Degenerative disc disease is a common entity often implicated as a cause of low back pain. This lecture will discuss the pathophysiology of degenerative disc disease and its role in the pathogenesis of low back pain. The concepts of internal disc disruption and discogenic pain will be introduced, as well as a discussion of disc herniations and vertebral endplate abnormalities. The role of various non-invasive and invasive imaging techniques in the assessment of degenerative disc disease will be reviewed, highlighting various diagnostic challenges involved and the significance of common imaging findings.
Seronegative spondyloarthropathies

The pathologic and radiographic abnormalities associated with articular involvement in rheumatoid arthritis and the seronegative spondyloarthropathies (ankylosing spondylitis, psoriatic arthritis, and Reiter's syndrome) are similar in many respects. Involvement of synovial and cartilaginous joints, bursae, tendon sheaths, enthuses, tendon, ligaments, soft tissues and bones can be encountered in any of these disorders. The distribution and extent of abnormalities differ among these diseases. In rheumatoid arthritis, alterations in synovium-lined articulations, bursae, and tendon sheaths frequently overshadow those in cartilaginous joints and sites of tendon and ligament attachment to bone. In ankylosing spondylitis, psoriatic arthritis, and Reiter's syndrome, abnormalities can be severe at cartilaginous articulations, including the discovertebral and manubriosternal joints and symphysis pubis. In addition, in these last three conditions, a peculiar enthesopathy produces bone erosion and proliferation at tendo-osseous junctions.

Hyperparathyroidism

Radiographic features allowing differentiation from rheumatoid arthritis include an ulnar-side erosive distribution, absence of joint space narrowing, marginal bone formation, and relative sparing of proximal interphalangeal joints. Subchondral resorption in hyperparathyroidism, which occurs near the joints, can mimic the periarticular erosion seen in rheumatoid arthritis. However, when present, subchondral resorption is always seen with subperiosteal resorption and does not demonstrate joint space loss, thus allowing for differentiation of hyperparathyroidism from inflammatory arthritis.

Rhupus syndrome

Despite its usual non-erosive nature of joint disease in the systemic lupus erythematosus, some patients develop an erosive form of disease similar to rheumatoid arthritis. The term rhupus has started being employed to describe this condition because, generally, such patients meet simultaneously the criteria for classification of both the systemic lupus erythematosus and rheumatoid arthritis.

Gout

The erosions are characteristic in that they are frequently near a joint but not specifically marginal, and they have sclerotic margins that produce a punched-out appearance. Another clue to the diagnosis of gout is the presence of marked soft tissue swelling from gouty tophi deposition. Gout may also produce soft tissue swelling from bursitis, such as olecranon bursitis. Bilateral olecranon bursitis can be seen in gout, whereas unilateral olecranon bursitis can be seen in the setting of infection process. The most common site for gout involvement is the first metatarsophalangeal joint of the foot. Other joints, such as the interphalangeal joints of the hands and feet are not uncommon. Another characteristic site for gouty erosions is the tarsal bones.

Erosive osteoarthritis

Erosive osteoarthritis is an inflammatory form of osteoarthritis that combines certain clinical manifestations of a synovial inflammatory disease and the radiographic manifestations of osteoarthritis. Erosive osteoarthritis commonly involves the interphalangeal joints of the hand, and osteophytes are quite obvious. Osteophytes that develop at the margins of the joint and central erosion produce gull-wing appearance, although this finding may be seen in other arthritides. This central erosion should not be confused with the marginal erosions of rheumatoid arthritis. Proliferative synovitis is present, and consequent inflammation of the involved joint can result in ankylosis of the interphalangeal joint, not seen in non-inflammatory osteoarthritis.

Amyloidosis

Dialysis-related amyloidosis occurs secondary to the deposition of amyloid fibrils, preferentially in osteoarticular structures, and starts insidiously with chronic arthralgia and periarticular swelling. Joint pain is the most common symptoms, with the shoulder being most frequently affected, followed by the hip, knee, and wrist. MR shows diffuse or focal amyloid deposition within or around the
joint. In the hip, the capsular ligament, especially the iliofemoral ligament thickening is present.

