Dual energy computed tomography (DECT) makes it possible to accurately differentiate numerous clinically relevant materials in vivo. Two CT datasets are acquired with different X-ray spectra, one with high energy (140–150 kV) and a second one with low energy (70–100 kV). Depending on the manufacturer of the CT scanner, these spectra are generated using two X-ray tubes with different tube potentials simultaneously, one X-ray tube in sequential mode, rapid tube voltage switching, layer detectors or quantum-counting detectors. Dedicated post-processing such as three-material-decomposition, allows the absolute quantification e.g. of iodine in each pixel. Its subsequent subtraction permits the calculation of quantitative iodine maps or virtual non contrast images. Beyond the quantification of iodine, the DECT-based visualization of monosodium urate in gouty arthritis represents a non-invasive alternative to joint aspiration with high sensitivity and specificity. Computing virtual non-calcium images, DECT offers the opportunity to detect bone marrow lesions such as bone bruise after trauma or tumor involvement e.g. in multiple myeloma. Additionally, virtual monoenergetic extrapolations between 40 and 190 keV can be computed, leading to enhanced iodine contrast at virtual low keV- or reduced beam-hardening artifacts at virtual high keV-images. By combining DECT and advanced raw data based algorithms for metal artifact reduction, even in the presence of metallic hardware, DECT post processing is accurately possible. So far, using DECT in detecting pathologies of tendons, ligaments and menisci seems to be limited to patients with absolute contraindications to MRI.
How are metallic artifacts presented in the MR image?

Metal-related artifacts created by metallic hardware are evident in four different forms.

1. Distortion: the spins may be mapped to an erroneous location within the image, resulting in the distortion of the shape of the metallic object along the axes of frequency encoding and section selection.
   - A. In-plane artifact
   - B. Through-plane artifact
2. Dephasing: a complete signal loss may be observed around the metallic object, as the local magnetic field is so strong that the spins are almost immediately dephased.
3. Displacement: a rim of high signal intensity may be present around the metallic devices as a result of the mismapping of a disproportionate number of spins to that location. The resultant misregistration effect mainly occurs in the direction of frequency encoding.
4. Disruption of fat saturation: depending on the composition and size of the metallic device, incomplete fat saturation resulting from the local magnetic field may affect an area surrounding the metallic hardware larger than that affected by another type of artifact, resulting in widespread suboptimal fat saturation throughout the multiple sequential images.

Practical remedies for metallic artifacts

Many practical remedies have been suggested to alleviate metallic artifacts. The susceptibility artifacts from metallic devices can be readily reduced by adjusting the sequence parameters.

1. Small field of view,
   - High-resolution matrix
   - Thin sections

   Increased readout bandwidth
   - Higher echo-train length
   - Swapping the phase and frequency encoding direction

Specific MR sequences reducing metallic artifacts

1. STIR imaging
   The STIR sequence is effective for suppression of fat signal and is less dependent than other sequences on homogeneity of the main magnetic field. In the presence of severe susceptibility field distortion due to metal implants, protocols with conventional spectral fat suppression are commonly replaced by STIR protocols to achieve more robust fat suppression.
2. Dixon technique
   The decrease in metallic artifacts was greatest for the peripheral rim of the high signal intensity surrounding the metallic devices. The use of IDEAL imaging allows superior visualization of the region of interest close to the metallic implants such as the dural sac in the spine or the intra-articular structures. In contrast to STIR imaging, the IDEAL technique has the strong advantage of offering contrast-enhanced imaging, which is essential for postoperative evaluation in patients suspected of having complications.
3. View-angle tilting (VAT)
   View-angle tilting takes advantage of the fact that the slice displacement and in-plane displacement because of off-resonance have a constant ratio. View-angle tilting replays the slice-selection gradient during the readout, which shears the image in the plane of the slice and readout directions.
4. Slice-encoding metal artifact correction (SEMAC)
   The SEMAC technique corrects metal artifacts via encoding of each excited slice against metal-induced field inhomogeneities. Although SEMAC-corrected MR images can suffer from relatively low signal-to-noise ratios, SEMAC correction is a potential technique for MRI in patients with metallic prostheses. SEMAC is a
metal-artifact-reducing sequence based on a 2D VAT-spin echo sequence and can correct both through-plane distortion and in-plane distortion by extending VAT, which can achieve some in-plane correction through z-encoding. By adding additional z-phase encoding steps in the slice-selection direction, SEMAC can restore the distorted signal to its actual location.

5. Multiple-acquisition with variable resonance image combination (MAVRIC)

MAVRIC uses a frequency-selective excitation (rather than exciting a slice or slab) to limit the range of frequency offsets imaged at one time. This is followed by a standard 3D imaging readout, typically using a spin-echo train. MAVRIC avoids slice-direction displacement by using phase encoding to resolve in this direction. The 3D images are repeated for a range of frequencies and combined together, typically using a sum-of-squares operation.
The diagnostic work-up of peripheral neuropathies is often challenging and is mainly based on a combination of clinical and electrophysiological examinations. One of the most important difficulties is the accurate lesion localization, lesion extension, and spatial lesion dispersion, which all represent essential diagnostic information crucial for finding the correct diagnosis and hence an adequate therapeutic approach.

MR imaging provides the best soft-tissue contrast for the evaluation of deep soft-tissue structures, including the nerves. However, the conventional MR sequences are thought to not be enough for the evaluation of peripheral nerve lesions in terms of resolution and contrast. With current high-resolution techniques owing to development of 3-Tesla MR machine and software techniques, magnetic resonance imaging of the nerves known as MR neurography (MRN) has been proven to be capable of improving the diagnostic accuracy by providing direct, noninvasive visualization of nerve injury with high structural resolution even reaching the anatomical level of single nerve fascicles (fascicular imaging) and at the same time with large anatomical coverage. It has been applied in patients with tumors, trauma, and neuritis of the brachial plexus. It is also feasible to detect structural nerve damage earlier and with higher sensitivity than gold-standard nerve conduction studies.

In the other hands, the interest in diffusion tensor imaging (DTI), which is a magnetic resonance (MR) technique that can be used for gaining quantitative information about tissue water diffusion, for the evaluation of peripheral nerves is rapidly growing. With their myelinated structure, peripheral nerves provide suitable structural bases to be assessed by DTI with FA measurements since diffusion is higher along axons than their perpendicular directions resulting in anisotropic diffusion. In addition to conventional magnetic resonance imaging (MRI), assessment by DTI provides new information about the effects of the disease processes on tissue microstructure. In particular, assessment of the anisotropy index facilitates evaluation of the structural integrity and directional coherence of the nerve fibers. Previous studies have demonstrated the feasibility of DTI for imaging peripheral nerve structures such as the median nerves at the wrist; cervical nerve roots; the peroneal and tibial nerves at the knee, calf, and ankle; and the sciatic nerve.

In this lecture, the MR findings of various peripheral nerve lesions, technical aspect of advanced MR imaging tools including MRN and DTI, and their clinical significances will be discussed.
Fat quantification using magnetic resonance imaging

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We have entered the era of imaging biomarker using various modalities including ultrasonography, computed tomography, magnetic resonance imaging (MRI), and the other promising new imaging tools. There is no doubt that MRI has been validated as one of the most promising tool that allows for measurement of various tissue characteristics musculoskeletal field including those of bone, muscle, cartilage and so on.

Fat quantification using MRI in musculoskeletal field is now in horizon or might be just around the corner for its clinical use. Conventionally, T1-weighted image has been used to determine distribution and amount of fat in muscle (1) and reason bone marrow lesion out (2). Chemical shift imaging has been used to detect presence of fat particularly in various bone marrow lesion assessments (3). Fat signal fraction from a tissue using MRI is based on chemical shift encoding-based water-fat separation and has been widely applied and validated for quantification of hepatic fat (4, 5).

There have already been many investigations about the fat quantification in muscle (6–10) and bone marrow lesions (3), but it still needs to be elucidated whether fat quantification models validated in the other tissue can equally be applied to the musculoskeletal filed (11). Here will be presented on where are we in its application and which issues should we solve before we clinically apply measurement of fat signal fraction in musculoskeletal field.

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Advanced imaging technique in MSK field

Chairperson(s)
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Sungjun Kim  Gangnam Severance Hospital, Korea

**MC 03 MS-05  15:30**
Impact of iterative reconstruction type and radiation dose on musculoskeletal CT: a phantom study
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**PURPOSE:** To assess the impact of iterative reconstruction type and different radiation dose on musculoskeletal computed tomography (CT).

**MATERIALS AND METHODS:** CT examinations using an anthropomorphic pelvis phantom (RS-113T, Radiology Support Devices, Long Beach, CA, USA) were performed at 80, 100, 120 kVp without dose right index (DRI) (200 mAs) and with DRI (8, 14, 20) on 256-slice CT scanner (iCT256, Philips Healthcare, Cleveland, OH, USA): a total of 12 radiation dose settings. Images with bone algorithm were reconstructed with conventional filtered back projection (FBP), hybrid iterative reconstruction (iDose4, level 2) and iterative model reconstruction (IMR). Quantitative image assessment was done with 5-times repeated measurements of signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) in left femoral head of the phantom. Two independent blinded radiologists evaluated the images qualitatively using a 5-point scale: distinction of anatomic structures, pathology detection, noise, and artifact. We performed repeated-measure two-way ANOVA to evaluate the possible effect of reconstruction algorithm and radiation dose on the results of both quantitative and qualitative assessment.

