (6%) occurred in Cerament™ System. The refracture rates were 2 in each cement. There were 2 (7%) wound infections and 5 (24%) no-resorptions in ChronOS®.

**Conclusion:** Both bioresorbable bone cements provided stability and prevented refracture at the upper extremity and foot. For the proximal femur, additional stabilization is necessary. The outcome in Cerament™ system is better in treating SBC with lower infection rates and better resorption. The lower infection rates may be caused by the antibiotic (gentamicin) carried by Cerament™ G.

\*FM57

### Legg-Calvé-Perthes disease can lead to acetabular retroversion

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**Introduction:** Legg-Calvé-Perthes disease (LCPD) is a childhood hip disorder that leads to aseptic necrosis of the femoral head, initiated by a disruption of blood flow. Staging is performed using the modified Waldenström classification (I–IV). With progressing stage the osseous core of the epiphysis dies, collapses and is finally rebuilt when the blood flow can be re-established. LCPD mostly leads to some degree of deformation of the femoral head and sometimes the acetabulum as well. This is the main long-term problem as it can cause early osteoarthritis. Our aim was to analyze if LCPD leads to significant changes in acetabular version?

**Methods:** We collected 94 hips in 87 patients diagnosed with LCPD between 1992 and 2017 at the paediatric clinic of our hospital. Exclusion criteria were insufficient X-ray quality, less than two Waldenström stages in the X-ray series and patients who had already undergone hip surgery. We used two validated and indirect parameters for acetabular version (pelvic width index [PWI] and ilioischial angle) to determine the acetabular version, since the radiographic anatomy of the non-ossified acetabulum can typically not be directly evaluated in these young patients with LCPD. Disease stage was staged according to Waldenström. Retroversion was diagnosed by a PWI lower than 44%. The PWI of 44% represented the mean value of 50% ± 6% SD (41%–65%) of the PWI in the healthy hip of the 80 individuals with only one affected side. We measured the change in acetabular version over a time of 7 years ± 4.4 SD (1.6–22.7 years). Additionally, we compared the healthy hip to the affected hip by calculating the difference between both PWIs and both ilioischial angles on each radiograph.

**Results:** We found a mean value of 50% ± 6% SD (41%–65%) for the PWI in the healthy hip, which is in line with the results found in literature. 30% of the LCPD hips had a retroversion with a PWI lower than 44% when healed. We found a comparable value of 26% when using the ilioischial angle to look for retroversion. There were changes of the acetabular version along the course of the disease, some hips developed back from retroversion to normal version in the end-stage of the disease. The difference between healthy and affected side was highest in stage two and three of the disease.

**Conclusion:** LCPD can lead to acetabular retroversion. In some hips with progressive acetabular retroversion, retroversion was partly reversible in the healing stage of LCPD.

FM58

### High'n dry or worth a try?

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**Background:** In advanced PAOD patients, amputation remains often the last option to conquer uncontrollable pain or infection. In these patients, the healing potential of the amputation wounds is severely

limited due to the reduced perfusion. The more proximal the surgery is performed, the better the healing potential of the wound. Since most of these patients have severe cardiac and pulmonary limitations as well, chances to ambulate again are higher, if a transtibial amputation Level is Chosen instead of a transfemoral level. This is due to the increasing physical effort to mobilize a prosthetic device the more joints have to be replaced. The main test used is the measurement of the tcPO<sub>2</sub>-value, which is often misleading or just in between the generally accepted values for spontaneous or delayed healing of the wound.

**Methods:** 180 patients met the inclusion criteria. Patient demographics and clinical data were derived from the institutional electronic medical records. In all cases, amputation level was determined by a senior orthopedic surgeon (T.B., M.C.B.). All amputations were performed by or under the direct supervision of an attending orthopedic surgeon (T.B., M.C.B.). Information collected included demographic data, level and type of amputation, whether the revision was performed at the same level or a more proximal level, time from amputation to first revision, and presence of polyneuropathy or diabetic nephropathy. Risk factors like smoking and alcohol and their amounts consumed were extracted.

**Results:** We included a total of 180 patients. 125 males, mean age at first amputation 65.7 years (range 32–90), the mean age of the female patients was 68.6 (range 31–93). 24 of these patients were bilateral amputees. 55 (30.7%) patients had to undergo revision surgery, 42 (23.5%) at the same level, 13 (7.2%) had to be converted into an above knee amputation. 9 of these patients were male.

**Conclusions:** The preoperative measurement of the TcPO<sub>2</sub> is an important predictor for the outcome to be expected and a useful tool to have objective values to discuss with the patient. Concerning our results, it seems that these measurements may support the determined level of amputation, but they cannot be used as absolute determinants for the transtibial level.

FM59

### Compressive stockings after hind-foot and ankle surgery – a prospective, randomized controlled cohort study

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**Background:** Swelling and pain are common after foot and ankle procedures. We hypothesized that compressive stockings (CS) treatment after hindfoot surgery would positively influence patient outcomes.

**Methods:** We undertook this randomized controlled trial in 87 consecutive patients to analyze the clinical effect of CS after hindfoot and ankle surgery and evaluate CS-wearing compliance using sensors that were implanted into CS. Ankle swelling, pain status, quality of life (SF-36 score), and the American Orthopaedic Foot & Ankle Score (AOFAS) were set as the primary end points. The CS wearing time in hours and percentage were investigated as the secondary end points. All participants with CS (group I) were informed about the implanted sensor after the CS were taken off. A subgroup analysis of group I was performed to detect differences between patients with high vs low compliance.

**Results:** At 12 weeks, the results of ankle swelling (mean 234 mm in group I and 232 mm in group II), pain in the visual analog scale (1.7 group I vs 1.9 in group II), the SF-36 score (38 points in group I vs 30 points in group II), and the AOFAS score (a mean of 76 points in both groups) showed no statistical differences between the 2 groups. The mean wearing time was 136 (range, 0–470) hours, which corresponds to a compliance rate of 65%. Sixteen participants had high compliance (>80%, >170 hours), and 21 patients had low or noncompliance. The clinical results of patients with high wearing compliance were not significantly better compared to the results of patients with low compliance.

**Conclusion:** CS therapy after ankle and hindfoot surgery was associated with a low wearing compliance and did not influence ankle swelling, function, pain, and the quality of life compared to the control group. Furthermore, the clinical results of patients with high compliance were not better compared to the results of patients with low or noncompliance wearing behavior.

**Level of Evidence:** Level II, prospective randomized study of lower quality.



FM60

### Insertional Achilles tendinosis – results of surgical treatment in 51 patients

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**Introduction:** Insertional Achilles tendinopathy is a common disorder where conservative therapy frequently fails. Operative treatment typically consists of debridement of the insertion, reattachment of the tendon and augmentation via transfer of the flexor hallucis longus (fhl) tendon. Reports on functional results and complications are scarce. The aim of this study is to present the outcome and complications over ten years of experience with this surgical procedure.

**Methods:** All the patients who were operatively treated from 11/2007 to 11/2017 were evaluated. The tendons were debrided using a central incision, reattached with suture anchors and augmented with a flexor hallucis tendon transfer. Analyzed were complications and reoperations, general satisfaction, return to previous activity and general health using subjective health scores (SF-36, FFI), ankle range of motion, gait analysis and calf strength using functional scores (Thermann and AOFAS score).

**Results:** A total of 60 patients were operated. 9 patients were excluded. The remaining 51 patients (mean age 54 ± 12) were followed for 27 months (mean, range 12–90). Of these, 28 consented to an extended examination (gait analysis, Thermann and AOFAS score). Patient satisfaction was “very good” or “good” in 90%, return to previous activity was possible with minimal restriction (8/10 points). The mean Thermann score was 80 ± 12 (range 52–98), SF-36 score 85 ± 7%, AOFAS scores (Hindfoot 91 ± 13 points, Midfoot 86 ± 19 points, First ray 90 ± 18 points). There were no infections or thrombosis, but seven reoperations (14%) (2 wound debridements, 1 excision of heterotopic ossification, 1 excision of additional tendinosis, 1 fibrosis resection, 2 reattachments of avulsed tendon).

**Conclusion:** The presented procedure was an effective treatment for insertional Achilles tendinosis with high patient satisfaction in this comparatively young patient cohort. Complications were frequent but mostly minor and successfully treated. No definitive statement is possible regarding the value of adding the fhl tendon transfer to the reconstruction, further research is necessary.

\*FM61

### Midterm clinical and radiological outcome after autologous matrix-induced chondrogenesis (AMIC) for osteochondral lesions of the talus

Dr. Lizzy Weigelt, Dr. Rebecca Hartmann, Prof. Dr. Christian Pfirrmann, Dr. Stephan Wirth

**Introduction:** Autologous matrix-induced chondrogenesis (AMIC) has recently become an interesting treatment option for osteochondral lesions of the talus since it combines safety and efficacy with overcoming several drawbacks of other surgical techniques. With AMIC, donor site morbidity of osteochondral autografts is eliminated, two-step procedures like matrix-induced autologous chondrocyte implantation are minimized to a more cost-effective single step and restrictions due to limited availability of osteochondral allografts are resolved. The purpose of this study was to evaluate the therapeutic efficacy of AMIC by analyzing AMIC-repaired osteochondral talar lesions in consecutively treated patients after a minimum follow-up of 2 years.

**Methods:** All patients with an osteochondral lesion of the talus treated with the AMIC technique completing a minimum follow-up of 2 years were enrolled in the study. 36 of the 47 eligible patients (58% males; mean age at surgery 34.8 (range, 13–75) years); body mass index 27.6 ± 6.9 kg/m<sup>2</sup>) were available for clinical (visual analogue scale (VAS), American Orthopaedic Foot and Ankle Society (AOFAS) score, Tegner Score) and radiological (Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) scoring system) evaluation.

**Results:** After a mean follow-up of 4.5 (range, 2.3–7.9) years, the VAS improved significantly from 6.3 ± 2.0 preoperatively to 1.5 ± 2.2 at follow-up (p < 0.001). The mean AOFAS score was 92.9 ± 8.1 (range, 74–100) points. The sports activity level improved significantly from 3.7 ± 2.0 points preoperatively to 5.1 ± 1.8 points at follow-up (p < 0.001); 17% did not reach their pre-injury level of activity due to persistent ankle pain. The MOCART score averaged 61.3 ± 21.4 (range, 0–100) points. A complete filling of the defect was seen in 42%, of which 44% showed hypertrophy of the cartilage layer. Normal or nearly normal signal intensity was detected in 72%. All patients had subchondral bone edema or cysts. The MRI findings did not correlate with the

clinical outcome. 92% were satisfied with the outcome and would undergo the same procedure again.

**Conclusion:** AMIC is a reliable procedure to treat osteochondral lesions of the talus. Significant pain reduction and high ankle function were observed after a mean midterm follow-up of 4.5 years. MRI findings did not reflect the good clinical results and therefore should be interpreted cautiously in patients with persistent symptoms.

\*FM62

### Subtalar and naviculocuneiform fusion in treating the adult acquired flatfoot deformity with collapse of the medial arch at the level of the naviculocuneiform joint – a radiographic analysis of 34 cases

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**Introduction:** A conflicting problem in treating acquired flatfoot deformities is the break-down of the arch at the naviculocuneiform (NC) joints. After having encountered problems with extended triple fusion, in particular increased stiffness of the foot, we established a rationale to combine subtalar (ST) fusion with NC I–III fusion. Our hypothesis was that the break-down of the arch can be specifically addressed while sparing the Chopart Joint (TN and CC joint) to allow better accommodation to the ground. The aim of the study was to analyze the radiographic correction and fusion rate, and to determine patient's satisfaction with this procedure.

**Methods:** Between 2009 and 2015, a consecutive series of 34 feet in 31 patients (female, 23; male, 8; age 67 [45–81] years) were treated by combining a fusion of the ST joint with a NC fusion. In 15 patients, an additional medial sliding-osteotomy was done to fully correct valgus misalignment of the hindfoot. The following measures were taken on standard weight-bearing radiographs including hindfoot alignment view preoperatively and at 2 years: the talus-first metatarsal angle, the talocalcaneal angle, the calcaneal pitch, the talonavicular coverage, and calcaneal offset. Bony fusion was confirmed on plain radiographs. If no trabeculation was visible, a CT scan was performed.

**Results:** All radiographic parameters, except the calcaneal pitch, showed a statistically significant improvement. Solid fusion at the arthrodesis site was observed between 8 and 12 weeks in all but 2 cases (94.1%). One nonunion occurred at the ST joint and one at the NC joint. No interventions were necessary as both cases were asymptomatic. One patient developed an avascular necrosis of the lateral talus with need for a total ankle replacement after one year. All patients were satisfied with the results of this procedure and stated that they would undergo the surgery again. All patients were able to wear normal shoes without insoles.

**Conclusion:** Our results show that a combined fusion of the subtalar and NC joint is an effective and safe technique in treating the adult acquired flatfoot with collapse of the medial arch at the level of the NC joints. The deformity was corrected in all three planes. Even though the TN joint was not fused, its subluxation was significantly reduced. Although our radiographic results are promising, a clinical follow-up study is necessary to quantify the clinical benefit of this procedure.

FM63

### Pedobarographic and functional results after flexor hallucis longus tendon transfer for the treatment of chronic Achilles tendinopathy

Dr. Christophe Kurze, Dr. Christiane Körner, Prof. Dr. Martin Weber, Fabian G. Krause

The flexor hallucis longus (FHL) tendon transfer for Achilles tendon augmentation in chronic tendinopathy is a commonly used surgical procedure. Advantages are besides the good maximum strength, the synergistic momentum as an in-phase transfer (e.g. activation of FHL and triceps surae in the same gait phase). The biomechanical effects of the transfer on the gait pattern and in particular the push-off phase of the first toe have not yet been sufficiently studied. The aim of the study was to investigate the dynamic pedobarographic parameters and functional results after FHL transfer in chronic Achilles tendinopathy. 17 patients (11 women, 6 men, age 55.9 ± 13.8 years) were retrospectively investigated. The mean follow-up period was 44.1 ± 19.6 months. For pedobarographic examination (Footscan 7, RScan international) the foot was subdivided in 10 standardized areas. The following parameters were evaluated: start-, end-time, percentage contact, maximum pressure, load rate, impulse, contact area, active contact area and maximum peak value of pressure sensor in the area. For each patient three repeated measurements on both sides were averaged and statistical analysis was performed by paired t-test. In

addition to clinical results, the AOFAS scores (hindfoot, metatarsus, 1st ray), the Foot Function Index (FFI) and Thermann score were used as secondary outcome parameters. The maximum pressure of the first toe was  $5.5 \pm 2.8$  N/cm<sup>2</sup> on the operated side (OS),  $10.8 \pm 10.9$  N/cm<sup>2</sup> on the healthy side (HS). The impulse was  $1.4 \pm 1.1$  Ns/cm<sup>2</sup> OS vs.  $3.1 \pm 3.4$  Ns/cm<sup>2</sup> HS. These values were significantly lower (95% confidence interval,  $p < 0.05$ ) for OS. The remaining evaluated zones especially the metatarsal areas showed no significant differences. An average loss of  $5 \pm 5.7^\circ$  dorsi- and  $5.6 \pm 4.4^\circ$  plantarflexion in the MTP-1 joint were measured. The functional results were  $85.1 \pm 9.0$  points in the AOFAS-1st ray-,  $80.9 \pm 14.5$  points in the –metatarsal- and  $83.6 \pm 10.6$  points in the –hindfoot-score. The mean FFI value was  $13.3 \pm 9.8$  and the mean Thermann score  $73.8 \pm 16.1$ . The loss of function of the FHL can be clearly demonstrated. Despite the reduction of the 1st toe push-off pressure by half and the loss of mobility in the MTP-1 joint by  $10^\circ$ , most patients do not notice this while walking and do not experience any other disability. Surgeons can therefore continue using this augmentation technique, although its objective benefit remains to be scientifically quantified.

FM64

### Die tibio-talo-kalkaneale Arthrodese mit dem Rückfuss-Kreisbogennagel. Klinische Resultate anhand von 30 Patienten

PD Dr. Kaj Klaue, Prof. Dr. Thomas Mittlmeier

**Problemstellung:** Die tibio-talo-kalkaneale Arthrodese kann ausgezeichnete Langzeitergebnisse ergeben, wenn die dreidimensionale Einstellung zwischen distaler Tibia und Ferse anatomisch fixiert ist. Der Rückfuss-Kreisbogennagel erlaubt die anatomische Einstellung primär stabil zu fixieren. Offene Fragen liegen in der sicheren Durchführung, der Nachbehandlung und den Resultaten.

**Methodik:** 30 Patienten, (16 Frauen, 14 Männer) zwischen 46 und 84 Jahre alt (MW: 58 J) wurden mit dem Rückfuss-Kreisbogennagel für eine tibio-talo-kalkaneale Arthrodese versorgt und nachkontrolliert. Die Indikationen betreffen eine primäre Arthrose bei 9 Patienten, post-traumatische Zustände bei 9 Patienten, eine OSG Arthrose nach Triple-Arthrodese bei 2 Patienten, Polyarthritiden in 2 Fällen, diabetische Arthropathie bei 3 Patienten, 2 Klumpfüsse, 2 gelockerte OSG Prothesen und eine zerebrale Parese. Der chirurgische Zugang war in allen Fällen ein postero-lateraler Zugang zu OSG und USG in Seitenlage. Zur Korrektur wurde in einigen Fällen der Knochendistraktor zwischen Tibia und Tuber calcanei angewandt. Der Follow-up beträgt zwischen 4 und 54 Monate mit einem Mittelwert von 16 Monaten. Post-operativ wurden alle Patienten mit einem Liegegips für 2 Wochen behandelt und danach wurden sie mit einem «cam»-Walker mit Teilbelastung versorgt bis zur Röntgenkontrolle nach 2 Monaten.

**Ergebnisse:** Zwei Patienten mit Diabetes mellitus erlitten ihren Nebenleiden 8 Monate und 2 Jahre und 8 Monate nach der Operation bei konsolidierter Arthrodese. Von den restlichen 28 Patienten konsolidierten die Arthrodesen nach 2 Monaten in 23 Fällen und verzögert bei 5 Fällen. Bei einer Patientin kam es zum technischen Ausfall des Kreisbogenfräasers und konsekutiver instabiler Lage des Nagels; es musste reoperiert werden. Die Patienten mit guter Knochenqualität und anatomischer Einstellung der Arthrodese konnten nach 2 Monaten voll belasten. Bei einer Patientin verblieben Restbeschwerden 2 Jahre nach der Operation und ein Patient mit Klumpfuß meldete Restbeschwerden 1 Jahr und 11 Monate postoperativ bei verbleibender Mittelfuss-Deformität, die sekundär korrigiert wurde.

**Diskussion:** In unserer Serie von 30 nachkontrollierten Patienten nach Fixation einer tibio-talo-kalkanealen Arthrodese mit einem zentralen Kreisbogennagel wurde bei der grossen Mehrzahl eine rasche Konsolidierung festgestellt. Wir führen die rasche funktionelle Wiederherstellung auf die primäre Stabilität und die anatomische Einstellung des Rückfusses zu.

FM65

### Reduction accuracy and rate of reoperation after distal tibial fracture using four different treatment methods

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**Background:** Lower tibial fractures can be treated with various different treatment methods. It is unclear, if the accuracy of the fracture reduction or the rate of reoperation depend on the treatment method.

**Objectives:** The aim of this study was to assess the accuracy of the fracture reduction and the rate of reoperations using four different treatment methods: using an intramedullary nail, ORIF using a plate, open or closed reduction using an external fixator or closed reduction and immobilization in a cast.

**Study Design & Methods:** This is a retrospective study including 187 fractured ankle fractures (186 patients) treated at our institution. Postoperative reduction was quantified using the varus/valgus angle and the flexion/extension angle. Further were rate and indication for revision within two years assessed.

**Results:** 84 (45%) were treated using an intramedullary nail, 52 (28%) using a plate, 15 (8%) using an external fixator and 36 (19%) with closed reduction and immobilization in a plaster. The mean flexion/extension angle was best after treatment with a nail, second using a plate and worst after closed reduction and plaster ( $p = 0.033$ ).

The same trend was seen in varus/valgus angle but did not reach significance. Comparing the rate of reoperations, there was no difference between the treatment groups, neither in the entire rate of reoperations, nor in planned (metal removal) or unplanned (infections or non-unions) reoperation.

**Conclusions:** Reduction of distal tibial fractures was best using an intramedullary nail and second using a plate. The rate of reoperations seems to be independent of the treatment.

FM66

### Limited open reduction and internal fixation of calcaneal fractures: 16 years of experience

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*Investigation performed at Inselspital, University of Bern and Zieglerspital, Bern, Switzerland*

**Introduction:** The treatment of displaced intraarticular calcaneus fractures remains a challenge and the optimal approach is still controversial. The main reason to avoid the extended lateral approach is the high complication rate due to wound healing problems. We would like to report on 16 years of experience with a standardized limited open reduction and internal fixation technique.

**Methods:** Between 2001 and 2017, we prospectively followed 240 consecutive patients operatively treated for a displaced intraarticular calcaneal fracture. Excluded were patients with open, multiple, bilateral, extraarticular, Sanders IV fractures and those lost to follow up. A lateral subtalar approach was used, then a cast for 8 weeks; full weight-bearing allowed after 12 weeks. Follow-up examinations until 24 months. Subjective and clinical assessment included gait abnormality, subtalar and ankle range of motion as well as stability and alignment. AOFAS hindfoot score was calculated. Standard radiographs were obtained and alignment was analyzed.

**Results:** 131 patients were excluded (open 10, bilateral 36, polytrauma 24, extraarticular 14, Sanders type IV 15, lost to follow up 32). The remaining 109 patients were followed for a minimum of 24 months ( $34.4 \pm 14.2$  (24–102) months). The mean AOFAS score was  $87 \pm 13$  (32–100). “Excellent” and “good” results as well as hindfoot motion with “normal/mild” and “moderate” restrictions were seen in 80%. Reoperations were performed early for insufficient reduction (2), delayed wound healing (debridement: 3), haematoma (1). Late revisions were arthrodesis (3) and medializing calcaneal osteotomy (1), implant removal (53; 48%)

**Conclusion:** The presented approach has remained unmodified for 16 years delivering consistently good functional results. The technical expertise required for reduction and fixation was comparable to the extended approach. The dreaded wound complications of the latter approach are avoided. Sural nerve irritations did not occur. Bony healing was rapid, no losses in reduction or non-unions were seen. Main disadvantage was the high rate of implant removal which did not correlate to prominence of the screw heads.

\*FM67

### Operatively treated malleolar fractures in Switzerland 2002–2012: epidemiology and associations between baseline characteristics and fracture types

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**Background:** Malleolar fractures are common. Their incidence has been going up since the fifties-likely due to the increase of elderly, obese and athletic populations. Previous studies on the epidemiology of malleolar fractures were conducted in the US, Scandinavia and Scotland. Our objective was first to provide a current overview of the epidemiology of operatively treated malleolar fractures in men and women in Switzerland and second to evaluate the influence of age, sex, lifestyle factors and comorbidities on fracture types.

**Methods:** We included all consecutive operatively treated malleolar fractures presenting at a large Trauma centre in Switzerland between 1/2002 and 12/2012. Data were collected retrospectively from the health care records. Information on lifestyle factors (BMI, smoking status) and comorbidities (ASA score, diabetes) were retrieved from anaesthesia records, type of accident from emergency reports, fracture pattern from operative reports and radiographs (Weber classification; uni- vs. bi- vs. trimalleolaire, open vs. closed). Associations between baseline factors and fracture types were evaluated in multivariable logistic regression analyses.

**Results:** Overall, 2045 malleolar fractures were operated upon (median age 47 yrs, median BMI 25.6, 50.5% men). Men and women differed significantly ( $p < 0.001$ ) in age (median 41 vs. 57 yrs), obesity (16% vs. 23%), diabetes (5% vs. 10%), current smoking (45% vs. 24%), and accident type (domestic/daily activities 48% vs. 79%, transportation 24% vs. 9%, sports 21% vs. 8%, other 7% vs. 4%). Overall, there were 2% Weber A, 77% B, and 21% Weber C fractures. 54% were uni-, 25% bi-, and 21% trimalleolar. 75% of all fractures were open fractures. In multivariable regression analyses Weber C fractures (vs. A/B) were much more frequent ( $p < 0.001$ ) in men and with increasing BMI (lowest vs. highest category: 14% vs. 32%), but slightly less frequent ( $p < 0.05$ ) with increasing age and in current smokers. Trimalleolar fractures (vs. uni-/bimalleolar) were twice as frequent in women and increased with higher age (both  $p < 0.001$ ).

**Conclusion:** Men and women differed substantially in age, life style factors, comorbidities, type of accident and the type of the operatively treated malleolar fracture. The proportion of Weber C fractures linearly increased with increasing BMI, whereas the proportion of trimalleolar fractures increased with higher age. These findings from a large cohort in Switzerland are consistent with previous publications.

\*FM68

#### What is the best approach to access the posterior malleolus?

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**Introduction:** ORIF of posterior malleolar fractures has recently gained more attention due to better understanding of its importance for ankle stability and function. A variety of fracture patterns have been described and classified, each requiring specific access to be best visualized, reduced and fixed. The aim of this study is to analyse 3 different surgical approaches: the posteromedial, the posterolateral and the modified posteromedial. We specifically looked at how much of the posterior malleolus could be seen from each approach and quantified the magnitude of soft tissue tension (in Nm) required for retraction in each case.

**Methods:** Twelve fresh cadaveric specimens in which the anatomy and exposure of the posterior malleolus were reviewed. One only approach per leg was performed; the percentage of posterior tibial malleolus exposed and the amount of traction on the neurovascular bundle were measured with specific instruments.

**Results:** Exposure of the posterior tibial malleolus was greater with the modified posteromedial approach (91%) compared with the other 2 approaches (posteromedial = 64%, posterolateral = 40%).

Concerning the magnitude of the soft tissue retraction, the modified posteromedial approach was safer (7.0 Nm) compared with the posteromedial (21.5 Nm) and posterolateral (16.8 Nm) approaches.

**Conclusions:** Each of the posterior approaches has its indication depending on the morphology of the posterior fragment, with the modified posteromedial approach revealing more of the posterior anatomy than the other 2 approaches. Also, the modified posteromedial approach places the least traction on the flap containing the neurovascular bundle and should be recommended for those posterior malleolar fractures with substantial comminution and coronal extension.

\*FM69

#### Complications, reoperations and postoperative outcomes of simultaneous supramalleolar osteotomy and total ankle replacement in misaligned osteoarthritic ankles in comparison to total ankle replacement alone

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<sup>1</sup>KSBL

**Introduction:** A key for success in total ankle replacement (TAR) is a balanced ankle joint with an optimal loading to minimize the wear of the polyethylene insert. In ankles with distal tibia deformities, one possibility is a correcting tibial resection cut. Alternatively

supramalleolar osteotomy (SMOT) can be used to balance the ankle. To date however, no data exist whether a SMOT in addition to TAR results in better outcome, and which are the additional risks of such extensive surgery. The aim of the study was therefore 1) to determine the risk of a simultaneous SMOT in comparison to TAR only, and 2) to compare the postoperative clinical outcomes.

**Methods:** Between 2002 and 2014, 23 patients underwent simultaneously a SMOT and a TAR for treatment of a misaligned osteoarthritic ankle (tibial anterior surface angle [TAS]  $< 84^\circ$  [ $n = 9$ ] or  $> 96^\circ$  [ $n = 1$ ], or tibial lateral surface angle [TLS]  $< 70^\circ$  [ $n = 13$ ] (SMOT&TAR group). Statistical matching was applied to extract a subgroup out of 510 TAR patients from our prospectively collected database with the same baseline characteristics, including similar preoperative alignment (control group). The matched 23 TAR patients were compared regarding additional procedures, complications and reoperations. Pre- and postoperative alignment on radiographs and clinical outcome (range of motion [ROM], pain on the visual analogue scale [VAS] and AOFAS hindfoot score) were compared.

**Results:** While more additional osteotomies were done in the SMOT&TAR group, more ligament reconstructions and tendon transfers were done in the control group. There was no difference in the complication or reoperation rate between both groups. However, there was a tendency of more polyethylene wear and cyst formation in the TAR group. The postoperative TAS was closer to neutral in the SMOT&TAR (pre- to postoperatively:  $82.9^\circ$  to  $90.4^\circ$  vs.  $82.6^\circ$  to  $87.8^\circ$ ). While ROM was lower in the SMOT&TAR ( $30^\circ$ ) than in the TAR group ( $39^\circ$ ) ( $p = 0.01$ ), there was no difference in the clinical outcome (VAS pain 1.2 vs. 1.5 [ $p = 0.58$ ], AOFAS score 82 vs. 82 [ $p = 0.99$ ]).

**Conclusion:** A simultaneous SMOT with TAR for the treatment of severely deformed ankles resulted in a more neutral and better balanced ankle, and was not associated with a greater risk of complications or reoperations. The only disadvantage was a slightly smaller ROM. Thus, SMOT should be considered in TAR with greater distal tibia deformity as it is more powerful to address deforming forces without taking greater risks.

\*FM70

#### Flecting osteotomy of the distal tibia for salvage of an asymmetric osteoarthritic ankle joint

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**Introduction:** Deformity of the distal tibia in the sagittal plane with increased posterior tilt of the articular surface results in altered biomechanics and high contact pressure in the anterior tibiotalar joint with consecutive osteoarthritis (OA). As the talus becomes anteriorly extruded out of ankle mortise, the distance between its center of rotation and longitudinal axis of tibia is typically seen to be increased. In an attempt to restore physiologic load of such misaligned ankles in the sagittal plane, we have started to use a correcting osteotomy of the distal tibia to realign the center of rotation of talus and tibial axis. The aim of this study was to analyze the radiological and clinical outcome in a consecutive series of patients.

**Methods:** 39 patients were treated with a flecting osteotomy of the distal tibia. If necessary, simultaneous corrections in the frontal plane were performed to address additional valgus/varus deformities. Standard weight-bearing radiographs were used pre- and postoperatively to evaluate the tibial anterior surface angle (TAS), tibiotalar surface angle (TTS), tibial lateral surface angle (TLS), calcaneal pitch and talar offset ratio (TOR). A four-staged flecting score was used to classify the grade of OA of the tibiotalar joint in the sagittal plane, also taking the coronal joint congruency into account.

**Results:** The cumulative survival rate of the joint was 77% after 3 years, with 9 patients needing a joint sacrificing procedure. In the remaining 30 patients, pain decreased and the AOFAS hindfoot score improved significantly. The ROM, TAS, TTS and calcaneal pitch did not change significantly. The mean TLS increased by 6.6 degrees, the mean TOR decreased 0.239. Patient satisfaction with the outcome was good in 68% and moderate in 25%, 7% were not satisfied. Ten ankles (26%) showed an improvement, 22 (56%) no change and 7 (18%) a worsening in the flecting score.

**Conclusion:** The flecting osteotomy of the distal tibia was found to be an effective method to restore the tibiotalar joint congruency through moving the tibia axis anteriorly to the center of rotation of the talus, and lengthening the lever arm of the Achilles tendon. Besides normalizing the joint reaction forces of the tibiotalar joint, the procedure was also found to be effective to stabilize the talus against anterior extrusion. However, with a failure rate of 23%, there is need for further studies to determine the indication and limitation of this procedure.

FM71

### Syndesmotic instability after total ankle replacement – a neglected problem

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**Introduction:** TAA evolved over the last decades and has been shown to be effective in the treatment of ankle OA. In three-component designs, the second interface allows the PE inlay to find its position according to the individual physiological properties. This was believed to decrease shear forces within the ankle joint. However, it is not clarified to which extent such an additional degree of freedom may overload the ligaments of the ankle joint over time. This may in particular be the case for the syndesmosis. Therefore, the purpose of this study was to analyze all ankles after TAA that showed an overload of the syndesmotic ligaments and to determine the potential consequences.

**Methods:** 31 ankles (females, 17; males 14; mean age 60 years) were treated with a tibio-fibular fusion for symptomatic instability of the syndesmosis. Criteria for fusion were the presence of at least two of the followings: (1) tenderness over the syndesmosis, (2) pain while compressing the fibula against the tibia, (3) pain while rotating the foot externally, (4) widening of the syndesmosis on ap view. Alignment of TAA and hindfoot alignment were measured on standard radiographs. Intraoperatively, the syndesmotic instability was confirmed before fusion. The PE wear was documented.

**Results:** After a mean of 63 months after TAA, all patients evidenced pain at the level of the syndesmosis of at least 3 months. 25 ankles (81%; 24 after posttraumatic OA) showed a widening of the syndesmotic space and 22 ankles (71%) of the medial clear space with a lateral translation of the talus. Nine ankles (29%) evidenced cyst formation, and eight ankles (26%) showed a decrease in height of the PE; whereas, in 3 ankles (10%) a fracture of the PE was found. A valgus misalignment of the heel was found in 25 ankles (81%), a valgus TAA in 16 (52%) and a varus TAA in 11 ankles (36%).

**Conclusion:** A syndesmotic instability after a three-component TAA apparently occurred mostly after posttraumatic OA, in particular if the heel was left in valgus. If the talus starts to move lateralward, the PE seems to be at risk for increased wear and finally mechanical failure. Therefore, a valgus misaligned heel should always be corrected during TAA implantation. If there is any sign of syndesmotic instability, a fusion should be considered. Further studies must proof whether in cases with a syndesmotic instability the use of a two-component design will be superior, as it stabilizes the talus in the coronal plane.

\*FM72

### Introduction of a new index as an indicator for Achilles tendon tendinopathy

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**Introduction:** Achilles tendon tendinopathy is a common problem in our daily practice. The initial therapy consists of conservative treatment and usually leads to a reduction of pain. In some cases though, there is need for surgical treatment. The most common procedure is debridement of the tendon. If there is advanced damage of the tendon, a flexor hallucis longus (FHL) transfer may be indicated. In the current literature, there is a lack of hard criteria about the indications for such a transfer.

**Methods:** We searched our radiologic database from the years 2016 and 2017 for MRI scans of the achilles tendon. 60 patients were included in a tendinopathy group and 60 patients in a control group with no signs of tendinopathy. Inclusion criteria for the tendinopathy group were severe tendinopathy, no rupture or other relevant morphologic changes and no history of relevant previous surgery of the lower limb. Inclusion criteria of the control group were a normal Achilles tendon, no other relevant morphologic changes and no history of relevant surgery of the lower limb. Axial MRI scans were analyzed on a level of 4–5 centimeters above the ankle joint. The area of triceps surae (TS) and FHL were measured as well as the diameter of TS and an oblique diameter of FHL (from the posteromedial corner of the fibula to the posteromedial corner of the FHL muscle). Measurements were made in both groups by two independent investigators. Then quotients of the area of the FHL/TS and diameter of the FHL/TS were built. The Wilcoxon rank sum test was used to compare measurements between groups. Spearman correlation analysis tested for interobserver agreement.

**Results:** The quotients for area and for diameter of the FHL/TS showed significant ( $p < 0.001$ ) higher values in the tendinopathy group. We also found strong to very strong interobserver agreements ( $Rho = 0.744$ ). The median value for the quotient of diameter FHL/TS was 2.0 (IQR 0.8) in the tendinopathy group and 1.7 (IQR 0.3) in the control

group. The median value for the quotient of area FHL/TS was 1.8 (IQR 1.3) in the tendinopathy group and 1.3 (IQR 0.7) in the control group.

**Conclusion:** The quotient of the diameter FHL/TS is easy to obtain in our clinical practice. It indicates a relevant FHL hypertrophy which occurs in advanced Achilles tendon tendinopathy. A value of 2.0 and higher is indicative of symptomatic tendinopathy and may ultimately support the indication for a FHL transfer.

\*FM73

### Outcome after surgical treatment of calcaneal osteomyelitis

Dr. Alexander Klammer, Dr. Felix Waibel, Dr. Tobias Götschi, Dr. Thomas Böni, Dr. Martin Berli

**Introduction:** Common surgical procedures in calcaneal osteomyelitis are partial (PC) and total calcaneotomy (TC) as well as below knee amputation (BKA). Limb preserving surgeries seem to be the logical choice. According to the literature, secondary BKA rates ad up to 20% after primarily limb preserving surgery. Furthermore there is a high ratio of secondary minor revisions. The aim of this study was to perform an institutional retrospective analysis of all patients treated with one of the above named primary surgical procedures.

**Methods:** A total of 50 patients were included and a retrospective chart review was performed. All patients with surgically treated calcaneal osteomyelitis at our institution between 2002 and 2017 were included, patient demographics and clinical data were obtained from the institutional medical records. Fisher's Exact test, Mann-Whitney-U test and Kruskal-Wallis tests with Bonferroni corrections were used for statistical analysis.

**Results:** Minor revision was performed in 57.1% of the PCs, in all TCs and in 27.8% of the BKAs. Proximal reamputation had to be performed in 32.1% of the PCs, in 50% of the TCs and in 5.6% of the BKAs. There was a significant association between the type of surgery and the rate of proximal reamputations ( $p = 0.042$ ) but no significant differences between any specific combination of groups after adjusting p-values. Also a significant association between type of surgery and revision rate was found ( $p = 0.017$ ). The association between the tested variables age and proximal reamputations was found to be nonsignificant. Therefore, no risk factor for reamputations could be identified.

**Conclusion:** Primary BKA is a safe procedure in calcaneal osteomyelitis with only one proximal reamputation being seen in our cohort and with roughly one third of the patients needing minor revision surgery. PC can be considered with roughly one third needing more proximal amputation. When determining the surgical plan, this risk should be discussed with the patient. TC leads to more proximal reamputation in half the cases, all patients underwent revision surgery. Therefore we largely avoid total calcaneotomy as a surgical option in calcaneal osteomyelitis.

FM74

### Postoperative casting after Hallux valgus correction with a Reve-L ± Akin osteotomy: a technical description

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**Introduction:** Postoperative casting after a Hallux valgus correction is controlled with a Hohmann bandage or Hallux valgus cast. The patient has to redo the Hohmann bandage every day. For more patient comfort and controlling a individual postoperative position of the Hallux, in our institute we use during the early postoperative time the Hohmann bandage. When the stitches are removed, Kinesiology Tape replaces the Hohmann bandage using the following scheme. We use a 3d stretchable tape 5 cm × 450 cm.

**Preparation:** Clean the skin with an alcoholic fluid. Step 1: Place a tape, starting from plantar medial, 360° circular around the middle forefoot without tension and leave a spare end of tape of the same length as used. The tape around the forefoot is used as an anchor; the spare tape will act as a cover the following stripes. Additionally, cut two stripes of the tape with a length of 120–150 mm. Step 2: Position one end of the first stripe at the medial tip of the first toe over a distance of 10 mm without tension. Correct the Hallux in a neutral position unrolling the tape with tension until you reach the anchor with a straight position in the interphalangeal joint (IPJ) and metatarsophalangeal joint (MTPJ). Adhere the stripe without tension on the anchor. Step 3: Cut a stripe in 1/3 and 2/3 width over the whole length. Use the wide (2/3) stripe and cut one end over a distance of 25 mm in two parallel part, Y-like. Put those two parts from medial and apply it dorsal and plantar around the distal phalanx like a

stirrup. Hold the toe in a straight position in the IPJ and MTPJ. Unroll the Tape with a slight tension until you reach the anchor. Adhere the stripe without tension on the anchor. With this stripe you control the varus in the MTPJ. Step 4: Position the thin (1/3) stripe interdigital I–II at the halfway and build a sling around the base of the first toe without tension to fix the first two stripes and provide a bow string phenomenon. Step 5: Cover the anchor to fix all tapes with the spare tape from step 1 without tension. Patients are instructed to apply the tape, a change is recommended every five to seven days.

**Conclusion:** Taping is a feasible technique for external fixation after hallux valgus correction with a Reve-L ± Akin osteotomy. The application is simple and you can take the daily body care (eg. shower) with the tape.

FM75

### Augmented reality guided osteotomy in hallux valgus surgery

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**Introduction:** An optimal osteotomy angle can avoid shortening of the first metatarsal bone after hallux valgus surgery and therefore reduce the risk of transfer-metatarsalgia. Up to date the osteotomy is performed free-hand without guidance and is therefore prone to unwanted variability in accuracy. The purpose of the present ex-vivo study was to investigate whether overlaying a hologram (augmented reality, AR) would improve accuracy of the distal osteotomy during hallux valgus surgery.

**Methods:** A polyamide foot skeleton was constructed based a CT scan of a cadaveric foot and covered with medical silicon soft tissue. Three different polyamide first metatarsals were inserted to simulate a light, moderate and severe hallux valgus deformity. Distal Osteotomies of the first metatarsals were performed by two surgeons with different level of surgical experiences each with (AR, n = 15 × 2) or without (controls, n = 15 × 2) overlay of a hologram depicting an angle of osteotomy perpendicular to the second metatarsal in the transverse plane. Subsequently, the deviation to the plumb line of the second metatarsal in the transverse plane of all 60 osteotomies angles were optically measured and statistically analyzed.

**Results:** Overall, the AR-guided osteotomies were more accurate ( $4.9 \pm 4.2^\circ$ ) compared to the freehand cuts ( $6.7 \pm 6.1^\circ$ ) by tendency ( $p = 0.2$ ). However, while the inexperienced surgeon performed more accurate osteotomies with AR with a mean angle of  $6.4 \pm 3.5^\circ$  compared to freehand  $10.5 \pm 5.5^\circ$  ( $p = 0.02$ ), no significant difference was noticed for the experienced surgeons with an osteotomy angle of around  $3^\circ$  in both cases.

**Conclusion:** This pilot-study suggests that augmented reality guided osteotomies can potentially improve accuracy during hallux valgus surgery, particularly for less experienced surgeons. However, clinical studies are needed to investigate the clinical benefit of augmented reality in hallux valgus surgery.

FM76

### Results of the “European Knee Associates” survey on diagnosis of peri-prosthetic joint infection

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**Purpose:** Due to the juvenility of research in the field of periprosthetic joint infection (PJI), approaches employed for diagnosis of PJI vary amongst surgeons in different geographic regions. The aim of this study was to determine common diagnostic approaches utilized by European knee arthroplasty surgeons for the diagnosis of PJI.

**Methods:** A task force was established for questionnaire development, consisting of surgeons and clinical researchers who each had a record of publishing in the field of PJI. A pool of items was initially generated from a Medline literature search. These were organized into a file and independently sent to each task force member for evaluation and additional supplementation. After reaching a consensus, a final online version was generated and administered to all 4865 members of the “European Society of Sports Traumatology Knee Surgery & Arthroscopy”.

**Results:** There were 262 respondents between August 2015 and March 2016. Most European surgeons (41.1%) diagnose between 2 and 5 PJIs yearly, and only 5.8% diagnose >30 PJIs per year. Serum tests to rule out infection were commonly CRP (97.7%), leucocyte count (73.6%) and microbiology cultures (45.3%), while serum interleukins were least common (<5%). Synovial fluid exams most

commonly included microbiology (97.7%), leucocyte count (74.8%), percentage polymorphonuclear cells (65.8%), synovial fluid CRP (26.4%) and  $\alpha$ -defensin (19.4%). Conventional radiographs represent the most common radiographic exam (87.6%) followed by SPECT-CT scans (41.7%). The majority (93.6%) take biopsies at the time of surgery, 62.0% take 1–5 biopsies, and 34.9% take >5. Most biopsies (98.8%) are sent for culture exams and 72.5% for histology, and 36.4% of surgeons send the implants for sonication.

**Conclusion:** Microbiology and cell count remain the most commonly applied synovial fluid tests in Europe, while  $\alpha$ -defensin and leucocyte esterase are currently less common. Serum interleukins have not gained widespread use. Implant sonication, despite evidence of diagnostic effectiveness, was only applied by one-third of survey respondents, highlighting the problematic issues of cost and accessibility of some tools. The results highlight the current state of European diagnostic practice, emphasizing the areas of divergence from state of evidence and demonstrating the need for development of standard diagnostic algorithms.

FM77

### Rapid and accurate detection of periprosthetic infection in revision total joint arthroplasty by single-molecule microscopy: a prospective diagnostic test pilot study

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**Background:** Periprosthetic joint infection is among the most common and severe complications in total joint arthroplasty. Today, a combination of different methods is used for diagnosis because no single method with sufficient sensitivity and specificity is available. In this study, we explored the usability of single-molecule microscopy to detect periprosthetic joint infection in synovial fluid samples.

**Methods:** Patients (n = 27) that needed revision arthroplasty underwent the routine diagnostic procedures for periprosthetic joint infection of the University Hospital in Bonn. Additionally, the diffusion rate of two probes, dextran and hyaluronan, was measured in small volumes of periprosthetic synovial fluid samples using single molecule microscopy. To evaluate the suitability of single molecule microscopy to detect PJI the AUC for both markers were calculated.

**Results:** The diffusion rate of hyaluronan in periprosthetic synovial fluid from patients with septic loosening was faster than in samples from patients with aseptic loosening. Single molecule microscopy showed an excellent diagnostic performance, with an area under the receiver operating characteristic curve of 0.93, and allowed the detection of periprosthetic joint infection in patients that would be challenging to diagnose with current methods.

**Conclusions:** For the first time, single-molecule microscopy was used to detect periprosthetic joint infection. Our results are encouraging to study the value of single molecule microscopy in a larger patient cohort. The speed and accuracy of single-molecule microscopy may allow intraoperative diagnosis of periprosthetic joint infections in the future.

FM78

### Synovasure™ is less effective than the ELISA-based alpha-defensin test – a comprehensive meta-analysis of synovial biomarkers in periprosthetic joint infection

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**Purpose:** (1) To determine the overall accuracy of synovial alpha-defensin, synovial C-reactive protein (sCRP), interleukin-6 (sIL-6), and leukocyte esterase (sLE) as diagnostic markers for periprosthetic joint infection (PJI) and (2) to independently evaluate the accuracy of both the laboratory based ELISA alpha-defensin test and the Synovasure™ testkit.

**Methods:** An EMBASE and MEDLINE (PubMed) database search was performed using a set of professionally set search terms. Two independent reviewers rated eligible articles. Sensitivity and specificity were meta-analysed using a bivariate random-effects model.

