



Annual Meeting Abstracts of the International Skeletal Society (ISS) 2019, Vancouver, Canada

Scientific Session Program

Monday, September 9, 2019, 13:30 - 15:30

Session 1

13:30 - 15:30

13:30. DETECTION OF MUSCULOSKELETAL INFLAMMATORY LESIONS IN PATIENTS WITH CHRONIC SYMPTOMS OF CHIKUNGUNYA INFECTION WITH 3T WHOLE BODY MAGNETIC RESONANCE IMAGING

Aline Serfaty, Silvana Mendonça, Luiz Octavio D'Almeida, Edson Marchiori, Clarissa Canella. *Cabo Frio, Brazil*

Purpose: The purpose of this study was to describe the prevalence of musculoskeletal inflammatory lesions with whole body magnetic resonance imaging (WBMRI) in patients with chronic Chikungunya infection.

Materials and Methods: In 2018, eighty-six patients diagnosed at least six months prior with positive Chikungunya specific serology (IgM/IgG anti-CHIKV) with a history of chronic polyarthralgia and no pre-existing rheumatic disorders were selected to undergo 3T WBMRI for the evaluation of musculoskeletal inflammatory lesions that could be correlated with chronic Chikungunya infection. Sagittal MR images of the whole spine, coronal images of the sacroiliac joints and localized multiplanar images of wrists, hands, ankles and feet in STIR sequence were also obtained. Exclusion criteria were claustrophobia and age greater than 70 years-old. Written informed consent was obtained from all patients. Two experienced musculoskeletal radiologists evaluated the images.

Results: Twenty-six patients met the criteria and agreed to participate in the study (ages ranged from 29 to 67; mean age 52 years; 21 females; 5 males). All patients presented with symmetric polyarthralgia mostly observed in hands and feet. The most prevalent findings in the wrists and hands were effusion in the distal radioulnar (n=13; 25%) and metacarpophalangeal joints (n=19; 36%) and tenosynovitis of the flexor tendons of the hands (n=23; 44%). In the ankles and feet, the most common findings were effusion in the tibiotalar joint (n=30; 57%) and edema in Kager fat pad (n=34; 65%). Other findings included bone marrow edema (BME) in the sacroiliac joints (n=3; 5%) and bursitis in the shoulder (n=13; 25%) and hip (n=8; 15%). In the spine, two patients presented BME of the vertebral corners. Bilateral BME of the carpal bones associated with distal radioulnar effusion similar to rheumatoid arthritis was demonstrated in one patient. Intra and interobserver analyses were performed with results showing concordance.

Conclusion: According to our knowledge, this is the first study in which 3T WBMRI has been used to evaluate musculoskeletal inflammatory disorders in patients infected with Chikungunya virus, with the purpose

to identify the joints most frequently affected and the most prevalent lesions. Further studies are suggested to define the role of WBMRI in identifying distribution patterns of this disease.

13:40. LUMBAR EPIDURAL STEROID INJECTION: ASSESSING THE AFFECT OF ADDING BUPIVACAINE ON IMMEDIATE AND DELAYED POST-PROCEDURE PAIN SCORES

Cody Quirk, Anthony Onofrio, James Patrie, Nicholas Nacey. *Charlottesville, VA, USA*

Purpose: A local anesthetic is frequently administered as part of a lumbar epidural steroid injection. However, there is a rare potential for Bupivacaine to result in transient paralysis which can be alarming to patients. The purpose of this retrospective study is to determine if the addition of Bupivacaine significantly improves patient-reported pain scores to justify its utilization in lumbar epidural steroid injection.

Materials and Methods: This retrospective review included patients undergoing lumbar epidural steroid injection over a two year time span. Pre-procedure, immediate post-procedure, and one week pain scores from 0 to 10 using a visual analog scale were recorded in a database. Statistical analysis, including linear mixed model ANOVA, compared differences in pain scores between Bupivacaine and non-Bupivacaine patients. Patients with a pre-procedure pain score of 6 or higher were also compared as to the percentage of patients who received a 50% or greater reduction in pain.

Results: 258 patients met the inclusion criteria (126F:132M, mean age 64.7 years) with 164 receiving Bupivacaine and steroids and 94 receiving steroids alone. Pre-, immediate, and 1-week post-injection pain scores for the non-Bupivacaine and Bupivacaine patients were 5.8/3.1/3.7 and 5.2/2.4/3.3 respectively. There was a statistically significant decrease in pain score immediately post-injection and at one week for both Bupivacaine and non-Bupivacaine patients ($p < 0.001$). There was no statistically significant difference in the adjusted change in pain score between the Bupivacaine and non-Bupivacaine patients at the immediate ($p = 1.0$) or one week ($p = 1.0$) time points. Among patients with higher pre-procedure pain scores, 59.7% of Bupivacaine patients had a 50% or greater reduction in pain at the immediate post injection time point compared to 47.9% of non-Bupivacaine patients, although this was not a statistically significant difference ($p = 0.212$).

Conclusion: The lack of a significant decrease in post-procedure pain with the addition of Bupivacaine questions its utility as a standard component of a lumbar epidural injection. Given the potential for complications such as transient paralysis, avoiding its use all together could be considered. There is possible benefit to including Bupivacaine in patients with a higher pre-procedure pain score of 6 or greater, although this remains unclear.

13:50. THE CONTRA-LATERAL KNEE CARTILAGE IN ANTERIOR CRUCIATE LIGAMENT INJURED AND RECONSTRUCTED SUBJECTS: MORPHOLOGICAL AND COMPOSITIONAL MRI ANALYSES OVER 3-YEARS

Julio Guimaraes, Luca Facchetti, Thomas Link, Jan Neumann, Alexandra Gersing, Benedikt Schwaiger. *San Francisco, CA, USA*

Purpose: The purpose of this study was to investigate overall longitudinal structural and biochemical changes in the cartilage of the contra-lateral knee in ACL-injured and reconstructed subjects over 3-years, comparing with a matched healthy control group, using morphological and quantitative MRI.

Materials and Methods: Fifteen subjects with complete traumatic acute ACL tear (32 females and 15 males; age 32.6 ± 8.3 y; BMI 24.5 ± 3.5 kg/m²) and 20 healthy controls (gender, BMI and age-matched) were included in this study. Morphological (high-resolution 3D fast spin-echo) and compositional (T1 ρ and T2-mapping) MRI at 3T was performed prior (BL), 1-year and 3-years after ACL-reconstruction. The morphological MR images were analyzed focusing on cartilage lesions using whole-organ magnetic resonance imaging scores (WORMS) at BL, 1-year and 3-years, comparing the progression of cartilage WORMS of the contra-lateral knee in ACL-injured and reconstructed subjects with those of control knees. Also, the cartilage was assessed longitudinally in these 2 groups with quantitative MRI sequences (T1 ρ and T2 maps). The Student *t* test (for numeric and approximately normally distributed data) and Pearson chi-square test (for categorical variables) were used to evaluate differences between these 2 groups.

Results: Cartilage Δ T1 ρ (1 year-BL) and Δ T1 ρ (3 years-BL) of the medial femur increased significantly more in the contra-lateral knee in ACL-injured and reconstructed subjects compared to controls (mean difference at 1 year follow-up (FU): MF=1.3 \pm 2.2 vs. 0.4 \pm 2.0, $p = 0.007$ and mean difference at 3 year FU: MF=2.6 \pm 2.2 vs. 0.2 \pm 2.8, $p = 0.003$). Also, cartilage Δ T2 (1 year-BL) and Δ T2 (3 years-BL) of the medial femur increased significantly more in the contra-lateral knee in ACL-injured and reconstructed subjects compared to controls (mean difference at 1 year FU: MF=1.0 \pm 1.8 vs. 0.1 \pm 2.2, $p = 0.03$ and mean difference at 3 year FU: MF=2.9 \pm 1.7 vs. 0.9 \pm 2.4, $p = 0.002$). We also found significantly more progression of cartilage lesions (WORMS progression, $p=0.04$) in the medial femur in the contra-lateral knee in ACL-injured and reconstructed subjects compared with the healthy controls over 3-years.

Conclusion: The contra-lateral knee in ACL-injured and reconstructed subjects presented higher compositional and morphological cartilage deterioration in the medial femur compartment compared to healthy control knees over 3-years.

14:00. MRI OF ACUTE ANKLE SPRAIN: ASSOCIATIONS BETWEEN JOINT EFFUSION AND STRUCTURAL INJURY SEVERITY IN A LARGE COHORT OF ATHLETES

Michel Crema, Ali Guermazi, Branislav Krivokapic, Predrag Gravilovic, Nebojsa Popovic, Pieter D'Hooghe, Frank Roemer. *Boston, MA, USA*

Purpose: To test the hypothesis if presence and amount of effusion in the tibiotalar and talocalcaneal joints is associated with an increased risk for severe structural injury in ankle sprains.

Materials and Methods: A total of 261 athletes sustaining acute ankle sprains were assessed on MRI for the presence and the amount of joint effusion in the tibiotalar and talocalcaneal joints, as well as for ligamentous and osteochondral injury. Specific patterns of injury severity were defined based on lateral collateral ligament, syndesmotom and talar osteochondral involvement. The presence and the amount effusion (grades 1 and 2) were considered as risk factors for severe injury, while

physiological amount of fluid (grade 0) was considered as the referent. Conditional logistic regression was used to assess the risk for associated severe injuries (syndesmotom ligament rupture and talar osteochondral lesions) based on the presence and amount of tibiotalar and talocalcaneal effusion.