**RESULTS:** There was no statistically significant difference in the performance of pathology detection according to reconstruction algorithms, although IMR was better in terms of SNR, CNR and noise reduction, and was worse in artifacts than iDose4. When images of different kVp settings without use of DRI were compared, the images of 80 kVp (25% radiation dose) showed significantly poor image quality in terms of artifacts and noise (p = 0.023 for beam-hardening artifact, p = 0.001 for background noise, and p = 0.001 for noise of volume rendering image). As for different levels of DRI, substantial increase in artifacts and noise was noted in the level of DRI 8 (12.5% radiation dose) (p = 0.008 for beam-hardening artifact, p = 0.014 for background noise, p = 0.032 for noise of volume rendering image).

**CONCLUSION:** We recommend the musculoskeletal CT to use at least 100 kVp (50% radiation dose) and DRI 14 (25% radiation dose) as a minimum radiation dose, and use iDose4 as a reconstruction algorithm because of their effects on reducing artifacts and noise, although the diagnostic performance was not affected significantly.

**MC 03 MS-06  15:40**
Resolution enhancement of plain radiograph images based on Wolff’s law
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**PURPOSE:** High-resolution radiograph images are vital for accurate and reliable diagnosis in clinical fields. In principle, however, the increase of radiation dose is inevitable to acquire high-resolution images. This study proposes a novel method of resolution enhancement that can reconstruct a high-resolution plain radiography image from a low-resolution one.

**MATERIALS AND METHODS:** Plain radiograph image of a cadaveric proximal femur was taken at the 140 μm resolution as the reference image. This image was downscaled to a 700 μm resolution as a low-resolution image which cannot represent trabecular architecture. Then, the downscaled image was enhanced to the 140 μm resolution using topology optimization. In the proposed enhancement method, a relative density of each pixel in a trabecular compartment was set to be a design variable, whereas that in a cortical bone was set to be fixed during optimization. Based on Wolff’s law, compliance of a trabecular compartment was selected as an objective function. Constraints for pixel value deviation were implemented in order to preserve the spatial bone distribution measured at the low-resolution radiograph images.

**RESULTS:** From a downscaled image which cannot represent trabecular patterns due to limited resolution, the proposed method successfully reconstructed an enhanced, high-resolution image which is similar with the reference image. Characteristic trabecular patterns in a proximal femur (e.g., principal compressive and tensile groups) were clearly observed in the enhanced image.

**CONCLUSION:** The proposed method successfully enhanced a low-resolution image of a proximal femur.
(700 μm resolution) to a high-resolution image (140 μm resolution). The enhanced image is very comparable to the reference image in terms of trabecular morphology. These results demonstrate that the proposed method can contribute to acquiring higher-resolution radiograph images with the limited radiation dose, thereby improving the accuracy and reliability of clinical diagnosis.

**MC 03 MS-07**  15:50  
Quantifying tumor vascular heterogeneity with DCE MRI in bone metastases of non-small cell lung cancer: comparison between lesions with and without EGFR gene mutation in primary lung cancer

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**PURPOSE:** To compare dynamic contrast-enhanced (DCE) MRI parameters using texture analysis for quantifying their heterogeneity between metastatic bone lesions with and without the presence of epidermal growth factor receptor (EGFR) mutation in primary non-small cell lung cancer (NSCLC) in consecutive patients.

**MATERIALS AND METHODS:** From June 2012 to June 2015, NSCLC patients with confirmed status of EGFR mutation of primary lesion who underwent MRI including DCE image for bone metastases were included. 30 consecutive subjects comprised of 14 patients with EGFR mutation (EGFR mutation group) and 16 patients without EGFR mutation (EGFR wild-type group) in primary NSCLC were finally included. For image analysis, the region of interest (ROI) was manually drawn on the parametric map by a single radiologist and K<sub>trans</sub>, V<sub>e</sub>, and V<sub>p</sub> were calculated using Tofts model. For texture analysis of these parameters, the global (mean, standard deviation, skewness, kurtosis, 2.5<sup>th</sup>percentile, 50<sup>th</sup> percentile, 75<sup>th</sup> percentile, and entropy) and regional features (intensity variability and size-zone variability) were extracted. Analysis of covariance (ANCOVA) was performed with adjustments for tumor volume for comparison between two groups.

**RESULTS:** K<sub>trans</sub> in EGFR mutation group showed significantly higher 50<sup>th</sup>, 75<sup>th</sup> percentile, and entropy (p = 0.037, 0.014, and 0.010, respectively) and significantly lower uniformity (p = 0.036) compared with those in EGFR wild-type group. V<sub>e</sub> in EGFR mutation group showed significantly lower size-zone variability (0.047). V<sub>p</sub> in EGFR mutation group showed significantly higher mean, 50<sup>th</sup>, and 75<sup>th</sup> percentile (p = 0.049, 0.050, and 0.043, respectively).

**CONCLUSION:** This study reveals that metastatic bone lesions of EGFR mutation in primary NSCLC have significantly higher heterogeneity of K<sub>trans</sub> and higher value of V<sub>p</sub> compared with lesions without EGFR mutation reflecting difference in hemodynamic profile.

**MC 03 MS-08**  16:00  
Early response assessment of neo-adjuvant chemotherapy in Ewing sarcoma family of tumors: does diffusion weighted imaging help?

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**PURPOSE:** To evaluate the role of MR Diffusion Weighted Imaging as an early marker of chemotherapy response in Ewing sarcoma family of tumors (ESFT).

**MATERIALS AND METHODS:** Twenty-eight biopsy proven patients of ESFT, who were planned for neoadjuvant chemotherapy were included in this ethically approved study, after taking informed consent. MRI was done on a 1.5 Tesla Scanner (Achieva; Philips, the Netherlands) at three time points: baseline, after first and fifth cycles of chemotherapy. Axial T1W, T2W, DWI/ADC and coronal STIR sequences were acquired at all the three time points. Percentage change in size (RECIST 1.1 criteria) after five cycles of chemotherapy was taken as the gold standard to identify the responders. ADC values were calculated at the baseline as well as the follow up MRI after first cycle. The percentage change in normalized ADC (normalized to muscle) was compared between responders and non-responders. Two experienced readers evaluated these studies in consensus.

**RESULTS:** Out of the 28 patients, there were 21 responders and 7 non-responders based on the gold standard. Mean baseline normalized ADC in responders and non-responders was 0.740 ± 0.254 x 10<sup>-3</sup> mm<sup>2</sup>/sec and 0.925 ± 0.262 x 10<sup>-3</sup> mm<sup>2</sup>/sec, respectively. Using a cutoff of 0.699 x 10<sup>-3</sup> mm<sup>2</sup>/sec for baseline normalized ADC, a sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of 61%, 85%, 91% and 42% respectively was seen for predicting response to chemotherapy (area under the curve: 0.735). Mean percentage increase in normalized ADC (baseline and after first cycle) in responders and non-responders was 81% and 48% respectively. A cutoff of 38% had sensitivity, specificity, PPV and NPV of 100%, 71%, 89% and 100% respectively, in early assessment of response to chemotherapy (area under the curve: 0.756).

**CONCLUSION:** Diffusion weighted MRI can be used as a surrogate marker of early response to neoadjuvant chemotherapy.
chemotherapy in patients with Ewing sarcoma family of tumors.

Responder by RECIST 1.1 (Gold standard)
DWI showing significant decrease in ADC (concordant)

Fig. 1. 22-year-old male with left humerus ESFT, who was a responder on the basis of gold standard and showed concordant finding on DWI. DW b-1000 images (A, C, E) and corresponding ADC maps (B, D, F) showing size measurement and ADC calculation at baseline, early and last time points. Baseline nADC showed 71% and > 100% increase at early and last time points respectively. T2W images at baseline (G) and last time point (H) shows significant reduction in size of the primary mass (partial response).

MC 03 MS-09  16:10
Comparison of OMAR (metal artifact reduction for orthopedic implants) versus FBP (filtered back projection): does OMAR have value in evaluation of postoperative hip CT?
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PURPOSE: To evaluate the value of OMAR technique compared with standard FBP technique on postoperative hip CT regarding image noise and detection of complications.

MATERIALS AND METHODS: 90 postoperative hip CT scans with standard FBP (SFBP) technique and OMAR application were prospectively collected from January 2013 to March 2014 and retrospectively reviewed. 43 total hip replacement arthroplasty and 16 bipolar hemiarthroplasty cases were evaluated for quantitative evaluation of artifacts. Region of interests (ROIs) were drawn at the levels where acetabular cup and femoral head were seen as largest size at anterior and posterior acetabula, gluteus maximus muscle, subcutaneous fat adjacent to gluteus maximus muscle, and in area adjacent to the prosthesis stem where the lesser trochanter looks the largest. Hounsfield units (HUs) were measured in these ROIs and mean and standard deviations calculated and compared. Periprosthetic complications were also evaluated for all 90 cases and their visibility compared between the two reconstruction techniques; 1–SFBP better, 2–SFBP same as OMAR, 3–OMAR better.