**Behçet’s disease**

Imaging features of the arthritis of Behçet’s disease vary, and they may be rheumatoid-like finding or similar to psoriatic arthritis and Reiter’s syndrome. Erosion of the gull-wing type in the distal interphalangeal joint may be seen in Behçet’s disease.

**Knuckle pads**

Knuckle pads are benign, asymptomatic, well-circumscribed, smooth, firm superficial nodules at the proximal interphalangeal or metacarpophalangeal joints. They are caused by focal fibrous thickening at the proximal interphalangeal or metacarpophalangeal joints. A history of repetitive trauma related to sports or occupation is often present. Radiographs show nodular soft tissue thickening over the proximal interphalangeal or metacarpophalangeal joints. At MR imaging, this condition appears as multiple nodular or cordlike, superficial soft tissue masses.
1. Arthritis in children
- Septic arthritis
- Transient synovitis
- Juvenile Rheumatoid Arthritis (JRA by ACR), Juvenile Chronic Arthritis (JCA by EULAR), Juvenile Idiopathic Arthritis (JIA by ILAR)
  defined as arthritis of unknown cause, with disease duration of more than 6 months, occurring in children under 16 years. All other diseases that cause arthritis need to be considered and excluded (both common and usual) before diagnosis of JIA.
- most common rheumatic entity in childhood with a prevalence of about 20 in 100,000 children (F>M)
  The disease is characterized by chronic synovitis that leads to synovial proliferation, joint effusion, and pain.
  The exact pathogenesis is not fully understood but is thought to include both genetic and environmental components.

2. Juvenile Idiopathic Arthritis (ILAR)
- defined as arthritis of unknown cause, with disease duration of more than 6 months, occurring in children under 16 years. All other diseases that cause arthritis need to be considered and excluded (both common and usual) before diagnosis of JIA.
- most common rheumatic entity in childhood with a prevalence of about 20 in 100,000 children (F>M)
  The disease is characterized by chronic synovitis that leads to synovial proliferation, joint effusion, and pain.
  The exact pathogenesis is not fully understood but is thought to include both genetic and environmental components.

3. Subtypes of JIA
1) Systemic arthritis \((F = M)\)
- Age of onset; Throughout childhood
- Relatively mild arthritis and daily fever plus one or more of the following extra-articular symptoms: characteristic rash, hepatomegaly, splenomegaly, lymphadenopathy, serositis.
- Variable course; 5–8% develop macrophage activation syndrome

2) Oligoarthritis \((F \gg M)\)
- Age of onset; early childhood, peak 2–4 years
- Four or fewer joints involved the first 6 months
- Persistent type, extended type
- Knee, ankle, elbow, wrist

3) Polyarthritis, RF negative \((F = M)\)
- Age of onset; early peak 2–4 years, late peak 6–12 years
- Four or more joints involved within the first 6 months, absence of IgM RF. Heterogeneous disease with three subsets. Prognosis varies with the disease subset

4) Polyarthritis, RF positive \((F \gg M)\)
- Age of onset; late childhood-adolescence
- Four or more joints involved within the first 6 months, IgM RF positive. Resembles adult RA. Involvement of small joints. Progressive and diffuse joint involvement

5) Enthesitis related \((M \gg F)\)
- Age of onset; late childhood-adolescence
- Characterized by enthesitis and arthritis. Often HLA-B27 positive. Commonly hip involvement at presentation. Often a mild and remitting course but may progress with sacroiliac and spinal joint involvement, resembling ankylosing spondylitis

6) Psoriatic \((F = M)\)
- Age of onset; early peak 2-4 years, late peak 9-11 years
- Arthritis and psoriatic rash or psoriasis in close family. Controversial definition, resembles oligoarthritis but more often with dactylitis and involvement of both small and large joints

4. Radiologic findings of JIA
1) Periarticular soft tissue swelling
- Synovitis, tendinitis, bursitis

2) Periarticular bony change
- Bone marrow edema
- Periostitis
- Growth disturbances
  a. Epiphysis; overgrowth, shortening with abnormal articular surface
  b. Metaphysis, diaphysis constriction
- Osteoporosis