**Results:** Accuracy values were extracted from 42 articles. Pooled sensitivity and specificity of the represented biomarkers were: alpha-defensin ELISA 0.97 (95% CI: 0.91–0.99) and 0.97 (95% CI: 0.94–0.98), respectively. Synovasure™ testkit assay 0.80 (95% CI: 0.65–0.89) and 0.89 (95% CI: 0.76–0.96), respectively. sLE 0.79 (95%



CI: 0.67–0.87) and 0.92 (95% CI: 0.87–0.92), respectively. sIL-6 0.76 (95% CI: 0.65–0.84) and 0.91 (95% CI: 0.88–0.94), respectively. sCRP 0.86 (95% CI: 0.81–0.91), and 0.90 (95% CI: 0.86–0.93), respectively. **Conclusion:** The laboratory based alpha-defensin ELISA test showed the highest ever reported accuracy for PJI diagnosis. However, this did not apply for the Synovasure™ alpha-defensin test, which was comparable in its overall diagnostic accuracy to sCRP, sIL-6 and sLE. The later biomarkers also did not yield an overall diagnostic accuracy higher than that previously reported for synovial white cell count (sWBC) or culture bacteriology. Based on current evidence, no synovial biomarker should be applied as a standalone diagnostic tool. Furthermore, the use of the laboratory based alpha-defensin ELISA test should be encouraged, not the Synovasure™ testkit.

\*FM79

#### Treatment of prosthetic-joint infections: success rate over the last 10 years

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**Introduction:** There is a constant increase of total joint arthroplasties to improve the quality of life of an aging population. Prosthetic-joint infections are rare, with an incidence of 1–2%, but they represent serious complications in terms of morbidity and mortality. Different therapeutic options exist, but their management is still poorly standardized because of the lack of data from randomized trials. The aim of this retrospective study is to assess the infection eradication success rate over the last ten years using different patient adapted treatment options.

**Methods:** Patients having a prosthetic-joint infection at Lausanne University Hospital (Switzerland) between 2006 and 2016 were included. The success rate depending on age, type of prosthesis, type of infection and type of surgical procedure was analyzed.

**Results:** 444 patients (61% hips, 37% knees) were identified with a median age of 70 years. The success rate was 93% for two-stage exchange, 78% for one-stage exchange and 75% for debridement with retention of the prosthesis. The failure rate was higher for knee prosthetic-joint infections (27%) than hip infections (13%). Furthermore, chronic and in elderly prosthetic-joint infections seemed to have a worse prognosis.

**Conclusion:** The infection eradication depends on age, type of prosthesis, type of infection and type of surgical procedure, with three times less failure in two-stage exchange surgery.

FM80

#### Risk factor analysis for above-the-knee-amputation in patients with periprosthetic joint infection of the knee

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**Introduction:** Periprosthetic joint infection (PJI) is a severe complication following knee arthroplasty. Therapeutic strategies comprise a combination of surgical and antibiotic treatment modalities and aim to eradicate the infection while salvaging the limb. In certain patients, however, control of the disease can only be attained by above-the-knee-amputation (AKA). This study offers an in-depth analysis of such patients, with the objective to identify risk factors that may differentiate them from those with limb salvage (LS).

**Methods:** Between 2005 and 2015 11 cases of PJI of the knee were treated with AKA. In a retrospective case-control study they were juxtaposed to 57 cases of PJI with LS. Data evaluation examined 1. demographics and comorbidities represented by the ASA (American Society of Anesthesiologists) classification system and the calculated 10-year survival rate based on the age-adjusted Charlson comorbidity score 2. factors related to previous surgeries and the inherent implant 3. disease related factors including the time interval between arthroplasty and onset of symptoms, clinical and laboratory parameters, as well as microbiological aspects, and 4. therapy related factors such as revision strategy, number of surgeries, and details of antibiotic treatment. By application of Pearson's chi-square test and student's t-test results of patient subgroups were compared.

**Results:** A total of 68 cases were analyzed, thereof 37 women and 31 men. The mean age was 71.02 years ( $\pm 11.22$ ), the mean BMI 30.62 kg/m<sup>2</sup> ( $\pm 8.17$ ). Sixteen patients were smokers, 15 of which suffered an early or acute infection as opposed to delayed infection, identifying nicotine abuse as a risk factor for the former ( $p = 0.027$ ). The subgroup analysis of AKA versus LS showed alcohol abuse as well as a comparatively lower preoperative hemoglobin level (AKA: 99.89 g/l

( $\pm 15.09$ ); LS: 118.17 g/l ( $\pm 19.87$ )) to be significantly more often associated with AKA ( $p = 0.015$ ;  $p = 0.011$ ). The number and severity of comorbidities, as measured by ASA grading (AKA: ASA I: 1, ASA II: 1, ASA III: 9, ASA IV: 0, ASA V: 0; LS: ASA I: 0, ASA II: 26, ASA III: 26, ASA IV: 5, ASA V: 0) and by the estimated 10-year survival rate (AKA: 90.0% [ $\pm 20.5$ ]; LS: 74.9% [ $\pm 34.9$ ]), tended to be higher ( $p = 0.009$ ;  $p = 0.053$ ).

**Conclusion:** AKA in the setting of PJI of the knee is rarely necessary. Those patients with a history of alcohol abuse, severe comorbid conditions and low preoperative hemoglobin may be at higher risk.

FM81

#### Should native septic joint arthritis be considered as immediate surgical emergency?

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Acute native joint septic arthritis is generally considered a surgical emergency, requiring immediate drainage within hours, including during night shifts. However, there are few data supporting the need for this degree of urgency.

**Methods:** We performed a retrospective review of all adult patients seen in our medical center from 1997–2015 with culture-proven arthritis, specifically examining the epidemiology of sequelae, and their possible association with the surgical delay.

**Results:** Of 204 septic arthritis episodes, 46 (23%) involved interdigital hand and foot joints. The large joints included the knee ( $n = 67$ ), shoulder (48), hip (22), ankle (8), acromio-clavicular (5), elbow (4), wrist (3), and sterno-clavicular (1) regions. All patients underwent surgical drainage and received targeted systemic antibiotic therapy. Sequelae of varying severity occurred in 83 patients (41%): recurrences ( $n = 15$ ); secondary arthrosis (30); pain (9). Girdlestone procedure (9); arthrodesis (9); amputation (8); stiffness (8); and algodystrophia (2). By multivariate Cox regression analysis, the following factors did not predict sequelae: age; treatment with corticosteroids; pre-existing clinical or radiological arthropathy; total duration of antibiotic therapy; location or type of joint; and the number of surgical interventions. Similarly, there was no influence on sequelae of the number of days of pre-hospitalization arthritis symptoms (odds ratio 1.0, 95% confidence interval 0.99–1.01) and hours spent in the emergency room (OR 1.0, 0.9–1.2). Specifically, joint lavage performed within 6 hours of presentation yielded the same functional outcome as lavage done between 6–12 hours, 12–24 hours, or >24 hours.

**Conclusion.** Our data suggest that, in the absence of clinical sepsis, immediate emergency joint drainage does not seem to reduce the risk of sequelae in patients with septic arthritis.

FM82

#### Does temporary external fixation and staged protocol for closed fractures lead to bacterial contamination of the surgical site and associated complications? – A prospective trial

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**Introduction:** Temporary external fixation is a viable option for numerous conditions and fixations in orthopaedic and trauma surgery. If the external fixator is left in place it is necessary to disinfect it prior to surgery, yet the subsequent risk for bacterial contamination of the surgical site originating from the external fixator remains unknown.

**Methods:** In a prospective study samples were taken at the time of definitive osteosynthesis to assess bacterial contamination of the surgical site and the external fixator in twenty consecutive patients treated with temporary external fixation for closed fractures from October 2016 until March 2017.

**Results:** Twenty patients with twenty external fixators were available for analysis with complete sampling and a mean follow-up of 92 days (range: 81–124). Ten out of 120 cultures of the surgical site (8.3%) were positive for bacterial growth in a total of seven patients (35%). Pathogen's detected were *Propionibacterium acnes* (60%) and *Staphylococcus epidermidis* (30%). No contamination of the external fixator was detected.

**Conclusion:** We conclude that the presented perioperative management to decontaminate external fixators allows for a safe definitive osteosynthesis in a staged protocol without increasing bacterial contamination of the surgical site. It is safe to leave the external fixator in place for definitive osteosynthesis.

FM83

### Cutibacterium avidum colonization in the groin is associated with obesity: a potential risk factor for hip periprosthetic joint infection (PJI)

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**Background:** An increase in the incidence of hip periprosthetic joint infections (PJIs) caused by *Cutibacterium avidum* has recently been detected after implantation of hip arthroplasties with an anterior surgical approach. We raised the question of whether skin colonization with *C. avidum* differ between the anterior and the lateral thigh as areas of surgical incision fields.

**Methods:** Between February and June 2017, we swabbed the skin at the groin and the anterior and lateral thigh in all patients undergoing a primary hip arthroplasty. We anaerobically cultured swabs for *Cutibacterium* spp. for at least 7 days. Univariable logistic regression analysis was used to explore associations between body mass index (BMI) and colonization rate at different sites.

**Results:** Twenty-one of 65 patient (32.3%) were colonized with *C. avidum* mainly at the groin (n = 16, 24.6%) which was significantly higher than at the anterior (n = 5, 7.7%, P = 0.009) or lateral (n = 6, 9.2%) thigh (P = 0.019). Patients colonized with *C. avidum* did not differ in age or sex compared to non-colonized patients, but BMI was significantly higher (30.1 kg/m<sup>2</sup> and 25.6 kg/m<sup>2</sup>, respectively, P = 0.019). Furthermore, increased BMI was also associated with colonization at the groin (odds ratio per unit BMI increase: 1.15, 95% confidence interval: 1.03–1.29, P = 0.014).

**Conclusions:** Not the anterior thigh but the groin showed colonization for *C. avidum* in obese patients. We propose to consider a more intensive skin disinfection of the groin to avoid contamination of the closely located anterior surgical field when using the anterior approach in hip arthroplasty.

FM84

### Soft tissues sarcomas, a review of 221 cases

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**Introduction:** Soft tissue sarcomas (STS) are rare tumours (1–2% of all cancers) that should be referred to specialized centers with multidisciplinary teams. As compared to neighboring countries, our sarcoma center is of small size, with 74 new cases treated in 2017 (34 musculoskeletal). The purpose of our study was to compare our results with the literature.

**Material and method:** From 2000 to 2014, we found 221 patients treated for musculoskeletal STS in our institution. We analysed the medical files regarding the epidemiologic data, treatment modalities and oncological outcome. There were 125 male and 97 female patients. Median age was 49 y.o. (12 to 94.) The most frequent histotypes were unclassified sarcomas (28%), liposarcomas (24%), myxofibrosarcomas (10%) leiomyosarcomas (7%) and synovial sarcomas (7%). Most of the tumours were located on lower limb (82%) mostly on the thigh (49%), 14% were on upper limb and 4% in the spine. Location was deep in 71% and subcutaneous in 29%. Size was >10 cm in 33% and <5 cm in 37%. Twenty-nine percent were referred after unplanned excision and needed a re-excision; it increased to 59% for subcutaneous STS. Most patients had surgical excision (96%) in our centre, 62% had radiotherapy, mostly pre-operative, 14% chemotherapy and 10% had isolated limb perfusion. All patients who did not have a surgical excision were in a palliative situation.

**Results:** Mean follow-up was 6.5 years (9 month to 10 years). Eleven patients were lost for follow-up. Local recurrence rate was 9%, distant recurrence 30% and mortality due to STS was 15% (9% after 2 years and 14% after 5 years). Mortality rate may be underestimated because some patients had less than 5 years of follow-up. All patients but one who died of the disease had distant recurrence.

**Discussion:** Our demographic data, mode of treatment and results are comparable with literature. Minimal caseload is a major concern in the treatment of rare diseases like sarcomas. As compared to most neighbouring countries, Switzerland has more so-called "specialized centres" per inhabitant. European CanCer Organisation (ECCO) established checklists of essential requirements for Sarcoma reference centres to provide a high-quality care. To maintain quality of treatment, there should be only a limited number of certified sarcoma centres, and any patient with a suspicion of bone or soft tissue sarcoma should be referred to one of them.

### Impact of biopsy sampling errors and quality of surgical margins in treating chondrosarcoma

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**Introduction:** The purpose was to examine the frequency of CT-guided biopsy sampling errors in chondrosarcomas, as well as the impact of these errors and the achieved surgical margins on the local recurrence free survival (LRFS) and the disease specific survival (DSS).

**Methods:** 68 consecutive patients treated for biopsy-proven chondrosarcoma from 2000 to 2015 were retrospectively reviewed. Biopsy sampling error was present if the histopathology of the resection revealed different histological grade compared to the preoperative biopsy. Surgical margins were classified according to Enneking. Additionally, the resection margin (mm) and the presence of an anatomical barrier (fascia, periosteum) at the closest margin were recorded.

**Results:** The primary location was at the extremities in 46 patients (68%) and at the axial skeleton in 22 patients (34%). 14 patients (9%) underwent planned intralesional curettage for a low-grade lesion at the extremities. Surgical margins were assessed in the remaining 54 patients and included 21 wide, 39% 25 marginal (46%) and 8 intralesional (15%) resections. Biopsy sampling errors occurred in 10 patients (15%). In 4 patients, the grading was corrected from low- to high-grade, in 3 patients from high-grade to dedifferentiated and in 3 patients from benign to low-grade. 2 out of these 10 patients required further surgery due to the sampling error. LRFS was 82% ± 8 at 5 years and 77% ± 8 at 10 years. An intact anatomical barrier was associated with the most preferable LRFS at ten years (89%). DSS was 79% ± 9 at 5 years and 76% ± 7 at 10 years. The metric distance of the surgical margin and the presence of a biopsy sampling error did not affect the LRFS and DSS.

**Conclusions:** Even though histologic grading in chondrosarcoma is difficult, sampling errors in preoperative biopsy are relatively rare and do not deteriorate outcome. Presence of an anatomical barrier has higher impact on LRFS than metric distance of surgical margins.

FM85

### High Intensity Focused Ultrasound treatment for relapsing extra-abdominal desmoid tumors

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**Purpose:** Desmoids are locally infiltrative, non-malignant soft tissue tumors. Currently, initial observation depending on tumor size is advocated, alternatively, combination of well established treatment modalities is envisaged. Local recurrence or disease progression is often a challenging problem. MR-HIFU (Magnetic resonance – High Intensity Focused Ultrasound) is increasingly recognized as a treatment modality. We assessed the success rate of MR-HIFU for the treatment of extra-abdominal desmoids at our institute.

**Patients and Methods:** Five patients with relapsing desmoid tumors (three males, two females; age range 40–79 years) were treated with MR-HIFU. Changes in total tumor volumes were measured with a tumor tracking software (IntelliSpace, Philips). Adverse events were documented.

**Results:** MR-HIFU was successfully applied in all patients without severe side effects. Follow-up periods range from 2 to 60 months. Initial median tumor volume was 23 ml (range 3–70 ml), volumes decreased significantly in all patients. Two patients required more than one treatment session. After HIFU, there was no relapse or progression of disease for at least six months. No patient needed general anesthesia and all patients were treated as outpatients. Skin injury was correlated with distance to skin (average 0.7 cm [0.5–0.9 cm]) and/or proximity to bone (i.e. ribs). Both patient accepted the risk beforehand. Complete healing of the skin burns was recorded after a few weeks.

**Conclusion:** MR-HIFU can safely be applied in patients with recurring desmoids, and can be used as an effective, outpatient treatment. Small lesions have a high probability of complete ablation. In cases of incomplete ablation, MR-HIFU can be repeated until the desired therapeutic effect is achieved. There is repeated risk of skin burns when lesions are in the proximity of bones, or less than 10 mm away from skin.

FM87

### Cortical bone allograft in the treatment of bone deformity caused by fibrous dysplasia

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**Introduction:** Fibrous dysplasia (FD) is a benign, medullary, fibro-osseous lesion. In the proximal femur it can lead to severe deformity and pathologic fracture. Allogenic cortical bone graft (instead of cancellous bone) was suggested due to the reduced tendency of resorption and replacement by dysplastic tissue.

**Objectives:** We wish to draw attention to the therapeutic problems of extensive FD with impending fracture and to present 3 cases of osteotomies or stabilization following grafting.

**Patients:** Case 1: Female patient (38 y) diagnosed to have FD at age 8 years presented with a shepherd crook deformity caused by extensive changes of the left femur and hemipelvis. The neck-shaft-angle was 70°, femoral neck retortorsion 15°. In 11/2016 fresh frozen cortical tibia struts were inserted into the femoral neck and shaft in "gamma-nail-style". 11 months later the proximal femoral anatomy was restored by intertrochanteric shortening wedge osteotomy with 40° valgisation and 20° rotation. Case 2: Male patient (26 y), progressive pain with weight bearing, extensive fibrous dysplasia of the left proximal femur and ilium together with AVN of the femoral head. Surgical treatment was necessary due to impending fracture of the proximal femur - fixation was done with 95° blade plate and cancellous bone graft together with retrograde drilling of the femoral head AVN. 8 weeks later bone grafting of the ilium with cortical bone powder was done through a Smith-Peterson approach. Case 3: Female patient (18 y), pain during 3 years with weight bearing activities. X-ray and MRI showed an extensive lesion of the proximal femur without deformity and a fissure of the calcar. In 03/2016 the lesion was curetted and filled with allogenic cortical bone powder and the femoral neck stabilized with a 130° blade plate.

**Results:** Case 1: Pathologic examination of the resected wedge showed incorporation of the cortical graft to the patient's cortex. 9 months after the osteotomy she was full weight bearing and pain free. Case 2: At 12 months f/u the bone graft was united and the patient had slight residual pain from the nonprogressive AVN. He now presents with adequate bone stock to implant a THA if needed lateron. Case 3: At 24 months postop the patient is painfree, fully weight bearing and back to sports.

**Conclusion:** Structural allografts and cortical bone powder in our patients united well and made further surgical procedures possible – which consisted of corrective osteotomies or stabilisation.

FM88

### Mid- and longterm survivorship and clinical outcome of tumor prosthesis reconstruction around the knee

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**Background:** Distal Femur and proximal tibia are the most and second most common sites for primary malignant bone tumors, special tumor prosthesis were commonly used to rebuild the bone defect after the tumor resection. We reviewed retrospectively the long-term results in 33 patients with knee tumor prosthesis reconstruction and evaluated the risk factors associated with survivorship and clinical outcome of tumor patients.

**Patients and Methods:** We collected the patients with musculoskeletal tumor around knee joint including proximal tibia and distal femur treated by tumor prosthesis during 1990–2017. The mean age was 34.06 years old (8–74 years). The overall median follow-up was 7.03 years (0.6 to 27.2 years). The minimum follow-up of alive patients was at least one year. Survivorship outcome will be evaluated by the overall survival and revision-free survival (5 years and 10 years). Complications and failure were classified according to Henderson. The function after the operation was evaluated by the Musculoskeletal Tumor Society (MSTS) score. Other major factors including tumor size, previous knee joint relative surgery, silver coated and cemented implants.

**Results:** The median overall oncological survival of all patients was 17.9 years and 5 patients died. 10-year oncological overall survival of all patients was 80.64%. The median revision-free survival was 10.9 years (1.8 to 10.9 years). 5-year revision-free survival was 91.23%, 10-year revision-free survival was 54.15%. Prosthesis failure

was observed in 9 cases (26.7%), four caused by structural failure, 4 caused by aseptic loosening and 1 by infection. Patients' age less than and equal to 40 years old ( $p = 0.0269$ ) and diagnosis with osteosarcoma ( $p = 0.0089$ ) had a shorter survival time and higher failure rates. The mean MSTS- Scores in normal group were 25.4 (84.7%), range 14 to 30 (46% to 100%). In failure group were 24 (80%) range 14 to 30 (46% to 100%). No amputation was made and the limb salvage rate was 100%. When failure happened, another 1.9 times (range from 1–5) prosthesis relative operations were needed to solved the prosthesis failure problem.

**Conclusion:** The age less than 40 years old and osteosarcoma at diagnosis were two risk factors for the failure of the knee tumor prosthesis in our research series. The knee tumor prosthesis can achieve long-term limb survival in the all patients and majority with satisfying function, even underwent prosthesis failure and revision surgery.

FM89

### Primary bone lymphoma – a diagnostic challenge

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**Introduction:** The highest rate of non-diagnostic musculoskeletal biopsies was found for bone lymphoma with 21% [1].

**Rationale:** The diagnosis of primary bone lymphoma is based upon a high index of suspicion. Based on our experience we wish to sensitize recognizing the typical pattern by our data as a "model", how to avoid diagnostic pitfalls.

**Patients:** 17 patients aged 19–74 y newly diagnosed with non-Hodgkin large B-cell primary bone lymphoma 2009–2017; symptoms averaged 4 mo. Involved bones were Ilium (3), Tibia (2), Femur (9), Humerus (1), Sacrum (1), and Radius (1). Imaging included standard X-Rays exhibiting a diffuse mixture of radiolucency and radiodensity of permeating destruction pattern and MRI. In all lymphoma was considered in the initial work-up; in 7 the 1st biopsy was not diagnostic; in 3 a 3rd and in 1 the 4th biopsy definitely proved the diagnosis. All biopsies were tru-cut (8 or 11G) or core biopsies with 6mm diameter. All patients received systemic chemotherapy and except one adjuvant radiotherapy 36/40 Gy.

**Representative case:** The 26 y old man had acquired Chlamydia trachomatis-urethritis. Simultaneous painful swelling of the knee In spite of bacteriologic negative puncture showing pleocytosis, he was treated as chlamydial gonarthrit with doxycycline and repeated intraarticular corticosteroid injections. Because of progressive changes in the MRI 3 mo later the patient was sent for 2nd second. The first biopsy in spite of 95% necrosis appeared compatible with the suspected lymphoma. Repeat biopsies at implantation of a Port-A-Cath confirmed the diagnosis of large B-cell Lymphoma. The patient received chemotherapy and radiotherapy. Unfortunately due to the extensive destruction and necrosis of the medial femoral condyle he needed an infracondylar valgisation osteotomy 13 mo later.

**Results:** Presently 16 patients are diseasefree, one for now 7 years has stable disease.

**Conclusions:** The indication for biopsy of musculoskeletal lesions must be based on strong evidence. Following non-diagnostic results (either normal or non-pathologic tissue) it is mandatory to perform additional biopsies until a conclusive result is achieved. We have repeatedly encountered patients with delayed sometimes catastrophic outcome, when a result 'no malignant tissue' was accepted without further studies.

**Reference:** 1. Chang C.Y. et al. Percutaneous CT-guided needle biopsies of musculoskeletal tumors: a 5-year analysis of non-diagnostic biopsies. *Skeletal Radiol* 2015(44):1795–1803.

\*FM90

### Carbon/PEEK implants in orthopaedic oncology: a case series

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**Introduction:** Whereas primary bone tumors are comparatively rare, the bone is a frequent site of metastases of a variety of tumors. Radiation therapy is an important element in musculoskeletal oncology, especially when encountering multiple or osteolytic lesions. Often, a surgical stabilization with implants is required. However, metallic implants not only make the CT-based planning of a subsequent radiation therapy more difficult, but might also have an

uncontrolled dose modulating effect in adjuvant radiotherapy. In addition, follow-up imaging and the diagnosis of local recurrences is often obscured by metallic artefacts. Radiolucent implants consisting of carbon/polyether ether ketone (PEEK) therefore facilitate adjuvant radiation therapy and follow-up imaging of bone lesions. We hereby present first clinical cases with application of carbon/PEEK implants in orthopaedic tumor surgery.

**Methods:** We report a single-center experience of three patients with surgical stabilization of osteolytic bone lesions using carbon/PEEK implants. Detailed information about the clinical presentation, preoperative considerations, intraoperative surgical procedures and postoperative results is provided for each case.

**Results:** One spinal lesion (T12 vertebral body), one lesion of the upper extremity (humerus) and one of the lower extremity (tibia) were surgically stabilized with use of carbon/PEEK implants. With a mean follow-up of 9 months (range 3–22 months), no adverse events were observed. Two patients received adjuvant radiotherapy. Follow-up imaging was obtained in all patients.

**Conclusion:** The clinical applicability of carbon/PEEK implants in orthopaedic tumor surgery is good with respect to intraoperative handling, application of adjuvant radiotherapy and postoperative imaging. However, some limitations as to material properties and current implant availability need to be considered. Larger comparative studies need to verify clinical and radiotherapeutic benefits.

FM91

### Acromion index and supraspinatus muscle degeneration are positively correlated in patients undergoing reverse shoulder arthroplasty

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**Introduction:** The acromion index (AI) has been reported to be significantly higher in patients with supraspinatus tendon tears. The AI has however not yet been correlated with an objective quantification of muscle degeneration. Therefore, our objective was to test the hypothesis that the AI is correlated with rotator cuff muscle degeneration.

**Methods:** We selected 27 patients (8 M / 19 F, age range 68–86 years) diagnosed with primary glenohumeral osteoarthritis and who underwent reverse total shoulder arthroplasty. The AI measurement was extended in 3D, from the initial 2D description by Nyffeler et al. It was defined as  $AI = GA/GH$ , where GA is the gleno-acromial and GH is the gleno-humeral distance, respectively. In 3D, we selected the most lateral point (along the scapular axis) of the acromion from a 3D model obtained by segmentation of preoperative shoulder CT scans. Glenoid cavity points were identified from the 3D model, based on a curvature criterion. The acromion and glenoid points were projected on the scapular plane. Principal axes of glenoid points were calculated, and the major axis was used to measure the distance from the acromion point, to determine GA. GH was estimated by the diameter of a sphere fitting specific 3D landmarks on the humeral head. The degeneration of the supraspinatus (SS), subscapularis (SC), infraspinatus (IS), and teres minor (TM) muscles was semi-automatedly quantified on the classic sagittal-oblique ("Y view") CT section perpendicular to the scapular plane and passing through the spinoglenoid notch. We calculated correlations between the AI and muscle degeneration ratios.

**Results:** The AI was  $0.56 \pm 0.14$ . Degeneration ratios of SS, SC, IS, and TM were  $63\% \pm 12\%$ ,  $48\% \pm 18\%$ ,  $51\% \pm 18\%$ , and  $44\% \pm 20\%$ , respectively. The AI was moderately positively correlated with SS degeneration ( $r = 0.435$ ,  $p = 0.0234$ ). There were no significant correlations with the other three rotator cuff muscles.

**Conclusions:** We confirmed and quantified the hypothetical positive correlation between the AI and SS muscle degeneration. The strength of this study was to propose an innovative 3D, quantitative and thus objective method for measuring both the AI and rotator cuff muscle degeneration from CT scans. It was however limited by its relatively small sample size. The AI may thus be considered as a risk factor for SS muscle degeneration, and help better understand its biomechanical causes.

### Relative angular velocity of scapular rotation during shoulder abduction: normal reference motion pattern in healthy volunteers

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**Introduction:** Normal scapular kinematics is still not well understood. Increasing popularity of reverse shoulder arthroplasty accentuates the need for comparative normal values using a methodology that can safely and non-invasively be applied in patients as well. The relation between scapulo-thoracic (ST) and gleno-humeral (GH) motion may change after reverse shoulder arthroplasty. The aim of this study was to find how scapular motion participates in overall shoulder abduction in healthy normal population.

**Methods:** We studied the shoulder kinematics including the scapula in 20 healthy young individuals (age mean 27 y; range 22–33 y; w:m 7:13). We applied the validated ULEMA model (Upper Limb Evaluation in Motion Analysis) using 8 infrared cameras (VICON) and skin-markers. Numeric analysis has been performed with MatLab, and R. We studied ST rotation and GH abduction during global shoulder abduction (SA). Relative contribution of ST and GH throughout the SA was assessed and visualized. This enabled to study relative angular velocity (per frame) instead of cumulative contribution (scapular rhythm) in single static positions.

**Results:** There were two different patterns of relative contributions of ST and GH to SA. In 55% relative angular contribution of GH was always higher than ST. In the other 45% we observed switching from higher GH to higher ST contribution in the SA range between 70° and 110°. We also observed that with initial muscle activation the scapula exhibited unexpected medial (instead of lateral) rotation before any visible SA. This was a constant finding at the beginning of the motion cycle.

**Conclusion:** Scapular kinematics in healthy young population shows two normal basic patterns: continuously lower relative ST contribution, or switching between higher GH and higher ST contribution.

FM93

### Variability of the acromion index and critical shoulder angle: computed tomography evaluation in 500 non-osteoarthritic shoulders

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**Background:** The AI and CSA have recently been shown to be predictors of rotator cuff tendon tears and/or glenohumeral osteoarthritis. While originally measured on shoulder radiographs, CT proved to be a highly reliable alternative. Most previous studies on the AI and CSA were performed on relatively small patient cohorts or cadavers with shoulder disorders, yet data on normative values in the general population are scarce. The aim of the study was to determine the variability of the acromion index (AI) and critical shoulder angle (CSA) in a large patient population with non-osteoarthritic shoulders on computed tomography (CT), and evaluate the influence of gender, age, height, and the side-to-side symmetry.

**Methods:** We retrospectively reviewed whole-body CT scans of 250 polytrauma patients over 6 years. We selected 50 patients per decade for five consecutive decades (1950-9 to 1990-9), taking 35 males per decade, yielding 175 males and 75 females overall. Exclusion criteria were incomplete CT coverage and CT signs of osteoarthritis or fractures. Three independent observers measured the AI and CSA of both shoulders.

**Results:** Overall ( $n = 500$ ), the mean  $\pm$  SD AI and CSA were  $0.64 \pm 0.06$  and  $32.3 \pm 3.5^\circ$ , respectively. The AI and CSA were strongly positively correlated ( $r = 0.720$ ,  $p < 0.001$ ). The AI was significantly larger in right ( $0.65 \pm 0.06$ ) than left ( $0.64 \pm 0.06$ ) shoulders ( $p < 0.001$ ), though the effect size was small ( $d = 0.17$ ). The CSA was comparable between right and left shoulders ( $p = 0.797$ ). There were no significant differences in AI ( $p = 0.537$ ) nor CSA ( $p = 0.960$ ) between genders. No significant correlations were found between the AI, respectively CSA, and patient age ( $p = 0.138$ ) nor height ( $p = 0.130$ ). Interobserver reliability was good (ICCs =  $0.762$ – $0.869$ ).

**Conclusions:** The AI and CSA are strongly positively correlated and do not vary with patient gender, age, and height in non-osteoarthritic shoulders. While the CSA is side-to-side symmetric, the AI is very slightly larger in right shoulders, which may be related to arm dominance.

\*FM94

### Reverse shoulder arthroplasty in patients with Os acromiale: a matched case-control study

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**Introduction:** Os acromiale is reported to be associated with massive rotator cuff tears. Reverse total shoulder arthroplasty (RTSA) is a common method to treat cuff tear arthropathy. This procedure increases deltoid tension which potentially leads to excessive stress the os acromiale. This study assesses outcomes and complications using a matched case-control analysis.

**Methods:** From 2005 to 2016, 962 RTSA were performed at the author's institute. Preoperative CT scans review identified 53 shoulders (6%) with os acromiale. Analysis matched these to three controls considering: age, gender, length of follow-up, type of surgery (primary, revision and fracture) with minimum 1 year follow-up. Primary outcomes included: Constant Score (CS), subjective shoulder value (SSV) and range of motion (ROM) at 1 year, 2 years postoperative and at latest follow-up. Secondary endpoints included: tenderness over the os acromiale, complications and revision surgery.

**Results:** Absolute CS, SSV and mean flexion did not differ significantly when compared to the control group at 2 years postoperative (CS:  $56 \pm 17$  vs.  $60 \pm 19$ , SSV:  $70 \pm 24$  vs.  $69 \pm 27$ , mean flexion:  $109 \pm 34$  vs.  $121 \pm 35^\circ$ ). All of these improved in both groups significantly when compared to preoperative state ( $p < 0.001$ ). Mean flexion was significantly better at latest follow-up (mean 56 months range 25–121) in the control group ( $101 \pm 40$  vs.  $118 \pm 32^\circ$ ;  $p < 0.05$ ). All 12 cases (23%) with persistent local pain were treated non-operatively, after 24 months 8 of these resolved, 4 are still painful (3 under and 1 above 24 months).

**Conclusion:** Functional outcome of RTSA in patients with os acromiale is not significantly inferior compared to a matched case-control group at 1 and 2 years postoperative with slightly inferior ROM, nonetheless controls seem to have better outcomes in the long term. Local tenderness is the most common complication after RTSA in patients with os acromiale which usually resolves around 2 years postoperative without surgery.

FM96

### Different acromial roof morphology in concentric and eccentric osteoarthritis of the shoulder: a multiplane reconstruction analysis of 105 shoulder CT scans

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**Introduction:** The pathomechanism of static posterior humeral head subluxation and eccentric, posterior glenoid wear remains still unclear. While there are increasing evidence of bony differences between shoulders with rotator cuff tears and osteoarthritis, similar couldn't be shown for primary concentric and eccentric osteoarthritis. So far, research focused mainly on glenoid version and inclination, but with inconclusive results. The aim of this study was to examine the acromial roof as a potentially pathologic factor in development of posterior glenoid wear in primary EOA of the shoulder.

**Methods:** We analyzed CT images of 105 shoulders (86 patients) with primary osteoarthritis. Based on the classification of Walch, the shoulders were defined as concentric (Walch A, group COA) (45 shoulder) or eccentric (Walch B, group EOA) (60 shoulder). A comparison of acromial shape, acromial roof orientation and antero-posterior glenoid coverage was performed in a multiplane reconstruction analysis of CT scans.

**Results:** 1.) Acromial shape: Acromial length, width, area and lateral margin was not significant different between concentric and eccentric osteoarthritis. 2.) Acromial roof orientation: The acromial roof associated with concentric osteoarthritis was on average  $5^\circ$  steeper (sagittal tilt  $p < 0.01$ ) and  $5^\circ$  more up-ward tilted (coronal tilt  $p < 0.01$ ). There was no difference in axial rotation (axial tilt  $p = 0.47$ ).

3.) Antero-posterior glenoid coverage: The glenoid was on average  $4^\circ$  more posterior ( $p = 0.01$ ) and  $4^\circ$  less anterior covered by the acromial roof ( $p = 0.04$ ) in patients with concentric osteoarthritis. No differences could be shown for overall glenoid coverage ( $p = 0.99$ )

**Conclusions:** The acromial roof could play a role in the pathogenesis of eccentric osteoarthritis of the shoulder. Missing posterior support due to a flatter acromion with less posterior glenoid coverage could be a reason for static posterior subluxation of the humeral head and posterior glenoid wear. Further biomechanically investigations are needed to confirm this hypothesis.

FM97

\*FM95

### Anteroposterior acromion tilt as a predictor for posterior glenohumeral erosion (B2/C)

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**Background:** Predisposing factors for posterior translation of the humeral head, with or without glenohumeral osteoarthritis, are unknown. In this study we tested the hypothesis that there is an association between glenoid wear and anatomical parameters affecting anteroposterior joint stability such as posterior acromial slope and glenoid version.

**Methods:** Ninety-nine patients with joint degeneration involving advanced cartilage wear and/or rotator cuff disease scheduled for anatomical or reverse total shoulder replacement underwent standardized conventional radiographic and computed tomographic shoulder imaging. Measurements included glenoid version, humeral torsion, posterior acromial slope and critical shoulder angle (CSA). Additionally the glenoid shape was classified according to Walch and the integrity of the rotator cuff was assessed.

**Results:** Patients with glenoid types B2 or C according to Walch had significantly more  $4^\circ$  of glenoid retroversion ( $p = 0.022$ ), greater values for posterior acromial slope  $61^\circ$  vs.  $56^\circ$  ( $p = 0.004$ ) and a higher combined score (glenoid version minus slope; odds ratio 0.93 [95% confidence interval 0.89–0.97],  $p < 0.001$ ; cut-off  $-27^\circ$ ). Regarding rotator cuff tears, the lesions of subscapularis, supraspinatus and infraspinatus were significantly associated with less posterior erosion on the glenoid.

**Conclusion:** The study's hypothesis was confirmed that the bony shoulder structure, particularly of the acromion, at least partly determines the type of glenoid wear. Both, a more horizontal posterior acromial slope and more posterior glenoid version are found in posterior shoulder wear and are thus being partially responsible for the development of posterior osteoarthritis. It may be speculated, that with the rupture of the tendons, a weaker pull affects the humerus which, therefore, reduces the grinding against the glenoid.

### Scapular rhythm throughout shoulder abduction before and after reverse total shoulder arthroplasty: preliminary results

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**Introduction:** Scapular kinematics after RTSA is still not well understood. From the ULEMA (Upper Limb Evaluation in Motion Analysis) model, we developed a method to assess continuous relative scapular contribution in global shoulder abduction. In a previous study, we presented two normal kinematic patterns, which can now compared to motion patterns after RTSA. The aim of this study was to find how scapular motion participates in overall shoulder abduction after reverse total shoulder arthroplasty (RTSA).

**Methods:** We prospectively studied the scapular kinematics in 10 patients assigned for RTSA (age mean 74 y; range 65–86 y; w:m 7:3). The patients underwent kinematic analysis preoperatively, at 3, 6 and 12 months postoperatively. We applied the ULEMA model using 8 infrared cameras (VICON) and skin-markers. Numerical analysis has been performed with MatLab, and R. We studied scapula-thoracic rotation (ST) and gleno-humeral abduction (GH) during global shoulder abduction (SA). Relative contribution of ST and GH throughout the SA was assessed and visualized. This enabled to study relative angular velocity (per frame) instead of cumulative contribution (scapular rhythm) in single static positions.

**Results:** Preoperatively all patients showed compressed (due to low SA) crossing patterns. After 3 months, the patterns were no longer compressed, but still crossing indicating two-phasic motion: at the beginning of SA GH contributed more, later the ST motion was higher than GH. Only one of 10 patients developed a pattern showing the predominance of GH over ST throughout the shoulder abduction.

**Conclusion:** Scapular kinematics before and after RTSA shows biphasic motion: first predominance of GH then ST. The same pattern (however less exaggerated) could be found in approximately half of normal subject. A fully coordinated pattern (no crossing point) cannot be expected after RTSA.

FM98

### Glenosphere size in reverse shoulder arthroplasty: is larger better for external rotation and abduction strength?

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**Background:** The role of glenosphere size in reverse shoulder arthroplasty (RSA) may be important in prosthetic stability, joint kinematics, rotator cuff tension and excursion, scapular impingement, humeral lateralization, deltoid wrap, and the occurrence of "notching." This study compared short- and midterm clinical and radiographic outcomes for 2 different glenosphere sizes of a single RSA type with respect to implant positioning, glenoid size, and morphology.  
**Methods:** This retrospective analysis included 68 RSA procedures that were prospectively documented in a local register during a 5-year postoperative period. Two glenosphere diameter sizes of 36 mm (n = 33) and 44 mm (n = 35) were used. Standard radiographs were made preoperatively (ie, baseline) and at 6, 12, 24, and 60 months after surgery. Range of motion, strength, the Constant-Murley score, and the Shoulder Pain and Disability Index were also assessed at all follow-up visits. The effect of glenosphere size on measured outcomes was adjusted for baseline values, patient gender, and humeral head diameter.  
**Results:** No significant differences were found in the functional scores between treatment groups at all follow-up assessments. At the 12-month follow-up, patients with a 44-mm glenosphere had greater external rotation in adduction (mean difference, 12°; P = .001) and abduction strength (mean difference, 1.4 kg; P = .026) compared with those with the smaller implant. These differences remained at 60 months. Scapular notching was observed in 38% of all patients, without any relevant difference between the groups.  
**Conclusion:** An increase in glenosphere diameter leads to a clinically moderate but significant increase in external rotation in adduction and abduction strength at midterm follow-up.

FM99

### Does Hamada grade influence the 2-year outcome of reverse total shoulder arthroplasty (RTSA) for unilateral cuff arthropathy?

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**Introduction:** We wanted to measure the influence of different stages of cuff arthropathy (as Hamada grades) for RTSA and confounders (age, gender, dominant side, comorbidities) on the 2-year outcome in an open European multicenter study. The REPP method (relative effect per patient) measures the result for each patient; REPP = (complaints before – complaints after)/complaints before. The best result is 1 = patient without complaints, 0 = unchanged. It can be used to measure the outcome and analyze the influence of different factors.  
**Methods:** The patients of 5 European clinics were included. Each patient had reversed total shoulder arthroplasty (Affinis<sup>®</sup> inverse, Fa Mathys, Bettlach, Switzerland) in a standardized way. The primary outcome were the REPP's at 2-years calculated for each patient using the American Shoulder and Elbow Surgeons (ASES) score. The patients were stratified on their grade of cuff arthropathy (measured as Hamada grade) and confounders of interest included: age, gender, dominant side, and general co-morbidities measured using ASA grade.  
**Results:** 203 patients were included for this analysis of whom 161 patients had a complete 2-year follow up ASES score. By 24-months, the mean inverted ASES score reduced from 79.4 to 21.9 (a difference of 57.5 95% CI (54.3 to 60.7), p <0.001). The REPP's ranged from 1 to 0.09 at the 24-month follow up with a median REPP 0.76 95% CI (0.73, 0.79). We had no patient with a negative score. The median REPP's did not differ according to Hamada grade and other confounding factors of age, gender and dominant side. Only the patients with higher ASA grade had worse REPP scores (median REPP in ASA 1 was 0.85 versus 0.67 in ASA grade 4).  
**Conclusions:** The outcome of reverse total shoulder arthroplasty can be measured with the REPP method using the inverted ASES score. General comorbidities (ASA grade ≥3) can influence the outcome; Hamada grade, age, gender, dominant side seem not to influence the outcome.

\*FM100

### Complications after arthroscopic rotator cuff repair (ARCR): evaluation of standardized recording of adverse events based on a local Swiss register

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**Introduction:** Standardized recording of adverse events (AE) is a core component of our local prospective arthroscopic rotator cuff repair (ARCR) register introduced in 2010. Relevant events were defined in a "core event set" (CES) in 2016 by an international Delphi consensus process and integrated into the register. The objectives of this study were to 1) evaluate the application of the defined CES in a register setting, 2) classify AEs according to severity and 3) report local AEs following ARCR.

**Methods:** Four clinicians trained about the CES performed a retrospective evaluation of AEs from the medical records of registry patients from surgery until the final clinical and sonographic follow-up 6 months postoperatively. AE severity was classified using an adapted Clavien-Dindo complication classification in 5 grades from I (low severity) to V (dead). One clinician carried out a thorough data quality control. Cumulative complication risks (CR) were calculated per event group and stratified by the extent of rotator cuff tears.  
**Results:** A total of 1685 ARCRs in 1616 patients (57 years [range 16–77]; 37% women) were documented between 02-2010 to 09-2016. All AEs could be classified using the CES as well as the adapted severity classification. Intraoperative AEs occurred in 42 ARCR (CR = 2.5%). Most of these were implant problems (n = 33). The cumulative risk (CR) of local postoperative AEs was 19.1%. The most common AEs were capsular stiffness (7.4%), pain (3.7%), recurrent rotator cuff defects (3.0%), neurological lesions (1.7%) and biceps tendon ruptures (1.0%). Infections were rare (0.8%). The CR was 23.3% in patients with partial tears, 15.9% in single-tendon tears, 18.1% in cases with two ruptured tendons and 27.7% when 3 tendons were involved. Severity classification of all 321 AEs revealed 87 grade I, 192 grade II, 50 grade III, 2 grade IV, and no death (grade V).

**Conclusion:** This retrospective registry evaluation was limited by the clinical follow-up of 6 months. It showed that a comprehensive documentation of local AEs is possible from a clinical perspective. The severity classification requires further validation. Intraoperative AEs were rare, postoperatively stiffness occurred most frequently. The highest risk of AE was noted in tears involving 3 tendons as well as partial tears. Further evaluations require to consider the patients' perspective.

FM101

### Salvage reverse total shoulder arthroplasty for failed operative treatment of proximal humeral fractures in patients younger 60 years. Long-term results

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**Introduction:** Serious concerns exist about the longevity of salvage RTSA in the working population. It was the purpose to analyze the long-term outcome of RTSA as a salvage procedure for failed operative treatment of complex proximal humeral fractures in patients younger than 60 years.

**Methods:** Thirty patients with a mean age of 52 (range, 30–59) years were personally reviewed after a mean follow-up of 11 (range, 8–18) years. There were seven patients (23%) with RTSA for failed ORIF and 23 patients (77%) for failed hemiarthroplasty. Clinical and radiographic outcome were assessed longitudinally.

**Results:** At final follow-up, the absolute and relative, mean Constant scores improved from preoperatively 21 (range, 5–45) to 49 (range, 19–82) points (p <0.001); and from 25% (range, 5–53%) to 58% (range, 25–94%; p <0.001), respectively. Significant improvements were seen in mean SSV (20% to 56%), active elevation (45° to 106°), abduction (42° to 99°), pain scores and strength (p <0.001). Clinical outcome did not significantly deteriorate over 10 years and the functional results of patients with RTSA for failed primary hemiarthroplasty (n = 10) were not inferior to those after failed ORIF (n = 6). Patients with RTSA for failed secondary hemiarthroplasty (n = 8) compared with those after failed ORIF showed inferior elevation (93° vs. 113°; p = 0.190) and abduction (77° vs. 116°; p = 0.023). Patients with a healed greater tuberosity (n = 8) showed significantly better external rotation compared with patients with a resorbed greater tuberosity (n = 13; 8° vs. 15°; p = 0.014). One or more complications occurred in 21 shoulders (71%), and six (20%) resulted in explantation of the RTSA.



**Conclusion:** Although salvage RTSA in patients younger than 60 years is associated with a substantial complication rate, it leads to significant subjective and functional improvement without clinical deterioration beyond 10 years. Inferior shoulder function is associated with greater tuberosity resorption and with RTSA for failed secondary hemiarthroplasty.

\*FM102

### Feasibility of computer-assisted osteosynthesis of distal radius fractures using patient-specific instruments

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**Introduction:** Distal radius fractures are common and a considerable part is qualifying for surgical treatment. Despite advancements in imaging and intraoperative fracture management, malunions with anatomic incongruity and implant misplacement can occur and affect the clinical outcome. Current developments in computer-assisted-planning with the application of patient-specific instruments demonstrated a successful implementation in malunions of the forearm and in scaphoid pseudo-arthrosis. By segmentation of the 3D bone models from CT data, a more accurate analysis of fracture morphology is possible. So far, no reports are available about 3D-planned osteosynthesis of the distal radius performed with patient-specific instruments. In this study, we assess the feasibility of such a computer-assisted approach applied to two cadaver specimens.