RESULTS: The average HU at posterior acetabulum was 179.10 vs. 86.78 for SFBP vs. OMAR, respectively (p = 0.000), and gluteus maximus muscle 83.82 vs. 60.20 (p = 0.034), subcutaneous fat −60.30 vs. −75.75 (p = 0.007), so significantly lower in OMAR. Standard deviation for HU was 306.23 vs. 261.36 (p = 0.005) at anterior acetabulum, 251.35 vs. 215.88 (p = 0.007) at posterior acetabulum, 134.87 vs. 105.48 (p = 0.001) at gluteus maximus muscle, and 112.46 vs. 87.37 (p = 0.003) at subcutaneous fat, and at stem level (p = 0.001). The mean visibility of periprosthetic complications was 2.0, so equivalent in all cases.

CONCLUSION: Reconstructions with OMAR technique in postoperative hip CT scans yielded significantly decreased image noise as compared with SFBP technique. However, the diagnosis of periprosthetic complications was not affected by reconstruction technique.

MC 03 MS-10  16:20
Fracture of ankle and foot: improved sensitivity by DIXON technique including opposed phase imaging
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PURPOSE: To evaluate if the out of phase from Dixon technique increase accuracy and sensitivity in the diagnosis of fracture of ankle compared with conventional MR imaging technique.

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study and waived the requirement for informed consent. This study included 45 patients (34 men, 11 women) with 95 CT confirmed ankle or foot fractures who performed MRI of ankle applying Dixon technique from March 2015 to June 2015. The images were divided in to set 1; represented conventional MRI and set 2; opposed phase imaging.
Two readers assessed 4 point confidence score to detect fracture. At first review session, readers were blinded to information and site of fractures. At second review, the information of site of the fracture was given. Sensitivity and positive predictive value (PPV) were calculated using generalized estimating equations. Concordance rate and movement of confidence score were analyzed using McNemar test.

RESULTS: In both session, the sensitivity of set 2 was significantly higher than those for the set 1 (session 1; 76.3 vs. 62.6, respectively, session 2; 80.5% vs. 65.3%). The PPV of set 2 was significantly lower compared with set 1 (85.8% vs. 97.5%, respectively). While 8.9% showed lower movement of confidence score at set 2 compared with set 1, 33.6% of cases showed upper movement of confidence score. The devised possible causes of false lesions were small fractures, subcutaneous fat lobule, bone marrow edema, intraosseous vessel mimicking fractures.

CONCLUSION: Opposed phase image from Dixon technique provides better sensitivity and better description of fractures compared with conventional MRI. However, cautions are required in opposed phase in diagnosis of fracture since it can be confused by adjacent BM edema or subcutaneous fat lobule.
of HAP-fat analysis successfully showed bone marrow edema of recent VCF of L5 vertebral body as shown on fat-suppressed T2 WI MRI (left).

**Chairperson(s)**
Sang Hoon Lee  
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**MC 03 MS-12  16:50**
Gemstone spectral imaging dual energy CT showing good correlation analysis for bone marrow edema of recent VCF of L5 vertebral body as shown on fat-suppressed T2 WI MRI (left).

**Chairperson(s)**
Hyun-joo Kim, Jewon Jeong, Jang Gyu Cha, Jong Kyu Han, Jung Hwa Hwang  
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**PURPOSE:** Gemstone spectral imaging (GSI) dual-energy CT (DECT) is a valuable tool for identifying and characterizing metallic foreign bodies within the body. Metal artifact reduction software (MARS) is also becoming more popular as a method of reducing image artifacts caused by metal implants. This study aimed to evaluate the diagnostic efficacy of MARS for metallic foreign bodies within the body.

**MATERIALS AND METHODS:** This retrospective study included 27 patients who received implant screw fixation surgery and underwent imaging with DECT and MARS. The images were evaluated for the presence of metallic foreign bodies and the improvement in image quality.

**RESULTS:** The images with MARS showed better diagnostic efficacy for metallic foreign bodies compared to those without MARS. The agreement between the observers was high, with an intraclass correlation coefficient (ICC) of 0.508--0.867. The screw diameter measurement from the images with MARS showed a significant difference compared to those without MARS.

**CONCLUSION:** MARS is a valuable tool for improving the diagnostic efficacy of metallic foreign bodies within the body, especially for small metallic objects.

**MC 03 MS-13  17:00**
Initial experience with synthetic MR imaging (MAGiC) for knee joints, comparative study
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**PURPOSE:** Synthetic MR imaging and quantitative MR imaging techniques are gaining interest as methods of reducing acquisition times while additionally providing robust measurements. This study aimed to evaluate the feasibility of implementing a new scanner type and to compare the qualities of images between synthetic MR imaging and conventional MR imaging in knee joints.

**MATERIALS AND METHODS:** This retrospective study included 18 patients who underwent MAGiC Synthetic MR imaging, conventional multi-echo T2 mapping and conventional routine knee MR imaging of the knee joint on a new GE MR750 3T scanner. The signal intensities and relative contrast of the articular cartilage, menisci, muscle, and bone marrow were compared between conventional T1-weighted MR images and Synthetic T1-weighted MR images. T2 relaxation values were also compared between the Synthetic T2 map from conventional multi-echo T2 mapping and the synthetic T2 map from MAGiC MR imaging.

**RESULTS:** Synthetic T1-weighted MR images showed equivalent signal intensities and relative contrast of the articular cartilage, menisci, muscle, and bone marrow compared to conventional T1-weighted MR images. Synthetic T2 relaxation values were also compared to the T2 map from conventional multi-echo T2 mapping and the synthetic T2 map from MAGiC MR imaging.

**CONCLUSION:** Synthetic MR imaging and quantitative MR imaging techniques are promising methods for reducing acquisition times while providing robust measurements. Further studies are needed to evaluate the clinical utility of these techniques in knee joints.
and synthetic T2 mapping using MAGiC MR imaging. **CONCLUSION:** Synthetic MR imaging can be an alternative to conventional MR imaging for generating diagnostic T1-weighted images and also additionally delivering fast and robust T2 relaxation measurements suitable for knee joints. Promising roles and future impacts are anticipated on the diagnosis of musculoskeletal disease with synthetic MR imaging.

**MC 03 MS-14   17:10**

**Monitoring therapeutic responses of osteosarcoma after neoadjuvant chemotherapy with MRI:**

- conventional MRI, diffusion-weighted MRI, and ADC histogram analysis of whole tumor volume at 3.0T
- Seul Ki Lee¹, Won-Hee Jee¹, Joon-Yong Jung¹, Chan Kwon Jung¹, Seung Han Shin¹, Yang-Guk Chung¹, Yohan Son²
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**PURPOSE:** To determine the added value of diffusion-weighted imaging (DWI) to standard magnetic resonance (MR) imaging to assess the response of osteosarcoma to neoadjuvant chemotherapy at 3T.

**MATERIALS AND METHODS:** The Institutional Review Board approved this retrospective study and informed consent was waived. From September 2010 through April 2016, 15 patients with osteosarcoma who had 3T MR imaging including DWI after neoadjuvant chemotherapy and underwent surgery were included. All patients underwent 3T MRI before and after neoadjuvant chemotherapy. One experienced musculoskeletal radiologist first scored standard MR imaging for identification of poor responder and scored a combination of standard MR imaging and DWI with quantitative analysis. ADC histogram analysis of whole tumor volume was performed using Oncotreat software. The percentage change of ADC was calculated. The patients were classified as good responders when they had ≥90% tumor necrosis and poor responders were defined as less than 90% tumor necrosis on histopathologic specimen. Statistical analysis was performed with Wilcoxon rank-sum test and Mann-Whitney U-test. The receiver operating characteristic curve with areas under the curve (AUC) was obtained for diagnostic performance.

**RESULTS:** There were five (33.3%) good responders and ten (66.7%) poor responders. In quantitative analysis of DWI, posttherapeutic mean ADC and minimum ADC were significantly lower for poor responders (1601 ± 441, 1217 ± 258 μm²/sec, respectively) compared to good responders (2200 ± 255, 1677 ± 134 μm²/sec, respectively) (p < 0.05). The percentage change of ADC was not significantly different between two groups (p = 0.071). In volumetric assessment of ADC histogram, posttherapeutic skewness was significantly different between two groups (poor responders, 0.072; good responders, −1.114, p = 0.010). Sensitivity, specificity and accuracy of standard MR imaging alone were 80%, 20%, and 60%, whereas 90%, 80%, and 87% on standard MR imaging combined with DWI for predicting poor responders. AUC of a combination of standard MR imaging and DWI were significantly higher than that of conventional MRI alone: 0.91 vs. 0.58 (p < 0.05).

**CONCLUSION:** The addition of DWI to standard MR imaging improves the assessment of the response of osteosarcoma to neoadjuvant chemotherapy at 3T.
MC 03 MS-15 17:20
Differentiation of malignant from benign musculoskeletal tumors at 3T: the influence of the choice of the smallest b value
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PURPOSE: To compare the diagnostic performance in the differentiation of malignant from benign musculoskeletal tumors on the choice of the smallest b value with the same highest b value at 3T.

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study and informed consent was waived. Thirty-six patients with primary musculoskeletal tumors who underwent MR imaging including intravoxel incoherent motion (IVIM) diffusion-weighted MR imaging (DWI) and histopathologic confirm were retrospectively analyzed. IVIM DWI was obtained with nine b values (0–800) at 3T. Four different ADC maps were calculated from b values of 0 and 800 sec/mm², 50 and 800 sec/mm², 100 and 800 sec/mm², and 200 and 800 sec/mm² using MR body diffusion toolbox. Two independent musculoskeletal radiologists drew the regions of interest in the solid portions of the tumors. The receiver operating characteristic curves with areas under the curve (AUC) were obtained for diagnostic performance in differentiation of malignant from benign tumors. Interobserver agreement for ADC measurement was assessed using intraclass correlation coefficient (ICC).