3) Destructive change of bone and cartilage
- Epiphyseal compression fracture
- Bone erosion
- Joint space narrowing, bone ankylosis, malalignment

4) Plain radiographs play an important role in the workup, and long-term follow-up in children with JIA, but are not sensitive to findings in the early disease stage. Both US and MRI are more sensitive to inflammatory
changes than clinical assessment alone. Compared to US or plain radiography, MRI is a powerful tool in detecting inflammatory changes in the joint and cartilage damage and is also able to evaluate the later manifestations of JIA, including erosions, loss of joint space, cartilage damage, and ligamentous involvement.

References


Rheumatoid arthritis (RA) is a chronic inflammatory disease characterized by synovial membrane inflammation leading to joint damage. Conventional radiography permits measurement of structural joint damage, which is currently considered the gold standard of treatment efficacy studies in RA, and scoring methods for radiography is used extensively in clinical trials as the primary outcome measure. However, currently established scoring methods, although widely applied, have been associated with several limitations such as restricted generalizability and objectivity due to the difficulty of standardized scoring by different readers with variable experience. To overcome these issues, various software for use in measuring the joint space width has been reported, and this provides a quantitative, reproducible, and more objective measure to assess structural joint damage in patients with RA. To further improve the computer-based analysis of the joint damage of RA patients, we developed and validated a computer-based quantification of joint space width difference using temporal subtraction which can detect slight changes in joint space narrowing (JSN) between two images and display the joint space difference index (JSDI). Positive correlation was found between the difference in joint spaces and the JSDI in phantom study. JSDI of the rheumatoid patients was significantly different between finger joints with and without JSN progression (p < 0.001). The computer-based quantification of joint space width difference using temporal subtraction can recognize the interval difference in finger joint space on radiographs and quantifies its degree objectively.
When I was young, I had a dream to be a baseball player. Although my dream did not come true due to complex reasons, my unaccomplished dream helped me become an orthopedic doctor and be inquisitive about major league baseball. With this context, I introduce former major leaguer pitcher “Kevin Appier” from America. He was a hero of game 6 in the 2004 World Series. After the World Series of 2004, he was forced to trade to the Cardinals. But the Cardinals refused to accept him in the final medical test because an X-ray detected a Bosworth screw inserted into his clavicle and coracoid with some looseness.

Let’s introduce his MLB career briefly. He won 18 games in 1993 and had an earned run average of 2.56 in the American League. He was the Royals Opening Day starter for six straight years. He had a magic ball with incredible movement around the hitting box.

At the end of 1997, he suffered a fall at home resulting in AC dislocation. He underwent modified Bosworth surgery with ligament repair. After that, he started pitching again at exhibition games and surprisingly, he got 2 victories in his 4 starting games. But his pitching speed dropped down to low 80 miles and sooner, MRI detected SLAP and RCT tears. As a consequence, he was forced to quit pitching and underwent additional surgery for SLAP and RCT. But he did not return to his original level of pitching after that and traded to another team sooner.

With his short story, we speculated that improper AC treatment or unrythymical AC movement might lead to scapular malposition at rest followed by scapular dyskinesis during shoulder motion.

The scapula is the origin of rotator cuff and 9 other muscles that do a variety of work to shrug shoulders, move upper arm. The scapula has one attachment to clavicle which provides the only solid bony attachment of hand, forearm, and shoulder to trunk. The clavicle has support from a number of muscles that help hold and stabilize the scapula on the posterior rib cage. The professional baseball players with shoulder pain often have a greatly decreased range of motion in internal rotation of the throwing shoulder. They linked the decrease in internal rotation with an increase in external rotation and tightening of part of the shoulder capsule. The tightening of the posterior shoulder capsule actually changes the axis of rotation of the shoulder, allowing for the increase in external rotation and decrease in internal rotation. This change in the axis of rotation and resulting increase in external rotation provides an opportunity for the development of a SLAP lesion.