Results: For ankles exhibiting large (grade 2) effusion in the tibiotalar joint (without concomitant grade 2 effusion in the talocalcaneal joint), the risk for partial or complete syndesmotom ligament rupture was increased more than 8-fold (adjusted odds ratio 8.7 (95% confidence intervals 3.7-20.7); $p < 0.001$). The presence of any degree of effusion in any of the joints was associated with an increased risk for severe talar osteochondral involvement (several odds ratio values reported; $p < 0.001$), including large subchondral contusions and any acute osteochondral lesion. The negative predictive value of severe joint effusion in the tibiotalar and talocalcaneal joints to rule out syndesmotom injury was 0.78.

Conclusion: The presence of tibiotalar and talocalcaneal effusion is associated with an increased risk for severe concomitant structural injury in acute ankle sprains.

14:10. IMAGING AND CLINICAL OUTCOMES FOLLOWING SUPERIOR CAPSULAR RECONSTRUCTION FOR MASSIVE IRREPARABLE ROTATOR CUFF TEARS

Mohammad Samim, Abigail Campbell, David Klein, Soterios Gyftopoulos, Hank Ross, SAMUEL BARON, Robert Meislin. *New York, NY, USA*

Purpose: Superior capsular reconstruction (SCR) has been recently developed as an arthroscopic treatment option for massive irreparable rotator cuff tears. The purpose of this study is to determine early imaging, clinical, and functional outcomes of SCR.

Materials and Methods: Patients having undergone SCR at a single institution were included. Pre-operative and post-operative radiographs and MRIs were evaluated for acromiohumeral interval (AHI), superior subluxation distance (SSD), glenohumeral cartilage loss, cuff muscle atrophy, and graft integrity. Postoperative outcomes including range of motion (ROM), muscle strength and clinical outcomes scores were collected.

Results: 24 SCRs were included. Mean clinical follow-up was 21.3 months. MRI was obtained in all patients at mean 9.4 months postoperatively. There were 12 intact grafts (50%) and 12 grafts (50%) with tear at least at one location. The most common location of tear was from the glenoid attachment (50%), followed by the posterior side-to-side attachment (25%), the anterior attachment (18%), and greater tuberosity (7%). There was a significant improvement of American Shoulder and Elbow Surgeons (ASES) ($p = 0.003$) and visual analog scale (VAS) pain scores ($p = 0.012$). Significant improvement was observed in forward elevation ROM ($p = 0.021$). There was no significant difference in functional outcomes or range of motion between patients with torn graft and those with intact graft. The severity of preoperative cartilage loss or rotator cuff muscle fatty atrophy were not associated with graft tear. There was a significant difference in the SSD between patients with complete tear of the graft at least in one location and those without tear on postoperative MRI. SSD greater than 7.9 mm had a 79% sensitivity and 91% specificity for a complete tear of the graft.

Conclusion: SCR using human dermal allograft had a 50% tear rate mostly from the glenoid in the current series despite that it results in significant improvements in short term function and range of motion in patients with massive irreparable rotator cuff tears. The chronicity of this procedure's action to depress the humeral head remains in question, as well as the time this procedure provides to delay reverse total shoulder arthroplasty.

14:20. COMPRESSED SENSING SEMAC MRI OF HIP AND KNEE ARTHROPLASTY IMPLANTS AT 1.5T AND 3T FIELD STRENGTHS: AN INTRA-SUBJECT COMPARISON STUDY

Iman Khodarahmi, Jan Fritz. *New York, NY, USA*

Purpose: Metal artifact reduction magnetic resonance imaging (MRI) of metallic arthroplasty implants at 1.5T field strength has inherently lower susceptibility artifacts than at 3T field strength. However, 3T MRI offers higher signal-to-noise and contrast-to-noise ratios, and allows for higher spatial resolution. In this study, we tested the hypothesis that compressed-sensing (CS) accelerated slice-encoding-for-metal-artifact-correction (SEMAC) MRI of hip and knee arthroplasty implants can generate similar image quality and visibility of periprosthetic abnormalities at 1.5 and 3T field strengths.

Materials and Methods: Thirty patients with symptomatic hip (7 women, 8 men; age, 71 (38–95 years) and knee (9 women, 6 men; age, 68 (48–92) years) arthroplasty implants were included in this prospective IRB-approved study after giving informed written consent. Each patient underwent consecutive 1.5 and 3T MRI using previously optimized protocols consisting of PD-weighted and STIR CS-SEMAC turbo spin echo (TSE) pulse sequences in coronal (hip) or sagittal (knee) planes. The 3T protocols utilized 25 SEMAC encoding steps while the 1.5 T protocols used 19 SEMAC encoding steps. The 3T protocols had higher spatial resolution. Each pulse sequence required 4–5 min acquisition time. Paired PD-weighted and STIR image datasets were separated, image annotations were removed and randomly reassigned. Two musculoskeletal radiologists qualitatively evaluated image quality and the presence of six periprosthetic abnormalities independently. Wilcoxon test, Kendall W agreement, and substitutability testing were applied. P-values < 0.05 indicated statistical significance.

Results: Image quality of hip and knee studies were overall good with slight non-significant (hip, $p=0.21$ / knee, $p=0.33$) dominance of 1.5T over 3T. Reader agreements were moderate to very good (W range, 0.53–0.81). Inter-method agreement was overall good (W, 0.67/0.71). For each joint, substitution analysis demonstrated that the higher resolution but slightly longer 3T CS-SEMAC could replace the lower spatial resolution, but faster 1.5T CS-SEMAC technique (p -value range, 0.41–0.94) in diagnosing the six abnormalities, including periprosthetic osteolysis, synovitis, bone marrow edema, fractures, tendon tears, and extra-capsular collections.

Conclusion: With the use of optimized pulse sequence parameters, CS-SEMAC at 3T field strength can generate high-resolution MR images with similar degrees of metal artifact reduction and detection of periprosthetic abnormalities than CS-SEMAC at 1.5T field strength.

14:30. 5-MINUTE QUANTITATIVE DOUBLE-ECHO IN STEADY-STATE IN KNEE MRI: COMBINING AN EFFICIENT MULTI-CONTRAST ACQUISITION WITH QUANTITATIVE IMAGING AND ARTIFICIAL INTELLIGENCE

Akshay Chaudhari, Murray Grissom, Zhongnan Fang, Jin Lee, Garry Gold, Brian Hargreaves, Kathryn Stevens. *Stanford, CA, USA*

Purpose: Diagnostic knee MRI typically requires over 20 minutes of scan time, leading to an interest in expedited protocols. Quantitative 3D double-echo in steady-state (qDESS) offers rapid and multi-contrast images and simultaneously generates quantitative T2 relaxation time maps. The purpose of our study was to determine if qDESS combined with deep-learning super-resolution (DL-SR) offered similar diagnostic capabilities to conventional knee MRI protocols.

Materials and Methods: DL-SR was used to enhance slice-resolution of a 5-minute qDESS sequence twofold, and its utility for performing diagnostic knee was evaluated for assessment of ligament, cartilage, bone

marrow, extensor mechanism, and synovial pathology in 51 patients referred for a clinical knee MRI. We also assessed the benefit of augmenting the morphological images with the simultaneous T2-relaxation-time map generated with qDESS. The DLSR-enhanced qDESS was compared to the conventional knee MRI protocol, as well as arthroscopic surgery when available.

Results: qDESS generated 74%, 97%, and 92% positive, negative, and total agreement with the conventional protocol findings respectively, for all tissues. Overall qDESS sensitivity, specificity, and accuracy for meniscal, ligament, cartilage, and synovial abnormalities were 61%, 71%, and 67% respectively, which was comparable to 65%, 70%, and 70% for the conventional protocol. There was high inter-reader agreement, with an overall Kappa value of 0.82. The presence of a T2 map added additional diagnostic value in 41 of 51 patients and in a total of 38% of all cartilage regions studied, showing areas of abnormal T2 signal in areas of morphologically normal appearing cartilage on conventional MR sequences.

Conclusion: Overall, the 5-minute qDESS method with DL-SR and T2 mapping had high agreement with the conventional knee MRI protocol, as well as comparable accuracy compared to the conventional MRI protocol with arthroscopy as the standard. This promising new technique of deep-learning super-resolution may enhance lower-resolution MRI sequences such as qDESS, in order to expedite MRI protocols and produce diagnostic knee MRI examinations.

14:40. SEPTIC FACET JOINTS - AN UNDERDIAGNOSED DISTINCT CLINICAL ENTITY FREQUENTLY ASSOCIATED WITH EPIDURAL ABSCESS AND PROLONGED BACTEREMIA

Claus Simpfendorfer, Maja Babic, Hakan Ilaslan. *Cleveland, OH, USA*

Purpose: Septic facet joints (SFJ) are deemed a rare imaging finding in current literature. We review a series of isolated infected facet joints that present as a distinct clinical entity compared to spondylodiscitis. We aim to raise awareness that septic facet joints are not a rare entity in the era of modern imaging.