**Methods:** First, a retrospective analysis of 20 cases of distal radius fractures, treated by conventional osteosynthesis, was performed. Based on preoperative CT scans, 3D models of the bone fragments were generated following fracture reconstruction by the means of 3D preoperative planning software. The outcome of the 3D planning was compared to the postoperative CT scans of the conventionally treated osteosynthesis to evaluate differences in reduction accuracy and implant position. Secondly, cadaver experiments were carried out in which two fractures of a common type (one extra- and one intra-articular) were generated by controlled chiseling. Afterwards, the fracture reconstruction was 3D-planned and patient-specific guides were designed and manufactured. The precision of reconstruction and implant position was assessed by postoperative CT.

**Results:** Corresponding to previous studies, in 20% (4/20) of the retrospective cases, the postoperative step-off was bigger than 2 mm. The analysis demonstrated on average an intra-articular stepoff of 1.4 mm (STD 0.85) and an intra-articular gap of 2.3 mm (STD 1.41). The postoperative analysis of the cadaver experiments demonstrated very accurate fragment reduction with no intra-articular gap or step-off. Implant position and screw directions were as planned without intra-articular screw misplacement.

**Conclusion:** Computer-assisted planning with patient-specific implants appears to be a feasible method in osteosynthesis of distal radius fractures. The technique can support reducing the incidence of residual anatomic incongruity and instrument misplacement.

\*FM103

### First experiences of using mixed-reality for surgical navigation of corrective osteotomies

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**Introduction:** Computer-assisted corrective osteotomy, using 3D simulation for preoperative planning and patient-specific instruments (PSI) for navigation, has become the gold standard in the treatment of complex malunions of the forearm bones. However, production of PSI is lengthy and expensive. Moreover, PSI have limited flexibility in case the preoperative plan needs to be modified intraoperatively. This study investigated whether the Microsoft HoloLens, a recently available off-the-shelf mixed reality device, could be an alternative to PSI for navigated reductions of forearm osteotomies. Besides a technical accuracy evaluation, cadaver experiments were performed to compare the precision between PSI- and HoloLens-navigated reductions.

**Methods:** Our developed HoloLens-navigation technique relies on optical markers attached to surgical pins. The markers allow real-time calculation of the three-dimensional position/orientation of the surgical pins. A technical evaluation was done with 3D-printed models containing different cylindrical sleeves with known orientation and distances among each other (ground truth). Two single-cut osteotomies of the ulna shaft were performed on human cadavers with PSI- and HoloLens-navigation, respectively. In the HoloLens-navigated

osteotomy, only reduction was navigated, by overlaying a virtual goal model over the real scene and by presenting the surgeon real-time information about the required rotation and translation to achieve goal reduction. Postoperative CT were acquired to assess reduction precision by comparison to the preoperative plan.

**Results:** In the technical evaluation 9420 and 5880 data points were recorded to assess the accuracy of the HoloLens to measure 3D rotations and translations, respectively. An average rotational accuracy of  $1.7 \pm 1.2^\circ$  and translational accuracy of  $2.1 \pm 0.6$  mm was measured. Cadaver experiments showed a similar precision in rotation between the two methods (3D angle error: PSI  $5.8^\circ$ , HoloLens  $5.9^\circ$ ), but a larger translational error for the HoloLens-navigated procedure (PSI 1.3 mm, HoloLens 4.5 mm).

**Conclusion:** Preliminary results show the Microsoft HoloLens has great potential to be used for surgical navigation of osteotomies. However, PSI were still needed for K-wire drilling and cutting due to the lack of navigating surgical tools. Next step will be reduction of the marker size and the implementation of tool tracking.

\*FM104

### 3-dimensional analysis of distal radioulnar joint morphology according to sigmoid notch-type in healthy subjects

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**Introduction:** The precise restoration of the ulna variance is of fundamental importance in corrective osteotomies of malunited forearm bones. Preoperatively, the ulna variance can be measured on 2D plain radiographs to assess the needed length correction. Translation of 2D ulnar variance measurements to 3D has not been validated so far, although a 3D measure would be needed for 3D preoperative planning of corrective osteotomies. A correlation between sigmoid notch-type and ulnar variance was investigated, as well, only on plain radiographs. Hereby, we describe the development of new 3D measurements for the assessment of ulnar variance and the sigmoid notch-type. We demonstrate the correlation of ulnar variance and sigmoid notch-type in 3D and compare our method with 2D measurements of plain radiographs and coronal CT scans.

**Methods:** In total, 64 patients being 18 yo or older included in the study. Further inclusion criteria were the availability of radiological data of the healthy forearm (X-ray and CT). For each case, ulnar variance and sigmoid notch-angle were measured with three methods in X-ray, CT data, and on 3D forearm bone models, respectively. The subjects were divided into three subgroups according to their notch-type orientation and a corresponding correlation with the ulnar variance was performed for the different measurement methods.

**Results:** As known also from literature, three sigmoid notch type subgroups could be identified in all image modalities, namely a positive sigmoid notch-angle in negative ulnar variances, neutral sigmoid notch-angle ( $-5^\circ$  to  $5^\circ$ ) in neutral ulnar variances and negative sigmoid notch-angle in positive ulnar variances. A moderate negative Spearman correlation ( $-0.59$ ) of sigmoid notch-type with ulnar variance was detected in the established 2D measurement of plain radiographs. A stronger negative correlation was observed in 2D measurements of coronal CT scans ( $-0.69$ ) and in 3D measurements obtained from the 3D forearm bone models.

**Conclusion:** We demonstrate a reliable method to measure ulnar variance and sigmoid notch-angle on 3D forearm bone models. The 3D method may be used for 3D preoperative planning of corrective osteotomies.

FM105

### Custom-made implants for corrective osteotomies of the distal radius using 3D-planning and milling

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**Introduction:** 3D computer simulation of corrective osteotomies offers highly individualized treatment of complex forearm malunions, tailored to the pathology and complaints of a patient. However, the procedure still relies on standard osteosynthesis implants for fixation of the bone fragments. Particularly in case of severe malunions, standard implants can have a poor fit with the corrected bone surface. Moreover, treatment possibilities are often limited as neither plate shape nor screw configuration can be adopted. Therefore, we have started to work on customizable implants, integrated into the 3D planning and optimized for a given patient. In this study, we report on our first experiences in performing two corrective radius osteotomies with this technology.

**Methods:** Each patient underwent preoperative CT acquisition. 3D bone models were generated and imported into the CASPA software for preoperative planning. The 3D planning revealed that no appropriate standard implants were available. Based on a generic plate template, the implant shape was adopted to the postoperative patient anatomy in the CAD Software Solidworks by virtual bending until optimal fit with the bone surface was achieved. Screw positions and directions were custom-defined by the surgeon. Based on the 3D models, the implant was manufactured using a milling device by Medacta SA (Castel San Pietro, Switzerland) together with patient-specific instruments for navigation (MyOsteotomy, Medacta SA). Machining of screw threads and surface finishing were done in post-processing steps.

**Results:** Compared to the standard approach, additional engineering time of 8 h per case was required for implant design and review. The costs for plate manufacturing accounted for 1800 € (raw material, machine programming). Intraoperatively, PSI and the custom-plates could be applied without any difficulties in both cases. So far, postoperative course was uneventful (3 m follow-up). The evaluation of the post-operative CTs showed high precision in implant positioning, excellent implant fit, and reduction accuracy comparable to state-of-the-art computer-assisted osteotomies performed with standard implants.

**Conclusions:** Despite the obvious clinical advantages, such as snugly fitting and optimized screw configuration, custom-made osteosynthesis implants are currently still too expensive for justifying its use in osteotomies. Other, more cost-effective manufacturing techniques have to be evaluated as an alternative to milling.

\*FM106

#### Improving accuracy of opening-wedge osteotomies of distal radius using a patient-specific ramp-guide technique

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**Introduction:** Opening-wedge osteotomies of the distal radius performed with patient-specific instruments are a promising technique for accurate reduction of malunions. Nevertheless, reports of residual malalignments and discrepancies of plate and screw position from the planned fixation exist. Consequently, we developed a patient-specific ramp-guide combining navigation of plate positioning, osteotomy cutting, and reduction. The aim of this study is to compare navigation accuracy of 3D planned opening-wedge osteotomies using a ramp-guide over patient-specific guide techniques only relying on the pre-drilled holes.

**Methods:** A retrospective analysis was carried out on opening-wedge osteotomies of the distal radius performed between May 2016 and April 2017 with patient-specific guides. Eight patients were identified in which a ramp-guide for distal plate fixation was used. We compared the reduction accuracy with a control group of seven patients in which the reduction was performed with pre-drilled screw holes using patient-specific guides. The navigation accuracy was assessed by comparing the preoperative plans with postoperative computed tomography scans. The accuracy was expressed by a 3-dimensional angle and in all 6 degrees of freedom (3 translations, 3 rotations) with respect to an anatomical coordinate system.

**Results:** Significantly, less rotational and translation residual malalignment error was observed in the open-wedged osteotomies in which patient-specific ramp-guides were used. On average, a residual rotational malalignment error of 2.0° (±2.2°) and translational malalignment error of 0.6 mm (±0.2 mm) was observed in the ramp-guide group compared to 4.2° (±15.0°) and 1.0 mm (±0.4 mm) in the control group. Plate position was not significantly positioned more accurately, but significant fewer screws (15.6%) were misaligned in the distal fragment compared to in the control group (51.9%).

**Conclusion:** The use of the presented ramp-guide technique in opening-wedge osteotomies of the distal radius is improving reduction accuracy and screw position compared to existing guide-based navigation methods.

\*FM107

#### Falls in patients with knee osteoarthritis undergoing total knee arthroplasty: a systematic review and best evidence synthesis

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**Introduction:** Falls frequently occur with impaired ambulation and may also lead to dramatic consequences like death especially in elderly population. Aim was to document the incidence of falls in knee osteoarthritis (OA) patients undergoing total knee arthroplasty (TKA), identifying factors and treatments that may influence the risk of falls.

**Methods:** A systematic literature search was conducted on three medical electronic databases, PubMed, PeDRO, and Cochrane Collaboration. The main aspects related to falls were analyzed: prevalence, risk factors, correlation with clinical outcome, effect of treatments. Furthermore a risk of bias analysis and best evidence synthesis were performed in order to provide a qualitative analysis of literature, using the Preferred Reporting Items for Systematic Reviews and Meta-analysis guidelines.

**Results:** The systematic review identified 11 papers involving a total of 1,237 patients. Pre-operative fall prevalence ranged from 23% to 63%, while post-operative values ranged from 12% to 38%. The qualitative analysis identified moderate evidence for no influence of clinical scales, no BMI differences between “faller” and “non-faller”, and on influence of limited pre-operative range of motion. Conflicting evidence was found for sex, history of previous falls, age, kyphosis, muscle weakness, fear of falling, depression, balance, gait impairment. No evidence was found for the effectiveness of surgical or rehabilitative strategies on falls reduction.

**Conclusions & perspective:** Risk of falls in OA patients undergoing TKA remains high, despite a reduction it is still present after surgery. Different risk factors were identified, but no studies could demonstrate the possibility to reduce the incidence of this deleterious event, this warrants further research efforts to better manage fragile populations, such as elderly patients.

FM108

#### History of previous knee surgeries is associated with higher risk of revision after primary TKA

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**Background:** Prior to primary total knee arthroplasty (pTKA), 15–35% of patients have undergone surgical procedure(s) of the same knee such as osteosynthesis, osteotomy, meniscectomy or arthroscopy (for treatment or, less often, for diagnostic reasons). History of previous surgery may influence the revision risk of pTKA.

**Objective:** To compare revision rates up to 16 years after pTKA in patients with and without history of previous knee surgeries for any indication, excluding partial arthroplasty.

**Materials and methods:** Hospital-based arthroplasty registry prospective cohort study including all pTKAs between 01/2000 and 12/2016. Information on previous surgery (in pre-specified categories) is routinely recorded by the operating surgeon at the time of surgery. Outcomes were revisions, evaluated using Kaplan Meier survival and Cox regression analyses, and the specific causes for revision.

**Results:** 3945 pTKAs were included (mean age at surgery was 71 yrs, 68% women, BMI 29.7). Of those, 844 (21.4%) had a history of previous surgery: meniscectomies in 50%, followed by arthroscopies and osteotomies. 189 revisions (66 in those with previous surgery) occurred over an average follow-up of 7.3 yrs. Five-year survival by previous surgery (yes vs. no) was 93.6% (95% CI 91.7–95.1) vs. 96.8% (95% CI 96.1–97.4). Unadjusted HR was 1.92 (95% CI 1.43–2.58). Baseline differences in age, gender, BMI, smoking status, ASA score, and surgery duration explained only part of the higher risk (adjusted HR 1.57, 95% CI 1.15–2.16). All causes for revision were concerned.

**Discussion/Conclusion:** TKA patients with history of prior knee surgery have a risk of revision almost twice as high as those without prior surgery.

FM109

### Joint awareness after TKA: a matched-pair analysis of a classic implant and its evolutionary design

Dr. Bettina Hochreiter, Dr. Vilijam Zdravkovic, Dr. Henrik Behrend

**Introduction:** Total knee arthroplasty (TKA) designs continue to be modified in an attempt to improve patient outcomes. The purpose of the current study was to compare the clinical results of a new TKA cruciate-retaining (CR) implant to its predecessor design. The hypothesis of this study was that joint awareness and range of motion (ROM) of the newer design would be comparable or better than the old design.

**Methods:** A consecutive group of 100 patients undergoing TKA using the newer design (Attune, DePuy Synthes) was matched by age, gender and BMI to 200 patients (ratio 1:2) having the classic design (LCS, DePuy Synthes). All patients underwent computer-navigated (Vector Vision, Brain-Lab) primary TKA by the same surgeon using the same technique. Patients data were collected preoperatively and at 12 months postoperatively in a prospective fashion in our institutional implant registry data base. The outcome assessments used were the Forgotten Joint Score-12 (FJS-12), the WOMAC score and ROM. Statistical analysis included unpaired t-test and Chi-squared test. Alpha value was set to 0.05.

**Results:** The mean age of patients at time of TKA was 70 years (range: 44–91 y). There were 153 female and 146 male patients. The mean BMI was 29.6 (range: 17–63). In the Attune group the mean FJS-12 and WOMAC at 12-months follow-up were 66 (range 0–100, SD 28.3) and 15.1 (range 0–66 and SD 15.2) respectively, compared to 70 (range 0–100 SD 34.6) and 14.7 (range 0–93 and SD 17) in the LCS group. The differences between the FJS-12/WOMAC in the LCS group and Attune cohort were not statistically significant. Preoperative average ROM was similar in both groups. 117° flexion in the Attune group and 115° flexion in the LCS group. There was no statistical difference in flexion at the 1-year follow up between the two groups (Attune mean 118°, range 90–135°, SD 10.4 and LCS mean 116°, range 80–140°, SD 10.3). Postoperative extension in the Attune group (mean extension deficit 0.6°; range 0–10°; SD 1.97) showed no statistical difference compared to the LCS group (mean extension deficit 1°; range 0–20°; SD 2.58). More than 5° flexion contracture was found in 3.5% of patients in the LCS group, compared to 1% of patients in the Attune group (not significant).

**Conclusion:** The newer TKA design achieved comparable joint awareness, WOMAC scores and range of motion at one-year follow-up compared to the classic design. Future studies are necessary to compare the long-term results.

FM110

### Perioperative vitamin C supplementation following total knee arthroplasty: a double-blind placebo-controlled randomized study

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**Introduction:** Arthrofibrosis (AF) is a debilitating complication after total knee arthroplasty (TKA). This study was designed to determine whether perioperative supplementation of vitamin C (VC) improves range of motion (ROM) and reduces the risk of AF following TKA.

**Methods:** Patients undergoing TKA were randomized to either oral VC (1000 mg daily) or placebo for 50 days, starting one day before surgery. VC plasma concentrations (VCc) were analysed in both patient groups before surgery, 4 and 7 days after surgery. The effect of VC supplementation was tested on Vitamin C plasma levels, ROM, AF, WOMAC and FJS-12 using two-sample T-tests, Chi-square test or Fisher test.

**Results:** A total of 95 patients were included for final analysis (48 patients in the VC group, 47 patients in the placebo group). VCc decreased significantly in the placebo group from 47.8 µmol/l preoperatively to 17.1/15.5 µmol/l on day 4/7 (p <0.001), while this was not the case in the VC group (56.0/58.1/62.4 µmol/l preoperatively, day 4/7 respectively). Perioperative VC supplementation significantly increased VCc in the VC compared to the placebo group both at 4 (58.1 vs. 17.1 µmol/l) and 7 days (62.4 vs. 15.5 µmol/l) postoperatively. Mean ROM at one year was not different between study groups. The prevalence of AF was 10.4% (5 of 48) in the VC group compared to 23.4% (11 of 47) in the placebo group (p = 0.09). Patients with a perioperative (preoperative to post-op day 7) drop of VCc ≥30 µmol/l developed significantly more AF at one year compared to patients with a VCc drop <30 µmol/l (p = 0.007).

**Conclusion:** Vitamin C plasma level drops have a significant effect on the development of AF after TKA. Perioperative VC supplementation successfully prevents postoperative VC depletion in most patients undergoing TKA. While the study was closed prematurely because of slow recruitment, results also strongly suggests VC supplementation successfully reduces the risk of postoperative AF.

FM111

### What is the most relevant angle for performing the distal femoral cut in total knee arthroplasty: the HKS angle or the mechanical femoral angle (FMA)?

Dr. Lukas Moser, PD Dr. Michael T. Hirschmann

**Introduction:** The clinical goal of total knee arthroplasty is to restore a stable, mobile and painless knee. At the technical level, the goal is to balance, in flexion and extension, the gaps created by the bone resections. Dogmatically, preoperative planning, with x-ray images of long axes in charge, consists of measuring the frontal deviation of the mechanical axis and planning a neutral femoral and tibial mechanical alignment. Intraoperatively, with conventional instrumentation, the distal femoral cut is performed considering a standard HKS angle (angle between the mechanical axis and the anatomical axis, 7° for varus and 5° for valgus). The objective of this study was to determine, for the same global deviation, the variability of the HKS angle and the mechanical femoral angle (FMA) and to evaluate whether or not one of the two angles is more relevant in the realignment strategy.

**Material and methods:** The preoperative anatomy of 25 patients, 13 women and 14 men, mean age 73.2 years (58–91) years, all with a frontal global deviation of 11° in varus (HKA angle of 169°), was analyzed on the scanner database and the KNEE-PLAN® software (Symbios). The angles HKS (angle between the anatomical axis and the mechanical axis of the femur) and FMA (angle between the mechanical axis of the femur and the tangent to the distal femoral condyles) were measured.

**Results:** The HKS angle was not constant at 7° but averaged 6°, and ranged from 5° to 8°. The Mechanical Femoral Angle was on average 90° but varied more than 10°, ranging from 84° (varus) to 95° (valgus).

**Conclusion:** Considering the HKS angle as a constant angle can induce a deflection of up to 2° with respect to an orthogonal distal femoral cutting objective. In addition, the great variability of the Mechanical Femoral Angle shows that the origin of the varus deviation of the lower limb can be multiple (wear, constitutional deviation, ligamentous, internal rotation of the knee ...) and can come either from the distal part of the limb or from the proximal part of the tibia. In this context, it is clear that a single preoperative planning strategy (realignment neutral) will have very different clinical and functional impacts for each patient and that a personalized solution that takes into account the individual constitutional morphotype should be favored. The mechanical femoral angle seems more relevant than the HKS angle to define the strategy of realignment of the lower limb.

FM112

### Possible signs fo early loosening in Attune® CR TKR femoral components

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**Introduction:** The Attune® TKR was introduced at our clinic in Spring 2013. As with every newly introduced implant, clinical & radiological follow ups are more stringent than with devices having a proven in house track record. Standard follow ups are meticulously scheduled at 1 & 2 years post-operative, including clinical and radiographic documentation. Patients complete a set of proms (COMI, UCLA, EQ-5D, OKS) accordingly.

**Objectives:** Subjective outcomes proved to be well up to expectations and favorable with regard to clinical findings. In contrast, radiographs with suspicious radiolucencies along the femoral component in the lateral view (zones 1 & 4) became alarmingly frequent. They show early on the 1 year images and tend to increase in the 2 year follow up. No clinical equivalent could be pinpointed with patients generally being asymptomatic and satisfied with the early functional outcome.

**Study Design & Methods:** 4 qualified in house orthopedic surgeons were assigned to review all available radiological and clinical data in the overall Attune® CR collective, specifically looking for radiolucencies in the femoral component but in parallel also noting any other irregularities. In parallel, patients showing signs of early loosening (femoral or tibial) are routinely screened for possible infections by means of a fluid aspiration & bacteriological analysis.

**Results:** In an initial analysis of all patients receiving an Attune® CR TKA between March 2013 and September 2015 (454), 34 knees (7.5%) were identified showing radiolucencies of 2 mm or more along the femoral shield & posterior condyle. In a control group of 600 Innex® TKR, 10 (1.7%) appeared similarly affected. No evidence for underlying infections could be found. Scintigraphic screening did not provide evidence for any active process.

**Conclusions:** The radiographic findings currently remain unexplained and unclear with regard to their significance. Partner clinics with similar stringent follow ups but using Attune® PS are not seeing this phenomenon. Further research is underway, including biomechanical modeling and fluoroscopic analysis, comparing Attune® CR to PS designs as well as earlier (LCS® & Innex®) and current (Persona®) implants used at our clinic. All of the currently over 900 implanted Attune® CR devices are being closely followed, those showing irregularities being seen at close 1 year intervals. Patients are fully informed and the findings have been made transparently available to the manufacturer.

FM113

### Clinical and radiographic two year results of the Attune CR total knee arthroplasty

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**Introduction:** The purpose of this study was to evaluate the clinical and radiographic two year results of the Attune CR (DePuySynthes) total knee arthroplasty (TKA).

**Methods:** Between April 2014 and December 2015, 268 Attune CR TKAs completed the COMI-knee, the Oxford Knee Score (OKS), the EQ5d5l and the UCLA Score preoperatively; 239 (89.2%) completed the questionnaires at 24 months follow-up. The complete datasets were available for 210 patients (78.4%). Radiographs were obtained preoperative and at two years (12–36 months) follow-up.

**Results:** The COMI score improved from 6.85 (mean, 1.65 SD) to 1.90 (mean, 2.15 SD) at 24 months respectively. The OKS increased from 23.34 (mean, 8.06 SD) to 40.43 (mean, 7.88 SD) respective 48.62 OKS100 (mean, 16.79 SD) to 84.22 (mean, SD). The EQ5d5l score increased from 0.63 (mean, 0.20 SD) to 0.87 (mean, 0.14 SD). The UCLA activity Score increased from 4.51 (mean, 1.88 SD) to 5.95 (mean, 1.65 SD). Eight patients (3.8%) presented with radiologic signs of lucencies >2 mm at follow up. Additional six patients (2.9%) required revision surgery for changing of the polyethylene for instability (2) with secondary patella resurfacing (1). Loosening of the tibial component (2), loosening of the femoral component (1) and in both components (1) were further indications for revision surgery.

**Conclusion:** The clinical two year results of the Attune CR TKA resulted in overall improved outcome scores. Revision surgery was needed in 2.9% of the patients with further 3.8% presenting with radiographic signs of lucencies. Since radiographic signs of tibial and femoral lucency are a current concern in the literature, the results are looked at carefully and patients followed closely. The long term results and further evaluation will be required to prove the promised benefits of the new prosthesis design.

FM114

### Back to work after unicompartmental knee arthroplasty (UKA): a work perspective

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**Background:** The amount of primary knee prosthesis is constantly increasing worldwide. Mainly in the under 65 population, still pursuing their professional activities. Many studies have shown that 71–83% get back to work within 3–6 months after total knee arthroplasty. However, little is known about back to work ratios after UKA. Our theory is that patients regaining their professional activities in 6 months will maintain it for the long run.

**Objectives:** Our aim is to assess the percentage of patients: 1) regaining their professional activities within 6 months; 2) maintaining their professional activities after 2 years; 3) having to change their profession, or location/circumstances of their original jobs.

**Study Design & Methods:** Out of 302 UKA performed from 2010–2014 in our hospital, 147 patients were under 65 years old. Those who weren't in the working age, without any professional activity, or 1 year from retirement were excluded. Finally, 117 were included, with a mean age of 57 ± 5 (37–63), a mean BMI of 28 kg/m<sup>2</sup> ± 4 (21–40), mostly males (59%). The professional activity of the patients before/after

surgery was classified according to the National Institute of Statistics and Economic Studies: primary, secondary, tertiary. We assessed the percentage of patients regaining their professional activity and the kind of work done 6 months after surgery. We studied the percentage of those pursuing their professional career and the type of work performed after 2 years. Finally, in this last class of population, we assessed the percentage changing their profession, type/circumstances of their original jobs.

**Results:** At the time of surgery, 33% were in the primary, 47% secondary and 20% tertiary sector. At 6 months, considering all 3 socioprofessional sectors, 85% regained their professional activity, 94% at 2 years. All patients in the tertiary sector regained their professional activity at 6 months; 80% in the primary, 85% the secondary sector. At 2 years, we observed a regained activity for 95% in the primary, 90% secondary, and 100% tertiary sector. 8% in the primary and 33% the secondary sector had to change their professional career or circumstances of their job.

**Conclusions:** Patients regaining their profession within 6 months maintain their professional career. Patients in the secondary sector have the highest rate of professional reconversion. Therefore, it is important for the orthopedic surgeon to inform the patient about the risk of professional change after knee replacement surgery, based on his initial socioprofessional category.

FM115

### Randomized controlled trials for arthroscopy of the knee: have we been asking the right questions in the right patients?

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**Background:** Several randomized controlled trials (RCTs) comparing physiotherapy with arthroscopy have questioned the value of arthroscopy in degenerative disease of the knee. A recent meta-analysis of these studies triggered a “rapid recommendation” in a high-impact general medical journal, in which a “strong recommendation against the use of arthroscopy in nearly all patients with degenerative knee disease” was made. As suggested by several guidelines, the first line of treatment in these patients is usually conservative, for instance with physiotherapy. The question of performing arthroscopy arises once conservative treatment fails. For that reason we asked, if the RCTs of that meta-analysis were performed in patients who have had conservative treatment prior to randomization.

**Methods:** We searched full-text publications of the recent meta-analysis by Brignardello-Petersen, and recorded if physiotherapy prior to randomization was mandatory.

**Results:** Of the thirteen RCTs in the meta-analysis, there were two in which physiotherapy prior to randomization was mandatory. In one additional multicenter RCT, prior conservative treatment was mentioned as mandatory in the publication, but not in the protocol.

**Conclusions:** Although the meta-analysis claims that it is based “on patients who do not respond to conservative treatment”, physiotherapy was mandatory prior to randomization only in two of the thirteen studies. Therefore patient selection in the remaining eleven studies may not represent the typical indications for arthroscopy where typically those selected have tried and failed conservative management prior to being offered surgery. As such, the external validity of the RCTs, and the resulting “strong recommendation against arthroscopy” is called into question.

\*FM116

### Trochlear dysplasia: an intrinsic risk factor for patellar fractures?

*Dr Vanessa Morello, Matthieu Zingg, Dr Philippe Tscholl*

**Introduction:** Abnormal patellofemoral morphology, particularly trochlear dysplasia (TD), is a contributing factor to patellofemoral dislocation, extensor mechanism overuse injury and anterior cruciate ligament (ACL) rupture. TD may indeed have a role in other patellofemoral pathologies such as patellar fracture (PF). The goal of this study was to evaluate the prevalence of radiographic TD and its role as a potential intrinsic risk factor for different types of PF.

**Methods:** All adult patients treated in our institution for PF between 2003 and 2016 were considered for inclusion and retrospectively evaluated. Based on strict lateral knee conventional x-ray (CR), TD was assessed according to Dejour's classification in low- (type A) and high-grade (type B, C, D). PF was analyzed on AP, lateral and axial knee CR and classified as non-displaced, transverse, avulsion, multi-fragmented non-displaced, multi-fragmented displaced, vertical

and osteochondral. Patellar dislocation at time of injury was also recorded. Prevalence of TD with PF was evaluated and then compared to the general population (3%, Dejour et al. 1994) and patients with ACL rupture (15%, Ntagiopoulos et al. 2014).

**Results:** Out of 482 cases of PF, a strict lateral knee CR was found in 166 cases (50.6% women, mean age 56 yrs  $\pm$  21, 51% right knee). TD was present in 19 (11.4%, 95% CI 6.9–17.9) and high-grade TD in 10 (6.0%, 95% CI 2.4–9.7%) cases: 15 cases (9.3%, 95% CI 5.2–15.3) without dislocation. TD prevalence in patients with PF is significantly higher than in the general population (3%; Chi2,  $p = 0.024$ ). It is lower than in patients with ACL rupture (15%), but this is not statistically significant (Chi2,  $p = 0.158$ ). PF distribution showed 17 non-displaced (10.2%), 38 transverse (22.9%), 15 avulsion (9%), 27 multi-fragmented non-displaced (16.3%), 56 multi-fragmented displaced (33.7%), 7 vertical (4.2%) and 6 osteochondral (3.6%) fractures. 4 knees had PF due to dislocation, all had osteochondral fractures and TD. When considering PF with dislocation, the incidence of osteochondral lesions is significantly higher in patients with TD (Chi2,  $p < 0.001$ ). This is not true for any other type of PF (Chi2,  $p = 0.14$ ).

**Conclusions:** TD prevalence according to Dejour's classification in patients with PF is higher than the general population and can be considered as an intrinsic risk factor. The type of PF is not influenced by the presence of TD, except for osteochondral fractures associated with patellofemoral dislocations.

\*FM117

### The tibial tubercle trochlear groove distance in patellar instability – is the deformity tibial or femoral?

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**Introduction:** The tibial tubercle trochlear groove distance (TT-TG) is one of the major risk factors for patellar instability. It may either be corrected by medializing osteotomy of the tibial tubercle (TT), or by lateralizing the trochlear groove (TG) performing trochleoplasty. The aim of the study is to define the deformity responsible for an increased TT-TG, either on the distal femur or the proximal tibia.

**Methods:** A consecutive series of 70 MRI performed for lateral patellar dislocation (PFD) were retrospectively analysed and compared to an age and gender matched control group (Ctrl, N = 70). TT-TG distance was measured on the most proximal axial image where the TG was first seen, to the centre of the patellar tendon at its tibial insertion. The position of the TG was located in the frontal plane on two standardized levels, and described in percentages in function of the maximal condylar width of the distal femur. The position of the TT was measured by the TT-PCL distance. The angle between the posterior condylar lines of the femur and tibia (pcl-a) was measured to quantify the intra-articular femoro-tibial torsion. Knees with patellar dislocation and a TT-TG above 15 mm (PFD+, N = 41) and below (PFD-, N = 29) were analysed separately.

**Results:** The trochlear groove in PFD+ measured on the two levels was 1.1 to 1.8 mm more medial than in Ctrl ( $p < 0.01$ ) and 1.2 to 1.4 mm more medial than in PFD- ( $p < 0.05$ ). No difference between Ctrl and PFD- was observed. No group difference was found for the TT-PCL distance. The pcl-a showed an increased tibial external rotation in PFD compared to Ctrl ( $6.8 \pm 0.9^\circ$ ,  $p < 0.0001$ ), whereas no difference in the pcl-a between PFD+ and PFD- was found.

**Conclusion:** Knees with an increased TT-TG and patellar dislocation show no deformity to the proximal tibia, and only minor changes in the localization of the trochlear groove. The results therefore question, whether an increased TT-TG should be corrected by osteotomy to the TT or the TG.

FM118

### Joint awareness after first time patellar dislocation: patient-reported outcomes measured with the forgotten joint score-12

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**Introduction:** The forgotten joint score-12 (FJS-12) has been extensively validated to assess outcome after arthroplasty. However, the new score has never been applied for evaluation of patellar dislocation. The objective of this study was to assess joint awareness after first time patellar dislocation with the FJS-12. The hypothesis was that patients treated for acute patellar dislocation would show higher joint awareness (i.e. lower FJS-12 scores) at midterm follow up compared to age and sex matched healthy controls.

**Methods:** A single institution retrospective analysis of patients treated between 2004 and 2014 was performed. Patients with confirmed first time patellar dislocation were included. Reasons for exclusion were recurrent instability, prior surgery of the affected knee joint, ligament injury (except MPFL), or incomplete data. Included patients were assessed with the FJS-12 and the Kujala Score. Reference values for the FJS-12 were obtained from an age and sex-matched healthy control sample with no history of previous knee joint pathology. We calculated Cronbach's alpha, assessed the ceiling effect for both scores, and calculated Spearman correlation coefficient between them. Significance level was set to 0.05.

**Results:** Fifty-eight patients (mean follow up 7.9 y, SD 3.3 y, Range 1.5 to 14 y) with a mean age of 26.6 years were analysed. Compared to the age and sex matched control group, the patellar dislocation group showed significantly lower (worse) mean FJS-12 scores (88 vs 69,  $p < 0.001$ ). Inter-score correlation between the FJS-12 and the Kujala was high ( $r = 0.58$ ) and significant ( $p < 0.001$ ). Cronbach's alpha of the FJS-12 was 0.92 (95% CI 0.85–0.98). The FJS-12 showed less ceiling effect (14%) compared to the Kujala score (22%).

**Conclusion:** The concept of joint awareness has been successfully applied to a patient population after first time patellar dislocation. The FJS-12 showed less ceiling effect compared to the Kujala score, suggesting the score to be able to capture more subtle knee problems in patients after patellar dislocation.

FM119

### CT measurement of lower limb axial alignment in patients with patellofemoral pain and instability

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**Background:** Anterior knee pain and patellofemoral instability represents a common condition and affects nearly 30% of the adolescent population. Long-term effects include disability and patellofemoral osteoarthritis. Recent literature focused on intraarticular pathologies such as tibial tubercle – trochlear groove distance (TT-TG), patellar height or valgus alignment. It remains understood as a two-dimensional problem despite the complex rotational biomechanics of the patellofemoral articulation and the entire lower limb. The analysis of the center of rotation and angulation (CORA) is crucial to understand the underlying cause of symptoms and propose possible treatment options. The aims of this study were to characterize lower limb rotation in patients with patellofemoral symptoms and to evaluate the correlation between femoral and tibial rotation to established radiographic risk factors for instability. We hypothesized that axial rotation positively correlates with accepted risk measurements.

**Methods:** CT scans with axial cuts of the proximal femur, knee, and distal tibia were obtained in 48 patients (31 women, 17 men) with clinically diagnosed patellofemoral instability and suspected lower limb mal-rotation. Patients with prior knee surgery or osseous trauma were excluded from the study. The study protocol was approved by the institutional review board. Measurements were made to determine femoral anteversion (FA), intra-articular rotation (IAR) between the distal femur (transepicondylar line) and the proximal tibia, tibial rotation (TR), tibial tubercle rotation (TTR), trochlear groove orientation (TGO) and TT-TG distance. Correlations were analyzed using a Pearson correlation coefficient.

**Results:** Average FA and TR angles were  $18.5^\circ$  (SD:  $15.5^\circ$ ) and  $30^\circ$  (SD:  $8.9^\circ$ ). The majority of tibial rotation (65%) occurred proximally at the level of the tubercle. FA and TR did not significantly correlate with TT-TG. IAR and TTR had the highest correlations with TT-TG (0.452). Intraobserver reliability showed excellent values (0.83).

**Conclusion:** The degree of rotation between the distal femur and the proximal tibia correlates with TT-TG distance. However, significant torsion between within proximal and distal femur as well as the tibia indicate that evaluation of rotation may be beneficial in patients with patellofemoral instability to understand the underlying cause of symptoms and propose possible treatment options.

FM120

### Osteoarthritis – a massive concern in former elite female football players

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**Introduction:** Early onset of osteoarthritis, especially of the knee and the ankle, is a major concern in professional football, and found in up to 32% of former male athletes. So far, no comparative data have been

published in former professional female players. The aim of the study is to assess the prevalence of degenerative changes in the knee joint in former elite female football players and its impact on their daily life.

**Methods:** For the purpose of this study, 48 former German elite football players (38 ± 5 years of age) were included in the study having played 9.9 ± 5.4 years on the highest level and ended their international career 9.5 ± 4.0 years previously. Players with a severe non-football-related knee injury or a generalised musculoskeletal disease were excluded from the study. Information on personal and football related characteristics as well as self-reported knee health (KOOS) and Tegner activity scale (TAS) was collected through a standardised online questionnaire. Osteoarthritis in both knees was evaluated using a standardised MRI protocol.

**Results:** Physical strain, a severe injury and chronic pain contributed in 40% of the reason referred by the player to end their career. 37.5% of the players were regular users of painkillers due to musculoskeletal complaints in relation to their career. Their current physical activity was on the TAS 5.1 ± 1.6, and total KOOS score was 75.5 ± 14.6 and for physical activity 64.5 ± 25.4. On the MRI, substantial cartilage lesion of grade III or more according to Outerbridge classification were found in more than 1 out of 4 knees on the medial or lateral femoral condyle and in even 31.6 % on the lateral tibial plateau. Eighteen knees showed medial meniscus extrusion and 21 knees of the lateral meniscus of more than 2 mm.

**Conclusions:** Serious degenerative changes are found in a high number of former elite female football players as soon as 10 years after their professional career with an important impact on their daily activities.

FM121

### The elastic capacity of a tendon-repair construct influences the force necessary to induce dehiscence

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**Purpose:** Most biomechanical investigations of Achilles tendon repairs were based on output measures from hydraulic loading machines, therefore accounting for construct failure rather than true dehiscence within the rupture zone. The aim of this study was to identify factors influencing dehiscence within the rupture zone of a tendon-repair construct.

**Methods:** A simulated Achilles tendon rupture was created in 48 porcine lower hind limbs, which were allocated to 3 fixation techniques: 1) Krackow, 2) transosseous and 3) anchor fixation. Loading was performed based on a standardized phased load-to-failure protocol. Rupture-zone dehiscence was measured with an external motion capture device. Factors influencing dehiscence formation were determined using a linear regression model and adjustment performed as necessary. A 3 mm dehiscence was considered clinically relevant. Analysis of variance (ANOVA) was used for comparison between groups.

**Results:** The two factors demonstrating an independent influence on the force needed to induce a 3 mm dehiscence (F 3 mm) were elongation ( $\beta$  of 7.6, confidence interval (C.I.) 0.8;14.5,  $p < 0.029$ ) and elasticity ( $\beta = 0.6$ , C.I 0.3; 0.9,  $p < 0.001$ ). Furthermore, the method of fixation did not influence F 3 mm ( $p = n.s.$ ).

**Conclusion:** The major result of this study reveals that the higher the elongation and elastic capacities of a tendon-repair construct, the higher the forces necessary to induce a clinically relevant dehiscence. These measures are of clinical relevance and should be considered when examining any fixation construct.

FM122

### Anterolateral ligament reconstruction protects the repaired medial meniscus: a comparative study of 383 ACL reconstructions with a minimum follow up of two years

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**Background:** The prevalence of osteoarthritis after successful meniscal repair is significantly less than the rate that is observed after failed meniscal repair.

**Purpose:** The aim of this study was to determine whether the addition of anterolateral ligament reconstruction (ALLR) confers a protective effect on medial meniscal repair performed at the time of anterior cruciate ligament reconstruction (ACLR).

**Methods:** Retrospective analysis of prospectively collected data was performed to include all patients who had undergone primary ACLR with concomitant posterior horn medial meniscal repair through a posteromedial portal between January 2013 and August 2015. ACLR autograft choice was either bone-patellar tendon-bone (B-PT-B), quadrupled hamstring tendon (4HT) or quadrupled semitendinosus tendon (4ST) graft with or without ALLR. At the end of the study period, all patients were contacted to determine if they had undergone re-operation. A Kaplan-Meier survival curve was plotted and Cox proportional hazards regression model was used to perform multivariate analysis.

**Results:** 383 patients (mean age 27.4 ± 9.2 years) with a mean follow-up of 37.4 months (range 24–54.9 months) were included. 194 patients underwent an isolated ACLR and 189 underwent a combined ACLR+ALLR. At final follow up there was no significant difference in postoperative side-to-side laxity (isolated ACLR group 0.9 ± 0.9 mm (-1 to 3), ACLR+ALLR group 0.8 ± 1.0 mm (-2 to 3)  $P = .2120$ ) or Lysholm score (isolated ACLR group 93.0 (91.2–94.7), ACLR+ALLR group 93.7 (92.3–95.1),  $P = .556$ ) between groups. 43 patients (11.2%) underwent re-operation for failure of the medial meniscus repair or a new tear. The survival rate of meniscal repair at 36 months in the ACLR+ALLR group was 91.2% (95% CI, 85.4%–94.8) and in the ACLR group it was 83.8% (95% CI, 77.1%–88.7%) ( $P = .033$ ). The probability of failure of medial meniscal repair was more than two times lower in patients with ACLR+ALLR compared to patients with isolated ACLR (hazard ratio, 0.443; 95% CI, 0.218–0.866). No other prognosticators of meniscal repair failure were identified.

**Conclusion:** Combined ACLR and ALLR is associated with a significantly lower rate of failure of medial meniscus repairs when compared to those performed at the time of isolated ACLR.

FM123

### Changes in ambulatory knee adduction moment with lateral wedge are influenced by the foot progression angle

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**Introduction:** Lateral wedge insoles (LW) are interesting interventions for medial knee osteoarthritis (OA), as they can decrease the peak (pKAM) and impulse (iKAM) of the knee adduction moment during walking, two variables related to disease progression and pain. Unfortunately, the response to LW is inconsistent among individuals. Therefore, there is a need to better understand the factors influencing this response in order to improve LW efficacy. Foot progression angle (FPA) has been related to KAM, but its possible influence on LW response is unknown. This study aimed to determine the effects of FPA on LW response.

**Methods:** Standard camera-based gait analysis was performed on 22 healthy subjects (14 males; 24 ± 3 years old; 23 ± 3 kg/m<sup>2</sup>). FPA, pKAM and iKAM were measured for each subject walking with and without 5° full-length LW. Participants were then separated in two groups: the 11 subjects with the smaller FPA vs. the 11 subjects with the larger FPA. Paired t-tests were done to compare pKAM and iKAM between LW conditions. Unpaired t-tests were also done to compare the changes in pKAM and iKAM with the LW between groups. Statistical significance was set a-priori at 5%.

**Results:** The smaller and larger FPA groups walked with mean FPA of 10.4 ± 3.1° and 20.0 ± 3.0°, respectively. For the smaller FPA group, walking with LW decreased pKAM by 13 ± 14% ( $p = 0.005$ ) and iKAM by 20 ± 23% ( $p = 0.006$ ). The larger FPA group had no significant changes in pKAM (3 ± 6%;  $p = 0.14$ ) and a decrease of 13 ± 9% in iKAM ( $p < 0.001$ ) with LW. The smaller FPA group had higher pKAM decreases compared to the larger FPA group ( $p = 0.04$ ), while no differences were found between the two groups for the iKAM decreases ( $p = 0.40$ ). Both groups walked at the same speed ( $p = 0.89$ ) and for neither groups did the speed differ between LW conditions ( $p > 0.90$ ).

**Conclusion:** Subjects with smaller FPA had better responses to the LW. Indeed, they decreased both pKAM and iKAM, while larger FPA subjects only reduced iKAM. This could be an important finding to explain the inter-subject variability in KAM responses to LW, and possibly the variability in clinical benefits among patients wearing LW. While further studies are needed to confirm these observations with OA patients, it is possible that the FPA, and the dynamic posture linked to it, influence the efficacy of LW. Thus, in the future the FPA could reveal to be a key factor to select the patients most likely to benefit from LW.



FM124

### Subchondral bone mineral density and cartilage thickness alterations occur simultaneously with medial knee osteoarthritis

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**Introduction:** There is a critical need to improve therapeutic options in the early stages of knee osteoarthritis (OA). While knee OA has been originally described primarily as a disease of cartilage, there is evidence that it alters the entire osteochondral unit. Recently, it has been proposed that changes in the subchondral bone precede cartilage degeneration, thus suggesting that assessing the bone could provide early markers of OA and that early intervention on the bone could protect the cartilage. However promising, this theory remains to be proven especially by simultaneous analyses of cartilage thickness (CTh) and subchondral bone mineral density (sBMD), two major indicators of bone and cartilage integrity. In fact, while the chronology of CTh alterations has been well described, there is a paucity of data regarding the sBMD at different stages of the disease. This study aimed to compare sBMD and CTh between non-radiographic OA and medial femorotibial OA knees of increasing severity.

**Methods:** CT-arthrography images of 152 knees with Kellgren and Lawrence (KL) grades 0–4 were processed using custom software to calculate three-dimensional CTh and sBMD maps. Average sBMD and CTh were measured for the medial and lateral load-bearing regions of the femur. Medial-to-lateral (ML) sBMD and CTh ratios were also calculated. CTh and sBMD measures and ratios were compared among KL grades using Kruskal-Wallis and post-hoc Wilcoxon rank-sum tests, with an alpha-level at 5% and Bonferroni correction for multiple comparisons.

**Results:** There were significant differences in CTh and sBMD between the KL grades in both the medial region and the ML ratio ( $p < 0.001$ ). The KL4 knees exhibited significantly denser bone, thinner cartilage, higher sBMD ratio and lower CTh ratio ( $p < 0.001$ ) compared to the KL0-3 knees, while the KL3 knees exhibited similar differences compared to the KL0-2 groups ( $p < 0.005$ ). No significant differences between the KL0 to KL2 groups were observed in any of the variables ( $p > 0.03$ ).

**Conclusion:** This study suggests that CTh and sBMD alterations occur at the same stages of OA development, thus questioning the value of sBMD for early detection and treatment. The co-occurrence of CTh and sBMD alterations may be explained by similar sensitivity to the differences in knee mechanics developing with the disease. Other measures of cartilage and bone properties should be considered in the future as they could provide early markers of OA.

\*FM125

### Is direct anterior approach a credible option for severely obese patients undergoing total hip arthroplasty?

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**Background:** Severely obese patients present a significant challenge for arthroplasty surgeons due to their body habitus. Up to date, there is no clear consensus on the safety of the direct anterior approach (DAA) in obese patients undergoing total hip arthroplasty (THA). Therefore, the purpose of the current study was to determine whether DAA is a credible option in severely obese regarding complication rates, clinical outcome and component positioning.