RESULTS: There were 17 malignant and 19 benign tumors. Sensitivity, specificity and accuracy of ADC 0–800, ADC 50–800, ADC 100–800, and ADC 200–800 were 82%, 74% and 78%; 82%, 74% and 78%; 77%, 74% and 75%; 77%, 74% and 75% for reader 1 and 82%, 79% and 81% on four ADC maps for reader 2. AUCs were 0.769, 0.786, 0.786 and 0.783 for reader 1 and 0.808, 0.805, 0.786 and 0.793 for reader 2, respectively. The optimal cutoff values of to differentiate malignant from benign tumors were 1273, 1301,1260, and 1224 μm²/sec for ADC 0–800, ADC 50–800, ADC 100–800, and ADC 200–800 on reader 1 and 1252, 1278, 1282, and 1280 μm²/sec on reader 2. Interobserver agreement were excellent (ICC = 0.98–0.99)

CONCLUSION: With the same highest b value, the choice of the smallest b values (0–200 mm²/sec) does not affect the diagnostic accuracy in the differentiation of malignant from benign musculoskeletal tumors at 3T.

CLINICAL RELEVANCE: With the same highest b value, the choice of the smallest b values (0–200 mm²/sec) does not affect the diagnostic accuracy in the differentiation of malignant from benign musculoskeletal tumors at 3T.

MC 03 MS-16 17:30
Tumor margin infiltration of soft tissue sarcoma: use of additive diffusion-weighted MR imaging to standard MR imaging at 3T
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PURPOSE: To determine the added value of diffusion-weighted imaging (DWI) to standard magnetic resonance (MR) imaging to assess tumor margin infiltration in soft tissue sarcoma at 3T.

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study and informed consent was waived. Forty-five patients who underwent 3T MR imaging including DWI and were pathologically confirmed as soft tissue sarcoma after surgery were included in this study. One experienced musculoskeletal radiologist and one musculoskeletal fellow retrospectively scored standard MR imaging. Then, they assessed a combination of standard MR imaging and DWI. Margin infiltration on pathology were retrospectively reviewed by one experienced pathologist blinded to MR findings. The receiver operating characteristic curve with areas under the curve (AUC) was obtained for diagnostic performance. Interobserver agreement for scoring of tumor margin infiltration of soft tissue sarcoma was assessed using kappa statistics.

RESULTS: Among 45 patients with soft tissue sarcoma, 33 soft tissue sarcomas had tumor margin infiltrations at pathology. Sensitivity, specificity, and accuracy of each reader were 100%, 17%, and 78%; 97%, 25%, and 78% on standard MRI alone and 94%, 67%, and 87%; 88%, 42%, and 76% on standard MR imaging combined with DWI. Specificity of standard MR imaging combined with DWI was significantly higher than that of standard MR imaging alone for reader 1 (p = 0.0313). AUCs of a combination of standard MR image and DWI were significantly higher than those of standard MR imaging alone: 0.890 vs. 0.678 (p = 0.0123), and 0.780 vs. 0.645 (p = 0.1252) for each reader, respectively. Interobserver agreements of standard MRI alone and standard MR imaging combined DWI were fair to good (k = 0.646, k = 0.533, respectively)

CONCLUSION: The addition of DWI to standard MR imaging improves the assessment of tumor margin infiltration in soft tissue sarcoma at 3T.

CLINICAL RELEVANCE: DWI should be added to standard MR imaging protocols to help assess the tumor
margin infiltration of soft tissue sarcoma in preoperative imaging.

**MC 03 MS-17** 17:40

**Quantitative assessment of meniscal degeneration with UTE-T2* and standard T2 mapping MRI**

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**PURPOSE:** To evaluate the sensitivity of standard T2 mapping and ultrashort echo-time (UTE)-T2* mapping to detect the meniscal degeneration.

**MATERIALS AND METHODS:** MR imaging including standard T2 mapping and UTE-T2* mapping were acquired on two hundred eight menisci of ninety nine patients. UTE-T2* mapping images were acquired at seven echo times (TE = 0.1 2.5 4.8 7.2 9.5 11.8 14.2 ms) with a field of view (FOV) of 18 cm, TR = 20.2 ms and matrix size of 268 x 268. Standard T2 mapping images were acquired at 6 echo times (TE = 13.0 26.0 39.0 52.0 65.0 78.0 ms) with a FOV of 16 cm, TR = 2600 ms and matrix size of 320 x 320. One radiologist reviewed the images and graded the meniscal degeneration according to the morphologic criteria on T2 weighted or proton density sequences. [Grade 0, normal, no abnormal hyperintensity within meniscus; Grade 1, small focal area of hyperintensity within meniscus; Grade 2, linear areas of hyperintensity without extension to articular surface; Grade 3, abnormal hyperintensity extending to the articular surface, indicated tear]. Regions of interest (ROIs) were manually drawn on each meniscus and abnormal hyperintensity portion within meniscus to calculated the mean T2* and T2 values.

**RESULTS:** On morphological analysis, grade 0, 1, 2 and 3 were diagnosed in 50, 52, 50 and 56 menisci, respectively. Both mean T2 and T2* values of menisci were found to significantly different between the all grades and tended to be higher in more severely degraded meniscus (p < 0.0001 for both). The mean T2 values of the menisci were 10.78 ms, 15.81 ms, 20.26 ms and 30.80 ms, and the mean T2* values of the menisci were 7.10 ms, 9.64 ms, 12.01 ms and 18.98 ms for grade 0, 1, 2 and 3, respectively. Mean T2 and T2* values of hyperintensity portion within menisci (grade 1-3) were significantly higher than the values of menisci (p < 0.0001 for both) and also varied with grade of meniscal degeneration (p = 0.002 between grade 1 and 2 in mean T2 value, others p < 0.0001). Mean T2 values of hyperintensity were 20.05 ms, 24.39 ms and 38.92 ms and mean T2* values of hyperintensity were 10.94 ms, 13.67 ms and 22.36 ms at T2* values for grade 1, 2 and 3, respectively.

**CONCLUSION:** Standard T2 mapping and UTE-T2* mapping are both sensitive to detect degenerative changes in meniscus and can be used to quantitatively characterize meniscus degeneration in patients.

**MC 03 MS-18** 17:50

**Evaluating suspected malignant pathologic fracture in extremities: diagnostic value of diffusion-weighted imaging according to lesion apparentness at standard MR imaging**

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**PURPOSE:** When evaluating clinically suspected pathologic fractures in extremities, detecting malignant tumors at fracture site is crucial. We assessed added diagnostic value of diffusion-weighted imaging (DWI) according to apparentness of lesions on standard MR imaging.

**MATERIALS AND METHODS:** From September 2013 to March 2016 (2 years 6 months), we included 68 patients with clinically suspected malignant pathologic fracture in extremities who underwent contrast-enhanced standard MR imaging (CE-MRI) with DWI in emergency room and outpatient clinic. 63 patients had a primary cancer and 5 were in the clinical setting of suspected malignancy at visit. 2 musculoskeletal radiologists (R1, 2 year; R2, 16 year-experience) reviewed separate 2 imaging sets (CE-MRI alone, CE-MRI plus DWI) independently. To evaluate focal lesion at fracture site, T2-weighted, T1-weighted, post contrast T1-weighted with fat sat images were used, and then, with DWI, ADC map were placed side by side. For presence of malignant bone tumors at fracture site, qualitative analysis was done at each imaging set with 5-point scale. Then, we
modified 5 point-scale into 3 groups (1, unapparent; 2, equivocal; 3, apparent). Diagnostic performance of two imaging sets and each group was compared using ROC curve analysis, McNemar test (p < 0.05). Inter-reader agreement was tested with weighted kappa statistics. Medical records were reviewed, including primary cancers, operation and/or pathologic reports, clinical course. Causes of errors and changing decisions at 2nd imaging set were analyzed.

RESULTS: Malignancies at fracture site were positive in 34, and negative in 34 patients. For diagnosing malignant pathologic fractures, added DWI improved diagnostic performance significantly in R1 (area under ROC curve = 0.805 vs. 0.97, respectively; p < 0.001), but not in R2. In 11 equivocal cases of group 2, adding DWI improved specificity significantly in R1 (p < 0.05), not in R2. Diagnostic performance was not changed in the other groups of 1, 3. Interobserver agreement increased from 0.64 to 0.81. 4 errors and 13 changing decisions were caused by associated hemorrhage, inflammation, nonunion, and hematopoietic marrow at fracture sites.

CONCLUSION: In suspected malignant pathologic fracture, DWI could add diagnostic value, especially in cases of equivocal decision on standard MR imaging, by improving specificity.

SS 02 MS-01 08:00 Novel evaluation of chronicity in rotator cuff tear using shear-wave elastography Seungjin Yoo, Seunghun Lee, Yoonah Song, Bong Gun Lee Hanyang University Seoul Hospital, Korea.