Materials and Methods: We reviewed 353 patients with confirmed spine infections spanning a 9 year period from 2008 to 2017. Of the 353 cases- 152 facet joints were suspected to be infected based on MR imaging findings. Sixty-six presented as isolated septic facet joints (SFJ) without evidence of spondylodiscitis. The characteristics of the 66 isolated SFJ were reviewed.

Results: Patients were predominantly male 41/66 (62%). The mean age was 56.5 years (range from 22–81). Onset of back pain was more acute compared to spondylodiscitis and usually unilateral. The distribution was as follows: 7 cervical, 13 thoracic and 58 lumbar facets (12 cases had more than one level facet involved). The majority of the isolated SFJ were associated with an epidural abscess (EDA) 58/66 (88%). The cervical and thoracic EDA required surgical decompression more frequently than lumbar EDA, 71 %, 77% and 57% respectively. The majority, 63/66 (95%) cases were of known bacterial origin with only 3 cases where a pathogen was not detected due to prior antibiotic exposure. Sixty (91%) cases of SFJ were caused by gram positive organisms (staphylococci, streptococci and enterococci). Most cases were associated with bacteremia (50/66). In 13 cases the organism was retrieved intraoperatively or by aspiration of the SFJ. The average duration of bacteremia was 3.3 days ranging from 1–30 days. Seven SFJ were introduced iatrogenically, following facet injections. All iatrogenic SFJ required surgical decompression.

Conclusion: Septic facet joints (SFJ) are not rare, but frequently overlooked as the origin of an epidural abscess. The majority of cases are hematogenously seeded and associated with bacteremia. Surgical decompression is frequently required secondary to the high incidence of associated epidural abscess. Iatrogenic SFJ are rare but associated with significant morbidity. From a clinical standpoint- it is helpful to delineate

the origin of EDA as either secondary to spondylodiscitis or SFJ.

14:50. FEASIBILITY OF COMPREHENSIVE ASSESSMENT OF KNEE JOINT SYNOVITIS AT ULTRA-HIGH FIELD (7T) MRI USING CONTRAST-ENHANCED AND NON-ENHANCED SEQUENCES

Frank Roemer, Treutlein Christoph, Ali Guermazi, Armin Nagel, Amd Kleyer, David Simon, Georg Schett, Michael Uder, Tobias Baeuerle. *Erlangen, Germany*

Purpose: With clearance for clinical use recently, 7T systems are already used clinically and will potentially become more widely available. To date, no studies are available that have assessed the feasibility of 7T MRI for evaluation of peripheral arthritis. Purpose was to investigate the feasibility of contrast-enhanced (CE) and non-enhanced MRI at 7T for the assessment of knee joint synovitis.

Materials and Methods: 10 patients with an established diagnosis of psoriatic or rheumatoid arthritis underwent 7T MRI. Our study protocol consisted of sagittal intermediate-weighted fat-suppressed (FS), axial fluid-attenuated inversion recovery (FLAIR) FS, sagittal 3D T1-weighted dynamic contrast enhanced (DCE) and an axial static 2D T1-weighted FS contrast-enhanced sequence (T1-FS CE). Ordinal grading on non-enhanced (Hoffa- and effusion-synovitis) and enhanced images (11-point synovitis score), comparison between FLAIR-FS and static T1-FS CE imaging using semiquantitative (SQ) and volume assessment was performed. Inter- and intra-reader reliability was determined. For reliability assessment weighted kappa statistics for ordinal scores and intraclass correlation coefficients (ICC) for continuous variables were applied.

Results: Total duration of study protocol was 15 min 38 s. Synovitis was detected in all patients (mild: n=3; moderate: n=5; severe: n=2). SQ assessment yielded significantly lower peripatellar summed synovitis scores for FLAIR-FS compared to CE T1-FS ($p<0.01$). Peripatellar synovial volume between CE T1-FS and FLAIR-FS was comparable with FLAIR-FS showing significantly lower volumes ($p<0.01$) with a mean percentage difference of $18.6 \pm 9.5\%$. Inter- and intra-reader agreement for SQ scoring ranged from 0.21 (inter-reader Hoffa-synovitis) to 1.00 (inter-reader effusion-synovitis). Inter- and intra-reader agreement of SQ 3D-DCE parameters ranged from 0.86 to 0.99.

Conclusion: CE MRI of knee synovitis at 7T is clinically feasible. 7T FLAIR-FS imaging is a potential non-enhanced imaging method visualizing synovial inflammation with high conspicuity and holds promise for further application in research endeavors and clinical routine by trained readers.

15:00. POSTOPERATIVE, TRACTION MR ARTHROGRAPHY IN PATIENTS WITH PERSISTING PAIN AFTER HIP ARTHROSCOPY FOR FAI REVEALS UNEXPECTED HIGH PREVALENCE OF OSSEOUS DEFORMITIES AND INTRA-ARTICULAR LESIONS DUE TO UNDER-/ OR OVERCORRECTION

Florian Schmaranzer, Till Lerch, Klaus Siebenrock, Moritz Tannast, Ehrenfried Schmaranzer. *Bern, Switzerland*

Purpose: Numbers of hip arthroscopies for FAI correction have risen exponentially, leading to an increase of patients with persistent pain who undergo postoperative MR imaging. To assess prevalence of new/residual (1) osseous deformities, (2) intra-articular lesions and (3) progression of osteoarthritis in symptomatic patients undergoing pre- and postoperative MR imaging after hip arthroscopy.

Materials and Methods: IRB-approved, retrospective study. Between 2010-17, 806 patients underwent arthroscopic FAI correction and/or labrum surgery. Database was reviewed for symptomatic patients with

complete radiographs and traction MR arthrography (MRA) of the hip (1.5 T) obtained before and after hip arthroscopy according to the routine protocol. 49 patients were included: mean age 29 ± 10 years, 67% female. Traction was applied using a MR-compatible traction device with weight-adaptation. One reader assessed pre- and postoperative images. (1) Acetabular coverage ($LCE<25^\circ$ = dysplasia, $LCE>39^\circ$ = pincer deformity) and Tönnis osteoarthritis (OA) grade were assessed on AP pelvic views. Cam deformity was defined ($\alpha>60^\circ$) on radial MR images. Femoral torsion measurements were only available for postoperative MRI (low/high torsion: $<5^\circ/>30^\circ$). (2) Presence of residual tears-, rears of the labrum, capsular adhesions/defects was assessed on traction MRA. (3) OA progression on traction MRA was defined as new acetabular/femoral cartilage lesions and osteophytes formation.

Results: (1) Preoperatively 42 (86%) hips showed deformities: 2 (4%) dysplastic-, 11 (22%) pincer- and 39 (80%) cam deformities. Postoperatively 39 (80%) hips showed deformities; 9 (18%) dysplastic-, 8 (16%) pincer-, 20 (41%) cam deformity, 4 (8%) hips with torsion $<5^\circ$, 10 (20%) hips with torsion $>30^\circ$. (2) Postoperatively 14 (29%) cases with residual-, 12 (24%) cases with labrum rears were observed. 6 (12%) hips had capsular adhesions, 22 (45%) had capsular defects. (3) Radiographic OA progression was observed in 5 (10%) hips, in 14 (30%) hips on traction MRA.

Conclusion: Prevalence of osseous deformities due to over- or undercorrection and intra-articular lesions is high after failed hip arthroscopy. Traction MRA was useful for detection of OA progression. Identification of osseous over-/undercorrection after failed hip arthroscopy is essential because open surgical approaches must be considered for correction of dysplasia and abnormal femoral torsion.

15:10. RAPID HIGH RESOLUTION MRI OF ELBOW INJURIES: COMPARISON OF A NOVEL 10-MIN 3D TSE TECHNIQUE AGAINST A 20-MIN 2D TSE STANDARD OF REFERENCE

Filippo Del Grande, Dharmdev Joshi, Steven Stern, Jan Fritz. *Baltimore, MD, USA*

Purpose: To test the hypothesis that a 4-fold accelerated 10-min 3D CAIPIRINHA SPACE prototype protocol for MRI of the elbow is equivalent to a 2-fold accelerated 2D TSE standard for the diagnosis of internal derangement.

Materials and Methods: Our study was approved by our internal review board. Following informed consent, 40 patients underwent 3T MRI of their symptomatic elbow consisting of six axial, sagittal and coronal IW and T2FS 2D TSE (20 min) and two sagittal isotropic IW and T2FS 3D TSE (10 min) pulse sequences. The novel 4-fold acceleration of the 3D SPACE TSE sequences were enabled by bidirectional parallel imaging and CAIPIRINHA sampling pattern. Corresponding 2D and 3D TSE data sets were separated, anonymized and randomized into 80 studies and independently evaluated by two musculoskeletal radiologists. Outcome variables included 3 joints, 4 ligaments, 4 tendons, and 3 bones of the elbow for integrity and diagnostic confidence. Descriptive statistics, inter-rater reliability, inter-modality concordance, and diagnostic confidence test were applied. A p-value of <0.05 was considered significant.