**Methods:** Obese patients with a BMI  $\geq 35$  kg/m<sup>2</sup> ( $n = 129$ ) who received THA with DAA in our institution were matched for gender and age with non-obese patients with BMI  $\leq 25$  kg/m<sup>2</sup> ( $n = 125$ ). Mean follow up time was 2.8 y (SD  $\pm 0.8$ ). Intraoperative data, peri- and postoperative complications, radiographic evaluation and hip function (Harris Hip Score) were assessed.

**Results:** In group 1 mean cup inclination was 43° and anteversion 23°, leg length discrepancy was 0.02 cm and distance from center of rotation (COR) was -0.1 cm horizontally and 0.1 cm vertically. 6 hip infections (4.6%) were recorded. The all-cause reoperation rate was 9.3% (12 hips). A single episode of hip dislocation occurred in one patient (0.8%) treated with a closed reduction in the emergency department. The mean Harris Hip score improved from 50 to 95 points ( $p < 0.01$ ). In the control group mean cup inclination was 42° and anteversion 22°, leg length discrepancy was 0.04 cm and distance from COR was -0.4 cm horizontally and 0.25 cm vertically. The early infection rate in the control group was 0.8% (1 hip). The all-cause

reoperation rate was 2.4% (3 hips). The mean HHS improved from 42 to 97 points. A single episode of hip dislocation occurred in one patient (0.8%) treated with a closed reduction in the emergency department. The results of this study showed an increased risk of reoperation (RR: 4.0), mostly due to wound infection and dehiscence, in obese compared to the non-obese patients. No statistically significant difference between groups was observed for component positioning. **Conclusions:** Our data show that components can be placed accurately in severe obese patients using DAA. On the other hand, patients have higher complication and reoperation rates compared to non-obese patients. However, these rates are comparable to rates of the standard, more extensive approaches presented in the literature. The current data suggest that DAA might be a credible option for obese patients, with excellent functional and radiographic outcomes.

FM126

### Bikini skin creased incision for DAA THR: a comparative study in 964 patients

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**Background:** The classical longitudinal incision used for the direct anterior approach (DAA) does not follow the relaxation tension lines of the skin and can lead to impaired wound healing and poor scar cosmesis. The purpose of this retrospective study was to determine patients scar satisfaction, functional and radiographic outcomes comparing a modified skin crease “bikini” to the classic longitudinal incision in DAA THR.

**Methods:** 964 patients (51% female; 59% longitudinal, 41% bikini) completed 2 to 4 years after surgery a follow-up questionnaire including the Oxford Hip Score (OHS), the University of North Carolina 4P scar scale (UNC4P), and two items for assessing aesthetic appearance and symptoms of numbness. Implant position, rates of heterotopic ossification and required revision were assessed.

**Results:** UNC4P total ( $p < 0.001$ ) and OHS ( $p = 0.013$ ) scores were better in the bikini compared the longitudinal group. The proportion of aesthetically very satisfied patients was higher ( $p < 0.001$ ) in the bikini group. The proportion of patients reporting numbness in the scar was higher ( $p < 0.001$ ) in the longitudinal (14.5% versus 7.5%, respectively). Radiographic cup abduction angles, stem position and ectopic ossification rates did not differ between the groups. No differences in the revision rates of both groups being 2.3% in the longitudinal and 1.5% in the bikini group.

**Conclusion:** Although differences were not large, the bikini incision resulted in better patient-related outcomes and satisfaction related to the scar. Our study showed that a short oblique “bikini” skin crease incision for the DAA is safe without compromising implant positioning or increasing symptoms suggesting lateral femoral cutaneous nerve dysesthesia. As it is less extensible it should be used after having gained significant experience with the classic longitudinal incision.

FM127

### Short stem hip arthroplasty with the direct anterior approach: 5-year follow-up demonstrates radiological alterations indicating suboptimal stem fixation

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**Background:** Short bone-conserving femoral stems in THA have been designed to preserve proximal bone stock for potential revision surgery, and also to facilitate less-invasive surgical exposures. Our objectives were to assess the outcomes up to five years including radiographic results, complications, and revision of a primary uncemented Total Hip Arthroplasty (THA) with a short femoral stem performed through direct anterior approach (DAA).

**Methods:** A cohort study nested in a prospective hospital-based registry was conducted; all primary elective THAs performed through DAA between 2008–2014 were assessed. We included all primary THAs with an uncemented hydroxyapatite-coated stem (AMIS-Stem, Medacta, Switzerland), an uncemented cup (Versafit, Medacta, Switzerland) and HXLP-ceramic bearing. We evaluated occurrence of intra- and postoperative fractures, deep infection and revision. Radiological evaluation was performed on standard pelvic AP and lateral radiographs taken postoperatively and at follow-up visits. Stem fixation was evaluated using Engli's stability scale.

**Results:** Overall, 734 THAs were included (54.2% women). Mean age was 66.1 ( $\pm 13.0$ ) and mean follow-up 4.6 years (range 0–8 years). During the study period 57 (7.8%) patients died. There were 9 deep infections, 8 dislocations, and 14 (1.9%) fractures, 9 of which occurred perioperatively. Twenty-six (3.5%) THAs required revision surgery (mean time to revision 27.4 ( $\pm 25.1$ ) month). Of those, 9 THAs were revised for aseptic loosening of the stem on average at 49.7 ( $\pm 11.7$ ) month. 5-years survival with endpoint all-cause revision was 96.6% (95% CI 97.7–94.9). Five years after surgery, radiographs of 217 THAs (217/332 eligible = 65.4%) were available. Proximal radiolucencies were present in 57 hips (29.8%), cortical thickening in 31 (15.8%), and a pedestal in 132 (67.7%). For 40 hips (19.6%) the Engh score was between  $-10$  and  $0$  ("suboptimal but stable"). Compared to patients with an Engh score of  $>0$ , their risk of stem revision for aseptic loosening was significantly higher (1.8% vs. 11.9%, OR 7.2, 95% CI 1.7–31.7,  $p = 0.008$ ). An Engh score of  $<0$  was significantly more frequent in younger patients, with ASA score 1, and in those with a Dorr C femur.

**Conclusion:** Our results warrant further continued scrutiny of mid- and long-term survivorship of the AMiStem-H<sup>®</sup>, with radiological alterations at 5 years indicating suboptimal fixation of the stem, especially in younger, active patients and in those with a Dorr C femur.

FM128

#### Total hip arthroplasty in femoral neck fracture using the direct anterior approach and factors affecting the outcome: a matched-control, retrospective, clinical study

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**Background:** Femoral neck fractures are a major cause of mortality and disability. Early fracture fixation improves survival, reduces hospital stay and minimizes long-term disability. Recent evidence demonstrated significant functional benefits of total hip arthroplasty (THA) over hemiarthroplasty in generally fit patients with long life expectancy. The direct anterior approach (DAA) showed a low dislocation risk, excellent functional outcome and clinically significant reduction in recovery time in elective cases. However, the role of THA via the DAA is still not clear in patients suffering from a femoral neck fracture. The purpose of our study was to compare the complication rates and clinical outcomes in patients undergoing THA via DAA, electively due to hip osteoarthritis and femoral neck fractures.

**Methods:** Patients presented in our emergency department with a displaced femoral neck fracture ( $n = 150$ ) and received THA with DAA were matched for gender, age and BMI with patients treated electively with THA using the DAA for hip osteoarthritis ( $n = 150$ ). At a minimum 2-year follow-up, the postoperative complication and revision rate, and clinical outcomes were compared between groups. Multiple linear regression analysis was performed to evaluate whether postoperative complications were associated with patient factors such as BMI, age, gender or surgeon associated factors such as high caseload of THA.

**Results:** The mean hospital stay in elective THA and femoral neck fractures was 5 and 7 days, respectively. The mean blood loss and operation time was 200 ml and 87 min in elective THA and 300 ml and 95 min in femoral neck fractures, respectively. The mean postoperative Harris-Hip-Score was significantly higher in elective cases (99 points versus 93 points). The complication rate in elective cases was 6%, with 6 patients developing a wound infection, 2 intraoperative fractures, and one hip dislocation. In femoral neck fracture, the complication rate was 10.5%, with 9 patients developing a wound infection, 4 intraoperative fractures, and 3 hip dislocations. The mortality rate was 1.2%. BMI, ASA score and lower surgeon caseload were the associated with increased complications. The only factor associated with increased operation time was a lower surgeon caseload.

**Conclusion:** THA can be performed safely and effectively via DAA in femoral neck fractures but with significantly higher morbidity and mortality in comparison to elective THA cases due to hip osteoarthritis.

FM129

#### Versafit Cup and Quadra Stem in THA through the direct anterior approach: analysis of a consecutive series of 283 hips with a minimum follow-up of 10 years

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**Introduction:** The direct anterior approach (DDA) in primary total hip arthroplasty (THA) is known to be a reproducible technique with low morbidity, fast postoperative recovery and good midterm outcome.

Quadra<sup>®</sup>-H stem and Versafit<sup>®</sup>-CC cup (Medacta, Castel San Pietro, Switzerland) showed good 5-year outcome in line with other uncemented implants. The purpose of this study was to document complications, outcome and 10-year survivorship of primary THA using a DAA with the before mentioned implants.

**Methods:** A retrospective, consecutive series of 283 primary THA through a DDA approach with traction table using Quadra-H stem and Versafit cup with a minimum of 10 years follow-up was identified. The cumulative 10 years survival of the implants was estimated using Kaplan-Meier estimator. All complications, reoperations and failures were analyzed. Subjective and clinical outcomes (WOMAC, Subjective Hip Value = SHV, Harris Hip Score = HHS) were measured.

**Results:** Out of 259 patients (283 hips, 140 males and 119 females) with a mean age of 65 (range, 24 to 91) years, 74 patients deceased after a mean time of 83 months postoperatively. At 10 year follow-up there were 5 THAs revised; (1 deep infection with two stage revision, 2 aseptic cup loosening, 1 aseptic stem loosening and 1 psoas irritation with a subsequent cup exchange). The overall implant survival rate was 98.0% (CI 95.3–99.2) at 10 years. Implant survival rate for aseptic loosening alone was 98.8% (CI 96.3–99.6). Additionally to the 5 failures there were 3 major revisions with inlay and head exchange due to wear. At the last follow-up the WOMAC score reached a mean of 0.85 (SD  $\pm 1.24$ ; 0 best, 10 worst) points. The SHV and HHS reached a mean of 87 (SD  $\pm 16$ ) % and 93 (SD  $\pm 11$ ) points, respectively.

**Conclusion:** At 10 year follow-up, primary THA through DDA with Versafit Cup and Quadra Stem shows reasonable low revision rates and good clinical outcome compared to other reports in literature. Overall survival rate was 98.0% (CI 95.3–99.2) at 10 years and survival rate for aseptic loosening alone was 98.8% (CI 96.3–99.6).

\*FM130

#### Prospective five-year subsidence analysis of 100 cemented polished straight stems – a concise clinical and radiological follow-up observation

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**Introduction:** Early subsidence ( $>1.5$  mm) has been shown to be an early indicator for later aseptic loosening of cemented hip stems. For the cemented twinSys<sup>®</sup> stem we published excellent short-term results at two years. Mid-term data for this stem are available from national registers (NZL, NL, UK), however in all of these sources, clinical and radiological results are missing. Aim of our study was to analyse early subsidence and radiological changes around the cemented twinSys<sup>®</sup> stem 5 years after implantation.

**Methods:** We conducted a concise five year follow-up study of 100 consecutive hybrid total hip arthroplasties (THA). Median age at surgery was 79 (69 to 93) years. 22 patients died in the course of follow-up unrelated to surgery, 21 stems had an incomplete radiological follow-up and no patient was lost to follow-up. In all 100 hips, a polished, cemented collarless straight stem (twinSys<sup>®</sup>, Mathys AG<sup>®</sup> Bettlach, Switzerland) with an uncemented monobloc pressfit<sup>®</sup> cup (RM pressfit<sup>®</sup>, Mathys AG<sup>®</sup> Bettlach, Switzerland) were implanted. Patients had a prospective clinical and radiological follow-up. Survival rates were calculated using the Kaplan-Meier method. Clinical (Harris Hip Score [HHS]) and radiological (cementing quality, stem alignment, osteolysis, debonding and cortical atrophy) outcomes and an in depth subsidence analysis using EBRA-FCA were performed after 3 months, 1, 2 and 5 years.

**Results:** Only two stems were revised, both due to an infection. The survival rate for the stem at five years was 98.0% (95% CI 95.3–100%). The survival rate of the stem for revision due to aseptic loosening at five years was 100%. The HHS improved from 53 (14–86) points preoperatively to 90 (49–100) points five years after surgery. Osteolysis was found in two stems without clinical symptoms, correlation to subsidence or cementing quality. In 49 out of 55 patients with a complete radiological follow-up, the EBRA-FCA analysis was possible and showed an average subsidence of 0.66 (95% CI 0.46 to 0.86) mm five years after surgery. Ten patients showed a subsidence  $>1$  mm, 5 of which  $>1.5$  mm. Subsidence was independent from radiological changes and cementing quality.

**Conclusion:** The twinSys<sup>®</sup> stem showed excellent clinical and radiological mid-term results at five years follow-up and seems to be a reliable implant.

**Keywords:** Cemented, EBRA-FCA, RM pressfit<sup>®</sup>, straight stem, subsidence, twinSys<sup>®</sup>

\*FM131

### Undersizing the Exeter stem in hip hemiarthroplasty increases the risk of periprosthetic fracture

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**Introduction:** Tapered, collarless femoral stems such as the Exeter, have been shown to be more prone to periprosthetic fractures (PPF) than collared stems such as the Lubinus SPII. Biomechanical studies have pointed to stem undersizing as a possible explanation, showing that larger stems contribute to increased torsional stiffness in the proximal femur, increasing the torque needed for fracture to occur. Our aim was to investigate whether under- or oversizing the cemented Exeter femoral component of hip hemiarthroplasties impacts the risk of periprosthetic fractures (PPF).

**Methods:** Seventy patients from two Swedish hospitals were included in this retrospective case-control study. Twenty cases with PPF following hip hemiarthroplasty with cemented Exeter V40 stems were compared to 50 controls who did not suffer PPF after hemiarthroplasty with the same stem. The difference between stem size and post-hoc radiographic ideal templated size was investigated as a predictor of PPF.

**Results:** Cases had a median size difference to post-hoc templating of -2, while controls had a median size difference of -1. The difference between cases and controls was not significant (-1, 95% CI: -2 to 0). An ROC curve constructed to find an optimal cutoff point in size difference between cases and controls arrived at an area under curve of 63%, with -1.5 as the cutoff. Patients with size differences exceeding -1.5 had a significantly increased PPF risk (OR = 3.8, CI: 1.1–13.3, p < 0.05). This group covered 55% of all cases.

**Conclusion:** While the study is small, and a significant difference in stem size was not seen between cases and controls, we found that differences between optimal templating and actual stem size of -2 and larger clearly increase the risk of PPF in Exeter stems. Keeping stem sizes within 1 step of the optimum could thus theoretically halve PPF incidence in our patient cohort.

FM132

### Is cemented revision total hip arthroplasty (THA) a reasonable treatment option in a high-age population?

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Revision THA is increasingly performed in people of high age. The surgeon's challenge is to provide a solution that supports immediate full weight-bearing, despite poor bone quality. Cemented line-to-line revision stems facilitate that through a long fixation distance without requiring cancellous bone for proximal cement interdigitation. Here, we present our mid-term results using a long version of the Charnley-Kerboull stem. From 2010 to 2017 38 Centris® (Mathys, Bettlach) cemented long stems were implanted and followed prospectively. Surgery was performed via a Hardinge approach in supine position with a third generation cementing technique (Palacos R+G (Heraeus)). Patients were mobilized using full-weight bearing as early as possible. 20 stems had a minimum f/u of 2 years and were included for further analysis. Survival was determined for stem revision for aseptic loosening and stem and/or cup revision for any reason. Further, the presence of osteolysis, debonding, infection/reinfection was recorded. Subsidence, as an early predictor for later aseptic loosening, was analysed using EBRA-FCA. Mean follow-up was 4 ([2–6], SD 1) years. Mean age at index surgery was 81 ([74–87], SD 3) years. 5 patients died during f/u of causes unrelated to THA. No patient was lost to f/u. 3 hips were primary (pseudarthrosis after intertrochanteric fracture osteosynthesis) and 17 revisions (12 aseptic, 5 septic loosening). Stem survival was 100%. 1 cup was exchanged for recurrent dislocations 4 weeks after revision, thus cup survival was 95% (95% CI 85–100%). 1 early infection 2 weeks postoperatively was treated with debridement, head/liner exchange and antibiotics. Survival after 4 years for any revision was 85% (95% CI 70–100%). 2 intraoperative trochanteric fractures were treated with cerclage wires and healed uneventful. 2 periprosthetic fractures (both Vancouver C, 4 and 12 months after stem revision) were treated with osteosynthesis. There was no development of osteolysis or debonding during follow-up. EBRA-FCA showed no subsidence over the entire f/u period. None of the cases revised for septic loosening showed signs of persistent infection at final f/u. The Centris® stem provides a reliable early full-weight bearing solution for revision THA with excellent mid-term survival in a high-aged population. Even in cases without cancellous bone in the proximal femur we were not able to detect any subsidence of the stem as an indirect hint for pending aseptic loosening.

### Acetabular reconstruction using a roof reinforcement ring with hook for total hip arthroplasty in developmental dysplasia of the hip-osteoarthritis – minimum 22-year follow-up results

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**Introduction:** In patients with development dysplasia of the hip (DDH) the acetabular reconstruction in the total hip arthroplasties (THA) continues to be challenging. In the long-term patients with DDH have increased risk of aseptic loosening and migration of the acetabular component compared to patients with degenerative osteoarthritis and rheumatoid arthritis. The acetabular roof reinforcement ring with hook (ARRH) is designed for use in acetabular reconstruction with bone stock deficiencies. The hook is placed at the inferior margin of the acetabulum and helps to center the ring in the true acetabulum despite significant bony deficiencies. To address bony deficiency bone grafting can be done behind the ring. Coverage and surface for cement fixation of the polyethylene cup in the anatomical position is provided by the ARRH. We report here the long-term results of acetabular reconstruction using ARRH with a minimum follow-up of 22 years in DDH.

**Material and methods:** This study consists of 33 consecutive cases of THA for DDH in 17 women and 10 men. The average age at surgery was 53 years (range, 35–77 years). Eight hips had undergone previous attempts for corrective surgery of DDH. Ten hips were classified as Charnley group A and 23 as Charnley group B. Patients were clinically and radiographically assessed at follow-up. A Kaplan-Meier survivorship analysis was calculated and a cox regression analysis was performed with the endpoint of THA revision.

**Results:** The average follow-up was 24.8 years (range, 22–27.7 years) with a minimum follow-up of 22 years. The mean Merle D'Aubigné score increased from 7 preoperative to 15 points at follow-up. The survivorship of the hips at 22-years was 75% (95% confidence interval, 58–88%). Six hips underwent revision for aseptic loosening and one hip underwent revision for recurrent hip dislocations. Three hips were lost to follow-up. Structural bone grafting was identified as risk factor for failure (hazard ratio with 95% confidence interval, 6.6 [5.0–8.2], p-value 0.023).

**Conclusion:** As a versatile tool for acetabular reconstruction in bone stock deficiencies the acetabular reinforcement ring with hook shows favorable long-term outcomes. If structural bone grafting is needed for reconstruction failure rate is substantially higher.

FM134

### High revision rate in THA under 40 years of age; retrospective analysis with a minimum follow-up of 10 years

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**Introduction:** Total hip arthroplasty (THA) is a very successful operation with a low reoperation rate and a high survival of the implant in patients over 70 years of age. However, in a younger population under 55 in the Swedish hip arthroplasty registry the revision rate increases to around 35% in 20 years. Nevertheless THA is rising also in the younger population. The purpose of this study was to analyze the subjective and clinical outcome, the complication- and revision rates of primary THA after a minimum of 10 years follow-up in patients younger than 40 years at index surgery.

**Methods:** Patients, who received a primary THA for any reason under the age of 40 years at index surgery between October 1996 and November 2007, were retrospectively identified. This resulted in 47 consecutive patients with 53 hips (24 males and 23 females) with a mean age of 33 (range, 17 to 39) years with a minimal follow-up of 10 years. All complications, reoperations and failures were identified and the survival of the implant was calculated according the Kaplan-Meier survival curve. Subjective and clinical (WOMAC, HHS) outcomes were measured.

**Results:** The implant survival rate was 93.5% (1 stem and 2 both) and 90.7% (1 stem, 1 cup, 2 both) at 5 and 10 years follow-up, respectively. Two additional stem revisions occurred after 11 and 15 years, respectively. Reasons of the 6 failures at the latest follow-up were the following: two deep infections, periprosthetic femur fracture, implant fracture following stem revision, aseptic stem loosening, psoas impingement. There were 7 (13.2%) minor reoperations (removal of osteosynthesis material). One relevant nonoperative complication was a subtrochanteric femur fracture. Age, etiology of osteoarthritis or

previous surgery were no associated risk factors for the occurrence of postoperative complication. The overall WOMAC (0 best, 10 worst points) and HHS (100 best, 0 worst points) score reaching a mean of 1.16 (SD  $\pm$  1.89) and 89 (SD  $\pm$  17), respectively. The mean follow-up scores of patients experiencing a failure were lower (WOMAC: no failure 0.89 vs. failure 3.50; HHS: no failure 91 vs. failure 69).

**Conclusion:** Implant survival rate was 90.7% 10 years follow-up. However, there was only one aseptic loosening found. As expected this survival rate at 10 years is lower than in older populations. Age at surgery, etiology of OA or previous surgery was not associated with higher complication rates in this study.

FM135

### The effect of femoral offset on polyethylene wear in total hip arthroplasty: a CT-based finite element analysis of 15 patients with simulated gait

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**Background:** The contact patch to rim distance (CPR) is the distance between the point of intersection of the joint force vector and the closes point on the rim of the acetabular insert. CPR has been associated to edge loading, wear and implant longevity. We previously described the dynamics of CPR during normal gait. We postulate that changes of femoral offset in THA will affect polyethylene wear.

**Aim:** To quantify the effect of offset changes on CPR and polyethylene wear in THA during normal gait using a CT-based finite element analysis.

**Methods:** THA was virtually performed on 3D models built from preoperative CT scans of 15 patients undergoing THA. The acetabular center of rotation and leg length was reconstructed anatomically. Cup orientation was set at 42° inclination and 15° of anteversion with a head diameter of 32 mm. The femoral offset was reconstructed either anatomically, or with + or - 20% in each patient. These models were then combined with a generic musculoskeletal model (OpenSim) to predict orientation and magnitude of the joint force vector during normal gait. To calculate CPR, the predicted force vector was normalized by its magnitude, multiplied by the head radius, and converted into spherical coordinates of the acetabulum cup. Volumetric polyethylene wear was estimated during gait for one million cycles using constant wear coefficient.

**Results:** The contact patch followed a complex path during gait but is mostly moving in the antero-superior quadrant (0° to 90°) of the cup. An INCREASE of 20% of femoral offset was associated with a decrease of wear (by -5  $\pm$  2%), of CPR (-2  $\pm$  2%) and of joint force (-4  $\pm$  2%). In contrast, a DECREASE of femoral offset led to an increase of wear (+8  $\pm$  3%), CPR (+2  $\pm$  1%) and joint force (+7  $\pm$  3%). The effect of femoral offset changes on wear strongly correlated with changes of joint force (R-square = 0.88, p < 0.001) and moderately with changes of CPR (R-square = 0.36, p = .01).

**Conclusions:** Alterations of the femoral offset after THR have an impact on the direction and magnitude of the joint force and polyethylene wear during gait. The magnitude of the force more significantly contributes to wear compared to the direction of the force.

\*FM136

### What should we expect after total hip arthroplasty after failure of intramedullary nailing for trochanteric fracture?

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**Objective:** Fracture of the proximal femur is one of the commonest fracture of the elderly and 60% concerned the trochanteric part. Osteosynthesis is the treatment of choice for these fractures using dynamic hip screw, locking compression plate or intra-medullary nailing (IMN). Complications can occur and a surgery like total hip arthroplasty (THA) can be needed. Clinical outcomes are rarely reported after THA after failure of IMN. Thus, aims of this study are to assess 1) clinical outcome 2) mortality of patients at one year and 3) minor and major complications of THA.

**Methods:** A retrospective monocentric study using our local database was conducted. All patients who suffered from a trochanteric fracture whom underwent IMN and needed a revision surgery by THA between 2004 and 2017 were included. Thus 25 patients were included with a mean age of 85  $\pm$  9 years (67–99). The mean time between the index procedure (IMN) and THA was 10.8  $\pm$  17.5 months (0.5–61.4). Reasons of revision were cut out (13 cases), avascular necrosis (5),

periprosthetic fracture (3), osteoarthritis of the hip (2), pseudoarthrosis (1) and shortening (1). Patients were revised by THA using in 17 times a cemented stem and in all cases a double mobility cup was used. Osteosynthesis with cerclage was needed in 10 patients. The mean follow-up was 9  $\pm$  11 months (1–48). One patient was lost of follow-up. Clinical outcome was determined by the ability to walk and the Parker score, mortality was calculated at one year and major complications were reported.

**Results:** 19 patients were able to walk at the last follow up, but only 4 were able to walk without an auxiliary device. 11 patients had a Parker score more than 6 and the other had a score less than 6. At 1 year, 3 patients were died and 5 patients died after one year. Minor complications after THA were anemia (14), paralytic ileus (2) and cardiac decompensation (1). 5 patients presented a major complication and needed a revision: scar necrosis (1), improper stem length (1), adductors tenotomy (1) infection (1) and periprosthetic fracture (1).

**Discussion:** Findings of this study are that clinical outcomes of THA after IMN are poor, mortality is frequent and complications are common, even if THA represents a valuable option after failure of IMN. Good positioning of the cervical screw of the nail and control of comorbidities of patients are critical to improve results of nailing.

FM137

### Position of the greater trochanter and functional femoral antetorsion: what parameters matter in the management of the femoral antetorsion disorders?

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**Aims:** The first aim was to define and quantify three new measurements of the greater trochanter (GT) position. Secondary aims were to define "functional antetorsion" as it relates to abductor function, in populations both with and without torsional abnormality.

**Methods:** Three new measurements and their reliability were assessed on 61 CT scans of cadaveric femurs: "functional antetorsion", posterior tilt and posterior translation of the GT. These measurements and their relationships were evaluated also in three patient groups: a control group (n = 22), a "high antetorsion" group (n = 22), a "low antetorsion" group (n = 10).

**Results:** In the cadaver group, the anatomical and functional antetorsion were 14.7°  $\pm$  8.5 and 21.5°  $\pm$  8.1 respectively, the posterior tilt and translation were 73.3°  $\pm$  10.8 and 0.59  $\pm$  0.2. These measurements had excellent inter- and intra-observer agreement. When the anatomical antetorsion decreased, the GT was more tilted and translated posteriorly compared to the femoral neck axis, and the difference "functional-anatomical antetorsion" increased. In the three patient groups, the results are similar to the cadaver group.

**Conclusion:** The GT position and the "functional antetorsion" varied according to the anatomical antetorsion. In the surgical management of femoral retrotorsion, subtrochanteric osteotomy can result in an excessive posterior position of the GT and an increase in "functional antetorsion".

FM138

### Derotational femoral osteotomies reduce posterior and anterior hip pain in patients with posterior extraarticular ischiofemoral hip impingement

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Posterior extraarticular ischiofemoral hip impingement can be caused by high femoral torsion and is typically located between the ischium and the lesser trochanter in mostly young and active female patients with high femoral torsion. We asked if patients undergoing derotational femoral osteotomies for posterior FAI have (1) decreased hip pain and improved function and (2) subsequent surgeries and complications?

**Patients and Methods:** This is an IRB-approved, retrospective case series. We evaluated 33 hips (28 patients) undergoing derotational femoral osteotomies between 2005 and 2016 of mainly female patients (94%). Minimal followup was 1 year and mean followup was 3  $\pm$  2 (1–11) years. Of them 15 hips (13 patients) underwent derotational femoral osteotomies and 18 hips (15 patients) underwent derotational femoral osteotomies combined with varisation (neck-shaft angle >139°). Indication for derotational osteotomies was a positive posterior impingement test in extension and external Rotation (Apprehension test), high femoral torsion (48°  $\pm$  9) on CT scans. Femoral offset

correction in hips with a cam-type FAI and surgical hip dislocation was performed to avoid anterior FAI.

**Results:** (1) At latest followup the posterior and anterior impingement test decreased from preoperatively 100% to 3% ( $p < 0.001$ ) and from preoperatively 97% to 18% ( $p < 0.001$ ). The mean Merle d'Aubigné Postel score increased from  $15 \pm 1$  (11–16) to  $16 \pm 1$  (13–17) points at latest followup ( $p < 0.001$ ). At followup 32/33 hips had been preserved and one hip had been converted to THA. (2) As a complication in two hips (6%) revision osteosynthesis was performed for delayed healing of the femoral osteotomy. Four hip arthroscopies were performed, three for adhesiolysis, one for offset correction. At followup, Womac score was 15, UCLA 5, Harris hip score 77, HOOS 66. Internal rotation in 90° of flexion decreased from preoperatively 48° to 34°, External rotation in 90° of flexion did not change from preoperatively 43° to 41°, external rotation in extension increased from preoperatively 16° to 40°.

**Conclusions:** Derotational femoral osteotomies for the treatment of posterior extraarticular ischiofemoral impingement caused by high femoral torsion result in decreased posterior and anterior hip pain and improved function at midterm followup. But 6% had delayed healing requiring revision surgery. Derotational femoral osteotomies are safe treatment for young and active patients with posterior FAI due to high femoral torsion.

FM139

### Effects of intra- and perioperative process improvements in combination with the introduction of a digitized surgical procedure management in total hip replacement

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**Introduction:** Since 2005 the minimally invasive direct anterior approach was used for every total hip prosthesis. A leg positioner was developed in 2009 and used in combination with a retractor system. Since 2012 the procedure is additionally combined with a fast-track concept. In February 2018 we introduced the intraoperative digitized surgical procedure management. The purpose of this study was to analyze the effects of intra- and perioperative process improvements and to give a first initial assessment of the intraoperative digitization.

**Methods:** Retrospectively we analyzed the first 100 primary THA operated with the intraoperative process optimized concept. The collected objective data and the subjective assessment were compared with the first 303 cases which were since 2012 additionally treated with the fast track concept and the first consecutive cases with the additional implemented digitized surgical procedure management.

**Results:** The average age of the patients treated with the intraoperative process optimized technique was 68 years, with a mean BMI of 26.5. The mean time of surgery was 80 min. The blood loss showed an average of 511.5 ml. No intra-operative complications occurred. The postoperative complication rate was 6%. Length of stay was 8.5 days. The HOOS increased from 43 points pre-operatively to 90 (max 100 points) 3 months after surgery. The additionally introduced fast-track concept leads in 303 cases to a reduced length of stay from 8.5 to 6.8 days, the mean time of surgery decreased to 70 minutes and the blood loss showed an average of 432 ml. The subjective results were also excellent.

**Conclusion:** The combination of the process optimized DAA technique and the fast-track concept leads to booster effects. We detected a high quality of radiologic, clinical and subjective results, connected with less complication, reduced length of stay and reduced intra- and perioperative blood loss. In summary costs were reduced although a high treatment quality and high subjective satisfaction of the patients were realized. The introduction of the intraoperative procedure digitization leads to a mandatory intraoperative standardized surgical technique, which is implemented by all team members. We expect a steeper learning curve for new team members. The general spread of a complex operation technique is facilitated and networking with clinic information system including the automated ordering of the next patient is possible.

FM140

### Inflammatory disorders mimicking periprosthetic joint infections may result in false positive $\alpha$ -defensin

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**Introduction:** The antimicrobial peptide  $\alpha$ -defensin has recently been introduced as potential "single" biomarker with a high sensitivity and specificity for the preoperative diagnosis of periprosthetic joint infections (PJIs). However, most studies assessed the benefits of the

test with exclusion of patients with rheumatic diseases. We aimed to evaluate the  $\alpha$ -defensin test in a cohort study without exclusion of cases with inflammatory diseases.

**Methods:** Between June 2016 and June 2017, we prospectively included cases with a suspected PJI and an available lateral flow test  $\alpha$ -defensin (Synovasure®) in synovial fluid. We compared the test result to the diagnostic criteria for PJIs published by an International Consensus Group in 2013.

**Results:** We included 109 cases (49 hips, 60 knees) in which preoperative  $\alpha$ -defensin tests had been performed. Thereof, 20 PJIs (16 hips, 4 knees) were diagnosed. Preoperative  $\alpha$ -defensin tests were positive in 25 cases (22.9%) with a test sensitivity and specificity of 90% and 92.1% (95% confidence interval [CI], 68.3–98.8% and 84.5–96.8%, respectively), and a high negative predictive value of 97.6% (95% CI, 91.7–99.4%). We interpreted seven  $\alpha$ -defensin tests as false positive, mainly in cases with inflammatory rheumatic diseases, including crystal deposition diseases.

**Conclusion:** A negative synovial  $\alpha$ -defensin test can reliably rule out a PJI. However, the test can be false positive in conjunction with an underlying non-infectious inflammatory disease. We therefore propose to use the  $\alpha$ -defensin test only in addition to MSIS criteria and assessment for crystals in synovial aspirates.

FM141

### High survivorship and little osteoarthritis at longterm followup in severe SCFE patients treated with a modified Dunn procedure

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**Introduction:** The modified Dunn procedure has the potential to restore the anatomy in hips with slipped capital femoral epiphyses (SCFE) while protecting the blood supply to the femoral head and minimizing secondary impingement deformities. However, there is controversy about the risks associated with the procedure and mid- to long-term data on clinical outcomes, reoperations, and complications are rare. Therefore, we report on (1) hip pain and function, (2) the cumulative survivorship with endpoints AVN, OA progression, THA or hip arthrodesis at followup (FU) in patients treated with a modified Dunn procedure for severe SCFE (slip angle  $>60^\circ$ ).

**Study Design & Methods:** We performed a retrospective analysis involving 46 hips of 46 patients treated with a modified Dunn procedure for severe SCFE (slip angle  $>60^\circ$ ) between 1999 and 2016. During this time period, all patients with severe SCFE were treated with a modified Dunn procedure. Of the 46 patients, 44 were available for FU (mean 8 years, range 1–17). Two patients were lost to FU after the 1-year FU. The mean age was 13 years (range 9–19 years). Fourteen out of 46 hips (30%) presented with unstable slips. Mean preoperative slip angle was  $64^\circ$  (range 60–90). Pain and function were measured using the Merle d'Aubigné and Postel score, PROMs, and the presence of a positive anterior impingement test or Drehmann sign. Cumulative survivorship was calculated according to the method of Kaplan-Meier with three defined endpoints: (1) AVN (2) progression by at least one grade of OA according to Tönnis; (3) subsequent Hip arthrodesis or THA.

**Results:** (1) Mean Merle d'Aubigné and Postel score was 17 points (range 14–18), mean Harris Hip score (HHS) was 93 points (66–100), mean Hip Disability and Osteoarthritis Outcome Score (HOOS) was 90 points (67–100), 28% had a positive anterior impingement test and no hip (0%) had a positive Drehmann sign of the preserved hips at FU. (2) Cumulative survivorship was 93% at 10-year followup. Three hips reached at least one of the three endpoints. Two hips (4%) had AVN, one of them underwent hip arthrodesis.

**Conclusions:** The modified Dunn procedure for severe SCFE corrected slip deformities with little risk of progression to avascular necrosis, OA, THA or hip arthrodesis and high hip scores at longterm FU. However, AVN occurred in 2 hips (4%) and secondary impingement deformities persisted in some hips and some underwent further surgical corrections.

FM142

### Preliminary results on computer-assisted planning and navigation of femoral head reduction osteotomies in severe Perthes deformities

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**Introduction:** Legg-Calvé-Perthes disease can cause severe deformity of femoral head and acetabulum. The head is typically extruded with an irregular contour in the frontal plane leading to a

hinged abduction while the sagittal contour is rather rounded allowing reasonable flexion. Such hips cause pain and limited ROM already in childhood. Due to adaptation the acetabulum shows a more or less pronounced secondary dysplasia. Substantial improvement is difficult to achieve with classic osteotomy techniques, while reduction of the head size combined with acetabular reorientation has shown significantly increased motion and pain relief in 51 patients so far. Freehand sketching of osteotomy direction and resection extent to achieve a most spherical head was the most challenging part of the surgery. Therefore, we have started to employ 3D preoperative planning and patient-specific instruments (PSI) to improve precision for this highly three-dimensional osteotomy. We present our experience of 2 hips treated with this technique and 4 hips in which the planning is completed.

**Methods:** Each patient underwent preoperative CT from which 3D bone models were generated by applying threshold segmentation. The models were imported into the in-house developed preoperative planning software CASPA. Based on a first definition of the cutting planes (trochanter, medial head, and lateral head osteotomy) with

careful consideration of the blood supply, osteotomies and reduction were iteratively simulated and refined until the reduction yielding the most spherical shape was determined. A report with landmark measurements was created to support the surgeon intra-operatively during reduction of the remaining two segments. PSI for navigation of the osteotomies were designed and 3D-printed.

**Results:** For the first case, the time required for 3D planning and PSI design was 10 h. The time for the second case could already be reduced by 40% to 6 h. In the 2 patients with completed osteotomies the PSI could be placed without difficulties and the osteotomies could be performed as designed. The evaluation of the postoperative radiographs showed excellent agreement with the 3D planning. The early postoperative course was uneventful.

**Conclusion:** First results about the use of 3D planning on 6 hips are very encouraging. The surgeons assessed also the application of the PSI as helpful to achieve the planned reduction. Next efforts concentrate on an algorithm to further reduce simulation time and costs.

## POSTERS

### Shoulder stabilization technique using the medial glenohumeral ligament in patients with Buford complex: a report on three cases

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The Buford complex is an anatomic variation defined as the association of a cord-like middle glenohumeral ligament (MGHL) and an absent anterosuperior labrum. It is challenging to identify on preoperative imaging and remains mostly an arthroscopic diagnosis. It may however lead to problematic situations when encountered during an arthroscopic soft tissue stabilization procedure, as the treatment of choice in such cases is a bone block. Moreover, reattaching the MGHL to the anterior border of the glenoid rim has traditionally not been recommended, as it theoretically leads to severe restriction in external rotation. This case series includes three patients who underwent arthroscopic stabilization for anterior traumatic glenohumeral instability associated to a Buford complex. We describe a novel technique consisting in using the cord-like MGHL to reconstruct a neo-labrum, associated with an antero-inferior glenohumeral ligament plicature. At one year postoperative, there was no new episode of glenohumeral dislocation or subluxation. All three patients went back to their previous level of sports and work activities with full range of motion. Glenohumeral stabilization using the cord-like MGHL of the Buford complex may be an efficient alternative to a bone-block procedure, with satisfactory outcome at one year. More studies are needed to confirm these findings in a larger population.

P01

angles were calculated from the cartilaginous anatomic neck plane orientation (cNPO). Three independent observers- one medical student (MS) and two orthopaedic surgeons (OS)- determined the anatomic neck by selecting 24 points on the respective 3D models. These points were used to calculate retroversion and inclination for the anatomic neck plane in the model (mNPO) and root mean square error (RMS) distance from the polygon edges. Retroversion and inclination angles were compared with paired t-tests. ANOVA with Bonferroni post-hoc correction analysed RMS error between quadrants.

**Results:** cNPO inclination and retroversion angles were  $135 \pm 4^\circ$  and  $36 \pm 11^\circ$ , respectively. Inclination was higher in cNPO versus mNPO as defined by the MS ( $p = 0.010$ ), but not for the two OS ( $p \geq 0.074$ ). No differences in retroversion existed between cNPO and mNPO ( $p \geq 0.210$ ). RMS errors for quadrant 1, 2, 3, and 4 were  $2.1 \pm 1.1$ ,  $2.4 \pm 1.7$ ,  $1.9 \pm 1.1$ ,  $1.8 \pm 1.0$  mm, respectively. RMS error in quadrant 2 was higher than 3 and 4 ( $p \leq 0.026$ ).

**Conclusion:** Anatomic neck orientation can be accurately defined in 3D-CT models without a priori knowledge of the cartilage surfaces. Accuracy varies with surgical experience and reveals regional differences. This must be considered in studies evaluating prosthetic designs in SA or patient-specific preoperative 3D-CT based planning.

P03

### The influence of radiographic viewing perspective on the acromial tilt and acromial slope angles

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**Introduction:** Accurate and reliable assessment of the acromial tilt (ATA) and slope angles (ASA) is important in clinical evaluation of degenerative and traumatic rotator cuff tears. Since different radiograph collection protocols exist, this study analyzed the influence of radiographic viewing perspective on the ATA and ASA.

**Methods:** Three-dimensional computed tomography reconstructions of 10 cadaver scapulae without rotator cuff tears or osteoarthritis were studied. Digitally reconstructed radiographs were aligned perpendicular to the scapular plane to obtain a true lateral (TL) view. Incremental ante-/retro-version and up-/down-rotation views were generated up to  $30^\circ$  in each direction ( $10^\circ$  increments). The ATA and ASA were measured by two independent observers.

**Results:** Mixed effect models showed that anteversion views significantly decreased the ATA ( $-0.17^\circ$ ) and the ASA ( $-0.29^\circ$ ) ( $p \leq 0.006$ ) but retroversion had no effect. Up-rotation decreased the ASA ( $-0.25^\circ$ ,  $p = 0.001$ ) but had no effect on ATA. Down-rotation views increased the ATA ( $0.57^\circ$ ) and ASA ( $0.20^\circ$ ) ( $p \leq 0.006$ ). Intra-observer reliability was good and excellent for ATA (ICC  $\geq 0.67$ ) and above 0.62 for ASA except for views above  $20^\circ$  from TL. Inter-observer reliability was good and excellent for ATA (ICC  $\geq 0.79$ ) except

P02

### Regional and observer differences in determination of the humeral anatomic neck in 3D-CT models

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**Introduction:** Determining the anatomic neck on 3D-CT models is critical when designing anatomic implants, analyzing their biomechanics and in preoperative planning in shoulder arthroplasty (SA). This method has not been validated and since CT-scans lack cartilaginous topography the definition may vary by region and surgical experience. The purpose of this study was to evaluate if the humeral anatomic neck can accurately be determined on cartilage-free 3D-CT models, and quantify regional differences.

**Methods:** Anatomic necks of 29 non-pathologic cadaver humeri were digitized in the laboratory and data were transformed back to corresponding 3D-CT models, connected via a polygon, and subdivided into anatomic regions: anterosuperior (1), posterosuperior (2), posteroinferior (3), anteroinferior (4). Retroversion and inclination



for 30° down-rotation. For ASA inter-observer reliability was good and excellent (ICC  $\geq 0.59$ ) for all versions, but only  $\geq 0.59$  within 10° up-rotation to 20° down-rotation.

**Conclusion:** Both ASA and ATA were significantly affected to malposition in anteversion and down-rotation of the glenoid. Reliable ASA measurement was more susceptible to a changed viewing perspectives in up/down-rotation than the ATA. Up-rotation of the glenoid as proposed in the supraspinatus outlet view does not improve inter-observer reproducibility of ATA and ASA measurement. Future studies comparing ATA and ASA as risk factors for rotator cuff tears should adhere to a strict radiographic protocol and radiographic criteria have to be defined to ensure TL views are collected.

P04

#### Are angular stable plates more accurate than tension band wiring to reconstruct ulnar articular surface after olecranon osteotomy?

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**Background:** Complex distal humeral fractures are challenging to treat. Olecranon Chevron osteotomy (OCO) is the most popular approach. Predrilled tension band wiring (TBW) is classically used to fix OCO. The use of anatomic locking plates (LCP) in olecranon fractures led us to the hypothesis that this implant might improve articular surface reconstruction using the predrilled angular stable screws to achieve an anatomic reposition of the OCO. The aim of the study was to compare articular reconstruction accuracy of tension band and locking plate in olecranon osteotomy fixation.

**Methods:** Twenty ulnar Sawbones® were used. One senior and one board-certified orthopedic surgeons each performed ten predrilled olecranon osteotomies and fixation (5 with TBW and 5 with the Synthes® olecranon LCP plate). For the TBW, two 1.6-mm K-wires and 1-mm wire were used. The twenty olecranons were then X-rayed using a custom-made fixation device and a ruler to get reproducible and calibrated x-rays. An independent observer used the TraumaCad® software to analyze the articular surface geometry. The diameter of the best-fitting circle (Diam), the distance between the tip of the coronoid and the olecranon process (Dist), and the maximal articular depth (Dmax) were measured.

**Results:** Articular geometry was significantly different for all three measures between TBW and LCP. Diam was larger for TBW (30.4 + 0.3 mm) than for LCP (29.3 + 0.3 mm) ( $p < 0.001$ ), Dist was longer for TBW (32.4 + 0.4 VS 31.7 + 0.2 mm) ( $p = 0.004$ ), Dmax was shallower for TBW (10.2 + 0.2 VS 10.4 + 0.3 mm) ( $p < 0.001$ ). In contrast, the geometry was not statistically different between LCP and the native olecranon ( $p = 0.471$ ). On the x-rays, the osteotomy was visible as a regular line after LCP, but as a wedge (thinner on the articular side) after TBW.

**Conclusions:** LCP is more accurate than TBW in reconstructing the anatomic articular geometry after OCO. Cadaveric and clinical studies are necessary to further confirm these initial findings and assess their clinical relevance.

P05

#### Prospective sensor controlled compliance analysis of shoulder abduction brace after rotator cuff repair

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**Introduction:** The postoperative shoulder immobilization after rotator cuff repair in an abduction brace seems to be crucial for a successful tension free healing of the reconstructed tendon. The uninterrupted wearing of the abduction braces is highly uncomfortable for patients. The patient's wearing compliance of abduction splints is unknown. It was the purpose of this study to prospectively capture the abduction brace wearing time to evaluate the patient's wearing compliance of abduction braces.