PURPOSE: MRI, CT arthrography and B-mode US are widely used modalities at evaluating the rotator cuff tear. However they have limitation on evaluating the chronicity of the tear. Shear-wave elastography is an emerging tool which can quantify the elasticity of the tissue. Therefore we tried to evaluate the chronicity of supraspinatus tendon tear by applying shear-wave elastography.

MATERIALS AND METHODS: Retrospective study was performed. Between November 2015 and April 2016, 82 patients with shoulder pain were examined by B-mode US and shear-wave elastography (Siemens, Supersonic). Routine rotator cuff evaluation was done by B-mode US on the shoulder with pain and the elasticity value of supraspinatus tendon was measured in longitudinal view. 21 patients had no abnormal finding on B-mode US including rotator cuff tear, subacromial-subdeltoid bursitis, tendinopathy, and calcific tendinitis. 35 patients (M:F = 14:21; aged, 38–79 years) had supraspinatus tendon tear. The 35 patients were classified into 4 groups by the onset of the symptom (3 month or less, 6 month or less, 1 year or less, and more than 1 year). The Wilcoxon rank sum test was performed to compare the elasticity value of torn supraspinatus tendon by the onset of the symptom.

RESULTS: The mean elasticity value ± SD of normal and torn supraspinatus tendons was 95.97 ± 11.08 Kpa and 100.67 ± 23.65 Kpa each. Statistically significant difference of elasticity value was found between the patient groups who had symptom for 6 months or less and more than 6 months (p < 0.019). No statistical significance was found between the patient groups who had symptom for 3 months or less and more than 3 months; 1 year or less and more than 1 year.

CONCLUSION: As the injured tendon go through a healing process, eventually it loses elasticity. Therefore we propose the period of 6 month of symptom on patients with rotator cuff tear as a novel standard of the chronic supraspinatus tendon tear.

CLINICAL RELEVANCE/APPLICATION: Applying the shear-wave elastography which can quantify the elasticity of the rotator cuff tendon may benefit the clinician on determining the chronicity of tear and predicting the outcome of the surgery.

SS 02 MS-02 08:10 Painful shoulder: correlation of clinical impairments with ultrasound findings Hyungjoon Cho, Chan Ho Kang, Kyung-Sik Ahn, Min A Yoon, Suk-Joo Hong, Euddeum Shin, Baek Hyun Kim

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PURPOSE: To correlate high resolution ultrasonography findings of the shoulder and the patient’s level of pain and disability.

MATERIALS AND METHODS: Retrospective review was performed in a single tertiary center from January
2014 to June 2014 identifying 100 shoulders of 50 patients who underwent bilateral US exam to evaluate for painful shoulder. Investigation included the long head of biceps tendon, the supraspinatus and infraspinatus tendon, subscapularis tendon, subacromial-subdeltoid bursa, and finally identification of calcifications. Before the US exam, all the patients were asked to fill in the clinical questionnaire for painful shoulders and the asymptomatic or less symptomatic opposite shoulders. Sonographic reports and images were reviewed by two radiologists in consensus and in consideration of symptom duration and affected side as well as basic demographic data. Multinomial and binominal logistic regression analysis were performed to identify the ultrasonography finding which is significantly correlated with pain and disability score.

RESULTS: There were 81 US abnormalities including 28 rotator cuff tear, 7 tendinosis, 11 long bicipital tendosynovitis, 1 long bicipital dislocation, 17 calcifications and 17 subacromial-subdeltoid bursitis in painful shoulders, while 50 US abnormalities in the opposite shoulders. The pain score was positively correlated with supraspinatus abnormalities (full and partial thickness tear, tendinosis, and calcifications) and long bicipital tendosynovitis ($p < 0.05$). Interestingly, partial thickness tear was more strongly associated with pain than full thickness tear. On the other hand, the disability score was positively correlated only with subacromial-subdeltoid bursitis. Especially, fluid collection in the bursa was more strongly correlated with disability than bursal thickening. US abnormalities in subscapularis tendon show no significant association with patient’s pain and disability score.

CONCLUSION: We observed how US findings of the shoulder are correlated with the patient’s pain and disability. In particular, the strongest association was seen between partial thickness supraspinatus tear and pain score, and between fluid collection in subacromial-subdeltoid bursa and disability score.

Association between MRI findings of adhesive capsulitis and fat quantification of the muscles around the shoulder using multi-echo Dixon imaging

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PURPOSE: To assess the association between MRI findings of adhesive capsulitis and fatty infiltration of the muscles around the shoulder.

MATERIALS AND METHODS: This study included 18 patients (8 men; mean, 50.5 years) with clinical symptoms and signs of adhesive capsulitis, normal plain radiographic findings and without significant tears (> 50% of the cuff thickness) of the supraspinatus and infraspinatus tendons on MRI. MRI findings of adhesive capsulitis, including presence of capsular and extracapsular edema, capsular thickening, thickness of the capsule in axillary recess, as well as the thickness of the coracohumeral ligament (CHL) and the rotator interval (RI) capsule were evaluated. Fat percentages in the four rotator cuff muscles as well as teres major, posterior deltoid and triceps muscles were quantified using a multi-echo Dixon imaging in the oblique sagittal plane. Fat percentage measurements were made at three locations: at the level of glenoid cartilage, 1.5 cm and 3 cm medial aspect of the glenoid cartilage. Association between MRI findings of adhesive capsulitis and fat percentages of the muscles around the shoulder were assessed using Mann-Whitney U test and Spearman’s correlation analysis.

RESULTS: On qualitative analysis, following MRI findings of adhesive capsulitis were noted: capsular edema (n = 11, 61%), extracapsular edema (n = 13, 72%) and capsular thickening in the axillary recess (n = 16, 89%). On quantitative analysis, mean capsular thicknesses of the axillary pouch were 4.17 mm (humeral) and 3.98 mm (glenoid), and mean thickness of the CHL was 2.92 mm and RI capsule was 5.61 mm. Mean fat percentages of the muscles around the shoulder were as follows: supraspinatus (2.82%), infraspinatus (4.39%), teres minor (2.85%), subscapularis (2.97%), teres major (4.32%), deltoid (2.65%) and triceps (1.28%). Among the various MRI findings of adhesive capsulitis, thickness of the CHL showed moderate correlation with fat percentage of teres major with statistical significance ($r = 0.519$, $p = 0.027$) and posterior deltoid, which was statistically not significant ($r = 0.455$, $p = 0.058$). There was no significant association between MRI findings of adhesive capsulitis and fat percentage of rotator cuff muscles.

CONCLUSION: Thickening of the CHL was moderately associated with fatty infiltration of teres major muscle.
Evaluation of the subscapularis tendon tear on 3T direct MR arthrography: comparison of T1 SPIR and T2 TSE with arthroscopic findings as the standard
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PURPOSE: To compare the diagnostic performance in the evaluation of the subscapularis tendon (SCT) tear between T1-weighted spectral presaturation with inversion-recovery sequences (T1 SPIR) and T2-weighted turbo spin-echo sequences (T2 TSE) on 3-T direct magnetic resonance arthrography (MRA) with arthroscopic findings as the standard.

MATERIALS AND METHODS: Between September 2016 and December 2016, direct MRA of 56 consecutive patients (mean age, 63.1 years; M:F = 22:34) who underwent arthroscopic surgery within 3 months were analyzed. Two independent musculoskeletal radiologists, who were blinded to the arthroscopic results, evaluated T1 SPIR and T2 TSE and recorded the presence and grade (partial thickness [PT] vs. full-thickness [FT]) of the SCT tear in separate sessions. Arthroscopic results were used as the reference standard, then, sensitivity and specificity of T1 SPIR and T2 TSE were obtained and compared by the McNemar test. Interobserver agreement was measured with the kappa (κ) statistics.

RESULTS: Among the 56 patients in this study, 16 PT (28.6%) and 21 FT (37.5%) confirmed by arthroscopy. For the detection of the SCT tear, the sensitivity and specificity of T1 SPIR were 91.9%/94.6% (reader 1/reader 2) and 94.7%/84.2%, respectively; the sensitivity and specificity of T2 TSE were 70.3%/64.9% and 94.7%/89.5%, respectively. There was statistically significant difference in the sensitivity between T1 SPIR and T2 TSE by using the exact McNemar test (p = 0.016 for reader 1, p < 0.01 for reader 2). For the FT, the sensitivity and specificity of T1 SPIR were 42.9%/38.1% (reader 1/reader 2) and 100%/100%, respectively; the sensitivity and specificity of T2 TSE were 28.6%/27.3% and 100%/100%, respectively. Result of the McNemar test did not show significant difference in the sensitivity between T1 SPIR and T2 TSE (p = 0.25 for reader 1, p = 0.69 for reader 2). Interobserver agreement was substantial to almost perfect (κ = 0.913 for T1 SPIR; κ = 0.785 for T2 TSE).

CONCLUSION: T1 SPIR was proved to be an excellent imaging sequence with higher sensitivity when compared to the T2 TSE in the detection of the SCT tear on 3-T direct MRA. However, regarding the evaluation of FT of the SCT, both T1 SPIR and T2 TSE showed lower sensitivity without statistically significant difference.
10-month period. MRAs in patients with posterior decentering of humeral head (n = 27) were reviewed and compared with those of randomly selected control group without posterior decentering (n = 54). MRA was evaluated for posterior factors (posterior recess synovitis, posterior capsular thickening, sliver of contrast at posterior glenohumeral recess), fatty degeneration of rotator cuff, anterior factors (subcoracoid bursa effusion, rotator interval tear), posterior labral abnormality, by two experienced observers who reached in consensus. The Fisher exact test, linear by linear association was used for comparison of categorical data, and multivariate stepwise logistic regression analysis, pooled kappa coefficient was performed.