Results: There was a high degree of inter-rater reliability with exact agreements of 78% and 89% for 2D and 3D images, respectively ($p<0.05$). The degree of diagnostic concordance between 2D and 3D TSE was high with a Kendall's coefficient W for cartilage of 0.842, ligaments of 0.769, tendons of 0.890, and bone of 0.894. Readers diagnosed a total of 6 cartilage defects on 2D and 8 on 3D images, 14 ligament tears on 2D and 12 on 3D, 31 tendon tears on 2D and 33 on 3D, and 26 bone abnormalities on 2D and 28 on 3D. The disagreements between 2D and 3D diagnoses for cartilage, ligaments, tendons, and bone were 17.8%, 5.6%, 5.0%, and 3.8%, respectively. The readers' diagnostic confidence was significantly higher for 3D TSE ($p<0.05$).

Conclusion: The presented 10-min 3D CAIPIRINHA SPACE MRI protocol is equivalent for the diagnosis of internal derangement of the elbow to a 20-min 2D TSE standard of reference. Radiologists' concordance and confidence were significantly higher for 3D studies, indicating a higher diagnostic definitiveness and possibly increased accuracy.

15:20. PERCUTANEOUS ULTRASOUND-GUIDED SYNOVIAL BIOPSY - KEEPING IT SIMPLE.

Ankit Shah, Bipin Shah. *Mumbai, India*

Purpose: To assess the feasibility of ultrasound-guided percutaneous biopsy of thickened synovial tissue.

Materials and Methods: In this retrospective study, ultrasound-guided percutaneous synovial core biopsies were performed over a two and a half year period. A total of 21 biopsies were performed at the following locations: hip (7), shoulder (4), ankle (3), knee (2), sternoclavicular joint (2), mid-foot (2) & sacroiliac joint (1). Pre-procedure Magnetic Resonance Imaging (MRI) scans were assessed in all the patients. Biopsies from the hypertrophied synovium were obtained using a tru-cut needle with a co-axial system. Direct visualization of the needle guillotine with ultrasound made it possible to place the biopsies across the capsule sampling capsule and synovium. An attempt to aspirate the joint fluid was made prior to biopsy. Multiple cores were obtained & were collected in formalin & saline for histopathology & microbiology respectively.

Results: Of the 21 ultrasound guided procedures, diagnostic synovial tissue was obtained in 15 patients (71.4%). With the combination of synovial biopsy & assessment of the joint fluid, a definite diagnosis was obtained in 18 patients (85.7%). Aspiration did not yield any diagnostic fluid in four joints (19.04%). A definite histopathological diagnosis could be made in 5 patients (23.8%). 5 patients with a definite diagnostic biopsy had chronic synovitis with caseating granulomas – consistent with Tuberculous synovitis. The other 10 patients with sufficient synovial tissue had a non-specific diagnosis of acute / chronic synovitis. The final clinico-radiological diagnoses of the biopsied patients were: Tuberculous synovitis (7 patients), Rheumatoid arthritis (3 patients), osteoarthritis (2 patients), neuropathic joint (2 patients), inflammatory arthritis of undetermined nature (5 patients) & infective arthritis (2 patients). The 6 patients with insufficient synovial tissue yield had a synovial thickness of less than 7mm. While the thickness of the 15 diagnostic procedures ranged from 8.8mm to 21.2mm. None of the patients had significant post-procedural complications.

Conclusion: Synovial tissue & synovial hyperemia are well visualized with ultrasound. Apart from joint aspirations, synovial biopsies can be easily performed using ultrasound guidance. Unlike Computed tomography (CT), ultrasound can differentiate between effusion & synovial hypertrophy & hence can aid in a better yield of synovial tissue.

Scientific Session Program

Monday, September 9, 2019, 15:40 - 17:30

Session 2

15:40 - 17:30

15:40. DIAGNOSTIC PERFORMANCE OF TEXTURE ANALYSIS FOR DIFFERENTIATION OF INFLAMMATION VS. DEGENERATION IN THE SACROILIAC JOINTS

Felix Kepp, Florian Huber, Urs Mühlematter, Moritz Wumig, Malwina Kaniewska, Filippo Del Grande, Roman Guggenberger. *Zurich, Switzerland*

Purpose: to investigate the performance of texture analysis (TA) for differentiation of inflammation from degeneration in sacroiliac joints (SIJ).

Materials and Methods: MR images of SIJ from patients with clinically established ankylosing spondyloarthritis (AS), degenerative changes and healthy individuals (30 patients each) were analyzed retrospectively. Two residents blinded to each other rated typical structural and inflammatory changes on a four-point Likert scale and categorized patients into different groups, using paracoronal sets of TIRM, T1w and T1w fat-sat contrast enhanced (T1wCE) images. Additionally, same-sized regions of interest were placed into pathologic (where applicable) or random healthy spots of SIJ. TA was performed with open-source software (MaZda). Logistic regression with ten-fold cross validation was applied to detect relations with clinical labels. Standard statistical testing was applied for interreader agreements (IA) and regarding distribution of qualitative and TA findings among the clinical categories.

Results: Moderate IA was present for categorization into different groups ($k=0.40$). Qualitative ratings showed weak to moderate IA, but cumulative qualitative scores differed significantly among patient categories ($p<0.001$). TA showed perfect IA ($k>0.80$) for 203, 194 and 210 features in TIRM, T1w & T1wCE, respectively. TA outperformed qualitative evaluation for differentiation between AS vs. non-AS (AUC=0.89 vs. 0.75 for TA vs. qualitative) and between AS vs. degeneration (AUC=0.91 vs. 0.66). MR sets showed different impact on TA based differentiation of AS vs. non-AS with AUCs of 0.74, 0.76 and 0.81 for TIRM, T1w and T1wCE.

Conclusion: TA improves accuracy in differentiation of AS from degeneration in the SIJ. Its performance is predominantly determined by T1wCE images.

15:50. CORRELATION BETWEEN MR IMAGING TEXTURE ANALYSIS AND QUANTITATIVE TUMOR NECROSIS MEASUREMENTS AFTER NEOADJUVANT CHEMOTHERAPY IN PATIENTS WITH OSTEOSARCOMA

Ji Hyun Hong, Won-Hee Jee, Chan-Kwon Jung, Joon-Yong Jung, Yohan Son, Seung Han Shin, Yang-Guk Chung. *Seoul, Republic of Korea*

Purpose: To investigate whether the parameters derived from 3T magnetic resonance (MR) imaging texture analysis correlate with quantitative tumor necrosis measurements after neoadjuvant chemotherapy in patients with osteosarcoma.

Materials and Methods: The institutional review board approved this retrospective study and informed consent was waived. Twenty-two patients with osteosarcoma who had undergone neoadjuvant chemotherapy and preoperative 3T MR imaging including diffusion-weighted imaging after neoadjuvant chemotherapy were included. Texture analysis of whole tumor volume was performed on T1-weighted, T2-weighted, contrast-enhanced T1-weighted images and apparent diffusion coefficient (ADC) maps using prototype software (Multiparametric Analysis, Siemens Healthineers, Erlangen, Germany). Histogram features (mean, standard deviation, skewness, and kurtosis) and gray level co-occurrence matrix features (contrast, entropy) for each imaging sequence were correlated with the percentage of tumor necrosis on histopathologic analysis. Quantitative tumor necrosis measurements of whole tumor volume were calculated by one pathologist using ImageJ software. The Spearman rank correlation was performed for statistical analysis.

Results: The range of skewness on contrast-enhanced T1-weighted images and ADC map was -0.879 to 1.029 and -1.711 to 1.179, respectively. The range of necrosis of whole tumor volume was 5-100%. Skewness on contrast-enhanced T1-weighted images showed a significant correlation with tumor necrosis ($r = 0.49$, $P = .021$). There was a significant inverse correlation between skewness on ADC map and tumor necrosis ($r = -0.45$, $P = .035$). There was no significant correlation between the other parameters and tumor necrosis.

Conclusion: Skewness on contrast-enhanced T1-weighted imaging correlates with tumor necrosis, while skewness on ADC map inversely correlates with tumor necrosis in patients with osteosarcomas.

16:00. MACHINE LEARNING ALGORITHM FOR AUTOMATED LUMBAR MRI SCORING CORRELATES WITH PAIN AND DISABILITY INDEX IN PATIENTS UNDERGOING LUMBAR DECOMPRESSION

Brandon Roller, Ziyad Knio, Tadhg O’Gara, Josh Tan, Robert Boutin, Timor Kadir, Amir Jamaludin, Leon Lenchik. *Winston Salem, NC, USA*

Purpose: To determine if MRI findings assessed using a machine learning algorithm correlate with clinical findings of pain and disability in patients with single level lumbar microdecompression.

Materials and Methods: 141 consecutive patients with single level microdecompression (L2-3, L3-4, L4-5, or L5-S1 levels) and lumbar MRI exams (< 1 year prior to surgery) were retrospectively evaluated. A machine learning algorithm for automated evaluation of MRI exams (SpineNet; <http://zeus.robots.ox.ac.uk/spinenet>) was applied to sagittal T2-weighted images. At each lumbar level, the algorithm provided the following grading: 1) central canal stenosis (CCS), 2) disc space narrowing (DSN), 3) Pfirrmann grade (PG), 4) spondylolisthesis (SL), 5) endplate morphologic changes (EMC), and 6) marrow signal changes (MSC). An aggregate score based on the sum of the grades was also provided. The following clinical metrics were assessed: 1) preoperative back pain, 2) preoperative leg pain, 3) preoperative Oswestry Disability Index (ODI), 4) 12-month postoperative back pain, 5) 12-month postoperative leg pain, and 6) 12-month postoperative ODI. Spearman correlations between MRI metrics and clinical metrics were determined. Paired t-tests were used to compare results at operative levels and non-operative levels (significant if $p < 0.05$).