**Methods:** All patients who underwent primary arthroscopic supraspinatus tendon reconstruction after January the 1st 2017 received a sensor in the abduction brace. The sensor captures the body temperature and records herewith the wearing time. The patients were primarily not informed about the sensor implantation so that the natural wearing behaviour of the patients was not influenced. The declared wearing time was 23 hours a day for 6 weeks resulting in an absolute declared wearing time of 966 hours. At the six weeks postoperative appointment the patients were informed about the implanted sensor and were asked for the study participation. The

declared number of participant was prospectively set with 50 patients. The primary outcome parameter was the absolute wearing time in hours. The compliance rate in % (absolute wearing time/declared wearing time) was set as the secondary outcome parameter.

**Results:** 17 women and 23 men (40 right and 10 left shoulders) with a mean age of 55 (range, 28–79) years signed the study participation confirmation. 7 patients had to be excluded because they denied the read out of the sensor ( $n = 1$ ), the sensor was lost ( $n = 4$ ) or the abduction brace therapy was stopped for medical reasons ( $n = 2$ ). The absolute mean wearing time was 759 (range, 315–966) hours. The mean compliance rate was 78 (range, 55–100)%. 68% of participants showed a compliance rate of 80% or more. The remaining 32% had a compliance rate of less than 80%.

**Conclusion:** Two third (68%) of this study population show a high abduction brace wearing compliance after rotator cuff repair. The effect of high respectively low compliance wearing behaviour regarding the clinical outcome needs to be addressed in a follow up study.

P06

#### Rates of improvement following shoulder arthroplasty for proximal humeral fracture sequelae: register-based analysis and systematic review

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**Background:** The goal of this study was to investigate rates of clinical improvement in patients with non-constrained (NCA) or reverse (RSA) shoulder arthroplasty following different proximal humerus fracture sequelae.

**Methods:** 32 consecutive patients with NCAs in Boileau type 1 sequelae and 77 patients with RSAs in Boileau types 1, 3 and 4 were retrospectively included from a local registry. Clinical outcomes were compared at 6, 12, 24 and 60 months postoperatively. Databases were searched for clinical studies on NCA and RSA following fracture sequelae. Using metaregression analysis, reported clinical outcomes at baseline and follow-up were compared according to arthroplasty and sequelae type.

**Results:** In the retrospective study, range of motion, DASH, SPADI and Constant scores improved in all patients until 24 months postoperatively and did not deteriorate thereafter. At all follow-up time points, patients with NCA in type 1 sequelae showed better internal and external rotation than patients with RSA and/or other Boileau types ( $p < 0.001$ ). In metaregression analysis, follow-up Constant scores and range of motion correlated with baseline values.

**Conclusion:** In fracture sequelae, implantation of NCA and RSA lead to sustained clinical improvements in relation to baseline values. Surgeons may foster implantation of NCA in type 1 sequelae.

P07

#### Reliability of assessing shoulder kinematics using 3D motion capture

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**Introduction:** Assessing the treatment efficacy of interventions aimed to improve shoulder mobility in patients is challenging, as global shoulder motion is influenced by individual contributions of the glenohumeral and scapulothoracic joints as well as the torso. One approach to non-invasively identify these specific joint motion contributions is the use of a 3-dimensional motion capture system combined with a novel kinematic model customized for the shoulder joint. The aim of present study was to evaluate the reliability and the smallest detectable change (SDC) of this system when performing an arm abduction movement.

**Methods:** Reflective markers were fixed to the skin on arms, shoulder and torso of ten adult, asymptomatic participants using adhesive tape (7 women, age 33 ± 9, BMI 22 ± 2). Participants were seated on a stool and three arm abduction movements in the scapular plane were recorded using a 10-camera motion capture system operating at 200 Hz. The angle between scapula and humerus at 90° humeral elevation was extracted for further analyses. Two observers assessed participants in two consecutive measurements and again in a second session 5–9 days after the first session (40 assessments total). Inter- and intra-observer reliability was assessed using intra-class correlation coefficients and the SDC was calculated.

**Results:** No systematic differences in mean scapulo-humeral angle between or within observers was found ( $P > .05$ ). Intra-observer

reliability was good (ICC 0.79–0.83) while inter-observer reliability was good to excellent (ICC 0.84–0.96). A SDC of 10.8°–11.9° was found within observers. Between observers, the SDC was 10.4° in the first session and 5.8° in the second session.

**Conclusion:** The scapulo-humeral angle can be assessed reliably using 3D motion capture and any measurement change exceeding 12° from one measurement to another may indicate that a real change occurred. Additionally, the used method has the capability to separately quantify thoracic, scapular and humeral motions. This will enable clinicians and researchers to identify the origin of limited shoulder motion and to select the most appropriate treatment.

P08

### Biomechanical and biological response to orthopedic sutures: an experimental study in sheep

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**Introduction:** Surgical suture material is essential, effective and omnipresent to orthopaedic surgery. In shoulder surgery it positions and secures a tendon until a tendon-to-bone healing is achieved. For rotator cuff repair, a stable initial tendon-to-bone fixation is necessary and therefore often stiff, non-absorbable suture material is used. The effects of the suture material on the tissue and fixation properties to the tendon tissue are unknown. We hypothesized that different suture composition will not only result in different histological responses but also lead to different levels of tissue in- or on-growth. This may lead to varying hold of the suture in the tissue.

**Method:** Orthocord, Ethibond, FiberTape or FiberWire suture loops were implanted in to the intact supraspinatus tendon of 36 Swiss mountain sheep. Two suture of different suture types were randomly assigned per tendon and implanted for 6, 16 or 22 weeks. This resulted in 12 threads at each time point (6, 16 and 22 weeks) that could be used for the histological examination and another 11 for the biomechanical tests. In the histological examination consisted of: measurement of capsule thickness around the thread, qualitative and quantitative assessment of tissue maturity, activity of tissue reaction and invasion of cells and tissue into the suture material.

**Results:** The maturity of the surrounding tissue increased over the study period and the thickness of the fibrous capsule was reduced for all sutures except Orthocord. From week 6 to week 22, the number of vessels in all samples decreased. Cells and tissue increasingly grew in the filaments during the course of the study, except for FiberTape.

Overall, univariate analysis revealed a significantly increasing suture hold of all sutures until week 16. The difference between week 16 and week 22 was not significant. There was furthermore no significant difference between Ethibond, Orthocord and Fiberwire at any tested time point. A significant correlation between maturity of the surrounding tissue and the extraction force could be demonstrated.

**Conclusions:** The suture retention correlated with the maturity of the surrounding tissue and suture hold increased until week 16. Therefore it seems that the biomechanical properties of the suture-tendon contact change by the physiological response to the suture. The inflammatory reaction and the formation of a capsule contribute to the stabilization of the suture in the tissue.

P09

### Addressing instability in reverse shoulder arthroplasty

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**Introduction:** The approach to this complication remains unstructured with uncertain prognosis and cumbersome healing paths for the patient. The aim of the present study was to evaluate the success rates of conservative and operative treatment of unstable reverse total shoulder arthroplasties (RTSA).

**Methods:** During the study period from May 2003 to November 2017 19 cases of dislocations of RTSA were treated conservatively and 29 operatively (32 patients, 33 shoulders). Recurrence of dislocation after treatment was considered the primary endpoint. Demographic and radiological parameters before and after treatment were investigated for risk factor analysis. The group of patients, which remained stable after treatment, was investigated using the Constant score (CS; minimum follow-up, 9 months).

**Results:** Conservative treatment of early dislocation ( $\leq 3$  months) of primary RTSA was successful in 4/5 cases (80%) and associated with a mean CS of 41. Surgical treatment of early dislocation of

primary RTSA was successful in 4/4 (100%) cases with mean CS of 29 ( $p = .34$ ;  $p = .17$ ). Conservative treatment of early dislocation of revision RTSA was successful in 2/5 (40%) with a mean CS of 48 points, operative treatment was successful in 6/8 (75%) with a mean CS of 59 after surgical treatment, respectively ( $p = .21$ ;  $p = .61$ ). Only in 1/7 (14%) conservative and in 3/7 (43%) surgical treatments were successful after late dislocation (>3 months) of primary RTSA ( $p = .24$ ). Female gender, low acromio-humeral distance, cranially directed glenoid tilt and immobilization in neutral/internal rotation (no abduction brace) after reduction could be identified as significant risk factors for unsuccessful conservative treatment.

**Conclusion:** Closed reduction seems to be a viable treatment option in early dislocation of primary RTSA but not in late dislocation or after revision RTSA. Recurrence of instability is associated with risk factors: cranial tilt of the glenoid may need operative revision and immobilization on an abduction brace appears to contribute to successful restoration of stability.

P10

### Open inferior capsular shift through a subscapularis split for multidirectional shoulder instability in patients with genetic hypermobility

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**Objectives:** Multidirectional shoulder instability (MDI) in patients with genetic hypermobility, such as ligamentous hyperlaxity or Ehlers-Danlos syndrome, is a particularly difficult problem. Past research has shown, that even in young, overhead athletes, open inferior capsular shifts (OICS) can produce good and sustainable results. However, the subscapularis tenotomy required for full exposure of the capsule is a source of concern. This study assesses a group of 10 hypermobile patients undergoing OICS through a subscapularis split compared to the classic technique.

**Methods:** 10 patients with confirmed Ehlers-Danlos Syndrome or ligamentous hypermobility syndrome were assessed before and after undergoing an open capsular shift through a subscapularis split for MDI. Defined endpoints were improvement of pain, percentage and time to return to sport and activities, ASES scores, QuickDASH scores and complications. These endpoints were compared to a cohort of 15 patients with the same ailments treated with an OICS with a subscapularis tenotomy.

**Results:** All patients recovered from their surgery without complications. Return-to-sport (RTS) succeed in 80% of subscap-split patients, compared to 70% in the tenotomy group ( $p = 0.581$ ), with a mean time to RTS of  $4 \pm 1$  months vs  $7 \pm 3$  months ( $p = 0.031$ ). There were no significant differences in ASES or QuickDASH scores or in the improvement of pain. One patient in the subscap-split group suffered from delayed wound healing, otherwise there were no complications.

**Conclusions:** Open inferior capsular shifts are a reliable treatment option for MDI in patients with hypermobility or Ehlers-Dallos Syndrom. Using a subscapularis split instead of a tenotomy allows for quicker return to activities, but there are no indications for insufficient capsular reefing due to a limited exposure and subsequent effects on clinical outcome scores and/or pain. Advantages in long-time subscapularis function and structural integrity seem biologically plausible, but at this point there is no data to confirm this.

P11

### Coronoid injury is the sole outcome modifiers in reconstructive treatment of complex radial head fractures

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**Objectives:** Radial head fractures are a fairly frequent problem. Even in complex fracture types with associated concomitant injuries, reconstruction is increasingly being recommended over replacement, let alone resection. However, the mid and long term outcomes of reconstructive surgical treatment are still somewhat elusive, and – to date – the effect of concomitant injuries remains unknown.

**Methods:** Patients undergoing surgical treatment for a complex (Mason III and IV) radial head fracture were included in this analysis. Concurrent injuries were recorded in a standardized way (for the lateral ulnar collateral ligament (LUCL), extensors, ulnar collateral ligament (UCL), capitellum&cartilage, coronoid,interosseus membrane) and treated according to known guidelines. Outcomes studied were radiographic healing, secondary surgery, extension loss and loss of pronation compared to the contralateral side, pain on a VAS scale (0–10), function as per the Mayo Elbow Performance Score (MEPS) and full-time return to work without limitations. The effect of concomitant injuries on these endpoints was assessed in a

multivariate regression analysis, adjusting for Mason type and age as covariables and for multiple testing.

**Results:** At final follow-up, the mean VAS pain score was 2 points (95% CI 1.7 to 2.6), the average MEPS was 80 points (95% CI 76 to 84 points). 19 patients (66% 95% CI [48% to 83%]) were able to return to work, three patients had already retired before their injury. We found a significant effect of coronoid injury on postoperative outcomes; patient with coronoid damage had 1.5 points more pain, a 12 points less function on the MEPS. Their likelihood of returning to work changed by 22% (95% CI 0.12% to 46%).

**Conclusions:** Reconstructive treatment of complex radial head fractures leads to satisfactory outcomes in terms of pain, function and ability to return to work - even in the face of concomitant injuries. Ligamentous injuries, if treated, had no detrimental effect on these results. Coronoid fractures, even if repaired, have a statistically significant and clinically relevant effect on postoperative results.

P12

### Intra-observer agreement for a pathomechanical classification system for radial head fractures

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**Objectives:** We propose a simple classification of radial head fractures based on pathomechanics. This system of three types differentiates between the simple injuries and those with important associated soft tissue components. Details on this classification system have been published elsewhere and can be reviewed under <https://www.vumedi.com/video/pathomechanic-radial-head-fracture-classification/>. The purpose of this study was to assess the intra-observer agreement for this new classification.

**Methods:** An online questionnaire was designed. Per an a priori power calculation, 18 lateral elbow radiographs were included to be scored via multiple choice as type I, II, III, unclear, or healthy/normal. Demographic data for all respondents were included. All analyses were performed using intercooled Stata 13 (StataCorp LP, College Station, Tx). Interobserver agreement was calculated using Fleiss' multi-rater kappa. A alpha value of 5% was considered significant.

**Results:** 438 physicians answered the questionnaire. 83% were board-certified orthopedic surgeons, 10% were certified in hand or plastic surgery, 4% were general surgeons. 77% worked at either a trauma center or an orthopedic department, the next most common was private practice at 11%. 98% treated at least 10 elbow fractures annually, 95% performed at least 10 elbow surgeries per year. Among the 18 cases, the overall kappa was 0.46 ( $p < 0.001$ ). Agreement was highest for type III injuries and healthy elbows (kappa 0.64 and 0.60 respectively). Type I and II injuries had less agreement with kappa values of 0.36 and 0.38.

**Conclusions:** In a large population of elbow surgeons from various backgrounds, the overall agreement for our newly proposed fracture classification system kappa was "moderate" according to Landis and Koch. Looking at the individual types, we found that agreement for type III and healthy was "substantial". There was less agreement for type I and II, suggesting that the definitions of these types could be improved. Of note, this assessment was based on a single image only and could be improved by use of more advanced imaging.

P13

### Clinical reliability for vertical (AC-DC) and horizontal (GC-PC) measurements for acromio-clavicular joint dislocations

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**Aim:** The aim of this study was to assess the inter-observer and intra-observer reliability for the acromial-centre-line-to-dorsal-clavicle (AC-DC) and the glenoid-centre-line-to-posterior-clavicle (GC-PC) measurements in acromioclavicular joint (ACJ) dislocation in the clinical practice.

**Background:** Two novel radiographic parameters to measure vertical and horizontal instability in ACJ dislocations has been described recently: the AC-DC and the GC-PC. An in-vitro study using a Sawmodel of the scapula simulated the different Rockwood dislocation degrees. Although both AC-DC and GC-PC demonstrated very high intra- and inter-observer reliability and validity with reasonable inertness to malpositioning in the simulation model, reliability in a patient population has not been assessed.

**Methods:** We retrospectively reviewed Alexander X-ray of 82 patients who had different degrees of ACJ dislocation. Two different shoulder fellows measured independently the AC-DC and GC-PC in affected

and unaffected shoulders using the PACS software. Inter- and intra-observer reliability was assessed with intraclass correlation coefficient (ICC 2,1).

**Results:** AC-DC showed high inter-observer reliability with 0.90 (95%-CI: 0.78–0.94), and intra-observer reliability was even higher with 0.95 (95%-CI: 0.90–0.97). GC-PC demonstrated moderate inter- and intra-observer reliability (both 0.56). Comparison between affected and unaffected shoulder showed increased reliability for healthy shoulder, for both AC-DC and GC-PC. Median difference between observers was 2 mm and 8 mm for AC-DC and GC-PC, respectively.

**Conclusions:** The new parameter AC-DC confirmed the high reliability in a patient population in clinical practice. Reliability for GC-PC was lower compared to AC-DC due to the challenge in identifying the vertical glenoid axis. GC-PC measurement requires some training, but learning curve is short.

P14

### MRI assessment of ligaments, plicae, and cartilage in the pediatric and adolescent elbow

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**Objectives:** Elbow injuries in young athletes are becoming an increasing concern for orthopedic sports medicine specialists. The most frequent are ligament injuries and cartilage injuries such as OCD. While their open and arthroscopic treatments are well described, imaging is complicated. The purpose of this study was to assess MRI in imaging the affected anatomy in pediatric and adolescent patients.

**Methods:** 65 elbow MRI studies were selected and analyzed "as are". First, we tested if the collateral ligaments were clearly discernable, and, if so, measured their size. Second, we specifically looked for cartilage damage including pseudodeficits, and for posterolateral plicae. Third, we tested if these endpoints differ between patients with open and closed physes. All assessments were done in independent duplicate.

**Results:** 9 MRIs (13%) did not allow unequivocal assessment of any of the endpoints because of poor quality or artefacts. 29 patients were skeletally immature with at least one open physis, 27 had all physes closed. In skeletally mature patients, the radial and ulnar collateral ligament were clearly discernable in 94% and 77%, measuring  $1.5 \pm 0.6$  mm and  $1.9 \pm 0.6$ , compared to 55% and 59% in the immature patients with a mean thickness of  $1.1 \pm 0.6$  and  $1.4 \pm 0.6$  mm. This is consistent with a significant difference for both discernability and size ( $p < 0.05$ ). 65% of the mature patients showed a posterolateral plica with a maximum extension of  $2.2 \pm 1.7$  mm, compared to 41% ( $p = 0.082$ ) of the immature patients ( $1.1 \pm 1.2$  mm,  $p = 0.006$ ). 100% of patients with OCD had a posterolateral plica, compared with only 47% of those without OCD ( $p = 0.03$ ). In OCD the plica was significantly larger with  $4 \pm 0.7$  mm compared to  $1.3 \pm 0.2$  in those patients without OCD ( $p = 0.001$ ). 42% of all patients with closed physes had a posterior pseudodeficit in the capitellum, compared to 17% in the skeletally immature patients ( $p = 0.08$ ).

**Conclusions:** Elbow MRI in pediatric and adolescent patients is associated with a considerable amount of problems. 1 in 10 cannot be assessed reliably. In skeletally immature patients assessment of the collateral ligaments is limited. Posterolateral plicae are more frequent and larger in size in patients with OCD, implicating their involvement in the pathology. Lastly, pseudodeficits, which are seen in 85% of asymptomatic adult patients, are encountered in 42% of adolescents but only 17% of immature patients. Thus any irregularity in the cartilage of the pediatric elbow patient should be further assessed with the utmost diligence.

P15

### Glenoid inclination or acromial coverage – what is more relevant for the determination of the critical shoulder angle in patients with osteoarthritis or rotator cuff tears

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**Introduction:** It is still unknown whether glenoid inclination or lateral acromial roof extension are more important determinants for the development of rotator cuff tears (RCT) or concentric osteoarthritis (COA) of the shoulder. Strong evidence could be found for both. Because inclination and lateral acromial roof extension are linked, predominance of one over the other is very difficult to investigate. The aim of this study was to search a potential predominance of either glenoid inclination, lateral acromion roof extension or acromial height for distinguishing shoulders with degenerative RCT or COA.

**Methods:** We analyzed 70 shoulders with advanced degenerative RCT and 54 shoulders with COA undergoing primary shoulder arthroplasty (anatomical or reverse) using conventional antero-posterior radiography and multiplanar computed tomography (CT). The two groups were compared in relation to glenoid inclination, lateral acromion roof extension and acromial height.

**Results:** CSA, glenoid inclination, lateral acromion roof extension and acromial height were all highly significantly different between RCT and COA. Detailed analysis of effect size with Cohen's d test found a superiority of lateral acromion roof extension. However, no single factor showed an effect size which was as high as that of the CSA. Interestingly, a ratio of lateral acromion roof extension and acromial height could enhance the effect size near to values of the CSA.

**Conclusions:** Glenoid inclination, lateral acromion roof extension and acromial height are highly associated with RCT and COA. Lateral acromion roof extension is more relevant than acromial height and glenoid inclination. Glenoid inclination shows only an intermediate association in Cohen's d test. Only the ratio of lateral acromion roof extension and acromial height could improve the predictive value of the investigated parameters to near the predictive value of the CSA.

P16

### The bra strap incision for open Latarjet procedure

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**Introduction:** The anterior deltopectoral approach is the standard approach for the open Latarjet procedure. By medialisation of the skin incision the scar can be covered by the bra strap in women. We call this incision the bra strap incision. The intention of this study was 1) to evaluate clinical results of patients in which the bra strap incision was used 2) to define shoulder anatomic orientation points of which the bra strap incision can be predicted on the skin and 3) if women desire a bra strap incision.

**Methods:** The clinical results, assessed with the Constant and Murley score (CMS) and the Subjective Shoulder Value (SSV) of all women who underwent a bra strap incision were retrospectively analysed as the primary outcome parameter and compared to prior published data from our institution. To determine the anatomical bra strap line the distances from bra strap centre to four anatomical shoulder landmarks (1. acromioclavicular joint 2. tip of the coracoid process and 3. the anterior axillary fold) were measured in 108 consecutive female patients, who were seen in our outpatient clinic. The coefficient of variation of the four measured distances was evaluated as the secondary parameter. The women scar satisfaction, assessed with two questions was assessed as the third outcome parameter.

**Results:** Between January 2015 and January 2017 a bra strap incision was performed in 17 women with a mean age of 29, (range 17–52) years. The mean follow up was 21 (range, 12–31) months. All patients were available for a follow up visit. The mean CMS was 84 (range 64–97) points and the mean SSV scored 85 (range, 60–100) % and did not differ to prior published data from our institution (SSV 79% and CMS 85%). The coefficients of variation from the distances from the bra strap to the coracoid tip, the anterior axillary fold and the AC joint line were 0.5395, 0.3695 and 0.3604. Therefore, none of the landmarks can be used to reliably predict the bra strap position. 16/17 women were very satisfied with the scar and 15/17 women would prefer the bra strap incision.

**Conclusion:** The clinical results after the use of the bra strap incision in open Latarjet procedure are good and comparable to prior published data in which the bra strap incision was not used. The bra strap line cannot be reliably assessed with help of shoulder anatomical landmarks and has to be marked before surgery. The bra strap incision is desired by the majority of women.

P17

### Chronic sternoclavicular instability: technique and results of corrective clavicular osteotomy

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**Introduction:** Anterior, recurrent sternoclavicular (SC) instability is a rare, but potentially disabling condition. It can arise in conjunction with trauma and/or hyperlaxity. SC-instability is often position-dependent and can be reduced with the arm in a specific position. In order to directly address this issue, we used a technique of corrective osteotomy of the clavicle with the goal to reorient the articular portion

of the medial end of the clavicle so that it remains stable in most positions of the arm. Evaluation of the clinical outcome in four patients treated for recurrent anterior sternoclavicular instability with reorientation of the medial end of the clavicle and 3-D CT comparison of the postoperative SC- joint congruity with that of the contralateral, asymptomatic side.

**Method:** 4 patients treated between 2003 and 2013 for recurrent anterior sternoclavicular instability using a clavicle osteotomy were included. An osteotomy was performed approximately 4 cm lateral to the medial end of the clavicle with the SC- joint dislocated. After the osteotomy the medial end of the clavicle reduced automatically or was assisted in finding its stable position with regard to the sternum. The resulting position of the two clavicular portions was then stabilized using a third tubular plate. For review clinical assessment included the SGOT minimal dataset, Subjective Shoulder Value (SSV) and Constant Score (CS). CT scans and clinical scores were obtained at final follow-up and compared to preoperative scores. The amount of three-dimensional correction for osteotomies was computed using an anatomic coordinate system.

**Results:** Mean follow-up was 64 (19–191) months. The mean CS improved from 58 (45–68) preoperatively to 73 (69–84) postoperatively, the SVV from 42 (15–80) to 79 (50–100). All patients reported good or very good stability of the SC-joint at last follow-up. We recorded no intra- or postoperative complications. During follow-up, 3 patients needed removal of the plate, once for 1 plate breakage. The mean postoperative correction for combined rotation is given as a 3-D angle and was in mean 28.0° (8.6–39.7°).

**Conclusions:** In conclusion, in this pilot study, corrective clavicle osteotomy using the described technique treated anterior sternoclavicular instability with improvement of clinical shoulder function scores and good patient satisfaction. The technique appears simple and safe and deserves further evaluation.

P18

### How reliable can the fragment dislocation in isolated greater tuberosity fractures be quantified?

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**Introduction:** Little is known about the amount and direction of GT displacement that warrants surgical intervention after GT fractures. Furthermore, there is no standardized and reproducible method described to quantify displacement of GT fragments. We want to investigate several new quantitative radiographic parameters and validate with CT/MRI Scan. The aim of our study was to establish a standardized and reproducible method to evaluate fragment dislocation in patients with isolated fractures of the greater tuberosity (GT).

**Methods:** Two orthopedic surgeons independently reviewed plain ap x-rays of 104 patients with isolated fractures of the GT. The following parameters were evaluated in each radiograph: (1) Fragment dislocation-distance perpendicular to the humeral axis (DA) and -distance from the rotational center of the head (DR). (2) Two proposed impingement angles – the angle between the GT fragment and the axis of the humerus (Omega1) and the angle between the GT fragment and the lateral acromion (Omega2). (3) Relationship of the humeral head to the glenoid (Theta-Angle, HHD). Interobserver reproducibility was assessed with intra-class-correlation-coefficient (ICC 2,1). For subgroup analysis, general direction of dislocation was defined according to all further available images (CT/MRI).

**Results:** Reproducibility for the distances and the impingement angle were high. While the reproducibility for DA (0.83) and DR (0.79) were comparable, Omega2 (0.80) was slightly better than Omega1 (0.70). The Theta-Angle as well as HHD showed low to moderate reproducibility (Theta-Angle: 0.38, HHD: 0.46). The best median differences between observers were seen in DA (1 mm) and Omega2 (1°). Subgroup analysis showed no significant differences in interobserver-reproducibility.

**Conclusion:** The novel parameters DA and Omega2 show highest reliability for assessing the GT fragment. This may lead to a better understanding of the fracture type and hence may support clinical decision making.

P19

### International consensus for minimum radiological monitoring and complication reporting in shoulder arthroplasty: completion of a Delphi process

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**Introduction:** Valid reporting of the occurrence of shoulder arthroplasty (SA) complications requires standardization of event definitions and monitoring. We aimed to reach international consensus on 1) a minimum set of monitoring parameters by imaging and 2) a core set of negative events (CES) of SA.

**Methods:** We implemented a Delphi consensus process with on-line surveys. An international panel of 181 experienced shoulder surgeons was nominated through professional societies. An initial survey with open questions was performed with two parts: one concerning imaging parameters for SA monitoring in asymptomatic patients and the other covering intra- and postoperative adverse events. The nominated panel were invited again to complete a second survey focusing on imaging parameter definitions, specifications and time points. For closed questions consensus was reached with at least two-third agreement.

**Results:** Ninety-six (53%) surgeons responded to at least one survey. At the second survey, consensus with 91–99% agreement was reached regarding definitions and specifications of 6 radiographic features (Implant migration, radiolucency around the implant / implant loosening, signs of shoulder instability, bone resorption / bone formation / osteolysis, implant wear, and scapular notching (specific to reverse SA)). 75% agreed for a minimum set of radiographs within the first week as well as at three and 12 months after implantation. At the first survey already, consensus with 91–93% agreement was reached for a core list of local events including 3 intra-operative event groups (device, osteochondral, soft tissue) and 8 post-operative event groups (device, osteochondral, pain, surgical site infection, peripheral neurological, vascular, superficial soft tissue, deep soft tissue), along with definitions and specifications. A final survey will address minor relevant changes for a consolidated proposal.

**Conclusion:** A structured core set of local radiological parameters and adverse events of SA was developed by international consensus. Our proposal is a major step towards the standardization of SA monitoring and complication reporting. Field testing was initiated.

P20

### Custom, patient-specific glenoid component in reverse shoulder arthroplasty for the treatment of complex bone deficiency due to multiple shoulder revisions: a case report

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**Background:** Reverse shoulder arthroplasty (RSA) is a highly successful surgery in the treatment of end-grade cuff-tear arthropathy regarding pain relief, restoration of function and improvement of the quality of life and excellent long-term survivorship. An adequate glenoid bone stock is a prerequisite for secure glenoid component fixation, and a severe glenoid bone defect presents a challenge to the shoulder surgeon.

**Aim:** The purpose of the current case report was to introduce a novel, custom-made, RSA glenoid component as a therapeutic possibility in patients with a severe glenoid bone deficit and excessive medialization, not amenable to other treating options.

**Methods:** We present an 81-year-old female with end-staged rotator-cuff arthropathy and complex glenoid bone deficiency with retroversion and excessive medialization, because of multiple shoulder revisions due to early implant loosening and pathological humerus fracture. The patient was treated with a reverse shoulder arthroplasty using a custom, patient-specific glenoid component.

**Results:** Postoperative, an adequate lateralization of the center of rotation was achieved. In the six weeks follow-up, the patient was extremely satisfied with the outcome of the operation. She demonstrated a substantial pain relief, and she could flex her arm until 80° and abduct her arm until 60°. She had a Constant-Murray score of 63. In the x-ray, there were no signs of implant loosening.

**Conclusions:** RSA is an effective treatment of cuff-tear arthropathy. Severe glenoid bone defect presents a challenge to the shoulder surgeon. In cases of complex glenoid defect not amenable to impaction grafting, a RSA using a custom-made, patient-specific glenoid component might be a reasonable treatment possibility.

P21

### Revision and re-intervention rates after primary reversed shoulder arthroplasty – implication of different endpoint definitions in arthroplasty registries

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**Introduction:** Not only revisions but any re-intervention after shoulder arthroplasty may impair the outcome of the surgery. However, those rates reported in arthroplasty registries differ depending on which endpoint definition was used. Therefore, our aim was to evaluate both the revision and re-intervention rates after primary reversed shoulder arthroplasty (RSA) in a local shoulder arthroplasty register (SAR).

**Methods:** Since 07/2006, implantations of RSA are consecutively registered in our local SAR and prospectively controlled with regular follow-ups. Revisions were defined as surgeries with any exchange, removal or addition of at least one component. Re-interventions were defined as interventions after primary implantation of RSA requiring any return to the operating room for any other reason related to the shoulder. The survival rate at 2, 5 and 10 years follow-up were evaluated with both definitions as endpoint.

**Results:** Until 10/2017, a total of 32 out of 1471 primary RSA (2.2%) needed revision of any prosthesis component. In another 31 cases (2.1%) at least one re-intervention (max. 4) was necessary. The indications for all cases included periprosthetic fractures (n = 24), aseptic loosening (n = 9), instability (n = 8), infection (n = 7), pain (n = 5), implant failure (n = 3) and other problems (n = 7). Surgical re-interventions predominantly comprised of ORIFs for periprosthetic fractures (n = 14). The median time interval between the index surgery and the first re-intervention was 23 months (range 1–115 months). For revisions, the survival rate at 2, 5 and 10 years were 99%, 98% and 96%, respectively, and for re-interventions, 98%, 96% and 93%.

**Conclusion:** Overall, a low revision rate after primary RSA was found in our SAR. Still, a relevant number of additional interventions were noted, which did not require any revision of the components, but may impair the final outcome after RSA. We propose to consider the documentation of re-intervention rates in arthroplasty registers.

P22

### Clavicle reconstruction with free vascularized peroneal graft in a case of chronic non-bacterial sclerosing osteomyelitis

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**Introduction:** Chronic non-bacterial sclerosing osteomyelitis (CNSO) of the clavicle is a rare disease. If not treated it leads to progressive limitation of shoulder range of motion. Surgical management is rarely indicated and first line treatment is pain control with NSAIDs, sometimes associated to bisphosphonate. Claviclectomy alone may be associated with a fair outcome. Nonetheless, several reconstruction techniques with autograft, allograft or even cement spacer have been described in order to achieve a better cosmetic outcome, pain control and neurovascular protection.

**Case report:** A 21-y.o. female patient had developed since the age of 9 a bulky osteomyelitis of her left clavicle, associated with chronic pain and limited range of motion. She was diagnosed with CNSO and subsequently treated with painkillers until her teenage years. After a new open biopsy at the age of 19, she developed a chronic fistula with persistent flow. To improve symptoms and avoid infectious complications, we performed a total claviclectomy and reconstruction using a free vascularized peroneal graft. Complete ligamentous reconstruction was done using hamstring tendons and anchors. Follow-up at 13 months showed satisfactory esthetic and functional outcome.

**Conclusion:** Treatment of CNSO of the clavicle is primarily conservative. In our case, the patient was a young woman with chronic pain and a fistula with recurrent flow, making total resection of the clavicle necessary. Although some authors reported fair outcome after claviclectomy alone, on the contrary, others have questioned these results. Three options have been described after clavicle resection. Cement prosthesis is used for patient with short life expectancy and allograft seems to be associated with more complications. Use of free vascularized peroneal graft is a viable option, and complete ligamentous reconstruction with hamstring tendons and anchors seems to provide optimal stability.

P23

### Ariadne's Thread: an easy way to find your way back to the glenohumeral joint through the posterior portal once you left

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Almost every shoulder arthroscopy starts with the establishment of a dorsal viewing portal for glenohumeral joint inspection. Further usually anterior or anterolateral working portals are then added depending on the type of surgical procedure the surgeon intends to perform. Once the glenohumeral work is done and the camera position is changed to the subacromial space the posterior access to the glenohumeral joint is temporarily abandoned. This is particularly the case in superior and posterosuperior rotator cuff reconstructions where the most time consuming part of the surgery is done in the subacromial compartment. In many cases after successful reconstruction the surgeon wants to scrutinize the proper re-attachment of the tendons from the glenohumeral space. Due to swelling and/or shifting of the different soft-tissue layers the re-insertion of the scope through the initial posterior channel back into the glenohumeral joint might be difficult or even potentially harmful to the reconstructed posterior cuff. The following technical tip using a transarticular suture allowing for easy re-insertion of the scope into the glenohumeral space was invented to reduce unnecessary additional soft-tissue damage and to spare the surgeons nerves. We call it Ariadne's Thread according to the Greek mythology saga where princess Ariadne from Crete, daughter of King Minos who helped Theseus to find his way out of the Minotaur's labyrinth providing him with a ball of thread.

P24

### Preservation of the osteochondral fragment in osteochondritis dissecans of the capitellum humeri

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**Background:** Osteochondritis dissecans (OD) of the capitellum humeri is the third localization in frequency after OD of the knee and the talus. Untreated lesions can lead to early osteoarthritis of the involved joint. Stable lesions regularly are treated non-operatively by immobilization of the joint. Unstable small lesions are most frequently treated by arthroscopic debridement and microfractures. Unstable larger lesions can be treated either by autologous osteochondral transplantation from the knee or the rib, or closing wedge osteotomy. Only few reports deal with surgical refixation of large osteochondral fragments.

**Method:** We report two cases of successful refixation of relatively large OD fragment of the capitellum humeri. Both, a 28-year-old man and a 16-year-old boy, respectively suffered from a symptomatic OD of the elbow. In both cases the joint was exposed through a small Kocher approach. Then, the bed of the OD fragment was debrided, the remaining defect filled of using autologous bone taken from the olecranon, and the fragment stabilized either by resorbable sutures (case 1) or with 3 HCS 1.5 mm screws (case 2).

Case	Age (years)	Size of OD (mm)	Fixation	Follow up (months)
1	28	4 × 5	Suture	12
2	16	15 × 15	1.5 mm HCS screws	20

Postoperatively, early mobilization in supination without axial load for 6 weeks was allowed in both cases.

**Results:** Healing of the OD fragment was undisturbed and without secondary displacement in both patients. The clinical functional score was excellent for both cases (46 of 48 points with the Oxford Elbow Score).

**Conclusion:** Preservation of even large osteochondral fragments in OD of the elbow is possible. Key for success are the careful debridement of scar tissue in the OD bed, autologous bone grafting of the defect, and stable fixation of the osteochondral fragment by suture or small screws. Functional rehabilitation is possible preventing joint stiffness and having a positive effect on the nutrition of the cartilage.

P25

### Development of a 3D biomechanical AC-joint model

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**Introduction:** Treatment of the AC-joint instability is still missing an agreement on an optimal algorithm and surgical techniques especially for handling Rockwood III injuries. This study shows a step by step development of a 3D biomechanical model of the AC-Joint. With our model we are able to measure the exact rotational and translational displacement of the AC joint. The aim is to apply this model to fresh frozen shoulder specimen to test existing and future treatments of AC-joint dislocations and thereby providing the base for comparison of existing and novel implants.

**Methods:** First a Synbone model (Synbone AG) was used to express the anatomy roughly and establish the optical (Hybrid Polaris Spectra, Northern Digital Inc.) and mechanical measuring devices. 3D printed (3-D Drucker Stratasys Objet Connex 260) forms designed to fix the shoulder in the hydraulic testing system (Hydropulser LFV-5, Walter+Bay AG) were attached to the clavicle and scapula. In a second step these results were transferred on a Thiel-fixed specimen. A dynamic force of 10 N, 20 N or 30 N depending on the direction was introduced linearly to the clavicle. The extent of rotation, superior and posterior translation was measured optically and physically in the native anatomic state. We repeatedly performed 1000 or 3000 cycles with a sinusoidal motion of 1 Hz.

**Results:** Lower forces showed irregular movements while performing a superior/inferior translation. At 30 N the superior translation was  $M = 2.6197$  mm ( $SD \pm 0.917$  mm). For posterior translation at 20 N a relative dislocation of  $M = 2.6972$  mm ( $SD \pm 0.46$  mm) was measured. Rotational movements showed no significant translation in superior/inferior or anterior/posterior direction. Anterior rotation was performed with 5 N and measured in length at  $M = 6.2455$  mm ( $SD \pm 0.26$  mm). From there anterior rotational angle could be calculated as  $M = 7.901^\circ$  ( $SD \pm 0.32^\circ$ ).

**Conclusion:** This new biomechanical model of the AC-joint is able to express translation in all three axis and reproduce reliable results. Due to the use of human specimen in combination with optical and physical measurements further studies to understand AC-joint injuries and its operative treatment are made possible. Furthermore the model sets a technological base to perform rigid body registration and to produce digitalized models in the future.

P26

### Isolated trapezoid fracture. A rare injury

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**Introduction:** Diagnostic investigations, treatment an follow-up imagines of an isolated non-displaced trapezoid fracture.

**Methods:** Our case report is about a 38 year old man with an isolated non-displaced coronal trapezoid fracture after a motorcycle accident. Fractures of the trapezoid bone have been rarely reported in the literature, they represent less than 0.2% of all carpal injuries.

**Results:** In radiographs, including standard wrist and scaphoid views, we often miss a non-displaced trapezoid fracture. Mostly a CT scan or an MRI is necessary. Treatment with a short-arm cast for 6 weeks followed by 2 weeks ROM-exercises and protection with a removable wrist-splint, result in a completely symptom free patient. For the follow-up imagines a plain radiograph is enough. We only have to eliminate a fracture displacement or a bony collapse. No further CT scan or MRI is needed.

**Conclusion:** In the reported cases there are differences regarding the type of casting and the length of immobilization. For isolated fractures with no or minimal displacement, cast immobilization shows good results. Surgical treatment was performed for displaced fractures or for complex injuries. A trapezoid fracture must be suspected based on mechanism of injury, patient complaints and clinical examination. It is likely that an isolated non-displaced trapezoid fracture will be missed on plain X-rays, especially coronal fractures, therefore a CT scan or an MRI is necessary.



### Keep on working with a sterile thumb splint: a case report

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**Introduction:** Nonoperative treatment of injured ulnar collateral ligament of metacarpophalangeal (MCP) joint (skier's thumb without a Stener lesion) is managed by immobilization. A splint is applied from the radial side with the thumb in slight flexion fixating the MCP joint and allowing motion in the interphalangeal joint. For daily activities, thermoplastic splints are mainly used with the advantage of custom fabrication for optimal wearing comfort. To immobilize the thumb during the operative work as an orthopaedic surgeon, splints made of sterilized materials are however needed and to our knowledge not yet available.

**Methods:** We present the case of a 36-year-old orthopaedic surgeon diagnosed with a skier's thumb and the development and application of a reusable, patient-specific splint to immobilize the MCP joint in a sterile environment. In a first step, a CT scan of a modified thermoplastic template splint with contact only from the radial thumb side was conducted. By segmentation of the CT data, a 3D model was generated using commercial software. The polyamide splints were 3D-printed with a laser sintering device by an external company. In preparation for the surgery, the orthopaedic surgeon put as first layer standard sterile gloves on. The splint was attached with sterile tape around the proximal phalanx and the wrist before the second layer of sterile gloves was put on.

**Results:** By stabilizing the MCP joint with the sterile splint, the orthopaedic surgeon was able to perform open and arthroscopic surgeries of the shoulder as usual.

**Conclusion:** To our knowledge, this is the first description of an individualized and reusable splint to immobilize a joint in a sterile environment. Without the possibility of sterile splinting, sick leave of the surgeon for several weeks would have been the consequence.

P27

Our patient came to the emergency department in Riaz hospital (public peripheral hospital) because of a trauma to the left hand resulting in non-displaced left distal metaphyseal fracture of the 2nd metacarpus after a direct shock on the dorsal aspect of the left hand during a small quarrel with another pupil.

**Methods:** The clinical examination of the left hand shows, unexpectedly, a big laxity and a painless joint instability of the TMC joint with a disability to grasp or pinch. The same situation was noticed on the right TMC joint. Bilateral TMC joint dislocation was suspected. The detailed anamnesis, done in the presence of the patient's family, has shown that the patient has been suffering of global learning difficulties with a particular limitation during manual skills. Actually, the patient presented a functional impairment of both hands, especially when it came to tasks involving both thumbs like buttoning a shirt or locking the door with a key. The paediatrician's previous investigations had already found Asperger's syndrome. Consequently, the patient has been following a specific program dedicated to learning. As for the fortuitous discovery of left TCM dislocation a complementary radiological study was done with PA, lateral and stress radiographies. A CT scan was done too, confirming the presence of a bilateral dislocation of the TCM joint.

**Result:** For the 2nd metacarpal fracture, a conservative treatment was initiated with intrinsic position left hand cast immobilization for 4 weeks. The outcome was favourable with complete osseous consolidation without secondary shift. The neglected bilateral TMC dislocation in this patient is due to chronic ligamentous laxity and consecutive joint instability. Therefore the supportive treatment will not be effective and basically surgical treatment is recommended specially in the absence of radiological sign of OA. An open reduction and reconstruction of the ligaments were programmed for our patient.

P30

### Is the recurrence of the fibroma of tendon sheath underestimated? An interesting case report and a revision of the literature

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**Introduction:** Fibroma of tendon sheath (FTS) is a rare and benign slow-growing soft tissue tumor that has a predilection for the palmar hand. Especially, adult males are affected. The etiology of the tumor remains unclear. The main symptom is an insidiously growing mass causing tenderness or pain. In few cases, patients present trigger finger or carpal tunnel syndrome (CTS). The treatment consists in a surgical marginal excision. The series of Chung and Enzinger (1979) showed a recurrence rate of 24%, however most recent studies state no recurrence rate at all. The authors explain the differences with the use of loupes and tourniquet and a more radical surgical technique to ensure complete excision. The main limitation in the recent literature is that in the presence of a slow-growing tumor, the follow up may be too short, and the recurrence rate underestimated. We want to present a case of recurrence of a FTS, 4½ years after surgery, and performed a literature review on the recurrence rate of the FTS.

**Methods:** A 21-year-old right-handed woman presented with a limited extension of the 4th right finger, trigger phenomenon and pain in the right palm. Surgery for trigger finger was performed by a senior orthopedic surgeon. A polylobate tumor was found coincidentally during surgery. It was carefully dissected from the flexor tendons and neurovascular structures, and removed in toto in February 2013. The histological diagnosis was a FTS. The patient recovered well and returned to her previous job without having further problems until May 2017, when she presented with similar clinical findings as previously – a new growing tumefaction in the scar area for 3 weeks. The physical examination showed a loss of active extension of the 4th right finger. An MRI underpinned the suspicion of a recurrence and a second excision was performed by the same surgeon in June 2017. The aspect of the tumor was similar to the previous and the histology of the lesion revealed a clear FTS, as previously.

**Results:** Our case shows a late recurrence of FTS with the reappearance of the same symptoms of a trigger finger, more than 4 years after a complete excision of the mass was performed. Most of the recent studies would have missed this late recurrence we presented.

**Conclusions:** FTS is a rare cause of trigger finger or CTS. Recurrence rate of FTS may be improved with surgical techniques, but is probably underestimated because of short-term follow up periods.

P28

### Increased trapezial slope is associated with early trapeziometacarpal osteoarthritis

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**Introduction:** Trapeziometacarpal osteoarthritis is a common unpleasant condition. Trapezial slope as a mechanical risk factor for trapeziometacarpal osteoarthritis is discussed controversially and insufficiently understood. The evaluation usually is done by radiographs (x-rays). The purpose of this study is to clarify the trapezial slope with 3d analysis and reassess the association with trapeziometacarpal osteoarthritis.

**Material and Methods:** In a retrospective review all patients suffering from trapeziometacarpal osteoarthritis with present computertomography were identified. CT segmentation and 3d-Reconstruction was performed. The trapezial slope was measured with 3d planes between the axis of the MCP II and the trapeziometacarpal articulating surface. The control group consisted of 30 healthy people with present forearm/wrist computertomography of the clinic database.

**Results:** 15 patients with trapeziometacarpal osteoarthritis and 20 healthy patients could be included. The average trapezial slope in patients suffering from osteoarthritis was 31°, whereas in the control group an average of 42° was found.

**Conclusion:** 3d analysis of the trapezial slope in our collective reaffirms the hypothesis that an increased slope is associated with osteoarthritis of the trapeziometacarpal joint.

P29

### Congenital neglected bilateral TMC joint dislocation in Asperger's syndrome patient

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HFR

**Introduction:** Congenital trapezo-metacarpal joint (TMC) dislocation is a rare condition. In fact, quasi no literature data regarding its occurrence and associated diseases. Though some scattered case reports mentioned some cases of congenital trapezo metacarpal dislocation in Ehlers-Danlos syndrome patients, we report here a medical case of a 14 years old patient with Asperger syndrome suffering from congenital neglected bilateral TMC joint dislocation. As far as we know, no similar case has been published until now.