RESULTS: Posterior decentering of humeral head was found in 27 (14%) patients. At univariate analysis, posterior synovial proliferation (29.6% [8/27] in posterior decentering group vs. 7.4% [4/54] in control group; p = 0.008), posterior capsule thickening (25.9% [7/27] vs. none; p < 0.001), fatty infiltration of supraspinatus, infraspinatus and teres minor (linear by linear association, respectively p < 0.0, respectively), rotator interval tear (55.6% [15/27] vs. 31.5% [17/54]; p < 0.037) were more frequently found in posterior decentering group with a statistical significance. At multivariate analysis, only the posterior synovial proliferation was significantly associated with posterior decentering of humeral head (Odds ratio, 5.263; 95% CI, 1.418–19.532).

CONCLUSION: Posterior recess synovitis was statistically significantly associated with posterior decentering of the humeral head. In addition, rotator cuff as well as posterior labral abnormality was associated with posterior decentering of the humeral head to lesser extent. Awareness of the association of the posterior decentering of the humeral head with the described MR findings above will facilitate the effective interpretation of shoulder MRA.

SS 02 MS-07  09:00
MR imaging and clinical findings of lateral epicondylitis: comparison in patients treated with and without arthroscopic surgery and factors associated with management plans
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PURPOSE: Although lateral epicondylitis is a common cause of elbow pain, the need for and timing of surgical intervention isn’t clearly established. We compared MR imaging and clinical findings of lateral epicondylitis in patients treated conservatively and with arthroscopic surgery to identify factors associated with management plans.

MATERIALS AND METHODS: 60 patients with lateral epicondylitis who treated conservatively (n = 38) and with arthroscopic surgery (n = 22) were included. Two radiologists reviewed elbow MR images independently as follows: grade of common extensor tendon (CET) abnormality and size of tear which were measured as a maximum length on axial and coronal planes — grade 1, tendinosis or ≤ 2 mm partial tear (PT); grade 2, 2 mm < PT ≤ 6 mm; grade 3, PT > 6 mm or complete tear, presence of increased signal in adjacent muscles, injury of RCL complex, synovitis/effusion, synovial fringe, increased signal of ulnar nerve, radiocapitellar joint space widening, chondral lesions. Clinical data recorded were frequency (intermittent/persistent), duration, NRS (numerical rating scale) of pain, trauma history, range of motion. MR imaging and clinical findings in both groups were compared and analyzed with univariate analysis and multivariable logistic regression models.

RESULTS: All MR imaging findings except a chondral lesions, frequency and NRS of pain were significantly different between both groups (p < 0.05). Among them, factors with significant association (p < 0.01) which needed to be tested with multivariable analysis were grade of CET abnormality and size of tear on axial and coronal planes, presence of increased signal in muscles, frequency of pain. On multivariable logistic regression analysis, the grade of CET abnormality on coronal plane (grade 2, OR 343, p = 0.021; grade 3, OR 2922, p = 0.015, respectively), increased signal in muscles (one muscle, OR 156, p = 0.022; multifocal muscles, OR 116, p = 0.019) and persistent pain (OR 68, p = 0.006) were significant factors associated with arthroscopic surgical treatment.

CONCLUSION: In lateral epicondylitis, grade of CET abnormality on longitudinal plane, extent of muscle edema on MRI and presence of persistent pain were correlated with conditions may require surgical management. MRI along with clinical information, may aid surgical decision-making in patient with lateral epicondylitis.
Assessment of acetabular and femoral morphologies and their relations: are there any differences in lumbar spine and hip radiographs compared to pelvic radiographs?

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PURPOSE: To retrospectively evaluate the interchangeability of the radiographic measurements of the hip (acetabular and femoral morphologies, and their relations) obtained from lumbar spine anteroposterior (AP) and hip AP radiographs (L-AP and H-AP), compared to those from pelvic AP radiograph (P-AP).

MATERIALS AND METHODS: Institutional Review Board approval was obtained. A total of 101 patients (M:F = 40:61; mean age, 58.4 years) who underwent L-AP, H-AP, and P-AP within a time period of less than two weeks were included. Three independent reviewers evaluated L-AP, H-AP, and P-AP to measure the radiographic parameters of the hip (center-edge angle of Wiberg [CEA], acetabular roof angle of Tönnis [AA], femoral head extrusion index [FHEI], cross over sign, and pistol grip deformity). Statistical analyses were performed using the repeated-measures analysis of variance (ANOVA), Bland-Altman plots, Cochran Q test, and intraclass correlation coefficient (ICC).

RESULTS: There was no significant difference among both CEs, cross over sign, and pistol grip deformity in the three different radiographs (p = 0.07–0.94). The average differences of the right and left CEs between L-AP and P-AP, and between H-AP and P-AP were less than 0.60°. Additionally, no significant difference was shown among both AAs and FHEIs of H-AP and P-AP (p = 0.10–1.0). The average differences of the right/left AAs and right/left FHEIs between H-AP and P-AP were 0.63°/0.50° and −0.41%/−0.18%, respectively. However, significant differences among both AAs (right, p = 0.006; left, p = 0.04) and FHEIs (right, p < 0.001; left, p = 0.03) of L-AP and P-AP were shown. The average differences of the right/left AAs and right/left FHEIs between L-AP and P-AP were −1.20°/−0.84° and 1.24%/0.77%, respectively. ICCs for all measurements were either good or excellent (range, 0.763–0.935).

CONCLUSION: Except for AA and FHEI from L-AP, radiographic measurements of hip they obtained with L-AP and H-AP were interchangeable with those from P-AP. L-AP and H-AP are acceptable for evaluating hip dysplasia and femoroacetabular impingement syndrome when compared to P-AP.
비 인대와 종비 인대는 발바닥쪽 굽힘 영상에서 평균 점수는 3.7과 3.1이었으며, 중립 자세에서 얻은 영상에서 평균 점수는 2.6과 1.8이었다. 중립 이외의 자세에서 얻은 영상에서는 평균 점수는 3.3이었으며, 중립 자세에서 얻은 3D MR 영상에 평균 점수는 2.3이었다.

**CONCLUSION:** 발목 관절의 MR 영상을 얻기 원할 때 발바닥쪽 굽힘 자세에서 얻은 영상은 발목 외측 인대와 관절강 파악에 더 도움이 될 수 있었다. 근골격 MR 영상을 얻을 때 해당 구조물에 대한 영상 획득 방향을 바꾸는 방법도 도움이 되지만, 구조물의 자세를 바꾸어 얻는 방법도 영상의 질을 높이는 한 방법이다.

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Nineteen of 21 patients had contrast-enhanced images and we analyzed the presence of atypical enhancement, which defined as lobular enhancement against peripheral or septal enhancement.

**RESULTS:** Eleven cases were classified as R group (52%), 5 as P group (24%) and five as NC group (24%). Time interval between two MRI were significantly shorter in NC group than P or R group. There were no significant difference between groups regarding age, gender, direction of progression or regression, anatomical location, size, endosteal scalloping, peritumoral edema, fat entrapment and morphology. Atypical enhancement was seen in R (6 of 10, 60%) and NC (2 of 5, 40%) groups, but not in R group (0 of 4, 0%).

**CONCLUSION:** Low-grade chondroid tumors can either regress or progress in MR imaging follow-up. The presence of atypical enhancement might be a negative predictor of tumor progression.

**CLINICAL RELEVANCE:** This is the first study that demonstrates the evolution of low grade chondroid tumors by using MR imaging. The presence of atypical enhancement might be suggestive of tumor healing with endochondral ossification, although further prospective study is needed.
both Pfirrmann and modified Pfirrmann grading system. **MATERIALS AND METHODS:** Approval of Institutional Review Board was obtained with waived informed consent. Retrospective review of 70 lumbar spine MRs with DWI (M:F = 1:1; mean age, 48.6 years) in a 1.5T MR unit from March 2014 to December 2014. DWI was obtained with inversion recovery prepulse, and b-value 0 and 500. Severity of lumbar disc degeneration at the levels of L3-4, L4-5 and L5-S1 was graded according to Pfirrmann and modified Pfirrmann system by two experienced musculoskeletal radiologists separately, and reader 1 graded again of disc degeneration 1 month later. And the third radiologist measured ADC value of discs within the center of disc in midsagittal plane. Correlations of each grading system, age, gender with ADC value were statistically analyzed. Interobserver and intraobserver correlations were also analyzed for each grading systems. Multivariate linear regression was performed with each grading system, age, gender, and ADC values. **RESULTS:** A total 210 lumbar discs were analyzed. ADC value was obtained in 209 discs because of collapse of a disc. Interobserver agreement of both Pfirrmann and modified Pfirrmann grading system between the two readers was almost perfect, and intraobserver agreement of the both grading system by reader 1 was also excellent. Both grading systems for degenerated disc were negatively correlated with ADC values (p < 0.001). Comparison of ADC values in each grade was significant in Pfirrmann grades except between grade 4 and 5, and in modified Pfirrmann grades except above grade 5. Correlations of each grading system, age and gender with ADC values were also statistically significant. But multivariate regression revealed that ADC was statistically correlation with each grading system, not age and gender. **CONCLUSION:** Both Pfirrmann and modified Pfirrmann grading systems are negatively correlated with ADC values. Quantification with ADC value for degenerated spine may be useful except severely degenerated disc.