Results: 130 patients had preoperative clinical scores and 84 had postoperative scores. At the operated levels, the following MRI findings were significantly correlated with clinical findings: DSN and preoperative back pain ($r = 0.19$) and leg pain ($r = 0.20$), PG and preoperative leg pain ($r = 0.20$), SL and preoperative ODI ($r = -0.21$), CCS and preoperative ODI ($r = -0.25$), EMC and postoperative back pain ($r = 0.26$), MSC and postoperative back pain ($r = 0.22$), and aggregate MRI score and postoperative back pain ($r = 0.24$). At the non-operated levels, the following MRI findings were significantly correlated: MSC and postoperative leg pain ($r = -0.24$), and CCS and postoperative leg pain ($r = 0.27$). All MRI metrics were significantly higher at the operated levels compared to the non-operative levels.

Conclusion: The lumbar MRI machine learning algorithm produces data that correlate with preoperative pain, postoperative pain, and disability index. This approach may assist with goals of accelerating workflows and promoting improved patient-centered outcomes.

16:10. CROSS TEST OF DEEP LEARNING BASED BONE AGE ASSESSMENT TRAINED WITH TWO LARGE DATASETS FROM DIFFERENT INSTITUTION

Kyu-Chong Lee, Kyung-Sik Ahn, Chang Ho Kang, Hee Mang Yoon, Byeong Uk Bae, Woong Bae. *Seoul, Republic of Korea*

Purpose: The purpose of the study was to test whether the fusion data from two large institution can help improving the performance of deep learning based bone age assessment.

Materials and Methods: Deep learning based bone age assessment model using convolutional neural network was trained separately by two institution’s pediatric left hand radiographs; institution A training set involved 15,772 radiographs (male: 6106, female: 9666) and institution B training set involved 15,940 radiographs (male: 4226, female: 11714). Then, total 23,619 radiographs (male: 7,673, female: 15,946) were used

in fusion training set that deal with problem of label unbalance through adjusting amount of data. Three validation sets (institution A, institution B, and fusion) were used to monitor the performance of each deep learning based bone age assessment model. The model was constructed the modified inception-V3 based on regression task for predicting bone age (months). Two test sets (institution B, RSNA challenge set) were used to measure final model performance. Root mean square error (RMSE, year) were used as evaluation metric that is the square root of the mean value of the squared difference between the predicted value and the label value.

Results: Fusion training model showed the highest performance for the two test sets (institution B, RSNA) whereas the single center based model (institution A, institution B) showed best performance only in their own validation set. Interestingly, fusion training model showed higher performance in institution B test set than institution B training model. RMSE (year) of each training model (institution A, institution B, fusion) for institution B test set were 0.857, 0.533, and 0.507. RMSE of each training set (institution A, institution B, fusion) for RSNA challenge test set were 0.773, 0.792, and 0.665.

Conclusion: The highest performance for the two test sets was achieved with the fusion training set, not the single institutional training set. This results implies the necessity of building a multi-center based large database in the development of deep learning based bone age assessment tool.

16:20. DEEP LEARNING PIPELINE FOR FULLY AUTOMATED BODY COMPOSITION SEGMENTATION FROM CT STUDIES

Andrew Tsao, Colleen Buckless, Benjamin Wang, Martin Torriani. *Boston, MA, USA*

Purpose: To develop a deep convolutional neural network (CNN) to automatically [a] detect the L4 level from an abdomen CT, and [b] segment an axial image at L4 for body composition measures. We hypothesized a deep CNN approach would achieve high accuracy in each task individually and combined.

Materials and Methods: We manually segmented vertebral bodies in 516 midline sagittal CT reconstructions from clinical abdomen CTs. Manual segmentation labeled background, sacrum, L5, L4, L3 and L2. Next, we manually segmented axial CT images at L4 in 220 subjects labeling background, muscle, bone, bowel/solid organs, visceral and subcutaneous fat. Segmentation accuracy was separately tested using 40 new sagittal images for level detection and 22 new axial images for body composition. Images were processed for histogram equalization and data augmentation [N=3,000 (spine) and 4,000 (L4 image)]. We trained models from scratch on Keras/Tensorflow using 80/20 training/validation split and U-Net architecture (8 batch, 50 epochs, dropout 0.2-0.3, learning rate 0.0001, softmax). Dice (F1) scores assessed similarity between manual vs. CNN-predicted segmentation. Performance of entire pipeline was tested on 60 abdomen CTs, yielding rate of correct L4 level detection, segmentation Dice scores for body composition at L4, and time to complete each case.

Results: Segmentation Dice scores for vertebral bodies were: background 99%, sacrum 80%, L5 85%, L4 86%, L3 85%, and L2 81%. Segmentation Dice scores for body composition at L4 were: background 98%, muscle 94%, subcutaneous fat 96%, visceral fat 93%, bone 89%, and other/bowel 94%. Evaluation of entire pipeline on test dataset of 60 abdomen CTs showed L4 was correctly detected in 95% of test cases (57/60) and segmentation Dice scores for body composition at L4 were background 98%, muscle 93%, subcutaneous fat 97%, visceral fat 89%, bone 88%, and other/bowel 86%. Mean time to analyze one abdomen CT was 13 seconds. Total time to analyze all 60 test abdomen CTs was 12min 57sec.

Conclusion: Our results show accurate automated L4 level detection and segmentation for body composition using a deep CNN algorithm on abdominal CTs. This pipeline may serve as a basis for large-scale body composition studies requiring automated segmentation of abdominal CTs.

16:30. DEEP LEARNING APPROACH TO PREDICT RADIOGRAPHIC KNEE OSTEOARTHRITIS PROGRESSION

Richard Kijowski, Bochen Guan, Arya Mizaian, Shadpour Demehri, Tuhina Neogi, Ali Guermazi, Fang Liu. *Madison, WI, USA*

Purpose: To determine the feasibility of using a deep learning (DL) approach to predict the progression of radiographic osteoarthritis (ROA) of the knee.

Materials and Methods: The study group consisted of 600 subjects in the Osteoarthritis Initiative with Kellgren Lawrence (KL) grades 1, 2, or 3 ROA of the knee at baseline. Two-hundred ninety-one subjects showed ROA progression and 309 subjects did not show ROA progression, which was defined as a loss of minimum medial joint space width greater than 0.7mm from baseline to follow-up. The study group was randomly divided into a training and validation dataset (241 subjects with and 259 subjects without ROA progression) and a hold-out test dataset (50 subjects with and 50 subjects without ROA progression). Two DL networks (Vgg16 and Densenet) were trained to provide a probability score for ROA progression using the baseline standing posterior-anterior knee radiographs. A support vector machine was used to create a clinical model to provide a probability score for ROA progression using well-established risk factors including age, gender, body mass index, history of knee trauma, baseline KL grade, and varus alignment. A logistic regression model utilizing the training and validation dataset was used to create a combined clinical and DL model by taking into account the probability scores of ROA progression generated from the clinical, Vgg16, and Densenet models together. Area under the curve (AUC) analysis was performed using the hold-out test dataset to evaluate model performance.

Results: The clinical model had an AUC of 0.577 with 62.0% sensitivity and 58.3% specificity for predicting ROA progression. The Vgg16 and Densenet models had an AUCs of 0.717 and 0.744 respectively, which were significantly higher ($p < 0.05$) than the clinical model. The Vgg16 and Densenet models had higher sensitivity but lower specificity than the clinical model for predicting ROA progression. The combined clinical and DL model had an AUC of 0.832, which was significantly higher ($p < 0.001$) than all other models, with 80.0% sensitivity and 78.0% specificity for predicting ROA progression.

Conclusion: Our study demonstrated the feasibility of using a combined clinical and DL model for predicting the progression of ROA of the knee using baseline knee radiographs.

ISS Grant #1

16:40. NOVEL CONTRAST ENHANCED VASCULAR SUPPRESSION TECHNIQUES IN MR NEUROGRAPHY

Darryl Sneag, MD

ISS Grant #2

16:50. QUANTITATIVE FUNCTIONAL AND METABOLIC WHOLE-BODY IMAGING IN PATIENTS WITH NEUROFIBROMATOSIS TYPE 1

Shivani Ahlawat, MD

ESSR Award Paper

17:00. TBD

SSR Award Paper

17:10. SAFETY AND EFFICACY OF IMAGE GUIDED RADIOFREQUENCY ABLATION OF GENICULAR NERVE PAIN MANAGEMENT IN PATIENTS WITH MODERATE TO SEVERE OSTEOARTHRITIS OF THE KNEE: INITIAL SINGLE INSTITUTION EXPERIENCE

Felix Gonzalez, MD, Philip Wong, MD, Stephen Cole, MD, Samia Sayyid, MD, Zachary Bercu, MD, RPVI, John Prologo, MD, FSIR, Janice Newsome, MD, Monica Umpierrez, MD, Adam Singer, MD, Nima Kokabi, MD, Nickolas Reimer, MD. *Atlanta, GA, USA*

Purpose: To assess the safety-efficacy of RFA for treatment of moderate-severe knee arthritis pain.