P31

### ACDF and disc replacement revisited: Are we comparing the same thing?

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**Introduction:** There have been numerous studies comparing anterior cervical discectomy and Fusion (ACDF) and cervical disc replacement (CDR). Both procedures have reported satisfactory results. CDR may be more beneficial in a subset of patients avoiding stress on the adjacent disc and potentially reducing the risk of adjacent segment disease. Aim of this study was to analyse the results in a longitudinal study over two years with multiple interviews at 6 weeks, 3, 6, 9, 12, 18 and 24 months.

**Material and Methods:** Preoperative MRI was assessed using the modified Pfirrmann Classification as published by Nakashima. Patients were assessed postoperatively using a semi structured interview, VAS neck and arm, Pain drawing, medication, work status, impact on daily life, EQ5D and NDI. Five patients with an acute brachialgia non responsive to six weeks of conservative treatment with otherwise normal looking discs on MRI received a disc replacement. 14 with a short History of arm but longer History of neck pain with good disc height and mobility on Flexion/Extension x-rays received one or two level disc prosthesis. 11 with similar clinical picture but less disc height and no motion on Flexion/Extension xrays received ACDF.

**Results:** Patients with acute hernia within 6 weeks did best after CDR. Patients with neck pain before did initially do worse after CDR compared to ACDF with longer pain medication, repeat visits for neck pain and the need for Facet injections.

**Discussion:** Our preliminary results show that CDR may work best in an acute setting with otherwise normal discs with normal signal on MRI. When there are degenerative changes with dehydration of the disc, the results seem less good or no better than ACDF in the short term despite probable advantages in the future. From the results of this small group we propose that this ought to be tested in a large randomised study with similar subgroups.

P32

### The correlation of CT- and MRI based disc height as well as CT-based disc height loss as a surrogate parameter for more severe, MRI-based endplate degeneration in the lumbar spine

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**Introduction:** Disc degeneration and back pain are associated with disc height (DH) loss and endplate degeneration (ED). The goal of the present study was to investigate the possible use of computed tomography (CT)-based surrogate parameters for magnetic resonance imaging (MRI)-based findings in the lumbar spine.

**Methods:** We retrospectively reviewed all individuals, who presented to our hospital and underwent a CT scan and MRI of the lumbar spine, between 2006 and 2012. DH and ED were measured between Th12/L1 and L5/S1. Spearman's rank correlation, univariate and multivariable regression analysis, adjusting for age and sex, were used.

**Results:** Our study included 198 individuals. Mean CT-DH was 8.04 millimeters (mm) for T12/L1, 9.17 mm for L1/2, 10.59 mm for L2/3, 11.34 mm for L3/4, 11.42 mm for L4/5 and 10.47 mm for L5/S1. MRI-ED was absent in 138 (70%) individuals and present in 58 (29%) individuals. CT-DH and MRI-DH showed strong to very strong correlations (rho between .781–.904,  $p < .001$ ), while higher values (mean of 1.76 mm) were found on MRIs. CT-DH and MRI-ED were significantly associated at L2/3 ( $p = .006$ ), L3/4 ( $p = .002$ ), L4/5 ( $p < .001$ ) and L5/S1 ( $p < .001$ ) with a cut-off point at 11 mm. The mean PI did not differ between individuals without and with endplate degeneration ( $p = .953$ ). Individuals with ED were more likely to have lumbar back pain ( $p = .021$ ).

**Conclusions:** CT-DH and MRI-DH are well correlated in the entire lumbar spine. Thus, in cases of trauma, CT images suffice to assess DH. Furthermore, DH loss is associated with more severe MRI-ED at the middle and lower lumbar spine. Therefore, we suggest the use of decreased CT-based DH (<11 mm) as a surrogate parameter for a more severe MRI-ED in the middle and lower lumbar spine. The pelvic anatomy may affect anterior structures (endplates) less commonly than posterior ones (facet joints). Endplate degeneration was associated with lumbar back pain in this study. Further studies may investigate the influence of increasing the DH with (intraoperative) reduction on endplate pressure or ED.

P33

### Reliability of the core outcome measures index scores and a single-item measure of "success" in patients after surgery for central spinal stenosis

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**Introduction:** The test-retest reliability of patient-reported outcome measures (PROMs) is typically evaluated in patients with chronic, stable symptoms, prior to treatment. Whether the same PROM delivers reliable results after treatment, when symptoms may be less extreme/variable between patients, is unclear. Further, few studies have examined the reliability of "global outcome" items commonly used as external criteria when determining minimal clinically important change (MCIC) scores for PROMs.

**Methods:** Data were extracted for patients with lumbar spinal stenosis registered in our in-house outcomes database who had completed our standardised PROM as part of their routine follow-up (FU) (ROUTINE) and had also completed the same PROM a second time, as part of a separate prospective study (LSOS). To be included, the two PROMs had to have been completed within 3 mo of each other for 1 y FU, within 4 mo for 2 y FU, and within 5 mo for 5 y FU. The PROM contained the multidimensional Core Outcome Measures Index (COMI) and a global treatment outcome (GTO) item ("how much did the operation help your back problem"; 5-point scale, dichotomised as "good" and "poor" outcome). Repeated measures ANOVA, intraclass correlation coefficients (ICC; 2-way mixed, absolute agreement), and Kappa values were calculated.

**Results:** 64 patients (72.9 ± 6.9 y; 48% female) had PROMs from the two sources (ROUTINE and LSOS) that could be compared for test-retest reliability. There were no significant differences between test and retest scores for any of the COMI domains or for the COMI summary score (all  $p > 0.05$ ). The corresponding ICCs showed good agreement between the repeated measures (0.74–0.79). In the LSOS and ROUTINE datasets, 81% and 83% patients, respectively, reported a "good global outcome"; the corresponding Kappa for agreement between the ratings on an individual basis was 0.73 ("good agreement").

**Conclusion:** Despite the more stringent nature of the evaluation given by this «real-life» test-retest design, the FU COMI scores showed good reliability, with ICCs comparable to those previously reported in the original COMI validation studies [1, 2] for assessments made 1–2 weeks apart in patients with chronic symptoms. The GTO was also confirmed as a reliable variable and thus suitable for use as the "external criterion" of success when establishing a PROM's minimal clinically important change score.

1 Mannion AF, et al. Eur Spine J. 14:1014–1026, 2005.

2 Ferrer M, et al. Spine 31:1372–1379.

P34

### Evaluation of two in situ-gelating hydrogels for annulus fibrosus repair

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**Introduction:** With lumbar discectomy the annulus fibrosus is left unrepaired and there remains a considerable risk for recurrent herniation. So far, annulus fibrosus (AF) repair strategies failed to be successful in restoration of biomechanical properties. A genipin crosslinked fibrin hydrogel (FibGen) might be promising for AF repair. Further, Bioglue, a commercially available adhesive composed of glutaraldehyde and albumin, offers fast gelation time and good biocompatibility when it is crosslinked. The scope of the present ex vivo biomechanical study was to compare and evaluate these two crosslinking hydrogels as possible AF sealants on different sized lesions.

**Methods:** A total number of 32 bovine coccygeal functional spine units (FSU) was randomly allocated into three groups to be left untreated (control,  $n = 10$ ) or to be repaired with either one of the tested hydrogels (BioGlue,  $n = 12$ ; FibGen,  $n = 10$ ). All specimens were subjected to a moderate biomechanical testing protocol in intact, injured and repaired state which involved axial compression and torsion. AF injury was induced by means of a cruciate incision at the dorsolateral aspect and removal of about 25% (200 mg) of the nucleus pulposus. For defect repair the two components of the hydrogels were mixed and immediately applied (0.2 ml) allowing gelation to take place

in situ. After completion of the moderate testing protocol, the samples underwent a ramp-to-failure test. Axial compression was increased up to a maximum of 2000 N or until herniation occurred. Two examiners observed herniation visually.

**Results:** Among other parameters AF injury significantly altered torsional range of motion ( $p < 0.001$ ) and disc height ( $p < 0.001$ ) of FSUs. 7 in 12 BioGlue repairs failed whereas only 1 in 10 FibGen repairs failed during torsional testing ( $p = 0.031$ ). Change in disc height after repair was nonsignificant for BioGlue ( $0.57 \pm 0.72$  mm) as well as for FibGen ( $0.07 \pm 0.55$ ) ( $p = 0.111$ ). FibGen tolerated higher axial compression forces without herniation compared to BioGlue repairs (median: 2000 N (range: 1200, 2000) vs. 1240 (range: 490, 2000),  $U = 8.500$ ,  $p = 0.046$ ).

**Conclusion:** AF injury results in considerable change of FSU mechanics. FibGen repair appears to be superior to BioGlue repair in herniation prevention and in combination with its low cytotoxicity offers great potential for clinical use in AF repair.

P35

### Outcome of surgical treatment for degenerative disorders of the cervical spine: a large-scale study of prospectively collected data

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**Introduction:** A recent large-scale study comparing the outcome of first-time lumbar spine surgery for degenerative disorders with that of large-joint replacement for end-stage osteoarthritis of the hip and knee, using a multidimensional, joint-specific patient-rated outcome measure (PROM) [1], highlighted the inferiority of the results for lumbar spine surgery, regardless of the measure used to indicate "success". Comparable data for the surgical treatment of degenerative disorders of the cervical spine have yet to be analysed.

**Methods:** Preoperatively and 12-mo postoperatively, 1,013 patients undergoing first-time surgery for degenerative cervical spine disorders completed the PROM, which included the Core Outcome Measures Index (COMI) for neck problems. The latter enquires about pain, function, symptom-specific well-being, quality of life, and disability, in relation to the neck problem. Other global ratings of outcome were reported 12 months postoperatively.

**Results:** The average age of the patients was  $57 \pm 12$  y; 54% were female. At 12 mo postop, COMI had improved from  $7.1 \pm 2.1$  down to  $3.3 \pm 2.8$ . Overall, 88% patients were satisfied with their medical care in the hospital, 80% reported a good global outcome (operation helped / helped a lot), 69% achieved the MCIC for COMI ( $\geq 2.2$ -point reduction) and 55% declared having achieved an acceptable symptom state.

**Conclusion:** The results were more similar to those previously reported for patients with lumbar spine disorders than those with degenerative hip/knee disorders [1] and highlight the significantly poorer outcomes, overall, after surgery for degenerative spinal disorders. Further work is required to hone the indications and patient selection criteria also for cervical spine surgery.

1 Mannion AF, et al. EUROSPINE Full Paper Award 2017. Time to remove our rose-tinted spectacles: a candid appraisal of the relative success of surgery in over 4'500 patients with degenerative disorders of the lumbar spine, hip or knee. Eur Spine J IN PRESS.

P36

### Long-term results of the Burch-Schneider antiprotusio cage

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**Introduction:** The Burch-Schneider anti-protusio cage (BSAPC) was developed for acetabular revisions with major bone deficiency. Mid- to long-term data for this device are scarce. We therefore investigated long-term survival and radiological results for revision THA using the BSAPC.

**Methods:** Between 10/1988 and 06/2012, a total of 608 acetabular revision were performed at our institution. Out of these, 144 revisions were performed using a BSAPC in 140 patients (74 female, 66 male, mean age 72 years). 74 cups (51%) were revised due to aseptic loosening, 50 cups (35%) due to infection and 19 cups due to other reasons. 55% of the defects were classified as AAOS defect grade III, 39% as grade IV. The stem was revised in 80 cases. Survival analysis

of the BSAPC was performed with death of the patient as a competing risk. Clinical follow up (Harris Hip Score, pain) was performed at 1, 2, 5 years and every 5 years thereafter. Radiological assessment was performed before re-revision of the BSAPC or in hips with a minimum follow up of 5-years. It included evaluation of osteolysis, migration and loosening at the latest radiograph.

**Results:** The mean follow-up time was 7.4 (0.5–23.4) years. 65 patients died during the follow-up, (24 of them before the 5-year follow-up). 14 patients were lost to follow-up within the first 5 years. 10 BSAPC were re-revised: 6 for infection, 2 for aseptic loosening and 2 due to mal-positioning of the cup. The cumulative risk for re-revision (CRR) for the BSAPC was 8.5% at 15 years (95% CI: 4.3–14.6%), while the CRR for death was 65.3% (95% CI: 53.3–74.9%). 96 patients had clinical follow-up data. The mean Harris Hip Score was 78 (range, 21–96). 88% of the patients had none or mild pain, 12% reported moderate hip pain. 19 of the 82 radiologically examined BSAPC showed signs of migration or loosening, 3 of them were revised.

**Conclusion:** Our data suggests that the long-term survival of the BSAPC in acetabular revision is excellent.

P37

### Benign labral or retinacular tumors as a cause of femoroacetabular impingement. Report of 2 cases

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**Introduction:** Femoroacetabular impingement (FAI) is mainly due to a morphological misfit between acetabular rim and the proximal femur. According to the type FAI leads to chondral lesions or labral degeneration or both, and finally to osteoarthritis. In the literature reports are found describing articular cysts, pigmented villonodular synovitis (PVNS), synovial chondromatosis, osteoid osteoma and osteosarcoma as a cause for a mechanical conflict. We present 2 cases of cam-type FAI with an intra-articular pseudotumor imitating PVNS radiographically.

**Case 1:** An 18-years-old sportsman presents in our outpatient clinic with sharp left groin pain. Clinically, the internal rotation of the flexed hip was significantly reduced, the anterior impingement test was positive, and radiographically a cam configuration of the proximal femur with an  $\alpha$ -angle of  $70^\circ$  was seen. MRI analysis revealed an intra-articular tumor suspected to be PVNS of the hip. Hip revision was performed using surgical hip dislocation with a trochanteric slide osteotomy. A soft tissue tumor of about  $20 \times 20 \times 40$  mm was found antero-inferiorly originating from the inferior retinaculum. No inflammatory disease of the synovial sheet was seen. Histopathological analysis of the tumor reveals an inflammatory tumor consisting of granulation tissue with fibroblastic proliferation, but, with no sign of malignancy or PVNS.

**Case 2:** A 23-years-old female presents with a two years history of right groin pain. Internal rotation of the right hip was limited, the anterior impingement test was positive. Radiographically a cam configuration of the hip was seen, and with the MRI PVNS was diagnosed. Intraoperatively, a soft tissue tumor sizing  $30 \times 15 \times 8$  mm was found with its pedicle on the external free surface of the antero-superior labrum. Histopathological analysis reveals a fibroblastic nodular proliferation embedded in a dense conjunctive matrix.

**Conclusions:** In both cases a cam-type configuration of the hip joint was present on conventional radiographs. Arthro-MRI showed signs being characteristic for PVNS. Histopathologically, in none of the cases the initial diagnosis of PVNS was confirmed. Only a fibroblastic proliferation without signs of malignancy in a dense granulation or conjunctive matrix was present. It remains unclear, whether these pseudotumors were caused by the concomitant cam impingement of the hip, or whether the spontaneous formation of the fibroblastic pseudotumors caused later FAI.

P38

### AMiStem Collared: radiological results at 1 year

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**Introduction:** According to the protocol of the AMiStem-H study from F. Kalberer et al. [1], the goal of this study is to evaluate the short-term radiological performance of the AMiStem Collared (Medacta International SA), which will be analysed with the Gruen Zone Classification. We used a collared stem with the idea of an improved primary stem-stability with less subsidence and in fact surgical revision.

**Methods:** This is an open retrospective clinical survey study. We performed our analysis on 135 total hip arthroplasties consecutively

implanted in 124 patients between march 2013 and april 2016. We included every hip arthroplasty which used the AMiStem H Collared (Medacta International SA). There was no exclusion criteria.

**Results:** As Kalberer et al. we divided the radiolucencies in "relevant" if they were greater than 2 mm and "minimal" if they were smaller than 2 mm. 62 patients (51.7%) presented no radiolucencies at all. At one year 8 hips (6.7%) showed radiolucencies greater than 2 mm. There were no significance ( $p \leq 0.005$ ) between radiolucencies and the femoral bone morphology (Dorr classification) or between radiolucencies and age. In the groups of patients presenting radiolucencies and non-presenting radiolucencies, the mean BMI is not statistically different (Mann-Whitney and t-test). Nevertheless if we consider the percentage of obese patients ( $BMI \geq 30 \text{ kg/m}^2$ ) presenting radiolucencies (18%) versus the percentage of normal/overweight patients (4%), we can find a statistical significance. This means that obese patients are more likely to develop radiolucencies. The mean HOOS score at the one year follow-up was 89.25%. There is no statistical significant difference in mean HOOS pain score between patients who has radiolucent lines (82.9, sd 15.4) and patients without (92.4, sd 10.1).

**Conclusion:** The results presented in this study show excellent short-term quality for collared uncemented total hip arthroplasties. The 1-year survival rate calculated according to Kaplan-Meier method is 99.2%. 62 patients (51.7%) presented no radiolucencies at all. At one year 8 hips (6.7%) showed radiolucencies greater than 2 mm. We found no statistical significant difference between radiolucencies and pain, age and the morphology of the bone (Dorr classification). Though a correlation between radiolucencies and BMI was found.

1 Kalberer et al., AMiStem-H: Radiological results at 5 years, M.O.R.E. Journal. September 2016.

P40

#### Hip dysplasia and acetabular overcoverage negatively affect longterm outcome after open surgical treatment for cam-type FAI – a 15-year followup study

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**Introduction:** Cam-type Femoroacetabular Impingement (FAI) has been described in 2003 and is a cause for pain and osteoarthritis of the hip in young and active patients. But longterm results after surgical FAI treatment are rare. Therefore, we intend to determine (1) the cumulative 10-year and 15-year survivorship with the endpoints total hip arthroplasty (THA), subsequent FAI surgery, progression of OA and Merle d'Aubigné score less than 15 points. (2) Predictive factors associated with the endpoints. (3) Clinical and radiographic results.

**Patients and Methods:** We retrospectively evaluated 116 hips of 100 patients that underwent cam resection using a surgical hip dislocation between 1997 and 2000. Mean followup was 17 years (range 1–20) and the followup rate was 94%. Mean preoperative age was 32 years. Surgical hip dislocation and cam resection was consecutively performed according to the technique without evaluation of the acetabular morphology (e.g. pincer morphology). To calculate the cumulative survivorship the method described by Kaplan Meier was applied. The following endpoints were used: THA, subsequent FAI surgery, progression of OA and Merle d'Aubigné score less than 15 points. Cox regression model was used to calculate predictive factors for failure.

**Results:** (1) The cumulative 10-year and 15-year survivorship was 79% (71–86%) and 73% (66–81%) with the single endpoint THA. Using all endpoints, the cumulative 10-year and 15-year survivorship was 66% (56–74%) and 59% (50–67%). At followup, 36 hips (31%) underwent conversion to THA and 67 hips (57%) reached one of the endpoints. (2) Preoperative hip dysplasia (LCE-angle  $< 22^\circ$ ), overcoverage (LCE-angle  $> 34^\circ$ ), female sex and preoperative age  $> 40$  years was associated with the endpoints and resulted in a lower cumulative survivorship. (3) The preoperative Merle d'Aubigné score significantly ( $p < 0.001$ ) improved from 14 (10–17) to 17 (10–18) at 1-year followup. Alpha angle on lateral radiographs decreased significantly ( $p < 0.001$ ) from preoperative  $62^\circ$  (29–100) to  $41^\circ$  (31–77) at latest followup.

**Discussion:** Preoperative hip dysplasia, acetabular overcoverage, female sex and preoperative age  $> 40$  years negatively affect the longterm outcome after open treatment for cam FAI. Careful assessment of acetabular morphology is recommended before cam FAI surgery. Concomitant acetabular overcoverage should be treated with concomitant rim trimming. Cam FAI surgery should be performed with caution in the presence of hip dysplasia.

#### Arthroscopic fixation of os acetabuli in symptomatic femoroacetabular impingement in a professional athlete

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**Introduction:** We report the case of a 23-year old professional floorball goalkeeper complaining of worsening left sided hip and groin pain. X-ray and MRI showed femoroacetabular impingement (FAI) with cam deformity and a large anterolateral os acetabuli covering 13% of the joint surface. Lateral center-edge (CE) angle measured  $34^\circ$  but only  $18^\circ$  without the rim fragment.

**Methods:** The patient underwent arthroscopic joint preservation surgery with osteochondroplasty of the femoral neck. The rim fragment was arthroscopically debrided and percutaneously fixed with cannulated screws. No labral tears were observed.

**Results:** For the first six weeks postoperatively only partial weight bearing was allowed with a maximal flexion of  $60^\circ$ . After six months the patient could resume competitive physical activity without restrictions.

The os acetabuli showed clear signs of consolidation in follow-up x-ray. **Conclusion:** Symptomatic FAI in a professional athlete should be surgically addressed. Arthroscopic techniques are safe and effective according to current evidence. Os acetabuli occur in 3–6% of patients with cam type FAI and are understood as stress fractures of the acetabular rim caused by the dysplastic femoral neck. Surgical treatment of FAI should always include osteochondroplasty of the femoral neck with offset correction. Because of their rarity there is no clear evidence on the management of os acetabuli. Larger rim defects should not be removed in order to avoid instability of the hip joint. Arthroscopic fixation is an option to enhance consolidation of the fragment. Only 5 cases have been reported so far in the literature.

P41

P42

#### Active training therapy for the non-surgical management of femoroacetabular impingement syndrome: preliminary results of clinical effectiveness and imaging predictors

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**Introduction:** To date, non-surgical treatment options for the management of femoroacetabular impingement (FAI) syndrome have been mostly overlooked. The actual effectiveness of non-surgical treatments for FAI syndrome is of clinical interest to provide patients with valid non-surgical options, and strengthen surgical indications. Aim of this study was to investigate the effectiveness of active training therapy for femoroacetabular impingement (FAI) syndrome, and differences in hip function, strength and morphology between responders vs. non-responders to therapy.

**Methods:** Patients with FAI syndrome underwent 12 weeks of active training therapy. Good therapy outcome (responders) vs. poor therapy outcome (non-responders) was determined at week 18 with the Global Treatment Outcome. Hip function was evaluated using the Hip Outcome Score (HOS) activities of daily living (ADL) and Sport at baseline, week 6, 12 and 18. Hip muscle strength and dynamic pelvis control were evaluated using dynamometry and video analysis, respectively, at baseline, week 12 and 18. Hip morphology was evaluated with imaging at baseline.

**Results:** Thirty-one patients (mean age: 24 years) were included. Sixteen patients were responsive and 15 were not responsive to therapy. Only responders improved HOS ADL and HOS Sport by 10 points (95% CI: 7 to 14,  $p < 0.001$ ) and 20 points (95% CI: 15 to 25,  $p < 0.001$ ), respectively, and hip abductor strength by 0.27 Nm/kg (95% CI: 0.18 to 0.36,  $p < 0.001$ ). The number of patients showing good dynamic pelvis control increased in responders, but not in non-responders. Strong tendency indicated a higher risk for poor therapy outcome if patients present with severe cam morphology at baseline (relative risk: 6.40, 95% CI: 0.87 to 47.12,  $p = 0.068$ ).

**Conclusion:** About half of patients with FAI syndrome benefits from active training therapy at short term. Responsiveness to hip abductor strength and dynamic pelvis control improvements is associated with good therapy outcome, whereas the presence of severe cam morphology seems to predict poor therapy outcome.

P43

### Obesity and smoking do not influence eradication rates but predict functional failure of septic revision hip arthroplasty

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**Background:** The aim of this study was to determine whether obesity or smoking show an influence on infection free survival of septic revision hip arthroplasty.

**Methods:** Patients undergoing revision for septic hip arthroplasty with a minimum follow-up of the revision implant 2 years were considered. Survival was estimated using Kaplan-Meier. A multivariate cox-regression model was applied to test for the influence of smoking or obesity (BMI  $\geq 30$ ) after adjusting for 16 potential patient-dependant variables.

**Results:** Kaplan-Meier showed an overall cumulative survival proportion of 80.4% (standard error S.E 4%) of the definitive implant at 5 years. Obese patients (BMI  $\geq 30$ ) and smokers had a significantly lower 5 year overall survival of 60.9% (S.E 1%) and 50.6% (S.E 1.4%), respectively at 5 years ( $p = 0.001$ ). Eradication of infection was however, maintained in 93.3% (S.E 2.9%). Considering functional failure alone demonstrated a pronounced hazard of functional failure in obese patients (HR 4.27 95% CI 1.29–14.13) and smokers (HR 4.01 95% CI 1.04–15.57). Considering infection eradication exclusively, precluded obesity, smoking, and alcoholism as influential factors.

**Conclusion:** Obesity and smoking are both factors determining infection free survival in two-stage revision hip arthroplasty. Both do not influence the success of infection eradication; though pose risk factors for functional failure of the revision implant. Enrolling patients in a weight-loss program immediately after implantation with the goal of maintaining a BMI  $< 30$  and encouraging abstinence from smoking would each reduce the hazard of functional failure by a 4-fold.

P44

### The influence of comorbidity on the risks and benefits of total hip replacement for hip osteoarthritis

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**Introduction:** Our aging society will see a growing number of patients presenting for orthopaedic surgery with appropriate indications but numerous comorbidities. This requires that, for each patient, the likely benefit of surgery (outcome) be carefully weighed up against its potential risk (complications), to ensure that the proposed procedure is appropriate. We assessed the influence of comorbidity on the risks and benefits of total hip replacement (THR) for hip OA.

**Methods:** 1,555 patients ( $67.3 \pm 10.4$  y; 53% men) undergoing THR for hip OA completed the Oxford Hip Score (OHS) before and at 12 mo follow-up (FU). They also rated the global treatment outcome, satisfaction with care, and acceptability of their symptom state. The American Society of Anesthesiologists (ASA) grade was used as a measure of comorbidity [1]. Perioperative complications were graded for severity from 1–52.

**Results:** 10% were ASA1 (normal healthy), 62% ASA2 (mild/moderate systemic disease), 27% ASA3 (severe), and 1% ASA4 (life-threatening). ASA was significantly associated with the incidence of complications ( $p < 0.05$ ): for ASA1, 2 and  $\geq 3$ , respectively, there were 3.2%, 2.9% and 6.6% surgical complications; 4.5%, 12.6% and 27.8% medical complications; and 7.1%, 14.6% and 30.9% complications of either type. ASA grade was significantly associated with complication severity ( $p < 0.05$ ). Global treatment outcome, satisfaction with care, and acceptability of the symptom state tended to decline with increasing ASA grade, but not significantly ( $p > 0.17 < 0.53$ ). Multiple regression (controlling for gender, BMI and baseline score) revealed a significant ( $p < 0.05$ ) independent effect of ASA grade but not age on 12-mo OHS score, and of both ASA grade (OR 1.72, 95% CI 1.31–2.26) and age (OR 1.06, 95% CI 1.04–1.08) on the likelihood of a complication of any type.

**Conclusion:** The influence of comorbidity on patient-reported outcomes in THR has not been well investigated. The ASA grade is easily obtainable for all patients planned for surgery and may be helpful in producing algorithms to assist with decision-making and preoperative counselling regarding the individual risks and benefits of THR surgery. There is no unique influence of age per se on joint-specific outcomes, suggesting that older patients are capable of achieving similar success to their younger counterparts. However, they carry a significantly increased risk of complications.

1 Bjorgul K. J Arthroplasty 25: 134–137, 2010.  
2 Sink EL. CORR 470:2220-2226, 2012.

P45

### Modified horizontal draping technique for the DAA without fracture table: technical description and clinical results

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**Background:** Performing the Direct Anterior Approach (DAA) for Total Hip Arthroplasty (THA) without a traction table often requires complicated draping that permits the surgeon to manipulate the operative leg to facilitate exposure. These draping techniques consume resources, take time, and risk contamination during surgery. We therefore present and evaluate a novel draping technique that utilizes a single, impermeable drape and facilitates both leg positioning and leg length evaluation during surgery.

**Methods:** We changed our DAA THA preparation and draping technique from a contemporary, stockinette-based technique, to the new technique in October, 2011. A retrospective comparison was performed for all DAA THAs performed three years before and after the draping change. Operative set-up (prep and drape) time and ratio of prep-and-draping time to overall time were compared, as well as the one-year postoperative rate of periprosthetic joint infection. A cost analysis was performed based on the minutes of operative time gained with either draping technique.

**Results:** 448 patients received the new draping technique and were compared to 308 with conventional draping. The new draping technique had a significant reduction in operative set-up time ( $14 \pm 0.2$  minutes;  $p < 0.0001$ ) and percentage of operative time used for draping ( $p < 0.0001$ ), with no increased incidence of infection. Reduction in set-up time was associated with a 693.76 USD cost savings per case.

**Conclusion:** This present a novel draping technique for DAA THA that saves time and money, is easy to reliably perform and permits full visualization and manipulation of both lower extremities.

P46

### Total hip arthroplasty through direct anterior approach in patients over 90 years of age improves their quality of life (QUALY) and functional outcome: a retrospective cohort study

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**Introduction:** Age-related physiologic changes and comorbidities increase the surgical risk for total hip arthroplasty (THA) in old patients. However, these patients have an increasing life expectation and thus longer demand for mobility and functionality. They are at risk to lose their independency and life quality due to limitations in case of hip osteoarthritis (OA) or femoral neck fractures (FNF). The goal of this study was to determine if THA through the direct anterior approach (DAA) provides a functional benefit and increases quality of life in patients older than 90 years.

**Methods:** A total of 24 hips in 23 patients (13 female, 10 male) with a mean age of 91.3 years (SD 1.8) and a mean follow-up of 3.8 years (SD 1.4) were retrospectively included. Seventeen patients (18 hips) underwent elective surgery due to hip osteoarthritis (OA) and six patients due to femoral neck fracture (FNF). The perioperative and postoperative complications were recorded. The surgical outcome and patients satisfaction were assessed with the Harris hip score (HHS) and subjective hip value (SHV). The additional Charlson comorbidity index and quality-adjusted life years (QALY) were calculated.

**Results:** The total complication rate was 16%. Postoperatively, two patients died due to cardiac arrest. The mean blood loss was 275 ml in elective patients and 492 ml in trauma patients. Eight patients (35%) required blood cell transfusion due to postoperative anemia. The median survival rate was 4.3 years. Twelve patients (54%) died within a mean period of 29 months (range 2 to 79, SD 27.6) without any correlation to the previous surgery. Nine patients reported a mean HHS of 87.6 (SD 10.5) with improvement of their SHV from 22% preoperatively to 95% postoperatively. The increase in quality-adjusted life years – QALY was 3.1 years.

**Conclusions:** THA through the DAA is a valid option for nonagenarian patients treated for osteoarthritis or a femoral neck fracture. Our data suggest that even very old patients can expect an improvement in their QALY with an acceptable risk profile.

**Level of evidence:** Retrospective Cohort Study, Level III

**Keywords:** total hip arthroplasty, direct anterior approach, nonagenarians, quality-adjusted life years (QALY)

### Passive kinematics of the knee with dynamic intraligamentary stabilization – a thorough biomechanical study

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**Purpose:** Dynamic Intraligamentary Stabilization (DIS) is a primary repair technique for acute anterior cruciate ligament (ACL) tears. For internal bracing of the sutured ACL, a metal spring with 8 mm maximum length change is preloaded and fixed to a high-strength polyethylene braid. The amount of spring shortening during knee movement is unknown. Spring shortening is a crucial measure because it defines the necessary dimensions of the spring and therefore the overall size of the implant.

**Methods:** Seven Thiel-fixated human cadaveric knee joints were subjected to passive range of motion (flexion/extension, internal/external rotation in 90° flexion, varus/valgus stress in 0° and 20° flexion) and stability tests (Lachman/KT-1000 testing in 0°, 15°, 30°, 60° and 90° flexion) in the ACL-intact, ACL-transected and DIS repaired state. Kinematic data of femur, tibia and implant spring were recorded with an optical measurement system (Optotrak) and the positions of the bone tunnels were assessed by computed tomography. Length change of bone tunnel distance as a surrogate for spring shortening was then computed from kinematic data. Tunnel positioning in a circular zone with  $r = 5$  mm was simulated to account for surgical precision and its influence on length change was assessed.

**Results:** Over all range of motion and stability tests, spring shortening was highest ( $4.98 \pm 0.23$ ) during varus stress in 0° knee flexion.

During flexion/extension, spring shortening was always highest in full extension ( $3.8 \pm 0.26$ ) for all specimens and all simulations of bone tunnels. Tunnel distance shortening was highest ( $0.15 \text{ mm}^\circ$ ) for posterior femoral and posterior tibial tunnel positioning and lowest ( $0.03 \text{ mm}^\circ$ ) for anterior femoral and anterior tibial tunnel positioning.

**Conclusion:** Knee laxity was significantly reduced by DIS ACL repair, whereas passive motion was not affected. Spring length of the DIS implant is highly dependent on knee flexion angle and on positions of bone tunnels. During passive flexion/extension, highest spring shortening was consistently measured in full extension with a continuous decrease towards flexion. As a consequence, preloading of the spring should be performed in extension so as not to generate extension deficits. If this recommendation is followed, the spring can be downsized to incorporate a maximum length change of 5 mm. However, if the surgeon deviates from the 0° position during preloading, an extension deficit may result with non-isometric tunnel positions.

P47

**Conclusions:** One radiological parameter related to the occurrence of ACS has been highlighted in this study, namely a longer distance from the center of the tibial fracture to the talar dome, meaning a more proximal fracture. A potential explanation is that a fracture occurring at a location surrounded by a bulkier muscle mass (proximal diaphysis) may lead to more energy transmitted to the soft tissues, thus to the potential development of ACS. This observation may be useful when clinical findings are difficult to assess (doubtful clinical signs, obtunded, sedated or intubated patients). However, larger studies are mandatory to confirm and refine the prediction of ACS occurrence.

P49

### Tibial Tubercle – Trochlear Groove distance (TT-TG) in osteoarthritic knees

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**Introduction:** Patellofemoral joint morphology and in particular the Tibial Tubercle – Trochlear Groove distance (TT-TG) are important factors for patellofemoral instability. However, little is known about the prevalence and potential role of this parameter in osteoarthritic knees. The objective of the current study is to investigate the TT-TG in a large cohort of osteoarthritic knees, in particular to analyse the association of knee alignment and TT-TG.

**Methods:** Prospectively collected data of 962 consecutive patients (mean age, 70.8 y; range, 37–96 y; 455 male, 507 female) that had undergone 3D-CT scanning and preoperative knee-planning with Knee-Plan® (SYMBIOS Orthopédie SA) before total knee replacement surgery were analysed. The coronal hip knee ankle angle (HKA), TT-TG, hip knee sulcus angle (HKS), femoral anteversion (AVF) and the external tibial torsion (ETT) were obtained with the Knee-Plan® system. Chi square statistics, Pearson correlations and stepwise linear regression analysis were performed.

**Results:** Mean TT-TG was 12.9 mm (range: 0.04–33.6, SD 5.62), 33.8% of all patients had abnormal ( $>15$  mm) and 10.5% had pathological ( $>20$  mm) values. A varus alignment was present in 74.4% of the cases ( $\text{HKA} < -1.5^\circ$ ), a neutral alignment in 10.4% and a valgus alignment in 15.2% ( $\text{HKA} > 1.5^\circ$ ). HKA showed a strong correlation with TT-TG ( $r = 0.488$ ;  $p < 0.01$ ) with 67.1% and 30.8% of valgus knees having abnormal and pathological TT-TG values, respectively. There were no significant correlations between parameters of rotational alignment (AVF, ETT) and TT-TG.

**Conclusion:** Our results show a relevant influence of coronal limb alignment on the TT-TG in osteoarthritic knees. We were not able to establish a clear cut-off point regarding alignment and abnormal or pathological TT-TG, there rather seems to be a continuum – the more valgus the higher and more pathological is the TT-TG.

P48

### Clinical and radiographic predictors of acute compartment syndrome in tibial shaft fractures

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**Introduction:** The aim of this study was to retrospectively evaluate the relationship between epidemiological, clinical and radiographic factors of patients with tibial shaft fractures and the development of acute compartment syndrome (ACS).

**Methods:** 270 consecutive adult patients sustaining 273 tibial shaft fractures between January 2005 and December 2009 were included in this retrospective cohort study. The outcome measure was ACS, which was clinically diagnosed. Patient-related (age, sex), fracture-related (high- vs. low-energy injury, mono-trauma vs. polytrauma, closed vs. open fracture) and radiological parameters (AO/OTA classification, presence or absence of a noncontiguous tibial plateau or pilon fracture, distance from the center of the tibial fracture to the talar dome, distance between tibial and peroneal fracture if associated, and total angulation and total translation of main tibial fragments) were evaluated regarding their potential association with ACS. Logistic regression was used for the analysis, predictors significant at the  $p < 0.2$  were included in the final model.

**Results:** ACS occurred in 31 (11.4%) of 273 tibial shaft fractures. In the univariate analysis age  $< 45$  years, male gender, high-energy trauma, polytrauma, closed fracture, higher AO/OTA classification and longer distance from the center of the tibial fracture to the talar dome ( $\geq 15$  cm, meaning a more proximal fracture) were significantly associated with an increased rate of ACS. In the multivariate analysis age  $< 45$  years, male gender, closed fracture, polytrauma and a longer distance from the center of the tibial fracture to the talar dome remained statistically significant predictors ( $p < 0.2$ ).

P50

### Thromboprophylaxis after hip and knee arthroplasty: Is aspirin an effective and safe solution? A retrospective comparative study

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**Introduction:** Patients undergoing total joint arthroplasty are at risk of developing venous thromboembolism. The recent years, improvements in thromboprophylaxis have been made with the use of less potent anticoagulation, such as aspirin, as alternatives. Aspirin has already shown to be an efficacious agent for the prevention of thromboembolism, to be inexpensive, easy to administer and well tolerated. However, there is scarce literature comparing the efficacy of aspirin to other thromboprophylactic agents. The aim of this study is to compare our current practice using low molecular weight heparin and aspirin to our previous practice using low molecular weight heparin and rivaroxaban, regarding complications and costs.

**Methods:** Patients having a total hip or total knee arthroplasty at our institution during 2017 were included. Patients with previous history of deep venous thrombosis and pulmonary embolism were excluded. The first half of the year, patients were given low molecular weight heparin for 2 weeks and then Rivaroxaban 10 mg once a day for 4 weeks (rivaroxaban group). Since mid-2017, we changed our protocol with low molecular weight heparin during the hospital stay and then aspirin 100 mg twice daily for two weeks (aspirin group). We recorded complications occurring within 45 and 90 days such as symptomatic venous thromboembolism (deep venous thrombosis and pulmonary embolism), bleeding (hemarthrosis), and death.



**Results:** 307 patients (60% hips, 40% knees) were identified. There was no significant difference in the incidence of venous thromboembolism between the aspirin group (0.3%) and the rivaroxaban group (0.3%) ( $p > 0.05$ ). Furthermore, the use of aspirin was associated with substantially less bleeding (0.5%) compared to rivaroxaban (2.4%) ( $p < 0.05$ ) and an average of 224 Swiss francs saving (80% less).

**Conclusion:** Aspirin appears to be an efficacious and safe agent for the prevention of thromboembolism in total joint arthroplasty. With its low cost, the use of aspirin may lead to cost savings in health care.

P51

### Are outside in sutures safe and efficient for bucket handle meniscal tears? A prospective cohort study

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**Introduction:** Outside in sutures have originally been described for tears involving the anterior horn of the menisci. Several authors reported their use for bucket handle meniscal tears (BHMT). However, there are no large prospective studies on the clinical and radiological outcomes of this procedure. Purpose: to analyze the outcomes and safety of outside in sutures for BHMT.

**Method:** this is a prospective single center cohort study. All patients presenting with a medial or lateral meniscus tear between 01.08.2015 and 30.12.2017 were eligible ( $n = 145$ ). Based on the posttraumatic MRI, we excluded all patients with radial and horizontal tears ( $n = 39$ ). Following the initial diagnostic arthroscopy, we further excluded patients with tears considered as not reparable (impossibility to approximate margins,  $n = 34$ ). The primary outcome measure was an assessment of meniscal tear healing by CT arthrography (CTA) at 6 months postoperatively. It was replaced by an arthroscopic evaluation when a second procedure was expected or by an MRI if the patient refused CTA for personal convenience. Clinical scores were used as a secondary outcome. Possible complications were defined a priori and collected during the entire follow up period (12 months).

**Results:** 72 patients met the inclusion criteria. 14 lost of follow up. 56 patients (58 knees) were analyzed. Sex ratio 2.625. Mean BMI  $23.9 \pm 3.4$ . Mean age  $29 \pm 9$ . Medial meniscus tears (41/58, 77%) were more frequent than laterals. Concomitant ACL reconstruction was performed in 38% (22/58). Assessment of meniscus healing by CTA for most (38/58), and by arthroscopy (10/58) or MRI (10/58) for the remaining. According to Henning's criteria, we observed full meniscus tear healing in 71% (41/58), persistent partial tear in 17% (10/58), and failure in 12% (7/58). Failure required revision surgery for most cases (4/7), either for partial meniscectomy (3/7) or for suture revision (1/7). In the absence of failure, we observed a significant improvement of total KOOS score at 12 months ( $54.0 \pm 24.2$ ) compared to the baseline value ( $37.2 \pm 26.2$ ;  $p < 0.01$ ). A similar result was noted for the 12 months IKDC score ( $40.3 \pm 18.3$  preoperatively vs.  $64.2 \pm 14.4$  at 12 months;  $p < 0.01$ ). Complications were partial saphenous nerve injury (hypoesthesia,  $n = 1$ ), superficial infection (stitch abscess,  $n = 1$ ), persistent joint stiffness ( $n = 1$ ). We will present updated data at the meeting.

**Conclusion:** Outside in suture is a valid, efficient and safe option for repair of BHMT.

P52

### Cartilage thinning occurs continuously with medial compartment knee osteoarthritis development: longitudinal analysis of data from the Osteoarthritis Initiative

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**Introduction:** Although cartilage loss is a hallmark of end-stage knee osteoarthritis (OA), the changes in cartilage thickness occurring earlier in the disease remain unclear. Indeed, inter-subject variability is too large for the cross-sectional studies done thus far to elucidate early morphological changes. A better understanding of these changes, particularly whether cartilage thins continuously or if it swells before it becomes thinner, is critical to improving early OA detection and treatment. This study aimed to test for longitudinal changes in medial femoral cartilage thickness in the earlier stages of medial-compartment knee OA by analyzing data from the Osteoarthritis Initiative (OAI), a population-based study following almost 10,000 knees over 8 years.

**Methods:** Twenty-four medial OA knees from the OAI dataset were identified with a progression from Kellgren-Lawrence grade (KL) 1, to KL2, to KL3 (13 females, at KL1:  $59.6 \pm 8.5$  years, BMI  $29.8 \pm 4.9$  kg/m<sup>2</sup>). Femoral cartilage thickness was measured for the first timepoints at which the knee reached the KL1, KL2, and KL3 grades by segmentation of the dual echo at steady state (DESS) magnetic resonance images. Average cartilage thickness was calculated for the total medial weight-bearing region and for its three standard subregions. Repeated measures ANOVA and post-hoc paired t-tests were used to detect cartilage thickness changes per (sub)region between OA stages (KL1, KL2, KL3). Bonferroni-corrected significance threshold was set at  $\alpha = 0.004$ .

**Results:** Thickness was significantly different across KL grades in each region and subregion of the medial femoral cartilage (ANOVA  $p < 0.001$ ). Post-hoc analyses indicated that cartilage in the total region and in its 3 subregions was significantly thinner at KL3 than KL2 ( $p < 0.004$ ) and at KL3 than KL1 ( $p < 0.001$ ). In addition, the total region had significantly thinner cartilage at KL2 than KL1 ( $p = 0.002$ ).

**Conclusions and Perspectives:** The results suggest that medial femoral cartilage thinned throughout OA progression from KL1 to KL3, with no cartilage swelling detected. Between KL1 and KL2, cartilage thinning was only seen with the total region measurement, suggesting that the location of cartilage thinning varied between knees at this stage. However, as OA progressed, global loss of cartilage tissue was observed. These new insights into the type, location, and chronology of cartilage changes in medial knee OA may have implications in early disease management.

P53

### Spherical osteotomy: a single cut new technique that allows correction of 1, 2 or 3 plane bone deformities without the need for bone grafting or external fixation. Surgical technique and case report

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**Introduction:** On standard X rays we tend to analyze bone deformities in a single plane. In reality, most deformities are a challenge involving more than one plane. The spherical osteotomy is a new useful technique that became possible thanks to the recent invention of the Patented Dome Saw Blade. It allows immediate correction of single or multiple plane bone deformities without the need for complex pre operative planning, calculations, bone grafting or external fixation.

**Methods:** We illustrate the concept of spherical osteotomy and the Dome Saw Blade with a case report. 62 yo white female, who consults with a 40 degree flexion deformity of her left knee due to severe malunion of the distal femur in flexion, valgus and internal rotation. A 3D print of the femur and the tibia was obtained from CT scan data allowing us to confirm the suitability of the Spherical osteotomy. Through a medial parapatellar approach, the Spherical osteotomy was carried out following at the site identified on the 3D model following CORA methodology using a 30mm spherical blade. Fixation was achieved with an anatomic distal medial tomofix locking plate (Depuy, Synthes)

**Results and Discussion:** The deformity was satisfactorily corrected in the three planes recovering full knee extension and a flexion limited to 90 degrees. Full contact between the surface areas was obtained. Gait significantly improved in only a few days. The osteotomy consolidated satisfactorily allowing full weight bearing. Theoretically the only way to achieve correction in the three planes with maximum bone contact was a Spherical osteotomy, which to the best of our knowledge had never been described before in humans.

**Conclusion:** The Spherical osteotomy allowed satisfactory correction of this multiple plane deformity. It is a simple, single cut osteotomy without the need for bone grafts or software guided external fixators. Other applications should be developed.

P54

### Outcome measures in clinical knee arthroplasty research

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**Purpose:** It is of essential importance nowadays to determine outcome measures for any planned clinical study prior to its begin. It was the purpose of this study to identify frequently applied outcome measures in influential clinical total knee arthroplasty (TKA) studies.

**Methods:** This Institute for Scientific Information (ISI) database was utilized for selection of TKA relevant articles with >150 citations under the subject categories of "Orthopaedics"; "Radiology"; "Geriatrics";

“internal medicine” and “rheumatology”. Outcome measures of selected articles were extracted and frequencies of utility calculated. A linear regression model was performed to determine factors influencing acquisition of citations.