**Assessment of sacroiliitis for the diagnosis of spondyloarthropathy: fat-saturated T2-weighted imaging with STIR versus fat-saturated contrast-enhanced T1-weighted imaging**

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**OBJECTIVE:** To evaluate the incremental value of contrast agent for diagnosing spondyloarthropathy in patients with inflammatory back pain.  

**MATERIALS AND METHODS:** Ninety-two patients with inflammatory back pain were enrolled in this study. All patients underwent magnetic resonance imaging (MRI) consisting of a coronal short tau inversion recovery (STIR) sequence, axial fat-saturated T2-weighted imaging (T2FS), and coronal and axial contrast-enhanced fat-saturated T1-weighted imaging (c & a T1CE). Two observers independently reviewed an image set of coronal STIR with axial T2FS, and an image set of c & a T1CE, at separate times. The degree of bone marrow edema and osteitis were evaluated from each image set. A decision for sacroiliitis positivity for each image set was made based on the findings. The presence of additional active inflammatory findings of spondyloarthropathy such as synovitis, enthesitis, and capsulitis were also evaluated.  

**RESULTS:** Interobserver and intersequence agreement for the degree of bone marrow edema and osteitis were good or excellent in all quadrants. Cohen’s kappa coefficients for sacroiliitis positivity between the two observers were 0.978 and 0.956, and Cohen’s kappa coefficients between the two image sets for each observer were 0.892 and 0.870, respectively. The intersequence agreement of additional active inflammatory findings was substantial, and the interobserver agreement was almost perfect or substantial. 

**CONCLUSION:** Coronal STIR with axial T2FS is sufficient to diagnose spondyloarthropathy, and contrast enhancement does not have additional value. C & a T1CE images could be helpful in evaluating additional active inflammatory findings of spondyloarthropathy such as synovitis, enthesitis, and capsulitis.
**SS 27 MS-04  16:30**

**Differentiation of acute osteoporotic and malignant vertebral fractures based on quantification of the fat-signal fraction using DIXON sequence**

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**PURPOSE:** To differentiate malignant from osteoporotic fractures by quantifying the fat-signal fraction in acute vertebral compression fractures using DIXON sequence.

**MATERIALS AND METHODS:** Thirty two acute vertebral compression fractures were assessed with turbo-spin echo T1-weighted images (T1WI) and 3D gradient-echo sequence with multiple echoes and T2\(^*\) correction (DIXON) at 3.0 T MR. The fractures were divided into malignant fractures (n = 12) and osteoporotic fractures (n = 20). Two radiologists independently measured quantitative parameters of fractures by placing regions of interest (ROIs) as possible as large, including the T1 signal intensity (SI) on T1WI and the fat-signal fraction (FF) on automatically reconstructed FF map. The lesion-disc ratio (LDR) was calculated by dividing T1 SI of the lesion to T1 SI of normal tissue. The FF ratio was calculated by dividing FF of the lesion to FF of the normal marrow. Parameters were compared between osteoporotic and malignant fractures. Also, we analyzed interobserver reliability, using Cronbach’s coefficient alpha, and assessed the diagnostic performance using receiver operation characteristic (ROC) analysis.

**RESULTS:** Among parameters, FF and FF ratio of malignant fractures were significantly lower than those of osteoporotic fractures (FF: 4.1% vs. 14.9%, respectively; p < 0.001) (FF ratio: 0.08 vs. 0.24, respectively; p < 0.001). There were no significant differences in the T1 SI and LDR between osteoporotic and malignant fractures. Also, we analyzed interobserver reliability, using Cronbach’s coefficient alpha, and assessed the diagnostic performance using receiver operation characteristic (ROC) analysis.

**CONCLUSION:** The utility of FF and FF ratio of fractures were significantly different between in osteoporotic and malignant fractures although other values were not. We suggest that the FF obtained from DIXON sequence might serve as good tool for the differentiation of osteoporotic and malignant vertebral compression fractures.

**CLINICAL RELEVANCE/APPLICATION:** The fat-signal fraction obtained from DIXON sequence could help differentiate acute osteoporotic fractures from malignant fractures in addition to the conventional qualitative findings suggesting osteoporotic or malignant vertebral fracture.

**SS 27 MS-05  16:40**

**Postoperative regression of retro-odontoid pseudotumor after atlantoaxial posterior fixation: ten years of experience in patients with atlantoaxial instability**

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**PURPOSE:** To investigate the incidence of the retro-odontoid pseudotumor in patients with atlantoaxial instability and to evaluate regression of the pseudotumor after posterior fixation.

**MATERIALS AND METHODS:** We retrospectively reviewed all the patients who underwent posterior fixation for atlantoaxial instability in the past ten years, using medical record and PACS system. Patients who underwent previous operation or had tumor/infection history in the cervical spine at C1-2 level were excluded. The study group was categorized according to their underlying disease (RA, Os odontoideum, atlanto-occipital assimilation, dens fracture, idiopathic, etc.) and the incidence rate of retro-odontoid pseudotumor in each group were analyzed. Pre- and post-operative MR or CT images were reviewed to confirm presence of the pseudotumor and to assess its regression following surgery. The size of the pseudotumor was measured in its largest sagittal diameter, from the anterior border of the odontoid process to the posterior border of the pseudotumor. The size difference was compared between pre- and post-operative MR or CT images.

**RESULTS:** Total 164 patients were included in our study. Among them, 38 patients had retro-odontoid pseudotumor (23.1%). Three patients were diagnosed as RA and the rest were non-RA patients including Os odontoideum (n = 12), dens fracture (n = 6), atlanto-occipital assimilation (n = 4), Morquio syndrome (n = 1), and idiopathic atlantoaxial instability (n = 12). The size of the pseudotumor regressed in all 38 patients after atlantoaxial posterior fixation. There was statistically significant interval decrease in size of the pseudotumor from a mean length of 17.7 mm to 14.9 mm (p < 0.001). The mean follow-up period was 13.9 months.

**CONCLUSION:** There were various underlying diseases and the overall incidence of the retro-odontoid pseudotumor in patients with atlantoaxial instability was 23.1% in our institution during the past ten years. All the patients who underwent posterior fixation for atlantoaxial instability showed statistically significant decrease in
size of the pseudotumor.

**SS 27 MS-06  16:50**

**Evaluation of responsiveness and reliability of treatment outcome measures in pain**

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**PURPOSE:** There are many assessment measures used for pain in manners of pain itself and functional states. Discrepancies in patients’ response to each measure might challenge a clinician to evaluate outcome and decide following treatment. The purpose of this study is to evaluate responsiveness and reliability of treatment outcome measure in low back pain or neck pain patient

**MATERIALS AND METHODS:** Among low back or neck pain patient who underwent epidural injection for the treatment during October 2014 to November 2014 were enrolled. Each patient were requested to answer their outcome in forms of pain or functional assessment measures; Oswestry Disability Index (ODI), Neck Disability Index (NDI), Visual Analogue Scale (VAS), five-scale satisfaction score, residual symptom percentage. For clinical outcome we review subsequent treatment on the follow-up and operation history. More than 30% reduction of NRS, ODI, NDI and less than 50% of residual symptom were considered improved. For 5-scale satisfaction score, “no pain", “much improved” and "slightly improved" were considered improved.

**RESULTS:** Among 173 patient, 110 answer concordantly to four measurements, whether they are improved or not. 38 patient answers concordantly to three measures, 25 patients to two measures. 98 patient of 110, showed concordance in four measures, answered they are not improved and only 12 answered improved. Interclass coefficient between four measures were 0.686 in case of lower back pain and 0.832 in that of neck pain (p < 0.001). ODI showed no significant concordance between NRS, residual symptom percentage, or 5-scale satisfaction score. Among these measures concordance between residual symptom percentage and 5-scale satisfaction score was highest of other measures. It showed no significant characteristics/demographics feature (age, sex, time interval, initial response to measures) difference between levels of concordance to measures.

**CONCLUSION:** Residual symptom percentage and 5-scale satisfaction score showed good concordance in showing treatment outcome. NDI also showed good reliability in assessment of treatment in patient with neck pain while ODI did not in low back pain patients. Therefore, residual symptom percentage and 5-scale satisfaction score are more reliable measures for assessing treatment outcome.

**SS 27 MS-07  17:00**

**Correlation of height restoration and kyphosis with clinical outcome after percutaneous vertebroplasty in patients with vertebral compression fractures**

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**BACKGROUND:** Percutaneous vertebroplasty (PVP) is widely used for the treatment of painful vertebral compression fractures (VCFs). Few studies reported correlation between restoration of vertebral body height and kyphosis and clinical outcome. It is unclear whether height restoration affects clinical outcome and whether kyphosis should be improved.

**PURPOSE:** To evaluate the correlation of restoration of vertebral body height and kyphosis with pain relief and clinical outcome after PVP in patients with VCFs.