Materials and Methods: 8-patients refractory to conservative treatments underwent genicular nerve RFAs. Anesthetic blocks were followed by RFA 1-2 weeks afterwards. Treatment efficacy was evaluated using the WOMAC index before and at 3 months.

Results: A total of ten knees were treated in 8 patients. The average age of the patients was 70.9 years. Mean follow-up time was 3.5 months. No procedure related complication was identified. The mean total WOMAC score (out of 100) improved significantly from baseline score of 47 to 65.9 at 3 months post treatment ($p = 0.019$). Subanalysis of the overall symptoms component of the WOMAC questionnaire demonstrated significant decrease in mean overall symptoms score from 11.4 to 7.3 ($p = 0.046$). Mean stiffness score decreased from 6.2 to 3.5 ($p = 0.003$) and mean pain score decreased from 22.5 to 13.3 ($p = 0.026$). There was also significant improvement in the functional daily living limitations with mean baseline score of 30.2 and 3 month post therapy score of 20.3 ($p = 0.037$). **Conclusion:** Imaged-guided radiofrequency ablation of genicular nerves is a safe treatment option resulting in significant improvement in osteoarthritic index, motility and quality of life in patients with moderate to severe knee OA refractory to conservation treatments
AMS Award Paper

17:20. ACCURACY OF ULTRASOUND IN THE CHARACTERIZATION OF SUPERFICIAL SOFT TISSUE TUMORS: A PROSPECTIVE STUDY

Stefanie WY Yip, James F Griffith, Esther HY Hung, Marina Ivory, Jeremiah CH Lee, Alex WH Ng, Cina SL Tong, Ryan KL Lee, Jason CS Leung. *Prince of Wales Hospital, The Chinese University of Hong Kong*

Objective: To prospectively evaluate the diagnostic accuracy of ultrasound in characterizing superficial soft tissue tumors.

Methods: 830 superficial soft tissue tumors were prospectively evaluated with ultrasound by one of five experienced musculoskeletal radiologists. The radiologist at the time of examination provided one to three specific differential diagnoses and the perceived level of confidence with regard to each diagnosis. Clinical diagnosis was recorded. Ultrasound and clinical diagnoses were compared with the histological diagnosis to determine the accuracy. Tumor malignancy was determined by histology or clinical follow-up.

Results: 234 (28.2%) of 830 tumors had subsequent histological correlation. Compared with histology, the accuracy of clinical and ultrasound examination for determining specific tumor type was 32.9% and 82.1% respectively considering all differential diagnoses provided. Radiologists were “fully confident” about the ultrasound diagnoses in 136 (58.1%) of 234 superficial soft tissue tumors and, in this setting, the diagnostic accuracy of ultrasound was 95.6%. When the radiologist was “not fully confident”, accuracy was 45.9% for the first ultrasound differential diagnosis and 63.2% for all differential diagnoses. Sensitivity, specificity, positive predictive value, and negative predictive value of ultrasound for identifying malignant soft tissue tumors was 91.7%, 94.1%, 45.8% and 99.5% respectively.

Conclusion: Based on the ultrasound appearances alone, the radiologist can be ‘fully confident’ with providing a specific diagnosis in over half of cases and, in this setting, diagnostic accuracy is very high. Ultrasound is also highly accurate at discriminating benign from malignant superficial soft tissue tumors.

Breakout Scientific Session

Tuesday, September 10, 2019, 12:00 - 12:30

Session 1

12:00. IMAGING FEATURES OF MESENCHYMAL CHONDROSARCOMA OF BONE AND SOFT TISSUE – EXPERIENCE OF A SINGLE TERTIARY CANCER CENTER

Soleen Ghafoor, Juliana Schilsky, Meera Hameed, Sinchun Hwang. *New York, NY, USA*

Purpose: To review imaging features of primary mesenchymal chondrosarcoma (MCS) and correlate with its biphasic histologic pattern and pattern of metastases.

Materials and Methods: This retrospective study included 23 patients (mean age 28.0±6 years) with pathologic diagnosis of MCS at a tertiary cancer center. Two radiologists reviewed in consensus available radiographs, CT, bone scintigraphy (BS), PET, and MRI. The size, location, appearance (lytic, sclerotic or mixed), matrix mineralization, cortical destruction, soft tissue extension, and radiotracer uptake were recorded. For CT and MRI, contrast enhancement (homogeneous, heterogeneous) and visibility of a biphasic morphology (two distinct calcified and non-calcified components corresponding to biphasic histology) was assessed. Location of metastases was documented.

Results: Thirteen skeletal and 10 extraskeletal MCS were analyzed. The mean size was 10.0 cm (0.6 – 21.3 cm). Subtype histology included undifferentiated round or spindle cell pattern (n=12), hemangiopericytoma-like (n=8), and combined (n=2) while 1 was unknown. Common locations were the extremities (n=11) followed by head and neck (n=4), chest wall (n=4), pelvis (n=3) and retroperitoneum (n=1). Skeletal MCS were mixed lytic and sclerotic (n=8), lytic (n=4), or juxtacortical (n=1), with all showing cortical destruction and soft tissue extension. Contrast-enhanced MRI or CT was available in 16 cases, heterogeneous contrast enhancement was common (n=13, soft tissue 6/13, bone 7/13). Calcified matrix was frequent (n=15), predominantly with a chondroid pattern (n=12). Six skeletal and 3 extraskeletal MCS showed a distinct biphasic morphology at MRI. The mean follow-up time was 42.2 months (0 -163 months). Metastases were present in 12 patients (6 at initial presentation). Mean tumor size with metastases (13.2 cm) was larger than that without metastases (7.0 cm, p<0.05). Common metastatic sites were lungs (75%), bone (58.3%), liver and soft tissues (33.3%). The lesions showed radiotracer uptake in BS and PET (mean SUVmax = 14.3, range 5.6-34.0).

Conclusion: Skeletal MCS commonly presents in young adults as a mixed lytic and sclerotic lesion with cortical destruction and soft tissue extension. A distinct biphasic morphology consisting of calcified and non-calcified soft tissue components is often present at imaging of skeletal MCS, correlating with its biphasic histology. Metastases are common at initial presentation with larger tumors.

12:06. SACRAL CHORDOMA. CLINICAL MANAGEMENT AND PROGNOSIS. LONG-TERM EXPERIENCE IN A SINGLE INSTITUTION

Irena Boulytcheva, Elmar Musaeov, Nikita Babkin. *Moscow, Russian Federation*

Purpose: Chordoma is a rare malignant tumor with predilection for the sacrum. We evaluated our institutional database from 1990 to 2018 to

identify patients diagnosed and surgically treated with sacral chordomas. Histological appearance, molecular characteristics, complications, recurrence and prognosis were our major targets.

Materials and Methods: Eighty (80) patients with sacral chordomas (47 males and 33 females; median age 58, range from 36-79) who were surgically treated at our institution were reviewed. The majority of tumors (53) were classified as classic low-grade chordoma, most of the recurrent tumors (19) were high grade. Features of dedifferentiated sarcomas were observed in 6 cases. In our series we have been able to detect 1 case of the benign tumor of notochord and 1 case of extra-axial chordoma. Immunohistochemical study was performed in all cases after 1998 (47 tumors). The major spectrum of markers included: Ki67, EMA, S-100, CK, brachyury.

Results: At a median follow-up of 78 months (0-256) continuously disease-free were 13 patients. Disease-free after local recurrence, or metastasis were 24 patients, alive with the disease were 17 patients, dead of the disease 16 and dead of another cause 6 patients. Local recurrence was observed in 28, all patients were treated surgically. Overall survival at 10 years was 72%. Local recurrence-free survival at 10 years was 47%. A statistical analysis confirmed the importance of negative surgical margins (p=0.0008). High resections were associated with worse prognosis. The diagnostic markers were EMA, S-100, CK, brachyury. Chordomas could be primary diagnosed by fine needle aspiration cytology only in a typical clinicoradiological setting. In 11 cases IHC markers helped to differentiate chondroid chordoma from myxoid chondrosarcoma. The Ki67 levels were the highest (> 35%) in classic (grade 1) chordomas (27/47).

Conclusion: A favorable outcome depends on early diagnosis, surgical excision with tumor free margins and high-dose radiation in certain cases. Currently, in Russia, there is no effective chemotherapeutic standard for chordomas.

12:12. CAN CT ATTENUATION RELIABLY DISTINGUISH BETWEEN SCLEROTIC (OSTEOBLASTIC) METASTASES AND BENIGN SCLEROTIC BONE LESIONS?

Hillary Garner, Nicholas Rhodes, Daniel Wessell. *Jacksonville, FL, USA*

Purpose: To determine if CT attenuation values allow distinction between sclerotic (osteoblastic) metastasis and benign sclerotic bone lesions in an age-matched patient population.