**Results:** 35,035 papers were cited >150 times, from which 126 TKA relevant articles were identified. The most frequently applied outcome measures were: Radiographic measures 50.7%, Range of motion 25%, Mobility 20.5%, Pain 20.0%, HSS score 15.2%, KSS score 12.9%, Complications 28.8%, Patient satisfaction 10.6% and the WOMAC score 10.6%. The independent factors showing a high influence on citation acquisition after adjustment were level of evidence, the utility of the KSS score and article age.

**Conclusion:** This analysis reflects on the outcome measures utilized in highly cited clinical studies in the field of TKA. It also identifies factors likely to influence acquisition of citations. This is of both clinical and academic relevance when choosing appropriate measures for post-operative outcome evaluation, as well as the formulation of study designs.

P55

### The clinical relevance of Blackburne-Peel ratio and modified Insall-Salvati ratio after total knee arthroplasty

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**Introduction:** Alterations in patellar height and posterior tibial slope (PTS) are frequently measured radiographic parameters associated with postoperative impairments after total knee arthroplasty (TKA). As few data about their clinical relevance exist, the aim of this study was to analyse their clinical significance after TKA.

**Methods:** A total of 282 computer navigated primary LCS®-TKAs, implanted in our institution from 2008 to 2012, were included. Data (ROM, FJS-12, WOMAC and revision surgery) were independently and prospectively collected. Patellar height (Patella baja (PB): modified Insall-Salvati ratio (mISR), Patella Pseudo-baja (PPB): Blackburne-Peel ratio (BPR)), joint line position and slope were measured on pre- and postoperative radiographs. Bivariate and multiple regression analyses were performed.

**Results:** PB was found in 28 knees (9.9%), whereas PPB was found in 108 (38.3%) at one year follow-up. Apart from significantly lower flexion in patients with PPB ( $p < 0.001$ ), other outcome parameters were not significantly different in bivariate analyses between the groups normal mIS vs. PB and normal BPR vs. PPB. However, multiple regression revealed that BPR was a significant positive independent predictor for FJS-12 and flexion at one year follow-up. The postoperative PTS and initial patella height were both predictive for BPR at follow-up, while the joint line height was not.

**Conclusions:** Lowering the BPR should be avoided, as this may lead to significant restrictions in terms of ROM and PROMs. The effect of posterior tibial slope on BPR outweighs the effect of joint line elevation. Modified ISR showed no relation to outcome measurements.

P56

### The effect of malpositioning of patient specific instruments in high tibial osteotomy

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**Introduction:** Osteoarthritis of the knee is often associated with a varus malalignment of the mechanical leg axis. One of the preferred surgical treatment in young patients is high tibial osteotomy (HTO). Patient-specific navigation instruments (PSI) facilitate navigation of the osteotomy and reduction with very high precision. However, precision is reduced or even surgical failures can occur if PSI are wrongly placed on the bone. This study investigates the influence of malpositioned PSI on osteotomy, axis correction, and implant placement.

**Methods:** A mean 3D model of a lower limb was generated from a set of CT data of healthy subjects (0.5° varus) on which HTOs were simulated on the computer. The PSI included a cutting slit to guide the osteotomy and four drill sleeves used to set navigation pins for controlling reduction and implant placement. Wrong placements were simulated by adding rotational and translational offsets of different degree to the correct PSI position. Afterwards 5° valgisation osteotomies were simulated for correct and all incorrect PSI positions and the post-operative mechanical axis, distance between osteotomy and joint-plane and between screws and joint-plane has been measured.

**Results:** The statistical evaluation showed that incorrect translational or rotational placement of a PSI had not a significant influence on the mechanical axis correction. Malrotation of a PSI resulted in surgical failure with respect to the osteotomy (distance to the plateau <10 mm) in 17 of 76 HTO's. Referring to screw placement 7 of 76 times a wrong PSI caused a surgical failure (i.e., screw-joint distance <5 mm).

**Conclusion:** Malpositioning of a PSI within the possible degrees of freedom does not have a significant influence on the axis correction. Surgical failure can occur with a malpositioned PSI in respect to the planned osteotomy plane and implant screws.

P57

### Training with a low fidelity arthroscopy triangulation simulator improves performance in high fidelity virtual knee arthroscopy

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**Introduction:** Arthroscopic training can be performed outside the operating room with virtual reality based simulators or with a recently introduced validated low fidelity training box (ArthroBox). With the present study we wanted to clarify whether the training with the ArthroBox improves the arthroscopy performance with a validated high fidelity virtual reality simulator of the knee. We hypothesized that the training for three consecutive days with the tool leads to a better improvement of standardized arthroscopy tasks compared to the performance of a non-training group.

**Methods:** Nineteen volunteer medical students (14 females and 5 males) without any previous experience in arthroscopy were randomly assigned two either the ArthroBox training group ( $n = 10$ ) or the non-training group ( $n = 9$ ). The training group could practice during three days for 1 hour on the ArthroBox. For the basic and final assessment a validated virtual reality based passive haptic knee arthroscopy simulator was used for both groups. The results of the arthroscopy simulator were compared between the groups and analyzed.

**Results:** There were no significant differences between groups regarding age, sex, dexterity, video game experience, sport, and profession. The training group showed significant improvements from baseline to follow-up in almost all activities (e.g. time in seconds, intraarticular camera and grasp distance in centimeters). The change in time to perform a diagnostic arthroscopy was significantly better in the follow-up compared to baseline in the training group compared to the no training group.

**Conclusion:** The present study yielded that training, even as short as for three consecutive days with a portable and versatile low fidelity simulator improved arthroscopy performance with a validated high fidelity virtual knee simulator significantly when compared with a control group with no training exposure. These results are true for students with no arthroscopy experience. Future studies are needed to proof the benefit in residents and whether training on a low fidelity ArthroBox is increasing skills in arthroscopic real life surgery.

P58

### Sports participation after patellar stabilization surgery – a comparison to a gender and age matched control group

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**Introduction:** Patients suffering from patellar dislocation show low functional outcome and a moderate return to sports after conservative treatment. The aim of the study is to compare pre- and postoperative sports activity to an age- and gender-matched control group.

**Methods:** 146 patients (165 knees, 23.1 years (11.6–50.7), mean follow-up of  $6.4 \pm 3.5$  years) participated in this retrospective analysis. They underwent either isolated MPFL reconstruction (MPFL-R) or combined with tibial tubercle osteotomy (TTT) or trochleoplasty (TP). Pre- and postoperative physical activity in hours per week, the Tegner activity scale (TAS), and physical complaints during sports participation were evaluated and compared to an age- and gender-matched control group. An a priori power analysis to identify a difference on the Tegner activity scale (TAS) of 1 point showed a sample size of 165 knees per group as being sufficient to provide a desired power of 80%. Knees were analysed in function of the surgical technique, trochlear dysplasia and patellar height.

**Results:** Pre-operative TAS was 4.6 and remained constant at final follow-up (4.5;  $p = 0.276$ ), and did not differ significantly from its control group (4.6 and 4.5;  $p = 0.837$  and  $0.848$ ). Sports activity after MPFL-R, TTT or TP, did not differ significantly compared to their control group ( $p > 0.05$  for all). Impairment while participating in sports was significantly higher compared to the control group ( $p < 0.001$ ). In terms of supratrochlear spur found in knees with trochlear dysplasia type B and D, no significant difference was found in pre-operative sports participation in time and TAS compared to trochlear dysplasia type A and C ( $p > 0.05$ ). Patients after TP for type B and D dysplasia participated in significant more hours of sports activity per week compared to patients after MPFL reconstruction with TTT for type B and D dysplasia (6.7 vs. 3.4 hours/week;  $p = 0.044$ ), however not for isolated MPFL-R ( $p = 0.443$ ). Knees having a patella alta that was surgically corrected to normal showed a significant improvement in sports activity per week than knees with persisting patella alta (4.8 vs. 2.7 hours/week;  $p = 0.009$ ).

**Conclusions:** Sports participation in patients with patellofemoral instability and especially after patellofemoral stabilization surgery is comparable to an age and gender-matched control group, whereas impairment during exercise is significantly increased after surgery.

P59

### Reinterventions after dynamic intraligamentary stabilization in primary anterior cruciate ligament repair

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**Purpose:** The goal of this study was to perform an in-depth analysis of the frequency and cause of secondary interventions subsequent to primary ACL repair with Dynamic intraligamentary stabilization (DIS).

**Methods:** Between July 2009 and June 2014, 455 patients underwent DIS treatment. The minimum follow-up was 21 months (mean 28 months, range 21 to 64 months).

**Results:** A total of 215 (48.2%) reinterventions were performed in 190 (42.6%) patients. One hundred seventy-six (39.4%) were non-revision reinterventions, and 39 (8.7%) were revision ACL reconstructions. Re-arthroscopies included 26 (5.8%) scar tissue debridements with hardware removal due to range of motion deficits, 14 (3.1%) partial meniscectomies, 4 (0.9%) meniscal sutures, and 4 (0.9%) arthroscopies due to crepitation or knee pain. Minor non-revision reinterventions performed under analgesedation consisted of 97 (21.7%) hardware removals, 20 (4.5%) hardware removals with manipulations under anesthesia, and 4 manipulations under anesthesia alone (0.9%).

**Conclusions:** In our study, the revision rate was within the range of published results after ACL reconstructions. In over 90% of patients, the native ACL was preserved with no need for a secondary reconstruction. Most of the non-revision reinterventions were minor and included hardware removals and manipulations under anesthesia. The re-arthroscopy rate was lower than that after ACL reconstruction with fewer secondary meniscal sutures and partial meniscectomies. Early treatment of meniscal tears may be one crucial benefit of ACL repair with DIS.

P60

### Early and mid-term results of anatomic patellofemoral inlay resurfacing using the HemiCap Wave prosthesis

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**Introduction:** The treatment of isolated patellofemoral osteoarthritis (OA) is still a matter of debate. The HemiCAP Wave Patellofemoral Resurfacing Prosthesis (Arthrosurface) intends to replicate the complex contours and biomechanics of the joint space by mapping this intraoperatively. In addition isolated patellofemoral OA is often associated with patellofemoral malalignment and patellar instability. Therefore, a combined procedure, e.g. additional reconstruction and a soft tissue realignment are often necessary to achieve good results. The purpose of this study was to evaluate clinical and radiographic results and the revision rate up to 7 years after isolated and combined Patellofemoral Inlay resurfacing (PFIR), using the HemiCAP Wave prosthesis.

**Methods:** Between 2010 and 2016, 15 consecutive patients with patellofemoral osteoarthritis (OA) were treated with the HemiCAP Wave prosthesis. In 10 patients we implanted an isolated PFIR. In 5 patients a combined PFIR with concomitant procedures to address patellofemoral instability was applied. Four with a soft tissue realignment including a MPFL-Reconstruction medial with gracilis and a lateral retinacular lengthening and one with an HTO. Patients were

evaluated clinically and radiologically in the postoperative course at 1, 2 and 5 years follow up.

**Results:** At the 1- and 2-year follow-up mean functional outcome scores improved significantly. Within 6 years, one of the implants were revised to a total knee arthroplasty due to persisting knee pain and progression of patella baja. From the patients with a mid term follow up (>2.5 years,  $n = 5$ ), all of them were happy in the initial course of the first two years, but 3 of them worsened in the further follow up and at the moment two implants are at risk. Furthermore we want to outline some technical pearls in the management of patellofemoral resurfacing with the inlay technique in high grade trochlear dysplasia cases.

**Conclusion:** The present study demonstrated good results in short term follow up and rare implant-specific problems. Patella tracking is crucial and soft tissue realignment has to be addressed generously. In our collective there was tendency for increasing pain/discomfort in mid to long term follow up probably due to progression of OA or other reasons which still remain unclear.

P61

### Attune® Knee System Vs P.F.C.® Sigma® Knee Systems: do newer cruciate retaining total knee arthroplasty (CR-TKA) implants provide better functional results and less patellar overload in CR-TKA with unresurfaced patellae?

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**Purpose:** To evaluate if the Attune® Knee System (group A) provides better functional results and less patellar overload than the P.F.C.® Sigma® Knee Systems (group PFC) in cruciate retaining total knee arthroplasties with unresurfaced patellae (CR-TKA).

**Material and methods:** Twenty patients of group A and twenty-one patients of group PFC who underwent CR-TKA (period 2011–2014) were prospectively collected and retrospectively analysed.

Knee function was evaluated with the knee society score (KSS) preoperatively, at 12 and 24 months after CR-TKA. Radiological assessments included standardized radiographs and 99mTc-HDP-SPECT/CT. The BTU was assessed in eight different patellar regions. The position of the prosthetic components was measured on 3D-CT images. Patellar height, thickness, tilt and the tibial tuberosity-trochlear groove index were noted. All data were compared with the Mann-Whitney U-Test. A Spearman correlation was calculated on all data.

**Results:** Group A showed a higher BTU in the distal half patella ( $p < 0.01$ ). Proximal quadrants showed no significant differences ( $p = 0.42$ ). Group A presented more femoral flexion ( $p < 0.01$ ) and tibial varus ( $p < 0.01$ ). Postoperative KSS scores were similar ( $p = 0.17$ ). The Spearman correlation showed a high correlation between BTU of regions in the distal half patella and the femoral coronal alignment in group PFC.

**Conclusion:** Similar postoperative KSS scores were seen. Group A appears to increase the loading on the distal half of the patella and that seems to be related neither to the increased femoral flexion nor to the position of the patella.

**Key words:** Attune, PFC, total knee arthroplasty, SPECT/CT, KSS, Bone tracer uptake.

P62

### Is there a correlation between the 99mTc-HDP-SPECTCT Bone Tracer-Uptake and the ICRS score in knee osteoarthritis?

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**Purpose:** To investigate the value of a SPECT-CT in diagnosing osteoarthritis by relating the intensity of Bone Tracer Uptake (BTU) to the intraoperative findings assessed with the International Cartilage Repair Society (ICRS) in patients who underwent Total Knee Arthroplasty (TKA).

**Material and methods:** Thirty-three consecutive patients (male:female = 11:22; age:  $61 \pm 15$ ; side: right:left = 20:13) who underwent TKA and preoperative standard radiographs and SPECT/CT were included. Indications for TKA were knee pain and bi/tri-compartmental knee osteoarthritis. The knee was divided into 11 anatomical regions. In each region, maximal relative and mean relative BTU values were calculated twice with a 6-weeks interval and means of the measurements were used. Intraoperative, to every region a ICRS score was given. A Pearson's correlation analysed BTU values and the ICRS scores separately and together. A factor analysis was performed separately on BTU and ICRS scores.

**Results:** Strong correlations in almost all quadrants were seen with the Pearson correlation performed on mean relative BTU values alone and between mean relative BTU values and ICRS scores ( $p < 0.01$ ). Strong correlations among quadrants belonging respectively to the patellofemoral joint, the medial and lateral compartment were noted when maximal relative BTU values and ICRS scores were analysed separately ( $p < 0.01$ ). The medial compartment followed from the proximal trochlea presented the highest ICRS scores. Strong correlations between maximal relative BTU values and ICRS scores were noted on the lateral facet of the patella, proximal trochlea, medial condyle and ventral half of the medial tibial plateau ( $p < 0.01$ ). The Factor analysis evidenced that quadrants of the same compartments could be analysed together.

**Conclusion:** The SPECT-CT is a valid tool to detect osteoarthritis with a strong correlation to intraoperative findings. The tendency to a varus gonarthrosis of the considered patients could have led to highlight correlations only on the medial compartment.

**Key words:** SPECT CT, knee, osteoarthritis, total knee arthroplasty, ICRS.

P63

### Complex revision surgery of a failed femoro-patellar knee arthroplasty with an associated chronic patellar tendon rupture in a patient with diabetes and morbid obesity

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**Background:** Revision of partial knee replacement can be a challenging condition for orthopedic surgeons. A concomitant patellar tendon rupture with morbid obesity and diabetes gets the situation even more complicated. It is therefore relevant to detail the surgical management of this difficult setting.

**Case Presentation:** We report the case of a 53-year-old woman with morbid obesity (BMI = 45.8 kg.m<sup>-2</sup>) and diabetes who had a left femoro-patellar knee arthroplasty (FPKA) at the age of 18 years. At the age of 38 she sustained an ipsilateral patellar tendon rupture treated conservatively. She had a constant and severe internal pain in her left knee. The range of motion (ROM) was measured at 110-0-0 degrees and the extensor complex was insufficient. There was a strong pain in the internal compartment on palpation. X-rays showed a medial knee osteoarthritis classified as Ahlbäck III. No evidence of loosening and severe lateralization of the patella on the axial views. The Caton-Deschamps index of patella was measured 1.69. A neurological consultation before the surgery was organized with no major neuropathy founded. Operative treatment was decided and we performed the removal of the partial knee prosthesis, re-total knee arthroplasty (TKA) with reconstruction of patellar tendon augmented by ipsilateral hamstring autograft fixed in U-shape via proximal transtibial tunnel. A knee brace was placed for 6 weeks. Rehabilitation consisted in very progressive mobilization and exercises for muscle stretching and strengthening and proprioceptive training.

**Outcomes:** At 7-months follow-up the patient reported pain-free knee function with competent extensor mechanism. ROM was 100-0-0 degrees. The X-ray of the knee showed a TKA without any complication and the Caton-Deschamps index was measured at 1.07.

**Discussion:** This unique and difficult case is to our best knowledge the only described and well documented report of successful operative revision of a failed FPKA with concomitant chronic patellar tendon rupture in a patient with diabetes and morbid obesity. Based on projections there will be an important increase of knee revision surgeries and we will be possibly facing these challenging conditions more frequently. Meticulous preparation of each case including a detailed medical history, clinical and radiological exams adapted to the medical records as well as technical considerations (choice of implant, tissue grafting) of the surgery are the keys to the best functional outcome.

P64

### Posterolateral ankle arthrodesis with Talarlock® plate: biomechanical and clinical results

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**Introduction:** The arthrodesis of the ankle joint, in spite of the promising results of the ankle arthroplasty, is still an established procedure for the treatment of advanced ankle osteoarthritis. A number of authors postulate an insufficient rigidity and primary stability of screw arthrodesis in ankle with reduced bone quality, osteoporosis and distinct deformity.

**Methods:** This comparative biomechanical study analyses the biomechanical properties of the three-screw arthrodesis and posterolateral plate arthrodesis of the ankle. Particular attention was paid in the detection of differences in the mechanical stability of the bone-implant composite. Another question referred to the influence of the bone quality to each construct. The computer tomographic examination of human specimens allowed the analysis of the implant position. Finally, the clinical results of the posterolateral plate arthrodesis were evaluated.

**Results:** The biomechanical and clinical examinations showed outstanding results. The posterolateral plate arthrodesis has – compared to the three-screw arthrodesis – a significantly higher rigidity in osteoporotic bone. The posterolateral plate arthrodesis was applied in 47 Patients. Neuropathic disease was found in 29 patients, osteoporosis in 12, diabetes mellitus with polyneuropathy in 9. The preoperatively measured hindfoot axis was 13° varus (1° valgus – 33° varus) at average. Full weight bearing mobilisation in an arthrodesis boot was allowed postoperatively in 34 patients. One patient was mobilised with partial weight bearing in a plaster because of extensive intraoperative bone defects. One patient could not be followed up because of traumatic tear of the osteosynthesis. Two wound healing problems were observed in patients with diabetes. A pseudarthrosis was registered radiologically (computertomography) in further two patients. No revision was required because of painfree full weight bearing mobilisation without any limitations. The correction of the hindfoot axis succeed in all patients. Osteoporosis, neurogenic deformities and polyneuropathy did not increase the complication rate in the clinical analysis. In summary, the clinical examinations showed – regarding the high rate of neuropathic disease – outstanding results. Osteoporosis, neurogenic deformities and polyneuropathy did not increase the complication rate in the clinical analysis.

P65

### The effect of three foot types on the Achilles tendon lever arm

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**Introduction/Purpose:** During locomotion, propulsion of the body is created by the force of the triceps surae complex as it is transmitted to the metatarsal heads. The amount and pattern of the resulting propulsion force depends, among other factors, on the moment arm of the Achilles tendon. The aim of this study was to calculate the Achilles tendon lever arm with the foot in different degrees of dorsi- and plantarflexion for 3 foot types.

**Methods:** 99 study participants with a healthy ankle joint (males, 40; females, 59; mean age 49 [range, 14–78] years) were included. Participants' foot type was classified as a normal arched foot ( $n = 33$ ), as pes planus ( $n = 33$ ), or as pes cavus ( $n = 33$ ) based on the calcaneal inclination angle (CI). Besides the foot type, the foot length (FL), the calcaneal insertion of the Achilles tendon (ATI), the angle ( $\alpha$ ) between the line (L) connecting ATI with the center of rotation of the ankle (COR) and the horizontal line (L') were measured on the lateral radiographs. The interrater reliabilities of measuring  $\alpha$  on radiographs and on MRIs were compared. The lever arm of the Achilles tendon (L'calculated) was calculated as following (foot and tibia were regarded as two rigid segments; the influences of other muscles were neglected):  $L'calculated = \cos(\alpha - \text{plantarflexion}) \times L$

**Results:** The interrater reliability of  $\alpha$  was higher on radiographs (ICC = 0.84, [0.73–0.91]) than on MRIs (ICC = 0.61, [0.27–0.81]). The ICC comparing  $\alpha$  measured on MRIs and radiographs was 0.63 [0.50–0.74]. There was no difference in FL between the three foot types ( $p = 0.199$ ). However, the average  $\alpha$  was significantly different (normal arched foot 31°, pes planus 24°, pes cavus 36°,  $p = 0.021$ ), resulting in a statistically significant shorter Achilles tendon lever arm for pes cavus than for pes planus ( $p < 0.0001$ ) and normal arched feet ( $p = 0.006$ ) in neutral position. The maximum lever arm for the three different foot types was reached at different degrees of plantarflexion.

**Conclusion:** The assessment of the Achilles tendon lever arm using radiographs is reliable. The foot configuration determines the lever arm of the Achilles tendon for a given flexion position of the foot. It also determines the plantarflexion position where the Achilles tendon reaches the maximum of its lever arm. This has to be taken into consideration when planning surgeries that change  $\alpha$  or L, as they may also result in changes of plantarflexion power.

P66

### Evaluation of the distal transverse plantar approach in the surgical treatment of a Morton's neuroma

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**Introduction:** Morton's neuroma is a common painful condition of the forefoot. Neurectomy is indicated after failure of conservative treatment. Longitudinal dorsal and plantar approaches are commonly used, but have specific complications. The distal transverse plantar approach aims optimal exposure without the scars complications associated with the longitudinal approach. The purpose of this study was to evaluate the long-term clinical results following a distal transverse plantar approach in the surgical treatment of a Morton's neuroma.

**Methods:** Between 2002 and 2015, 49 patients underwent surgical treatment of a Morton's neuroma through a distal transverse plantar approach. The clinical results were assessed by two independent observers using validated outcome scores: the Foot and Ankle Ability Measure (FAAM) and the Vancouver Scar Scale (VSS). Additionally, a five-grade patient's satisfaction scale was administered.

**Results:** 49 patients were assessed at a median of 8.8 years (4–11 years) postoperatively. The mean FAAM score was 84.8. The mean ADL (Activities of Daily Living) and Sports subscores were 89.6 and 80.0, respectively. The mean Vancouver score was 1.57. 90% of patients were satisfied with the surgical treatment and 84% would recommend it. On clinical examination 14% of patients had painful scar.

**Conclusions:** Our evaluation of the distal transverse plantar approach in the surgical treatment of a Morton's neuroma showed good long-term clinical results with a high overall patient satisfaction, confirmed by two validated outcome scores despite a painful scar palpation in 14% of cases.

P67

### Scarf osteotomy for the treatment of hallux valgus deformity: evaluation of radiologic correction, metatarsal shortening and early complications

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**Introduction:** Scarf osteotomy has been widely used to restore axial orientation of the first ray to treat hallux valgus deformity, with one proposed advantage of lesser shortening of the first ray. Shortening of the first metatarsal reduces load bearing ability of the first ray and may cause transfer metatarsalgia. We present the results of Scarf osteotomy and determine preoperative and postoperative length of the first metatarsal by applying various methods.

**Methods:** A consecutive series of 118 feet in 106 patients (average age 51 years; 89% female, 11% male) was enrolled, who underwent hallux valgus correctional osteotomy (Scarf- with/without Akin-Osteotomy) from May 2015 to July 2017 at a single institution. Pre- and postoperative measurement of hallux valgus- and intermetatarsal angle was assessed at between six weeks and three months postoperatively on standardized weight-bearing radiographs in dorsoplantar plane. An assessment and comparison of different methods of measuring metatarsal length (length of first metatarsal, ratio first to second metatarsal, Coughlin method) was performed to identify the amount of shortening.

**Results:** Hallux valgus angle was significantly reduced by an average of 18.6° (28.3° preoperatively to 9.7° postoperatively,  $p < 0.001$ ), intermetatarsal angle by 7.7° (12.8° to 5.1°,  $p < 0.001$ ). All 3 measuring methods showed a statistically significant shortening of the first metatarsal. Mean absolute and relative shortening was 1.8 mm and 2.8% respectively ( $p < 0.001$ ). The ratio of the first metatarsal to the second metatarsal averaged  $-0.03$  ( $p = 0.02$ ). The mean relative lengthening of the second metatarsal, using the method described by Coughlin, was 0.42 mm (4.51 to 4.89 mm,  $p < 0.001$ ) on average. Of those three methods, the Coughlin method showed the highest correlation of pre- to postoperative values.

**Conclusion:** A significant reduction of hallux valgus angle and intermetatarsal angle with hallux valgus correction using Scarf-/Akin-Osteotomy could be demonstrated, with a low complication rate. However, significant shortening of the first metatarsal could be detected as well. Previously, it has been reported that a shortening of up to 4 mm does not cause transfer metatarsalgia. Thus, Scarf osteotomy does not seem to cause metatarsalgia. Nevertheless, the measurement of the metatarsal length seems to be challenging. Further research is necessary to evaluate measurement methods to reliably determine shortening of the first metatarsal.

P68

### Segmental free gracilis flap for the treatment of chronic osteomyelitis after multiple surgery for hallux valgus deformity

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**Introduction:** A 50-year old female presented with a chronic osteomyelitis after multiple operations for the treatment of a hallux valgus deformity. History revealed a first operation some 27 years ago followed by a deep infection with *S.aureus*. Multiple surgical revisions and long-term antibiotic therapy was performed without real success. The patient reported important pain and swelling of his toe. Clinical examination showed a fistula on the medial side of the MTP-I with purulent secretion, the scar tissue was thick and adherent to the underlying bone. Plain X-rays and MRI showed a chronic osteomyelitis of metatarsal bone and proximal phalanx of the 1st ray, an intact vascularity of the toe and parts of hardware in situ.

**Method:** First, a radical debridement of bone and soft tissues was performed and biopsies for bacteriological and histological examination were taken. Tobramycin loaded Calcium sulphate pellets were placed into the medullary cavity of metatarsal bone and the proximal phalanx of the 1st ray and the soft tissues, and the length of the toe maintained by means of a small ExFix. Microbiological analysis as well as the PCR confirmed a chronic infection with *S.aureus*. In a second step debridement was redone and the medullary cavity was covered with a segmental free gracilis flap with a "nugget design", supplied by the most proximal secondary pedicle, covered with a Thiersch skin grafting. Long-term antibiotic therapy with daptomycin and co-amoxicillin was administered. Three months later, an MTP-I arthrodesis was performed with interposition of a tricortical iliac bone graft and dorsal plate fixation. Antibiotic treatment continued with flucloxacillin i.v. for 14 days, followed by peroral therapy with co-trimoxazol and rifampicin for another 3 months. The patient was mobilized with partial weight-bearing and protection with a VacoPedS splint. Healing of the arthrodesis was shown by means of plain X-rays and CT-scan at 5 months postoperatively.

**Conclusion:** Chronic osteomyelitis needs a radical soft tissue and bone debridement and a careful workup with bacteriological, histological and PCR examinations. For the treatment of osteomyelitis of the greater toe the segmental free gracilis flap serves as a well vascularized filler of bone and soft tissue defects after initial debridement. Temporary stabilization by means of a small ExFix not interfering with the flap and followed by definitive arthrodesis of the MTP-joint are further steps of the treatment plan.

P69

### A rare combination of Bosworth injury with pilon and open talus fractures. Systematic approach of an unusual ankle trauma

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**Introduction:** A Bosworth fracture-dislocation is a rare lesion resulting in a fixed dislocation of the distal fibula behind the posterior tibial tubercle. Only few cases have been reported showing a single associated consequent fracture, namely a pilon or a medial malleolus fractures. We present the case of an unusual combination of a Bosworth injury with a pilon fracture and an open multifragmentary talus fracture and our approach for open reduction and internal fixation.

**Case report:** A 44-year-old male constructor worker fell from a 3-story high building and presented to our Emergency Department with a postero-medially dislocated distal fibula fracture, an open multifragmentary fracture of the talus (Gustilo type 3b) with a sagittal split and separation between body and neck associated with a tibial pilon fracture (AO-43C1). Neurovascular assessment was intact. First, the distal lateral malleolus was extricated through a postero-lateral approach and fixed with two axial 2.2 Kirschner wires. The Chaput fragment was also fixed with a single 1.2 Kirschner wire. A medial approach was used to access the talus, carrying out an incision starting 5 cm above the tip of the medial malleolus and extending to the navicular. Fixation of the talus with two Kirschner wires and two partially threaded lag screws was accomplished. Finally, a reconstruction plate was used to stabilize the pilon fracture.

**Conclusion:** Bosworth injury is an infrequent entity and is even more rare when associated with other fractures. Careful preoperative planning is necessary, as the combination of these fractures is a surgical challenge. Special care must be taken to preserve neurovascular bundle intact. Perry et al. had proposed a seven-stage

classification for supination external rotation injuries. This case, with its unique combination of fractures, describes a possible eighth stage to take into consideration.

P70

### Residual peak range of motion in the ankle with different orthoses during simulated walking

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Ankle sprains represent a frequent injury in sports and recreational activities. Undertreatment of first time ankle sprains or recurrent ankle sprains can have serious consequences for patients, resulting in chronic instability. Nowadays clinicians generally agree, that first line treatment of acute ankle sprains is non surgical. To support proper healing of the ligaments different types of orthoses can be used. To our knowledge yet there is no consent to what extent range of motion (RoM) in the ankle should be restricted. Moreover there is a lack of knowledge which peak RoM in the ankle remains, when walking with different orthoses. To elucidate the latter we conducted an experimental study using the ankle joint simulator with the fast testing method (FTM) as outlined in Bürgi et al. (2015). One adaptable semi-rigid brace (OrthoTri-PhaseTM), four non-adaptable semi-rigid braces (OrthoStandardTM, MalleoLocTM, MalleoSprintTM, VACOankleTM) and one rigid cast were tested and compared to each others concerning peak plantar-/dorsiflexion and in-/eversion with simulated walking. We found significant differences regarding peak RoM for the different orthoses. Discussing our results we concluded, that the use of different orthoses can possibly impact proper healing of the ligaments. With the present study we hope to support clinicians deciding what kind of orthoses should optimally be used in treatment of ankle sprains. Moreover more scientific work is needed to establish clear guidelines on the upper limits of range of motion to ensure proper healing of the ankle ligaments.

**Keywords:** Supination sprain, semi-rigid brace, adaptable orthosis, rigid cast, ankle kinematics, gait analysis.

P71

### Wound necrosis post ankle osteosynthesis treated with removable splint combined with negative pressure therapy: experience and technical points

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**Background:** Early complication following ankle osteosynthesis (OS) is related to necrosis of the surgical wound leading to exposure of underlying material. The two key points in management are immobilization and local wound care. Immobilization of the tissue envelope around the ankle may be accomplished by means of an external fixator (Ex-fix) or a splint. Local wound care is performed by negative pressure therapy (NPT) to decrease the bacterial load and to accelerate the granulation. Exposed OS material is maintained as long as possible, to ensure fracture stabilization during bony consolidation. In our practice we prefer immobilization by means of a circular removable splint. We consider that a splint is less restrictive and invasive, and as well has less of a psychological impact for the patient than that of an Ex-fix. In addition, a splint eliminates potential pin tract problems.

**Case Presentation:** A 72-year old female in good health sustained an open bimalleolar fracture dislocation of the ankle on 29.04.2016. Previous medical history included hypertension, stable under treatment, with no history of smoking or diabetes. On the same day of injury, she underwent open reduction internal fixation at another institution.

**Outcomes:** The wound was fully healed at three months post treatment with no necessity for early plates, screws removal or skin grafting. One year follow up standard radiographs showed a complete bony consolidation and solid wound healing.

**Discussion:** The postoperative course was marked by necrosis of the surgical wound without sign of superinfection. The patient came under our care and was taken to the operating room the following day where all necrotic tissue was excised, the wound was débrided and NPT was applied in the operative room with a continuous negative pressure. A circular removable cast was fabricated. This was made from a resin with a hard, posterior splint and circular soft cast. The splint is open anteriorly and completely removable. In order to prevent an equinus deformity the cast is kept at 90°. The patient was managed with local

wound débridement and weekly dressing changes and NPT as an outpatient until complete healing. In our experience, some post-operative wound necrosis with potential exposure of OS material can be advantageously treated with the above coupled therapy. This treatment modality lessens the physical and psychological impacts of an Ex-fix, avoiding pin track risks and the need for its removal.

P72

### Computer assisted navigation in surgery of the calcaneus

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**Background:** Intraoperative imaging, 3-Dimensional Computed Tomography (3-D CT), has dramatically increased in use in orthopaedic surgery. It provides real-time imaging of the surgical site anatomy and allows for higher accuracy in fracture reduction, planning of osteotomy, in placing and calculating implant sizes, all while avoiding risk to neighboring critical structures.

**Objectives:** The objective is to illustrate the value of navigated surgery especially in an anatomically challenging location, as well as defining specific technical protocols.

**Study Design & Methods:** Out of 40 consecutive computer navigated calcaneal surgeries from January 2015 to October 2017 performed for a variety of conditions, we selected to illustrate its use in corrections of calcaneal malunion. We demonstrate through two representative cases the technical aspects of reduction and fixation of acute calcaneus fracture, and the use of intraoperative imaging and navigation in the reconstruction of a hindfoot malunion.

**Results:** Representative case: Hind foot realignment and sub-talar arthrodesis in a 42 year-old manual laborer presents with a calcaneal malunion following a joint depression fracture. At 1-year post nonoperative treatment he presents to us with varus and loss of hindfoot height. Indication is for calcaneus osteotomy and subtalar arthrodesis. The operative plan is to perform an osteotomy of the calcaneus through the original fracture line followed by sub-talar joint arthrodesis, to regain normal height, width and alignment of the hindfoot. – Surgical tactics: • Two pins of the base piece are inserted on the neck of the talus to avoid any movement relative to the surgical site; • Intraoperative 3D scan; • Instrument calibration using universal adapter; • Navigation of the osteotome to recreate the original fracture line; • Navigation of the screws position and length for the internal fixation; • Final 3-D scan to confirm the final results; – Postoperative results: Weight bearing standard radiographs show the restoration of hindfoot height and width. The patient is functional and back to his job at 5 months postoperatively.

**Conclusions:** In our experience, a good and thorough planning of the computer assisted navigated surgery allows for a smooth running operation and optimization of the outcome while minimizing the risks for the patient. These cases together with our extended experience in 3-D navigated surgery support routine use of this promising technology.

P73

### Fixation of avulsion fractures of the calcaneal tuberosity with anchor sutures

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**Introduction:** Avulsion fractures of the calcaneal tuberosity are uncommon. Their surgical management is based on percutaneous or open reduction and lag screw fixation. The aim of this study is to analyse the performance of the Achilles SutureBridge System (Arthrex) as a method of fixation of the calcaneus with anchor sutures. This technique can be used alone or in combination with lag screws.

**Methods:** From November 2016 to February 2018 we treated surgically 4 patients that had an avulsion fracture of the calcaneal tuberosity. According to the Beavis classification all cases were Type II, 2 cases were classical beak fractures and 2 of them had an atypical vertical fracture pattern. All 4 patients had an open reduction and fixation with Achilles SpeedBridge System. In 1 case an additional plate with screw fixation was used to treat a concomitant articular fracture type Sanders 2c and in 1 case the initial fixation was held by lag screws and the suture was performed as reinforcement.

**Results:** We achieved an initial reduction on all patients. A secondary displacement was found in 1 case. The patient started feeling muscle cramps and pain of the gastrocnemius at 3 weeks postoperatively and stretched with dorsal flexion of the ankle. This patient was revised using bone suture through a plate. Consolidation was evaluated and achieved in all cases at 12 weeks follow up. No infection rates were reported.



**Conclusion:** The suture with SpeedBridge System is a promising method for calcaneus fixation to neutralize the traction forces of the Achilles tendon that are the main cause of displacement. It can be used alone or in combination with lag screw fixation. It is a suture technique that has not yet been described for avulsion fractures of the calcaneal tuberosity in the recent literature. Further evaluation is needed to prove its value as a resource to avoid secondary displacement of the calcaneal tuberosity. However, compliance in partial weight bearing and maintaining plantar flexion of the ankle during the bone healing phase is needed, otherwise the implant fails. In cases of reoperation another method of fixation should be considered.

P74

#### Comparative irradiation between peroperative 2D C-arm and 3D CBCT in children: a study on phantoms

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**Purpose:** Exposure to ionizing radiation is a concern to the patient during intraoperative radiological imaging, especially for the growing child. Almost 10 years ago, the Geneva University Hospital acquired the O-arm® imaging system, a machine combining both two-dimensional (2D) fluoroscopy and three-dimensional (3D) computed tomography. We know its radiation level on adult. However, information concerning the risk is relatively scarce in pediatrics. We aimed to assess the radiation exposure to the pediatric patient.

**Methods:** To evaluate the radiation exposure, patient absorbed doses to the organs were measured on an anthropomorphic phantom representing a five-year-old sexless child, using thermoluminescent dosimeters for one 3D acquisition. For comparative purposes, organ doses were also measured using a standard C-arm for one minute of fluoroscopy. Skin entrance doses rates were evaluated during 2D fluoroscopy, with incident kerma rates measured on the phantom using both the O-arm® and the C-arm.

**Results:** We found that organ doses varied from a few µGy to a few mGy for one 3D acquisition on the phantom. For one minute of fluoroscopy with the C-arm those doses were between 1.3 and 25.1 times lower. The dose rate at the skin entrance in PA was 328.58 µGy.s<sup>-1</sup> for the O-arm but only 1.90 µGy.s<sup>-1</sup> with the C-arm.

**Conclusions:** Absorbed doses to the organs for one minute of fluoroscopy with the C-arm were found to be lower than with a 3D O-arm® acquisition. Doses at the surface of the skin were also consistently lower with the C-arm than with the O-arm®. Further clinical studies comparing organ effective doses are needed to assess ionizing risks of O-arm® imaging system.

P75

#### Traditional T1-S1 distance significantly underestimates the true 3-dimensional length of the spine

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**Introduction:** Traditionally, a straight line connecting the midpoint of the upper endplate of T1 with the midpoint of the sacral plateau on an anteroposterior (ap) whole spine X-ray is used to radiographically define the length of the spine (T1-S1 distance). This 2-dimensional method leads to an underestimation of the true 3-dimensional spinal length, especially in case of spinal deformities. A validated user-friendly and free available software can be used to measure the true 3-dimensional length of the spine.

**Methods:** We compared the results of spinal length measurements with the traditional T1-S1 distance on an ap whole spine X-ray with the 3-dimensional length of the spine obtained with the validated Spinal Measurement Software (SMS) in pediatric orthopaedic patients with and without spinal deformities.

**Results:** 50 pediatric orthopaedic patients with X-rays of the whole spine were eligible for spinal length measurements, both traditionally, and with the SMS. 43 of the patients had spinal deformities and 25 of them have had surgery for deformity correction. T1-S1 distance was significantly shorter when measured by the traditional technique (average 373 mm) compared to the SMS (average 425 mm). The difference was even more accentuated in patients with spinal deformities.

**Conclusion:** Treatment of pediatric patients with spinal deformities remains challenging. Knowledge about the true 3-dimensional length of the spine is crucial not only to assess spinal and thoracic growth, but also for the choice of the best treatment strategy. Traditional T1-S1 measurements significantly underestimate the true 3-dimensional length of the spine and alternatives, such as the SMS should be implemented when treating pediatric patients with spinal pathologies.

P76

#### Health-related quality of life and patient satisfaction after treatment for idiopathic scoliosis

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**Introduction:** Brace treatment is an accepted treatment for selected patients with juvenile idiopathic scoliosis (JIS) and adolescent idiopathic scoliosis (AIS). However, the quality of life (QoL) of these patients is poorly understood. Therefore we examined the health related quality of life in patients with JIS and AIS.

**Methods:** Patients with JIS (n = 12) and AIS (n = 34) who underwent brace treatment were sent two quality-of-life questionnaires, the Scoliosis Research Society-22 (SRS-22) questionnaire and the 36-Item Short-Form Survey Instrument (SF-36). Mean age at the beginning of the treatment was 7.5 years for patients with JIS and 13.1 years for patients with AIS. Most patients had a double thoracic and lumbar curve type. The prebrace major curve was on average 25° in the JIS and 33° in the AIS group. The mean treatment duration was 4.3 years for patients with JIS and 3.0 years for patients with AIS.

**Results:** In patients with JIS (and AIS) the mean SRS pain were 4.6 (and 4.0), for activity 4.2 (and 4.1), for self-image appearance 3.7 (and 3.6), for mental health 4.1 (and 3.9), and for satisfaction with management 3.7 (and 3.4). Brace treatment was considered helpful by 8 of 12 children with JIS and in 23 of 31 patients with AIS. In both groups only one patient reported that there were no limitations in daily routine by wearing the brace. However, in the JIS (and the AIS) group 8 out of 12 (and 18 out of 33) patients reported slight limitations in the daily routine by wearing the brace. Three out of 8 in the JIS group (and 13 out of 33 in the AIS groups) reported that the brace influenced the daily routine very much in a negative way. There was a statistical significant association between SRS satisfaction with management and whether the brace influenced daily routine. Patients with AIS treated surgically had significant lower scores in the physical component summary of the SF-36, while the mental component summary was not affected.

**Conclusions:** In this analysis brace treatment was considered helpful by the majority of patients, although most of the patients reported that the brace influenced their daily routine. There were statistical significant association between SRS satisfaction with management and whether the brace influenced daily routine. These health-related quality of life values reported here are helpful for guiding patient expectations at the initiation of brace treatment.

P77

#### Traumatic posterior dislocation of the hip in a 6 year-old girl

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**Introduction:** Traumatic hip dislocations are uncommon in children; only 5% of all hip dislocations occur to children under the age of 14 years. In children under the age of 7, they mainly result of a low-energy trauma, which is attributed to a soft pliable acetabulum and ligamentous laxity. They constitute a true orthopedic emergency because of the association between delayed reduction and the risk of developing a consecutive avascular necrosis (AVN) of the femoral head. A reduction delayed more than 6 hours has a 20 times higher risk of a consecutive AVN. Redirection or growth disturbance as coxa magna are other rare possible complications.

**Case report:** We report a case of a healthy 6 year old girl, who received a sledge in her leg and fell. Clinical examination showed the affected limb flexed, adducted and internally rotated. The neurologic examination was normal. An antero-posterior x-ray of the pelvis confirmed the diagnosis of a posterior hip dislocation. A closed reduction under general anesthesia was done in less than 6 hours. After reduction the child did not complain of any pain and the physical

examination did not reveal any neurologic symptoms. A post-reduction x-ray showed a concentrically reduced hip. MRI excluded any associated labral or bony lesion as well as rupture of the external rotators. The patient left our institution after 24 hours on crutches with weightbearing as tolerated for 6 weeks and sport exemption for 3 months.

**Result:** 2 month later the patient was pain free and showed a symmetric full range of hip motion. MRI indicates no sign for AVN or other morbidities.

**Conclusion:** Traumatic hip dislocation in children is a rare emergency and often a consequence of a trivial mechanism. A fast diagnosis and reduction is crucial to minimize the risk of AVN. In over 90% a closed reduction is successful. Actually there is no consensus in the literature on post-reduction care; various methods are described as immobilization with a hip spica, traction, bedrest or early functional mobilization on crutches with or without full weightbearing. Affected patients should have follow-up regularly at least for 2 years after the trauma, as AVN is reported to appear till 28 months following injury. Usually, long-term outcomes of hip dislocations in children under the age of 7 years are excellent.

P78

### Pediatric bilateral proximal tibial stress fracture in genua valgum after intensive sports activity

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We present the case of a 14-year-old adolescent referred due to lower leg pain. Bilateral pain (with leading left side) began few weeks after initiating intensive soccer training 3 times a week without any trauma. A short period of limping was reported by the parents. Pain occurred mostly during sports and walking without complaints during rest or nighttime. The patient presented without any sign of a torsional deformity but bilateral genu valgum with an intermalleolar distance in supine position of 8 cm. Full-limb radiograph and lateral view of the left, more painful tibia showed a callus reaction in both proximal medial tibial bones and a clear dreaded black line on the left side at the medial dia-metaphyseal junction indicating a tension fracture. Mean axis deviation was 20 mm lateral on the right and 15 mm lateral on the left side. The right side showed a mechanical femorotibial angle of 6.5° valgus, the left side 4° valgus, the mLDFA was 85° at the right, 87° at the left side, the mMPTA was 93° at the right, and 92° at the left side with a valgus deformity at the proximal meta-diaphyseal junction at the site of the stress fracture. Blood testing for bone metabolism showed only a slightly reduced vitamin D3 concentration (20 mcg/l) and was otherwise normal. Concerning bilateral proximal tibial fractures conservative treatment was pursued with cessation of sporting activities. The possibility on a temporary epiphysiodesis of the proximal medial tibia to correct the valgus deformity and to reduce tensile strain at the site of the stress fracture were explained and executed shortly thereafter. Removal of epiphysiodesis was performed after correction after 7 months on the left and after 24 months on the right side. Mechanical knee axis was 0.5° valgus and mLDFA 86° on both sides, mMPTA 87° on the right and 88° on the left side at the time of the latest long leg view shortly before removal of the second plate. The physeal plates adjacent to the knee were just about to close by then. Intermalleolar distance reduced to 3 cm on final follow-up.