**MATERIALS AND METHODS:** Between January 2007 and December 2013, 241 patients with VCFs who had failed conservative treatment and underwent PVP were included. Restoration of vertebral body height and kyphosis were measured on standardized radiographs. Pain and clinical outcome were assessed using the visual analogue scale (VAS) score and the Ronald Morris Disability Questionnaire (RMDQ) score, respectively. Pre- and post-operative restoration of vertebral body height and kyphosis and VAS and RMDQ scores were compared using the paired t test. Correlations between the height restoration and kyphosis and VAS and RMDQ scores were determined via Pearson correlation coefficient (r).

**RESULTS:** The height, wedge angle and local angle of the fractured vertebral body, and VAS and RMDQ scores, improved significantly after PVP. VAS and RMDQ scores correlated positively with the height restoration and kyphosis; the highest correlation was between the VAS score and wedge angle (r = 0.95).

**CONCLUSION:** PVP is a simple and viable treatment for VCFs patients as most patients experienced pain relief and improvement of clinical function after the pressure. In terms of VAS and RMDQ scores, preoperative height restoration and kyphosis can be prognostic indicators for the outcome of PVP.
RS 27 MS-08  17:10
Diffusion tensor imaging and fiber tracking of inflammatory and tumorous intramedullary spinal cord lesions
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PURPOSE: Inflammatory and neoplastic intramedullary spinal cord lesions have overlapping clinical features and it is occasionally difficult to distinguish one from another on conventional magnetic resonance imaging. We aimed to compare diffusion tensor imaging findings between inflammatory and neoplastic intramedullary spinal lesions, specifically focusing on patterns of fiber tracking.

MATERIALS AND METHODS: Diffusion tensor imaging was performed in patients with inflammatory or neoplastic intramedullary spinal lesions. The fiber tracking patterns (categorized as "intact," "displaced," or "interrupted") were compared between these two groups.

RESULTS: There were a total of 10 patients, including 5 with pathologically or clinically confirmed inflammatory lesions and 5 with pathologically or clinically confirmed neoplastic lesions. Among the patients with inflammatory lesions, 2 exhibited displaced patterns and 3 exhibited intact patterns. Among the patients with neoplastic lesions, 1 exhibited an intact pattern, 2 exhibited displaced patterns, and 2 exhibited interrupted patterns.

CONCLUSION: On fiber tracking, inflammatory and neoplastic intramedullary spinal lesions can present overlapping features including displaced fibers. The exclusion of inflammatory conditions based on displaced fibers on fiber tracking images should be avoided.

SS 27 MS-09  17:20
Assessment of spondyloarthritis using MR spectroscopy: a single peak at 8 ppm as a potential inflammatory marker
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PURPOSE: To evaluate the potential role of magnetic resonance (MR) spectroscopy in patients with inflammatory arthritis, and correlation between active inflammation, C-reactive protein (CRP) and clinical concordance.

MATERIALS AND METHODS: From May 2015 to March 2016, 130 consecutive patients with clinically suspected spondyloarthritis (M:F = 77:53; mean age, 30.3 years; range, 14 – 63 years) were assessed with 3.0-T MR imaging including single-voxel MR spectroscopy. We analyzed the presence of specific metabolite peak of active inflammation group compared them with those of inactive group. We draw two region of interest (ROI) in case of subchondral bone marrow edema and normal bone marrow. Two radiologists analyzed conventional MR findings by consensus: bone marrow edema, location, and presence/absence of active inflammation in sacroiliac joint. We use dedicated software (jMRUI) for analyzing MR spectroscopy. Demographic data, MR findings, spectroscopic spectrum and concordance between active inflammation and CRP were compared using chi-square test.

RESULTS: There are 66 patients with active inflammation and the other 64 patients with inactive lesion in sacroiliac joint. All patients with active inflammation showed a single peak of carnosine (8 ppm). However, only 29 patients with active inflammation in sacroiliac joint showed elevated CRP values. In discordant group, 71.7% (33/46) cases showed carnosine peak although negative serologic results. Diagnostic concordance between CRP and MR finding had statistically significant (p < 0.001). Carnosine peak and active inflammation had also significant (p < 0.001). There was no statistically significant between other variables.

CONCLUSION: MR spectroscopy at 3.0-T with metabolite detection is a helpful method in spondyloarthritis. 8 ppm carnosine peak may be a promising inflammatory marker to detect and follow up active inflammation in spondyloarthritis.

CLINICAL RELEVANCE/APPLICATION: 8 ppm carnosine peak add knowledge regarding inflammation. In the future, carnosine may be an inflammatory marker to evaluate activity.
SS 27 MS-10 17:30
Intravoxel incoherent motion analysis of vertebral bone marrow after radiation exposure from diagnostic imaging and interventional procedures
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PURPOSE: To assess changes in vertebral bone marrow diffusion and perfusion using intravoxel incoherent motion diffusion-weighted magnetic resonance imaging (IVIM-DW MRI) in hepatocellular carcinoma (HCC) patients after varying levels of exposure to ionizing radiation from diagnostic imaging and transarterial chemoembolization (TACE).

MATERIALS AND METHODS: A total of 21 IVIM-DW MRI sets, consisting of baseline and follow-up MRI with an interval less than 100 days, in 20 HCC patients without history of chemotherapy or radiation therapy, were reviewed, after varying levels of radiation exposure from TACE, dynamic CT of the liver, and plain radiography of the abdomen. Changes in IVIM parameters (apparent diffusion coefficient (ADC), true diffusion coefficient (D), pseudodiffusion coefficient (D*), and perfusion fraction (PF)) in the vertebral bone marrow were analyzed for significant differences using Wilcoxon signed-rank test, and for correlations with cumulative effective dose, as well as time interval between the last radiation exposure and follow-up MRI using Spearman's correlation.

RESULTS: Compared to baseline MRI, ADC, D* and PF values decreased on follow-up MRI with statistical significance (p < 0.05). Cumulative effective dose was moderately correlated with decrease in D* (r = 0.434). In addition, longer intervals between the last exposure and follow-up MRI were moderately and negatively correlated with changes in D and ADC (r = −0.352 and −0.333, respectively).

CONCLUSION: Vertebral bone marrow diffusion and perfusion parameters were significantly changed after exposure to radiation.

Figure. A 52-year-old woman with sudden-onset progressive left side weakness and binocular diplopia who was clinically confirmed as having an inflammatory intramedullary spinal cord lesion (case number 5). (A) An intramedullary lesion is located at the C2 to C5 level of the spinal cord on T2 weighted imaging. (B) The lesion shows focal enhancement. (C) FT of the lesion shows bilaterally displaced fibers. (D) After 5 months of steroid pulse therapy, a decreased extent of enhancement is noted on contrast-enhanced T1 weighted imaging.

SS 27 MS-11 17:40
Radiograph-based grading of infrapatellar pad opacity for assessment of knee synovitis: reliability study with contrast-enhanced MRI correlation
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PURPOSE: To determine the reliability of infrapatellar fat pad (IPFP) opacity grading based on lateral knee radiograph for assessment of knee synovitis using correlation with contrast-enhanced (CE) magnetic resonance (MR) imaging.
MATERIALS AND METHODS: Institutional Review Board approval was obtained. Retrospective review of lateral knee radiographs and CE knee MR examinations (time interval, 0–7 days) from 79 patients (M:F = 37:42; mean age, 60.1 years) was performed by two radiologists independently. They evaluated the following grades: (1) IPFP opacity alteration grade (CRIPFP grade 0–3) and joint effusion grade (CREFF grade 1–3) on lateral knee radiograph, (2) IPFP signal alteration grade (MRIPFP grade 0–3) and grade of joint effusion amount (MREF grade 1–3) on CE MR images, (3) individual synovitis grade (MR Syn grade 1–3) at 11 divided sites on CE MR images, and (4) compartments (parapatellar, periligamenous, perimeniscal) MR Syn grade (grade 1–3) and whole-knee MR Syn grade (grade 1–4) by adding individual MR Syn grade. For statistical analysis, the Spearman correlation test and weighted kappa (κ) values were used.

RESULTS: The CRIPFP grade was strongly correlated with the MRIPFP grade (ρ = 0.906), and also with the whole-knee MR Syn grade (ρ = 0.740), suprapatellar MR Syn grade (ρ = 0.708), infrapatellar MR Syn (ρ = 0.726), and the parapatellar MR Syn grades (ρ = 0.718). The CRIPFP grade was moderately correlated with MR Syn grades of the other 9 sites and 2 compartments (ρ = 0.502–0.687). The MRPFP grade was strongly correlated with the whole-knee MR Syn (ρ = 0.748) and the parapatellar MR Syn grades (ρ = 0.739). For CRIPFP grade and MRPFP grade, interobserver reliability were 0.830 and 0.844, respectively. For MR Syn grades of each site and whole-knee, interobserver reliability were 0.730–1.000 and 0.803, respectively.

CONCLUSION: CRIPFP grade enabled reliable evaluation and reporting of the knee synovitis. Especially, both CRIPFP and MRPFP grades were well correlated with the MR Syn grade of the whole-knee and the parapatellar compartment. Grading of IPFP opacity alteration on lateral knee radiograph is a potentially screening and an easy tool to evaluate the severity of knee synovitis.

SS 27 MS-12 17:50
US guided steroid injection for de Quervain’s tenosynovitis: anatomy based approach
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PURPOSE: To suggest different injection techniques based on sonographic findings of the first extensor compartment, and to evaluate usefulness of US guided steroid injection (USI) in patients with de Quervain’s disease.