Materials and Methods: A retrospective search of all CT exam reports dictated between January 1, 1995 and July 15, 2018 that contained the words that contained the words "bone island", "enostosis", "sclerotic focus", or "sclerotic lesion" was performed. Next, a search of all CT exam reports dictated between January 1, 1995 and July 15, 2018 that contained the words "CT-guided bone biopsy" or "CT-guided" AND "bone" was performed. The results from these two searches were compared to find age-matched patients. A total of 370 patients were matched. Patients were included in the final analysis if the pathology report from CT guided biopsy was available and if the bone lesion biopsied was determined to be sclerotic on retrospective review. 78 patients met the inclusion criteria. Two fellowship-trained musculoskeletal radiologists separately reviewed the 78 CT cases and drew regions of interest (ROI) in each biopsied bone lesion and then recorded the area of the ROI and the minimum, maximum, and average Hounsfield units (HU) of each lesion. Cut-off values for average and maximum HU as published previously (Ulano et al. *AJR*. 2016;207(2):362-8.) were used to calculate sensitivity and specificity.

Results: Of the 78 patients, 43 had biopsy-proven malignant sclerotic bone lesions and 35 had biopsy-proven benign sclerotic bone lesions. Using an ROI average HU cut-off of less than 885 to distinguish a malignant from benign sclerotic bone lesion resulted in a sensitivity of 0.88 and specificity of 0.26. Using an ROI maximum HU cut-off less than 1060 to distinguish a malignant from benign sclerotic bone lesion resulted in a sensitivity of 0.88 and specificity of 0.29.

Conclusion: Published HU criteria for distinguishing sclerotic metastases from benign sclerotic bone lesions had slightly decreased sensitivity and

markedly decreased specificity when applied retrospectively to our population of biopsy proven bone lesions.

12:18. CHARACTERIZATION OF LIPOMATOUS TUMORS WITH HIGH-RESOLUTION 1H MR SPECTROSCOPY AT 17.6T: DO BENIGN LIPOMAS, ATYPICAL LIPOMATOUS TUMORS AND LIPOSARCOMAS HAVE A DISTINCT METABOLIC SIGNATURE?

Laura Fayad, Santosh Bharti, Adam Levin, Carol Morris, Shivani Ahlawat, Zaver Bhujwalla, Brett Shannon. *Baltimore, MD, USA*

Purpose: The spectrum of lipomatous tumors includes benign lipomas and lipoma variants, intermediate-grade atypical lipomatous tumors (ALTs) and malignant liposarcomas (LPS). Some liposarcomas are suspected to arise through dedifferentiation of ALTs. The distinction of LPS and premalignant ALTs can be a diagnostic challenge, as can the distinction of ALTs and lipoma variants (lipomas without pure lipid composition), with implications for surgical and clinical management. The purpose of this study is to identify whether there are distinctive metabolic biomarkers for lipomatous tumors that characterize these tumors across the spectrum of benign, intermediate-grade and malignant lesions.

Materials and Methods: In a prospective study, de-identified human surgical samples were collected from subjects who underwent surgical resection of indeterminate lipomatous tumors (those with imaging features atypical for simple lipomas). Tissue samples were snap frozen and stored at -80°C until ¹H MRS analysis. Dual phase solvent extraction was performed on approximately 300 mg of tumor tissue. The water phase was separated, freeze-dried, and reconstituted in 600ul D₂O PBS for MRS analysis. All MR spectra were acquired on an Avance III 750 MHz (17.6T) Bruker NMR spectrometer. Computational modeling of pattern recognition based cluster analysis was utilized to look for significant differences in metabolic signatures between the lipomatous tumor types.

Results: In our on-going study, tissue specimens from lipoma variants (n=7), ALTs (n=5), dedifferentiated LPS (n=2) and adjacent non-involved subcutaneous normal fat (n=7) were examined using ¹H MRS. Quantitative metabolite information and the metabolic heat map derived from MRS for each tumor type was determined, and showed significant differences in numerous metabolites (lactate, glutamine, aspartate, taurine, phosphocreatine, uridine, and ionisine) between the tumor types, with ALTs having a significant increase in several metabolite levels, including lactate, compared to lipomas and normal fat. Cluster analysis further showed significant differences between normal fat, lipomas and ALTs. In addition, several levels of increased metabolite formation (including alanine, glutamate, glutamine) and decreased levels of pyruvate were found in LPS specimens that suggested a profile of increased oxidative phosphorylation.

Conclusion: Our preliminary data indicate that ¹H MRS is a potentially useful tool for the characterization of lipomatous tumor subtypes, and for understanding malignant degeneration in these tumors.

12:24. STRUCTURAL JOINT PATHOLOGY AS DETECTED BY MRI AND RISK OF SUBSEQUENT KNEE OSTEOARTHRITIS DEVELOPMENT OVER 10 YEARS

Ali Guermazi, Frank Roemer, Leena Sharma, Erin Ashbeck, Chengcheng Hu, Kent Kwok. *Boston, MA, USA*

Purpose: Structural joint pathology on MRI has been found in knees without radiographic evidence of osteoarthritis (OA). Aim was to estimate the probability of incident ROA over 10 years of follow-up, according to structural abnormalities detected on baseline MRIs.

Materials and Methods: A subcohort of participants (862 knees, one knee/person) from the Osteoarthritis Initiative with at least one knee at risk of developing ROA (i.e., Kellgren-Lawrence (KL) 0,1 at baseline)

was randomly selected. MRI-detected structural features of the knee were assessed by expert readers using the MRI Osteoarthritis Knee Score (MOAKS). Radiographs were centrally read for KL grade, with ROA defined as KL_≥2. Survival was estimated with the Turnbull non-parametric maximum likelihood estimator, a generalization of Kaplan Meier curves for interval censored data. Survival curves were compared using a log rank permutation test available in the R package interval. Hazard ratios were estimated using Cox models fit using the R package icenReg, designed for interval censored data. Features were considered one at a time, with no adjustments.

Results: Knees with any of the following structural abnormalities had higher probabilities for the development of radiographic OA within 2, 4 and 10 years of follow-up (Hazard ratios for severe changes): effusion-synovitis (HR 5.10, 95% confidence intervals (CI) 3.55-7.34) Hoffa-synovitis (HR 4.09 95%CI 2.75-6.07), bone marrow lesions in the medial compartment (HR 3.82 95%CI 2.49-5.86) and whole knee (HR 3.25 95%CI 2.49-4.24), surface area (HR 2.85 95%CI 2.45-3.32) and full thickness cartilage damage in the medial compartment (HR 2.70 95%CI 2.17-3.36) and whole knee (HR 2.43 95%CI 2.04-2.90), and medial meniscal extrusion (HR 2.88 95% CI 2.27-3.66). Differences in the probability for the development of ROA within two, four, and 10 years of follow-up were significant (pointwise 95% confidence intervals did not include 0), between knees without the abnormality and knees in the most severe category for all features, with one exception at the two-year follow-up. All of these abnormalities were significantly associated with time to ROA over 10 years of follow-up.

Conclusion: Our results demonstrate the prognostic value of effusion-synovitis, Hoffa-synovitis, bone marrow lesions, cartilage damage, and meniscal extrusion for the development of ROA up to 10 years later.

Breakout Scientific Session

Tuesday, September 10, 2019, 12:30 - 13:00

Session 2

12:30. EFFECT OF 9-MONTHS UNLOADER BRACING ON VOLUME OF BONE MARROW EDEMA AND T2 VALUES OF CARTILAGE AND MENISCUS

Elizabeth Bird, Torrance Tang, Aditi Vaidya, Yordanos Tesfai, Sheronda Statum, Won Bae, John Lane, Christine Chung. *La Jolla, CA, USA*

Purpose: Unloader knee braces aim to shift the weight off the damaged compartment of the knee, and may offer pain reduction and delay time to surgery. Despite perceived benefits, the efficacy of bracing to reduce pain and preserve integrity of joint tissues, is under debate. The purpose of this study was to investigate if quantitative magnetic resonance imaging (qMRI) measures of bone marrow edema (BME; a pain correlate), cartilage, and meniscus are preserved after 9 months of unloader brace use in patients with osteoarthritis (OA).

Materials and Methods: Patients with medial knee OA (n=4; 4 male; 50+/-13.4 yrs, mean +/- standard deviation) were imaged at 3T, before and 9 months after brace use. To evaluate BME, proton density fat suppressed images were processed to quantify the volume of high signal intensity within subchondral bone. To evaluate cartilage and meniscus, spin echo T2 map was acquired in sagittal plane, in the weight-bearing regions of lateral and medial tibiofemoral compartments. T2 values in tibial/femoral cartilage, and anterior/posterior meniscus, were determined. Using repeated measures ANOVA, effects of brace use and knee compartment on BME and T2 values were assessed.

Results: Initially, BME was found in 2 medial femoral condyles and all 4 medial tibial plateaus, with a mean volume of 1027+/-1103 mm³. After bracing, BME volume decreased by 82+/-9 % (p = 0.081). Femoral and tibial pooled cartilage T2 values (32.8+/-8 ms before, 32.6+/-5 ms after bracing) did not vary significantly with compartment (p=0.14) or bracing

($p=0.9$). Meniscus T2 values were initially higher ($p=0.01$) in the medial (17.4 ± 5.4 ms) than lateral (12.8 ± 3.5 ms) compartment, but did not change after bracing ($p=0.24$).