**Discussion:** There are no similar cases published in the literature with bilateral tibial stress fractures after starting moderate sport activity. We believe that the valgus deformity of both knees was an important contributing factor that increased tensile stress at the site of the stress fracture and that it was reasonable to execute a correction with temporary epiphysiodesis.

P79

### Traumatic obturator hip dislocation in a 15-year-old adolescent: a high-energy trauma. Report of a case

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**Introduction:** Traumatic obturator hip dislocations are rare in paediatric traumatology, only a few cases have been reported in the literature. A high-energy injury is needed to dissociate the femoral head from the acetabulum in adolescent patients. The main risk after hip dislocation is femoral head avascular necrosis.

**Methods:** A 15 years-old boy presented a left hip pain after a bike crash during a BMX race. X-rays confirmed the diagnosis of obturator hip dislocation. A closed hip dislocation reduction was immediately performed under general anaesthesia. Indeed, it has been shown that

avascular necrosis was significantly associated with the length of time a hip remained dislocated. A CT-Scan showed a small impaction of the supero-lateral part of the femoral head, Pipkin classification type 1, and a small bone piece in the obturator foramen, where the femoral head was initially found. A gadolinium contrast MRI was realised 2 month after the trauma, giving the diagnosis of avascular necrosis of the interne and middle femoral head's pillar (Steinberg classification type 1C). The decision was taken to perform a drilling of the femoral head with stem cells injection. After the operation the patient was allowed to bear weight a maximum of 5 kilograms for 6 weeks.

**Results:** The 4 months post-operative clinical control found a satisfying mobility: hip flexion was 115 degrees on both sides. The left hip abduction was 20 degrees, lateral and medial rotations were 30-0-15 degrees, versus 30-0-25 for the right hip. The patient had no pain and resumed biking.

**Conclusion:** Traumatic obturator hip dislocation must be treated as an emergency and reduced within 6 hours. Avascular femoral head necrosis is a serious complication that occurs on average in 10 percent of cases and can be shown with a gadolinium contrast MRI. If it happens, a surgical treatment can be proposed, in order to preserve the native femoral head.

P80

### Accidental sterility errors with implants during orthopaedic surgery: what to do?

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**Introduction:** Sterility errors during orthopaedic procedures can be source of considerable stress for the surgeon or scrub nurse and lead to devastating infectious complications and liability issues. Literature is very sparse on what to do when a sterility error occurs during surgery. This paper aims to review practices used by orthopaedic surgeons and propose possible attitudes to adopt.

**Material and methods:** One hundred and seventy orthopaedic surgeons (10 from our orthopaedic department and 160 from members of Swiss Orthopaedics or from members of the European Bone and Joint Infection Society) answered a Volunteer Feedback Template (multiple choice test) by SurveyMonkey® (San Mateo, CA, USA). In this survey a standard total joint replacement, a fracture surgery and an arthroscopic procedure are described during which a sterility error occurs. The volunteers had to decide on how they would react in such situations. Answers were collected anonymously.

**Results:** Sterility errors on the polyethylene during a total knee replacement operation, are mainly managed by waiting until the new definitive PE arrives if waiting time is less than 2 hours. When waiting time is longer, opinions are divided between implanting a provisional implant, or opt for a definitive less optimal implant. Dealing with a sterility error during fracture fixation, the majority would opt for finding an alternative solution concerning fixation. In the case of a sterility mistake during an arthroscopic procedure, most surgeons would wait until the arthroscope is sterilized again (approximately 2 hours). When a sterility error is seen, no consensus is found about the duration of antibiotics.

**Discussion:** There is no consensus on how to deal with sterility breaches during surgery and guidelines are missing. We propose to put the patient under antibiotics in all situations of sterility error. Duration of antibiotics remain however unknown. Although many surgeons have been exposed to such a situation, not enough effort has been put in the creation of a working group to edit a consensus on how to react in these rare occasions and try to solve a medicolegal problem. Meanwhile, we propose our decision tree, which reflect what most of participants would apply.

P81

### Systemic tuberculosis with extensive involvement of the femur in a patient who never lived outside Switzerland

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**Introduction:** Tuberculosis in Switzerland is mostly seen in patients with a background of immigration. The presented patient is of interest as she never has been outside Switzerland. The biopsy of the femur was performed for a suspected malignant tumor surprisingly revealing the diagnosis of miliar tuberculosis.

**Patient:** The 49 year old mildly mentally retarded female patient was hospitalized for evaluation of a swollen painful right knee and reduced general condition. The MRI of the knee showed a destructive mass with osteolysis of the distal femur with extraosseous extension into the posterior compartment of the knee. CT-guided biopsy for suspected sarcoma revealed a purulent mass. CT scan of the thorax revealed disseminated pulmonary nodules with a miliar pattern and a cavernous lesion in the right upper lobe. Cultures of the femur biopsy material and sputum grew *Mycobacterium tuberculosis* with resistance to Isoniazid. Treatment included Pyrazinamid, Rifampicin, Ethambutol and Moxifloxacin. Interdisciplinary discussion on the treatment strategy concerning the bony lesion around the knee comprised a literature review and expert opinions from the Bone Infection Units in Oxford and the Charité in Berlin as well as from Dar es Salaam. The recommendations ranged from conservative treatment to single or multiple-staged operative procedures with or without antituberculous-drug-impregnated cement spacers. It was decided to observe the development under medical treatment only and to postpone surgical measures mainly because of persistent purulent discharge from the biopsy.

**Results:** 9 months after establishment of tuberculostatic treatment the patient was painfree and ambulatory without walking aids. Sequential CT scans of the knee 3, 6 and 9 months after the first CT showed complete resolution of the abscesses in the posterior compartment of the leg and a progressive consolidation of the lytic changes in the distal femur with circumferential bony apposition of the cortical bone. Drainage of the biopsy site ceased 6 months after the biopsy procedure.

**Conclusion:** There is a wide range of published treatment strategies without clear evidence – expert opinions are even more comprehensive. In our case, conservative treatment of destructive osteomyelitis in disseminated tuberculosis was successful – sequential CT scans showed complete resolution of abscesses and the patient regained painfree unlimited function of the knee 9 months after establishment of tuberculostatic therapy.

#### Advanced septic arthritis of the shoulder treated by a two-stage arthroplasty

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**Background:** Septic shoulder arthritis is usually treated by arthroscopic or open lavage and debridement. In patients with osteoarthritic changes and/or massive rotator cuff tendon tears, infection eradication can be challenging to achieve and outcome is often not satisfying. In recent years a two-stage approach has gained popularity when facing knee septic arthritis in osteoarthritic patients. After initial resection of the native infected articular surface a spacer is implanted before final treatment with a total knee arthroplasty in a second stage. The aim of this study was to review our results using this two-stage approach in primary shoulder arthroplasty for advanced septic arthritis.

**Methods:** We retrospectively reviewed our institution database and included four consecutive patients over a five year period. All procedures were performed through a deltopectoral approach and consisted in debridement and synovectomy, articular surface resection and insertion of a custom made antibiotic enriched cement spacer. Shoulder arthroplasty was performed in a second stage.

**Results:** Mean age was 59 years (range 47–69). All patients had previous surgeries. Mean follow-up was 15 months (range 3–26). Persistent infection was documented in all four cases at the time of initial debridement. The shoulder prostheses were implanted six to twelve weeks after the first stage. There were two hemi and two reverse shoulder arthroplasties. All four patients had no clinical or radiological sign of persistent infection at last follow-up and were satisfied with the outcome.

**Conclusion:** Two-stage approach for septic shoulder arthritis is an effective treatment option. In our opinion, it should nonetheless be reserved for selected patients with advanced osteoarticular disease in which arthroscopic or open lavage and debridement have failed.

P82

#### Treatment outcome of infected total knee arthroplasty with severe soft-tissue damage

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**Introduction:** Implant-associated joint infections (IAI) are a feared and challenging complication after total knee arthroplasty (TKA). To ensure preservation of a pain-free, functional joint, the management of periprosthetic soft-tissue defects requires rapid assessment of the infection and consequent application of a valid treatment algorithm. In case of severe soft-tissue damage close cooperation between orthopaedic and plastic surgeons is mandatory. Aim of our study was to assess infected TKA treated at the University Hospital of Basel between 2000 and 2017 including an ortho-plastic procedure.

**Methods:** We retrospectively screened all patient charts from 2000 to 2017 for the keywords “implant”, “prosthesis”, “infection” and “flap”, in addition further in-house databases were scrutinized. All charts were screened for orthopaedic (kind of implant, number of surgeries), plastic surgical (which flap, local wound complications) and infectiological (germ, antibiotic treatment) parameters.

**Results:** In total, 472 patients were identified with IAI, 144 with an infected TKA. 35 TKA patients required one or more plastic surgical procedures. More than 2/3 of patients required a hinged revision TKA. Plastic-surgical procedures were local flaps (n = 10), regional flaps (pedicled medial / lateral gastrocnemius flap (n = 19) / fascio-cutaneous perforator flap (n = 1)), or free flaps (latissimus dorsi flap (n = 1) / transverse rectus abdominal myocutaneous (TRAM) flap (n = 1), lateral arm flap (n = 1) / antero-lateral thigh (ALT) flap (n = 8)). In 4 cases a reconstruction of the extensor apparatus with fascia lata was performed. Three cases needed definitive removal of the TKA. Infection control was achieved in 97% of the cases.

**Conclusion:** Close cooperation between orthopaedic and plastic surgeons improves the outcome in case of implant-associated infection after total knee arthroplasty. Analysis of the procedures let us formulate the following ortho-plastic key points: (i) immediate plastic-surgical reconstruction of a periprosthetic soft-tissue defect can prevent the exchange of the prosthesis. (ii) in case of severely damaged periprosthetic soft tissue, removal of the prosthesis, insertion of a spacer or fixateur externe is indicated followed by soft-tissue reconstruction. Re-implantation of the prosthesis is performed 6–8 weeks later at the earliest. (iii) Possibly critical soft-tissue should be replaced by well vascularized soft-tissue before implantation of the prosthesis.

P83

#### Lessons learned from implant-related infection with *Bacillus* spp of the proximal femur: a rare and insidious complication after internal fixation of closed fractures

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**Introduction:** *Bacillus* are Gram-positive, primarily aerobic, rod-shaped and spore-forming bacteria. Ubiquitous in environment, infections with *Bacillus* are known to occur after open fractures, but are rarely described as cause for infections after internal fixation of closed fractures. Based on a case of implant-related infection of the proximal femur with *Bacillus* spp after internal fixation, we report on the associated diagnostic and therapeutic challenges.

**Methods:** Case report with review of the essential features.

**Results:** A 74 year old male suffered a pertrochanteric fracture of the femur due to a low energy fall. He had an osteoporosis secondary to chronic alcohol and tobacco abuse. Internal fixation was performed with a cerclage and cephalomedullary nail. Three debridements were performed for postoperative wound oozing before infection with *Bacillus* spp was detected. Insufficient sampling with misinterpretation and empiric antibiotic treatment delayed proper diagnosis. One-stage implant exchange, supported by T and combined with systemic antibiomatic treatment (co-amoxicillin iv, followed by levofloxacin po), healed the infection and the fracture. Due to possible spore formation, the antibiotic treatment was maintained for a total of 6 months. Implant removal and total hip arthroplasty was performed for progressive osteoarthritis 18 months later. No recurrence of the infection was observed, now over 2 years later.

P84

**Discussion:** Orthopaedic or trauma implant-related infection with *Bacillus* spp is reported rarely, except after open fractures. Immunosuppression is a known risk factor. It usually presents with large seromas, recurrent hematomas or wound oozing. When revising an implant, proper sampling (4–6 microbiological biopsies and histopathological quantification of granulocytic infiltrate) is strongly recommended, as low virulence microorganisms might cause local infection without obvious septic signs. The assumption that the source of detected low-virulence microorganisms is contamination must be made with caution as the presence of an implant allows development and persistence of infections otherwise eliminated by the immune system. Extended duration of the antibiotic treatment should be considered for sporulating bacteria, with the aim of reducing the risk of late recurrence.

#### **Aneurysmal bone cyst of the proximal humerus and the expression of the novel FUS-NFATC2 fusion onco-protein: Does it change our surgical approach?**

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**Purpose:** Aneurysmal bone cysts (ABC) are destructive, expansile, benign neoplasms of bone composed of multi-loculated, blood-filled cystic spaces. Most often they occur during the first two decades of life, and the incidence is only 0.15 per 106. ABC contain cytogenetic rearrangements of the USP6 (ubiquitin specific peptidase6/Tre2) gene, and are found in approximately 70% of primary ABCs. Curettage is the treatment of choice, but local recurrence occurs in more than 20%. Oncogenic fusion proteins, which are important drivers of carcinogenesis, are pivotal in sarcomas and ever expanding such as in Ewing's sarcoma (EWS). Eg, the classification of small round blue cell sarcomas is recently rapidly evolving, defining new clinically relevant entities with CIC-, BCOR-fused and FUS-NFATC2-positive rearranged tumors.

**Patient and Methods:** A 12 yo boy complains about a six month history of right shoulder pain, particularly while climbing. Imaging revealed an osteolytic, expanding lesion of 3 × 2 × 2 cm in the right proximal humerus, abutting the physis. A CT-guided biopsy was performed, and the material was subjected to HE staining, Mib IHC, as well as FISH, and next generation sequencing (NGS) using the FusionPlex Sarcoma Panel from Archer.

**Results:** Histologically, a spindle cell proliferation was recognized with ovoid cells, but without severe atypia and no mitotic activity. Together with the presence of giant cells and the correlation with imaging, the diagnosis of ABC was likely. However, NGS revealed the novel presence of the FUS-NFATC2 fusion protein (but no USP6 rearrangement), which is previously described in four patients with malignant proliferative small round cell sarcomas, but so far never in ABC.

**Conclusion:** With the advent of molecular diagnostics, we may face more intriguing situations where conventional diagnostics may be challenged with molecular information. May the FUS-NFATC2 fusion protein merely represent a molecular artifact with no clinical consequences that can be neglected for treatment? Or does conventional analysis – because of potential sampling error- mislead the orthopedic surgeon – believing in molecular diagnostics- to overtreatment? To address these issues in the future, it is paramount to work-up all tumor tissues in a standardized fashion, including molecular analysis and the collection of relevant clinical information.

P85

P86

#### **Early complications and oncologic outcomes after treatment of soft tissue sarcomas with combined pre- and intraoperative radiotherapy**

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**Introduction:** Preoperative radiotherapy (PRT) achieves improved local control of extremity soft tissue sarcoma (STS) but is associated with postoperative complications. Additional intraoperative radiotherapy (IORT) may further improve local control and modify the risk of radiotherapy-induced complications. This study aimed at investigating local complications and oncological outcome after combined therapy of STS with PRT and IORT.

**Methods:** 27 patients (m = 15, f = 12, age 65 ± 19 years) with extremity STS (G1 (myxoid liposarcoma) n = 2, G2 n = 7, G3 n = 18) were retrospectively reviewed (mean follow-up of 21 (6–49) months). PRT (50 Gy) was delivered with a linear accelerator in rapid arc technique. For IORT, high-dose-rate brachytherapy (10 Gy) was

applied directly to the tumor bed after tumor removal. Tumor resections were wide (n = 5), marginal (n = 20), and intralesional (n = 2). Follow-up examinations took place after 2, 6, and 12 weeks and in 3 months intervals thereafter. All complications were recorded. Major complications were defined as complications requiring surgical intervention.

**Results:** All STS were locally advanced (T2a n = 2, T2b n = 25). R0 resections were accomplished in 25/27 cases. At final follow-up, 23 patients showed no evidence of disease, 2 were alive with disease, and 2 had died of the disease. Overall, local control was achieved in 26/27 cases. Minor complications occurred in 13 cases (grade 1 skin reaction (n = 10), grade 2 reaction (n = 2), non-surgically treated pathologic fracture (n = 1). 11 major complications were observed (deep infection (n = 5), wound healing disorder (n = 3), docking-site non-union (n = 1), pathologic fracture (n = 1), seroma (n = 1)).

**Conclusion:** Similar to the application of PRT alone, the combination of PRT and IORT includes an increased risk of local complications as compared to adjuvant RT. However, the present short-term results also demonstrate excellent local control despite a high rate of marginal resections in locally advanced tumors. In cases where wide resections would be associated with significant morbidity and loss of function, the combination of PRT and IORT helps to preserve a functional limb without compromising local control.

P87

#### **Recurrent priapism through subpubic cyst – a case report for interdisciplinary cooperation between orthopaedics and urology**

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**Introduction:** Subpubic cartilaginous cysts (SCC) are a rare condition in female and male patients. Until now only one case has been described in literature of a male patient with SCC causing sexual dysfunction.

**Case Report:** We report on a 67-year-old man who presented himself in the orthopaedic outpatient clinic with pain perineal for six months and repeated nightly priapism. Clinically a spherical space perineal was palpable. A fibropenis could be excluded. On MRI a cyst measuring three centimetres and emanating from the symphysis was observed (T2 phase). The MRI showed a compressing effect of the cyst on the erectile tissue in the region of branching into the crura cavernosa. Because of the duration of symptoms an orthopaedic, urologic joint surgery was performed. This was done via a perineal approach. After removing the cyst, the symphysis discus was partially resected. Arthrodesis of the symphysis was not performed while maintaining pelvic stability. At six weeks follow-up the patient showed no symptoms of pain and priapism.

**Discussion:** Subpubic cysts originate ganglion-like from the symphysis and are a very rare condition and mostly occur in women. Causes are usually arthritic changes. Most cysts are asymptomatic. Symptoms that could occur are pain, dysesthesia in the perineum and genital region as well as micturition and sexual dysfunction. Very few cases have been reported, with only one male patient who was treated conservatively. Our case shows that, depending on the size and location of the subpubic cyst, surgical therapy may be indicated. In view of the anatomical approach, possible complications and necessary osteosynthesis of the symphysis the operating team should obtain orthopaedic and urologic surgeons.

P88

#### **Acute leg compartment syndrome after CT-guided core needle biopsy of a giant cell tumor of the proximal fibula. A case report**

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**Introduction:** Acute leg compartment syndrome is a well-established complication of fractures, crushing injuries and burns. Less frequently, it can be observed in tight casts and dressings, or in post-ischemic edema. We present a case of acute leg compartment syndrome after CT-guided core needle biopsy of the proximal fibula.

**Case report:** A 26-year-old female patient was referred to our sarcoma center with progressive lateral knee pain. Radiographs showed a well-defined expansile lytic lesion of the proximal fibula. MRI and CT-scan evoked a giant cell tumor of bone (GCT), without soft-tissue

involvement. CT-guided core needle biopsy (CNB) was performed, without complication during and immediately after the procedure. The patient was discharged home on the same day. She presented at the emergency room 24 hours later with severe leg pain and edema, especially of the anterior compartment. Passive dorsiflexion of foot and toes caused excruciating pain. Plantar and dorsal foot paresthesia had appeared. Compartment pressure was measured at 40 mm Hg in the anterior compartment, while the others were within normal range. Emergent fasciotomy of all four compartments was performed, revealing muscle edema, without significant hematoma. Pain and paresthesia improved dramatically, but the patient maintained symptoms of neuropathy of the superficial peroneal and tibial nerves. Anatomic-pathologic analysis confirmed the diagnosis of GCT. After healing of the surgical wounds, a neo-adjuvant chemotherapy with Denosumab was initiated, followed by excision of the proximal fibula.

**Discussion:** Acute compartment syndrome is not a well-known complication of CNB in the diagnosis of bone tumors. In our case, in the absence of biopsy-related bleeding, the mechanism of the compartment syndrome remained unclear. This rare complication might be diagnosed too late, or even missed, due to pre-existing pain, which can sometimes be severe in GCT, and to insufficient surveillance in an outpatient procedure.

P89

### Treatment of Unicameral and Aneurysmal Bone Cysts by minimally invasive percutaneous injection of Grafton DBF Putty using the Medtronic® Cement Delivery Gun

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**Introduction:** Unicameral Bone Cysts (UBC) are benign lesions with poorly understood etiology. They may resolve spontaneously typically after pathologic fracture, but can recur and enlarge even after puberty. Aneurysmal Bone Cysts (ABC) are neoplasias typically containing USP6 rearrangements. Good results can be achieved by injection of alcoholic solutions. Once inactivated reconstitution of bone by additional measures is needed frequently.

**Objectives:** We have applied minimally invasive filling with Grafton DBF Putty (demineralised allogenic bone containing fibers) mixed with autologous bone marrow using the Medtronic Cement Delivering System (MCDS) with good results and reconstitution of bone.

**Patients:** 4 patients with ABCs (femur, tibia, pubic bone) not showing bone remodeling at a minimum follow-up of 3 months after inactivation by Aethoxysclerol and 4 patients with large UBCs (pelvis, femur, humerus) recurrent after different procedures were treated since 2016. Two 8G Jamshidi needles CareFusion are inserted under fluoroscopy or CT to have 2 portals – one for injection, the other for “ventilation”. Radioopaque dye is injected to prove the distribution and assure, there is no extraosseous leakage. Grafton Putty DBF (10 to 40 cc) was mixed with bone marrow aspirate in the relation of about 3:1 and injected using the Medtronic (MCDS) providing the well controlled high pressure needed to inject the paste.

**Results:** All patients showed sufficient incorporation/reconstitution of bone so far not needing additional intervention at a minimum f/u of 8 months.

**Discussion:** Good results with the injection of DBM mixed with autologous bone marrow aspirate into UBCs were published recently by [1]. The MCDS developed for the injection of cement in kyphoplasty proved to be a useful device to inject the pasty mixture of DBF Putty under well controlled pressure. DBF Putty (fully demineralized allogenic bone containing fibres) has superior osteoinductivity and -conductivity [2].

**Conclusions:** This technique of percutaneous treatment of inactive cysts appears effective, minimally invasive and may be considered as a primary choice instead of larger open procedures.

**References:** 1. Gundle KR, et al. Injection of Unicameral Bone Cysts with Bone Marrow Aspirate and Demineralized Bone ... The Open Orthopaedics Journal, 2017;11 (Suppl-3, M3):486–92.  
 2. Martin GJ, et al. New formulations of demineralized bone matrix as a more effective graft alternative ... Spine. 1999;24(7):637–45.

### Tenosynovial giant cell tumor (“PVNS”) of the toes in two pediatric patients

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**Introduction:** Tenosynovial Giant Cell Tumors (TSGCT, formerly Pigmented Villonodular Tenosynovitis PVNS) rarely occurs in the toes [1]. It is furthermore uncommon in children.

**Rationale:** We wish to draw the attention to this pathology in rare localization upon the observation of 2 children; in one of them bony destruction had occurred during a 2-year-follow-up treated with local corticosteroid injections misdiagnosed as juvenile digital fibromatosis.

**Patients:** Case 1: The 12 year old girl presented with a thickened painful third toe of the right foot to a tertiary tumor center. Under the diagnosis of juvenile digital fibromatosis and performed an open biopsy, which documented a diffuse type TSGCT. The lesion was resected subtotally and PIP-resection/arthrodesis performed in April 2017. Case 2: The 15 year old boy presented a slowly enlarging mass of the 4th toe of the right foot over about 4 years. MRI appeared best compatible with a tenosynovial giant cell tumor and it was decided to proceed with an excisional biopsy. Pathology proved a localized TSGCT.

**Results:** Both patients are free of recurrence based on MRI studies 10 months postoperative.

**Conclusions:** Though rare in children TSGCT should be considered. MRI findings are rather typical. However in any doubt biopsy should be performed. Usually fine needle aspiration (FNP) is sufficient to rule out malignancy allowing to perform resection. Presently anti-CSF-1R (RG7155) antibody (Roche) treatment is under study for suppression in inoperable patients. However the mainstay still appears to be resection.

**Reference:** 1. Sharma P, Tiwari V, Khan SA. An unusual case of Pigmented Villonodular Synovitis of the second toe: A case report and review of the literature. The Foot 2016;28:61–3.

P90

P91

### A novel method for the reconstruction of the lateral collateral ligament of the knee after proximal fibula resection

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**Purpose:** Chondrosarcomas and Giant cell tumors may occur in the proximal fibula, necessitating complete resection under preservation of the fibular nerve. Because the lateral collateral (LCL) attaches to the fibular head, it has to be resected. Because the LCL is paramount for the stability of the knee, it has to be reconstructed. Several methods of reconstruction were used in the past, whereby the remaining stump of the LCL was reattached to the tibia using anchors or staples. A common problem included – depending on tumor size – the remaining length after LCL resection, leaving often only a small portion not long enough to reach the tibia for secure fixation.

**Patients and Methods:** A 49 yo woman presented with pain over the lateral aspect of the right knee for months. Imaging revealed an expansive, lytic lesion of the fibular head. The cortex was intact, but a CT-guided biopsy revealed a destruction of bony trabeculae, establishing the diagnosis of a chondrosarcoma G1. Together with the patient, it was decided to resect the entire fibular head in toto.

**Results:** Through a separate, small medial incision over the pes anserinus, the semitendinosus tendon was harvested and prepared in a standard fashion. On the lateral side, the iliotibial tract was prepared to expose the eminentia on the lateral femoral condyle. Then, two bony tunnels were drilled 6.5 mm in the tibia perpendicular to each other at the anatomic position of the former LCL. Further, at the isometric position of the eminentia, another drill hole was prepared to accept the ends of the prepared semitendinous tendon. Then, the tendon was pulled through the canals at the tibia, to pass underneath the iliotibial tract to the canal at the eminentia, where the tendon was transfemorally set under appropriate tension and fixed.

**Conclusion:** The use of the semitendinous tendon to reconstruct the LCL after the resection of the fibular head provides a stable construct. This method is safe to use and independent of the resected length of the host LCL. The potential morbidity of tendon harvest is minimal.

P92

### Human myogenic stem cells overexpressing VEGF provide angiogenesis and improve cell survival after transplantation in injured mouse skeletal muscles

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**Introduction:** Fibrosis often occurs after severe skeletal muscle injuries, leading to aberrant muscle regeneration and incomplete functional recovery. Although there is still no gold standard treatment, myogenic stem cell-based therapies are a potential approach to enhance muscle regeneration and decrease muscle fibrosis. We have recently demonstrated that human myogenic reserve cells (hMRC), a population of quiescent myogenic stem cell, have the properties required for their use in cell therapy. In the present study, we explored the potential benefit of VEGF overexpression on the survival and regeneration capacity of hMRC after transplantation in injured mouse skeletal muscles.

**Methods:** Procedures undertaken with human tissue and mice were in compliance with national and international guidelines. Primary human myogenic cells were transduced with two lentiviral vectors encoding respectively the Renilla luciferase bioluminescence marker gene (Rluc) and the human VEGF165-IRES GFP (VEGF-GFP). Their capacity to proliferate and to form myotubes in vitro was evaluated. VEGF concentration in culture supernatant was quantified using Cytometric Bead Array. hMRC or hMRC-VEGF were transplanted in injured gastrocnemius muscles of immunodeficient mice. Cell survival was quantified using non-invasive bioluminescent techniques and the presence of humanized muscle fibers was evaluated by immunochemistry at 21 days post injection.

**Results:** hMRC-VEGF secreted high amount of human VEGF in culture supernatant ( $156 \pm 30$  ng/ml) as compared to control cells ( $0.8 \pm 0.1$  ng/ml). VEGF significantly improved cell proliferation and cell differentiation in vitro. At 21 days post injection, we observed a significant twofold enhancement ( $n = 6$ ) in the survival of hMRC-VEGF as compared to control hMRC. We also demonstrated, in both groups, the presence of human lamin A/C+ nuclei in muscle fibers and the density of CD31+ capillaries was higher in muscles injected with hMRC-VEGF.

**Conclusions:** Altogether, these data show that VEGF secreted by human myogenic stem cells provide angiogenesis and improve cell survival after transplantation. The capacities of hMRC-VEGF to reduce muscle fibrosis after injury are currently under investigation. With further development, the outcome of this study could have important applications in orthopedics. Combining gene with cell-based therapies may provide optimal multifactorial approach to treat severe muscle injuries.

P93

### A novel regenerative personalized technology to treat cartilage injury

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**Background:** Articular cartilage treatment modalities are still lacking convincing evidence on their efficacy especially long-term results. Personalized regenerative technology to treat cartilage injury is being developed with an innovative stem cell-based approach to regenerate human cartilage (patent under study). This approach allows i) to amplify chondrocytes taken from a patient's biopsy, ii) to generate a biomaterial and microtissue "chondrobeads" and iii) to re-implant it in patient's joints.

**Objectives:** To test the quality of the hyaline cartilage produced in vivo using adult post-operative material (mainly knee and ankle) as starting material, to: • Prove safety of cartilage microbeads (tumor formation, bone lesions, inflammatory degeneration); • Demonstrate efficacy of cartilage microbeads (graft quality, implant stability, durability). The final objective of our research is to deliver a high quality autologous transplantable cartilage tissue "chondrobeads".

**Study Design & Methods:** Fundamental Cartilage tissue engineering to isolate/identify chondrocyte-derived progenitor cells (2D/3D cultures). Define further potential stem cell markers and blocking compounds. Preclinical • Safety in rodents: chondrobeads tested in preclinical trial in SCID mice (immunosuppressed). This will validate the safety before moving to a clinical trial in human. • Safety and efficacy in large animals: cartilage grafting showing the integrity and the stability of the graft up to 6 months post transplantation.

**Results:** The key novelty that we are able to rapidly engineer cartilage tissue of the highest quality, independently of the patient's age (>50). Cartilage from 2 independent sites (knee and ankle) in different age groups has shown the ability to regenerate transplantable high quality articular cartilage chondrobeads with as little as 50 mg of harvest. Early safety study on SCID mice results predict the safety of the developed cartilage where no cell migration was noted nor degenerative changes. In the efficacy studies the minimal need for limp immobilization post grafting was put on evidence to obtain graft stability until its complete integration with the native cartilage.

**Conclusions:** Cartilage harvested even from patients above 60 years of age can be amplified and transformed into high quality transplantable chondrobeads. Safety and efficacy studies show promising primary results. A clinical trial phase I, will demonstrate efficacy in humans.

P94

### Force plates may be used for dynamic analyses of endoprostheses explantation procedures

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**Introduction:** The number hip arthroplasty replacement surgeries increases steadily. In combination of the aging of the populations and the number of periprosthetic complications, this development leads to the phenomenon that the need for revision surgery rises. The problem is, that, while implantation procedures of hip arthroplasties are more or less standardized, explantation is a non-standardized task for experienced specialists, due to the unpredictability of the adequate loosening method. To gain objective data on the mechanics of explantation, new measurement methods are required.

**Methods:** The aim of this study was to gain data for the design of task-specific measurement devices and future (semi-)automated explantation procedures and devices. The endoprosthesis and its physical embedding are coupled to a force plate by defined spring-damper system. The measurement data of the force plate is following the rules and equations of mechanics, representing the dynamics of the interactions of surgeons with the endoprosthesis. The structure and the parameters of the springdamper systems are tuned subjectively by the surgeon until a near-to-reality impression of the interaction with the objects under study. A coupling mechanism for prostheses was mounted on a standard Kistler<sup>®</sup> force plate (Type 9260AA6, Kistler Inc., Wintherthur, Switzerland). The data representing force and torque acting on the plate were taken from the standard equipment directly after ADC conversion, but without making use of the standard software. Data were processed using software packages MATLAB (MathWorks<sup>®</sup>, Natick, Massachusetts, U.S.A.) and Diadem<sup>®</sup> (National Instruments Inc., Austin, Texas, U.S.A.).

**Results:** Detailed analyses show, that three phases of interaction are detectable: "untightening", "driving out", and "solving and extracting". Analysis of peak forces shows just three main directions. Torques to solve and extract the prostheses determine the last phase of interaction. In combination of these different aspects of dynamic interaction of surgeon and endoprostheses, we are able to describe several types and strategies of beating with a variety of instruments.

**Conclusion:** To summarize: with manageable means of adaptation to specific tasks, standard force plates even in routine Orthopedic gait laboratories may be used for biomechanical analyses different from the standard applications in motion analyses, thus minimizing the investment into new infrastructure.

P95

### Validation of the Swiss Orthopedic Minimal Dataset (SO MD)

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**Introduction:** Swiss Orthopedic defined a simple and standardized dataset, which can be used as an outcome measure for all body regions of the locomotor system. Simplicity is needed if an outcome



measure will be implemented for daily routine in a nationwide set-up including private practices. The questionnaire includes six quality of life items (pain, work, recreational activity/sport, sleep, daily activity and subjective joint value. Scaling worst = 0, best = 100). All items are dynamically set in relation to the diseased body region (e.g. how strong was your right shoulder pain ..., how strong was your left hip pain ...). So other than the SF 12 or the EQ5D, the SO MD is a standardized, joint/bodyregion specific outcome measure where the impact of a diseased body region to the general conditions like sleep, leisure etc. can be quantified. The six quality of life items can be bundled in an average score (worst = 0, best = 100). Aim of this study was to validate the hip version of the SO MD.

**M&M:** The study included 967 patients treated at our institution between 1.12.2014 and 30.11.2017. To validate this new evolved score, internal consistency, external validity and floor- and ceiling effect were assessed. Test-retest reliability was assessed in 60 volunteers living in a senior residency with two assessments with an interval of 1 week in between.

**Results:** Cronbach's  $\alpha$  between the six items was 0.938, indicating a high internal consistency. Very high spearman's correlation was found with the modified HHS (0.860), OHS (0.905), and the physical and mental composite in SF-12 (0.801 and 0.730; all  $p < 0.001$ ). 0.7% of the patients reached the floor, 7.8% reached the ceiling of the score. ICC2,1 between the test- and the retest-values was 0.994 ( $p < 0.001$ ).

**Conclusion:** This hip score correlates strongly with similar hip scores, underlies a single dimension, showed a high reliability and no relevant floor-, or ceiling effect.

P96

### Efficiency of a multidisciplinary approach to osteogenesis imperfecta: 6 years experience in a Swiss tertiary health center

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**Introduction:** Osteogenesis imperfecta (OI) is a rare genetic connective tissue disorder with wide phenotypic and molecular heterogeneity, causing risk of fractures in early life, progressive bone deformity, tooth and hearing alterations, and poor quality of life. In rare diseases, there is a real lack of patient information and recognition. Starting in 2012, we have employed a multidisciplinary approach for OI in the CHUV, and created the CHUV OI group. The purpose of the present study is to evaluate the efficiency of this approach after 6 years.

**Method:** An OI day is organized annually. Patients attend an individualized medical checkup. The initial team was composed of two adult and pediatric bone disorder specialists, an orthopedic surgeon, a geneticist and two physiotherapists (adult and pediatric). In 2013 and 2016, a dentist and a ENT specialist joined the team respectively. Each patient receives a physiotherapeutic evaluation with a proposition of physical therapy or counselling in physical activity and sport. In the same day, a clinical and scientific information session about the latest updates of the disease is organized, open to families and professional caregivers.

**Results:** 50 patients have received a personalized medical evaluation since the beginning. 12 children (1 to 17 yrs, mean 8.5) and 38 adults (age 18 to 69 yrs, mean 43.5) participated. In 2012, 27 patients attended a medical check-up, 18 in 2013 (3 new cases), 22 in 2014 (6 new cases), 26 in 2015 (4 new cases), 28 in 2016 (4 new cases) and 24 in 2017 (8 new cases). Mean spine T score on adults DXA measurement was  $-2.55$  ( $-5.6$ ;  $+0.6$ ), hip T score  $-1.4$  ( $-3.3$ ;  $+1.6$ ), neck T score  $-1.58$  ( $-3.5$ ;  $+1.3$ ). 34 patients had a bone texture measurement by TBS with a mean spine TBS of 1.259 (1.003; 1.501). Genetic evaluation was performed in 39 cases, and revealed mutation in 34 cases. The multidisciplinary approach, including the DXA and genetic evaluation resulted in personalized treatment adaptation/new treatment/ for all patients.

**Conclusion:** The CHUV OI group multidisciplinary approach is efficient, resulting in better diagnosis, management and satisfaction of patients and their families as well as facilitating continuing education for the team members. Since 2012, the number of new patients has increased annually, with more patients benefiting of quality management including bone treatment and physical activity.

P97

### Video-assisted preoperative education in prosthesis surgery: improving patient's satisfaction by implementing educational videos in daily practice

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**Purpose:** Total hip and knee replacement are common procedures in modern orthopedic surgery. By now pre-operative informed consent is mostly performed using drawings, information leaflets and written brochures. Different studies showed the benefits of sufficient preoperative education on postoperative outcome parameters. Modern ways of visualization such as educational video clips are rarely in daily practice. We hypothesized that implementing an educational video in a same-day surgery consultation prior to elective prosthesis surgery will improve patient satisfaction and knowledge and will improve the consultation afterwards at the surgeon.

**Methods:** Informed consent is routinely done by a surgical intern using a standardized informed consent sheet with drawings and a 3D model of the hip or knee, respectively. In addition, two educational videos were produced for total hip and total knee replacement surgery in "product presentation by expert" mode. Every patient in the video group got to see the respective video on an iPad in the waiting room prior to the enlightenment talk. We compared two groups of patients (100 each) prior (Group 1) and after implementing the respective videos (Group 2). Directly after consultation every patient got a questionnaire about their experience in our consultation, their satisfaction about the education and their knowledge after consultation hour.

**Results:** Implementation of an education video in our same day surgery consultation hour improved statistically significant patients' satisfaction with their preoperative education about the therapy, postoperative procedure, risks and complication. They judge their time spent with the surgeon higher than without having seen the video before the consultation – without having the feeling of being just a number. No differences between different patient's ages could be shown and interestingly patient's age (cutoff at 65 years as well as at 70 years) had no impact on acceptance of the educational video.

**Conclusion:** Video-assisted patient education prior to elective surgery such as total hip or total knee replacement is well accepted and can lead to significant improvements in patients satisfaction and organization of consultation hours. Elderly patients accepted the audiovisual approach as younger patients did.

P98

### Predictors for length of stay outliers: a retrospective case-control study of 8,247 patients at a level 1 trauma center

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**Background:** Providing efficient healthcare is important for hospitals. Length of hospital stay (LOS) outliers influence financial results and reimbursement. The objective of this study was to identify independent diagnosis related group (DRG)-related risk factors for low and high LOS outlier status.

**Methods:** A retrospective case-control study was conducted at a Swiss level 1 trauma center between January 2012 and December 2014. The study included all patients with available information of LOS based on DRG. Many predictor variables were tested. The outcome variable was the DRG-based LOS. Logistic regression models were fitted for low and high outliers, respectively, with a significance level of  $< 1\%$ .

**Results:** A total of 8,247 patients were analyzed, of which inliers were more frequent than low and high outliers ( $n = 5,838$  [70.8%] vs  $n = 1,996$  [24.2%] vs  $n = 413$  [5.0%]). Predictors for low outliers were death (odds ratio [OR] = 4.89 [95% confidence interval (CI) 3.27–7.31], concussion (OR = 4.87 [95% CI 4.20–5.63], and psychiatric disease (OR = 1.85 [95% CI 1.46–2.34]). Predictors for high outliers were age  $\geq 65$  years (OR = 1.74 [95% CI 1.31–2.30]), number of diagnoses  $\geq 5$  (OR = 2.07 [95% CI 1.52–2.81]), comorbidity (OR = 1.75 [95% CI 1.28–2.40]), number of surgeries (OR = 1.76 [95% CI 1.36–2.28]), complication peri-operatively (OR = 1.69 [95% CI 1.24–2.30]), infection (OR = 2.66 [95% CI 1.57–4.49]), concussion (OR = 1.52 [95% CI 1.14–2.01]), and urinary tract infection (OR = 2.34 [95% CI 1.61–3.41]).

**Conclusion:** This large study showed that outliers, especially low outliers, are relatively common. Patients were discharged early if they died, had a concussion, or psychiatric disease. Contrarily, patients were discharged late if they were geriatric, had more diagnoses, were comorbid, had more surgeries, complications peri-operatively, infection, concussion, and urinary tract infection. For hospitals, this can help raise awareness and lead to better management of specific diagnoses in order to avoid monetary deficits. For the public health sector, this information may be considered in future revisions of the DRG.

## INDEX OF FIRST AUTHORS

The numbers refer to the pages of this supplement.

- |                               |                                  |                                |                          |
|-------------------------------|----------------------------------|--------------------------------|--------------------------|
| Agten C 9 S                   | Flury A 35 S                     | Kravarski M 51 S               | Rahm S 36 S, 37 S        |
| Ahmad SS 22 S, 34 S           | Fornaciari P 42 S                | Krieg A 16 S, 25 S             | Riedo S 27 S             |
| Al-Mayahi M 47 S              | Franz A-C 20 S                   | Krismer AM 53 S                | Roche D 32 S             |
| Albers CE 8 S                 | Frey A 10 S                      | Kuner E 3 S                    | Roner S 29 S, 30 S, 47 S |
| Anwander H 64 S               | Friesenbichler B 41 S            | Kurze C 18 S, 62 S             | Rüdiger H 38 S           |
| Aregger F 47 S                | Fuchs B 62 S, 63 S               | Kutaish H 58 S, 64 S           | Rudin D 31 S             |
| Arenas A 43 S                 | Fürnstahl P 39 S, 54 S           | Kwiatkowski B 16 S             | Ruiz R 21 S              |
| Audigé L 45 S                 |                                  |                                |                          |
| Babel H 35 S                  | Garavaglia G 35 S                | Ladurner A 33 S, 54 S          | Sailer J 46 S            |
| Bassi C 10 S, 49 S            | Gardon R 56 S                    | Lauper N 23 S                  | Scheibler A-G 48 S       |
| Batailler C 38 S              | Gaukel S 60 S, 65 S              | Laux C 25 S                    | Scheidegger P 20 S       |
| Beeler S 5 S, 27 S, 43 S      | Gay M 9 S                        | Leibold C 17 S                 | Schiapparelli F-F 55 S   |
| Berli M 17 S                  | Gieger J 19 S                    | Lenz C 57 S                    | Schmid J 2 S             |
| Bermont F 64 S                | Gkagkalis G 62 S                 | Lerch T 15 S, 38 S, 39 S       | Seidel A 15 S            |
| Bigdon S 2 S, 9 S, 44 S       | Glanzmann M 6 S                  | Leunig M 35 S                  | Seiler N 62 S            |
| Böni L 24 S                   | Goetti P 26 S, 41 S, 61 S        | Liebmann F 29 S                | Siebenmann C 59 S        |
| Born P 37 S                   | Grobet C 12 S                    | Liebs T 13 S, 14 S, 32 S, 59 S | Spross C 6 S             |
| Bouaicha S 4 S, 46 S, 54 S    | Grubhofer F 17 S, 41 S, 44 S     |                                | Stalder M 5 S            |
| Bratschi C 46 S               | Guggi T 11 S, 31 S               | Madörin K 36 S                 | Stambolsky C 58 S        |
| Bregou Bourgeois A 65 S       | Guttek N 56 S                    | Mannion AF 49 S, 51 S          | Stark T 49 S             |
| Bremer AK 19 S                | Häberli J 52 S, 55 S             | Mazzucchelli RA 6 S, 50 S      | Steiner C 18 S           |
| Bühler T 25 S, 60 S           | Habib N 10 S                     | Merckaert S 14 S               | Studer D 15 S, 59 S      |
|                               | Hanke MS 37 S                    | Meyer DC 4 S, 42 S             | Suter T 40 S             |
| Camenzind R 13 S              | Hasler A 4 S                     | Mints M 13 S, 37 S             |                          |
| Cardoso DV 19 S               | Hasler J 36 S                    | Miozzari HH 30 S               | Terrier A 26 S           |
| Carli A 51 S                  | Haveman R 7 S                    | Moerenhout K 57 S              | Thiele F 58 S            |
| Carpeggiani G 27 S            | Hirsiger S 44 S                  | Molinari D 40 S                | Thüring G 57 S           |
| Casartelli N 50 S             | Hochreiter B 31 S, 52 S          | Morattel B 24 S                | Todorski I 50 S          |
| Cochard B 40 S                | Hodel SM 23 S, 24 S              | Morello V 32 S                 | Tscholl P 33 S, 54 S     |
|                               | Horn N 32 S                      | Moser L 31 S                   | Tschopp B 53 S           |
| de Rosa V 16 S                | Huber J 8 S, 28 S                | Müller A 28 S, 41 S            | Tsoupras A 7 S           |
| Deforth M 56 S                | Hutter R 55 S                    | Müller S 4 S                   |                          |
| Delaloye J-R 34 S             |                                  | Mumme M 13 S                   | Ulrich B 34 S            |
| Dennler C 6 S, 7 S            | Indel C 29 S                     |                                |                          |
| di Laura Frattura G 30 S      | Jacxsens M 3 S                   | Najafi A 24 S                  | Valisena S 15 S          |
| Dimitriou D 45 S              | Jentzsch T 8 S, 11 S, 48 S, 65 S | Nam Le T 33 S                  | Vautrin M 60 S           |
| Durand Y 60 S                 | Jost B 26 S, 27 S                | Nauer S 48 S                   | Vavken P 5 S, 42 S, 43 S |
|                               |                                  | Ngo THN 57 S                   | Viehöfer A 22 S          |
| Ebert S 61 S                  |                                  | Nowak A 20 S                   | Vlachopoulos L 12 S      |
| Echeverri S 53 S              | Kaiser N 14 S                    |                                | Vogel R 2 S              |
| Eckers F 23 S                 | Klammer A 21 S                   | Osinga R 61 S                  | Weichsel F 46 S          |
| Edd SN 53 S                   | Klaue K 19 S                     | Ottersbach A 39 S              | Weigelt L 18 S           |
| Egloff C 33 S                 | Kleinstück FS 10 S               |                                | Wirth S 21 S             |
| Ernstbrunner L 3 S, 5 S, 28 S | Klenke FM 51 S                   | Pankert K 49 S                 | Wuarin L 52 S            |
| Exner U 25 S, 63 S            | Kohlhof H 22 S, 64 S             | Passaplan C 11 S               |                          |
|                               | Koller T 21 S                    | Perez V 38 S                   |                          |
| Farshad M 9 S                 | Kolling C 45 S                   | Pham C 45 S                    | Zdravkovic V 12 S        |
| Fillistorf L 16 S             | Körner C 18 S                    | Plate A 39 S                   | Zuodar C 58 S            |
| Fischbacher A 23 S, 52 S      | Krappel F 7 S, 48 S              | Prod'homme M 59 S              |                          |