Conclusion: In all patients, there was a decrease in BME volume without any new lesion development after 9 months of unloader brace use. Despite small number of subjects, this data is promising, considering that without intervention, BME size is equally likely to decrease or increase, suggested in a 30 month long study. Combined with stable cartilage and meniscus T2 values, these results demonstrate the feasibility of using unloader brace to manage knee OA.

12:36. DEVELOPMENT OF A TECHNIQUE FOR MRI GOLD-STANDARD DIRECT VOLUMETRIC MEASUREMENT OF HIP JOINT EFFUSION

Vanessa Quinn-Laurin, Geoffrey Bostick, Ramin Mandegaran, Adrian Schankath, Laurence Stillwater, Kieran Steer, Robert Lambert, Jacob Jaremko. *Edmonton, AB, Canada*

Purpose: Measuring fluid quantity in a joint effusion or collection on MRI is difficult due to articular recesses and loculations. Methods to detect fluid volume pixel-by-pixel are becoming more refined. We evaluated feasibility, reliability and validity of a semi-automated supervised technique to quantify hip effusion volume.

Materials and Methods: Ninety-three consenting hip osteoarthritis (OA) patients presenting for fluoroscopically-guided hip corticosteroid injection had coronal STIR and sagittal PDFS MRI pre-injection and 8 weeks later (354 hips). Two radiologists performed volumetric quantitative measurement (VQM) of joint fluid using custom MATLAB software. On coronal STIR, readers manually selected a rough region of interest on each slice, in which fluid pixels were automatically detected using Otsu's thresholding. On sagittal PDFS, two radiologists recorded the largest femoral neck fluid thickness measurement (FTM) in symptomatic hips. Self-report WOMAC and clinical measures of pain, stiffness and function were recorded. Correlations were tested with and without adjustment for low back pain (LBP).

Results: VQM was more time-consuming than FTM (mean 3.9 min vs. <1 min/hip), but VQM reader training was rapid (<1 h), and no specialized workstation was needed. Inter-observer reliability was significantly higher for VQM than FTM (ICC=0.96 vs. 0.83, $p<0.05$). VQM and FTM correlated moderately ($r=0.76$, $p<0.0001$). There was significantly more articular fluid in symptomatic than asymptomatic hips at baseline (mean = 9.8 vs. 5.9 mL). Without adjusting for LBP, few associations were found between joint effusion and other measures. However, in patients without LBP, statistically significant moderate correlations were present at baseline and follow-up between hip effusion and self-reported measures (e.g. WOMAC stiffness $r=0.38$), range of motion (e.g. abduction $r=-0.50$) and function (e.g. six-minute walk test $r=-0.44$).

Conclusion: Volumetric quantitative measurement of joint effusion is highly robust at the hip and correlates to clinical measures of OA in patients without confounding LBP. VQM can serve as a gold-standard against which to develop more rapid, simplified effusion measurements for the hip, other joints and fluid collections. VQM could eventually be automated by deep learning.

12:42. MRI OF THE WRIST IN EARLY RHEUMATOID ARTHRITIS AFTER 1-YEAR TREAT-TO-TARGET STRATEGY

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Purpose: To semi-quantitatively and quantitatively measure the degree of inflammation (synovitis, tenosynovitis, bone marrow oedema) and structural change (erosions, joint space narrowing) on MRI in early RA

patients following treat-to-target strategy treatment for one year and to compare this with change in clinical parameters.

Materials and Methods: Prospective cross-sectional study of 70 ERA patients underwent treat-to-target strategy treatment for one year. DAS28-ESR remission (DAS28-ESR score < 2.6), 2011 ACR/EULAR definition of remission, SDAI remission (SDAI ≤ 3.3) and Boolean remission was measured before and after treatment. High resolution MRI of the most symptomatic wrist was performed before and after treatment. MRI parameters including RAMRIS synovitis subscores, synovial volume (synovitis and tenosynovitis), synovial perfusion (max enhancement, enhancement slope), RAMRIS erosion subscore were measured.

Results: 55 (79%) out of 70 ERA patients completed baseline and one-year clinical and MRI assessments. Remission rates for DAS28-ESR, SDAI and Boolean were 60% (33), 44% (24) and 33% (18) respectively. Eight (24%) out of 33 patients with DAS28-ESR remission, showed progression in bone erosion. Four (16.7%) of 24 patients with SDAI remission showed progression in bone erosion while 1 (5%) of 18 patients with Boolean remission showed progression in bone erosion. Patients who achieved remission after treatment had a greater reduction in MRI-evident inflammation as well as bone erosion. At month 12, MRI-evident joint synovitis, tenosynovitis and bone marrow oedema was still frequently seen in ERA patients with clinical remission though patients who achieved Boolean remission had the lowest levels of joint synovitis, bone marrow oedema as well as bone erosion for all patients at one year.

Conclusion: MRI detected inflammation is common even in patients with clinical remission. Patients with Boolean remission had overall less residual inflammation than DAS28-ESR or SDAI remission patients as well as lowest number of patients who had bone erosion progression in remission group at month 12. Treat to target protocols should ideally target Boolean remission.

12:48. QUADRICEPS TENDON TEARS: MR IMAGING CHARACTERIZATION OF LOCATION AND PATTERNS

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Purpose: The purpose was to evaluate quadriceps tendon tears with regards to which tendon components are torn, tear sites, and presence of bony involvement.

Materials and Methods: IRB-approval was obtained and informed consent was waived for this retrospective study. Electronic medical records from >2.3 million patients were searched for key words, like quadriceps tendon rupture or tear and knee MRI. Cases were randomized and evaluated retrospectively and independently by two fellowship-trained musculoskeletal radiologists. Presence or lack of bone avulsion was documented on knee radiographs. MRI was used to characterize each individual quadriceps tendon as tendinosis, tear (location, partial versus complete including size and retraction distance), and bony avulsion. Descriptive statistics were calculated. Interreader reliability was calculated using Cohen's Kappa and Wilcoxon-signed-rank test.

Results: 52 patients with 53 quadriceps tears (28 right, 25 left knees) were evaluated (45 male, 7 female; mean age: 51 ± 13 years). The vastus intermedius (VI) tendon more often incurred a partial rather than a full width tear (39.6% vs. 37.7%), while the rectus femoris (RF), vastus medialis (VM), and vastus lateralis (VL) incurred full width tears more commonly (63.2-66%). Subjects with bone avulsion on radiographs had higher-grade tears of the RF, VM, and VL tears ($p=0.020-0.043$) but not the VI. Most tendons tore at or proximal to the patella (89.3%). Torn tendon retraction ranged from 2.3-2.7cm. Inter-reader reliability was substantial to almost perfect ($k=0.624-0.953$).

Conclusion: Quadriceps tendon tears most commonly involve the RF or VL/VM layers usually in proximity to the patella. A bone avulsion on radiographs indicates a more extensive tear.

12:54. COMPARISON OF ACCELERATED MAVRIC-SL WITH ROBUST-PCA AND CONVENTIONAL MAVRIC-SL IN EVALUATION OF SYMPTOMATIC TOTAL HIP ARTHROPLASTIES

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Purpose: To compare MR imaging of symptomatic total hip arthroplasties (THA) using a conventional metal artifact suppression sequence (MAVRIC-SL) and a novel sequence employing robust principal component analysis (RPCA) which allows additional 2.6-fold acceleration in scan time.

Materials and Methods: Thirty-six THA cases (25 patients) were analyzed using conventional MAVRIC-SL and RPCA MAVRIC-SL proton density-weighted sequences on a 3T GE Discover MR750 scanner with the following parameters: TR/TE 4000/6.6ms, FOV 36x36x9.6cm, matrix 384x256x24, ETL 20, with 2x2 parallel imaging for conventional MAVRIC-SL (6 minute scan-time), and complementary Poisson-disc sampling for RPCA MAVRIC-SL (2.3 minute scan-time). Overall image quality, geometric distortion and visualization of anatomic structures adjacent to the implants were assessed by two experienced musculoskeletal radiologists using a qualitative 5-point scale. The total extent of artifact was quantitatively determined by drawing an ROI around the total area of signal loss near metallic implants on the slice with the maximal artifact extent. The presence of clinical pathology was also evaluated using a 4

point-scale. The Wilcoxon signed-rank test was used to evaluate the difference between the two sequences.

Results: Mean scores for conventional MAVRIC-SL were slightly higher compared to RPCA MAVRIC-SL for all qualitative parameters (p-value <0.05). However, the statistically significant difference between mean scores was <1 for overall quality and <0.1 for the other tested parameters. The difference of the artifact extent was not found to be statistically significant between the two methods (p = 0.07), with a mean of 54.18 cm² for RPCA MAVRIC-SL and 52.84 cm² for MAVRIC-SL. In 32/36 cases (89%), pathologic imaging findings were determined by both observers to be either equally visible or slightly less convincing on the RPCA MAVRIC-SL sequence. In 4/36 cases, at least one reader gave differing pathology scores between the 2 sequences, but in all cases the pathology in question was a small joint effusion, which remains a subjective diagnosis.

Conclusion: Although there is a mild reduction in overall image quality, geometric distortion and visualization of adjacent anatomic structures with RPCA MAVRIC-SL compared to conventional MAVRIC-SL, the RPCA MAVRIC-SL sequence allows for significantly reduced (2.6-fold) scan time and maintains almost equal clinical sensitivity.

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