The change in position also causes another change in the axis of rotation of the scapula resulting in impingement of rotator cuff against posterolateral glenoid edge. This type of impingement, which is called “internal impingement” is mostly found in ABER motion of humerus.

Similar phenomenon can be seen in the computer worker, the recreational athlete, and the elderly who commonly have a protracted scapula.

Altered glenoid version as a result of scapular protraction, induces posterosuperior internal impingement even while performing simple abduction tasks. This implies that posterosuperior internal impingement due to scapular protraction might be one of the initiating factors of SLAP lesions and rotator cuff tear in nonthrowing shoulder, when contact is magnified both in intensity and frequency.

Treatment

The best treatment for impingement and resulting small sized rotator cuff or SLAP lesions are physical
rehabilitation. Stretching the posterior shoulder capsule, strengthening the muscles, and stretching/relaxing the tight muscles that pull the scapula into a different position. Building a surgical strategy in large sized rotator cuff tear is challenging because of its different level of chronicity including inelastic poor quality of tendon tissue, retraction, muscle atrophy, and fatty infiltration. Another factors such as recent episode of trauma, patient expectation for surgical outcome and kinematic adaptation to long term rotator cuff deficiency can influence the determination of the repair technique.

Surgical strategy

Biomechanical perspective
- Balancing the disrupted force-couples

- Restoring and strengthening transverse and coronal force-couples:
The rotator cuff musculature acts as a dynamic stabilizer to the glenohumeral joint, centering the humeral head on the glenoid.
- Filling the acromial humeral space at rest: Centering the humeral head by being occupied with tendinous dimension in acromiohumeral space.

Biological goal
- Providing maximal contact between tendon and footprint: higher chance of healing between two structures.
- Developing the scaffolds by adding biological patch on footprint

Means of fixation
1. Partial repair
The goal of the partial rotator cuff repair is to reconstruct the posterior part of the rotator cuff and restore the force couple between the subscapularis anteriorly and the infraspinatus and teres minor posteriorly
- Indicated in poor tissue quality, tendon loss, severe tendon retraction and limited functional demands
- Theoretically effective in improving the mechanical advantage of the rotator cuff by restoring the balance of transverse force couples without repairing supraspinatus
- High re-tear rate of 41.7% due to biomechanically higher tension in upmost repair site

2. Partial repair with patch graf
- Repair with acellular dermal patch - Favorable biomechanical properties and possible enhancement of tissue healing potential
- Indicated in young patient with adequate tendon and muscle quality
- It can be performed by both open and arthroscopic approaches.

![A) Schematic illustration of the allograft fascia lata patch
B) Arthroscopic demonstration](image)

3. Complete repair
Tears with extensive retraction often do not allow complete repair since it is not possible to mobilize the superior part of the rotator cuff adequately to accomplish a tension-free repair. In this circumstance, the interval slide including capsular release is amenable to complete repair but remains questionable benefit of force-couples because connections between tendons might be indivisible structures under compensatory rotator cuff mechanics
- Majority of large or massive rotator cuff tears can be achievable to double-row suture anchor repair although it is usually technically demanding
- Single row repair is recommend for the cases if the ability to mobilize the infraspinatus is limited by the loss of plasticity in the muscle and the degree of retraction or degree of tendon loss does not enable a footprint reconstruction with tension-free
- Double row fixation offers more benefit on healing and fixation strength of tendon, especially all cuff components are mobile enough or evident in recent traumatic rupture.
- However, even if a direct repair of tendon to bone is achievable, it is often difficult to reliably achieve long-term healing with a structurally intact repair because re-tear rate is distinctly higher than that associated with smaller tears.

![A) Single row repair illustration
B) Double row repair illustration](image)
Conclusion

All of shoulder joint and structure is linked organically. So, if it cannot maintain balance, it may lead to various shoulder problem like rotator cuff tear, SLAP, impingement, dyskinesis, labral injury. Most important thing in treatment is correct understanding of shoulder anatomy and maintain the balance through adequate posture and exercise.
Shoulder MR arthrography: a practical approach

Bruce B. Forster

University of British Columbia, Canada. bruce.forster@vch.ca

Goals and Objectives

1. Review indications and technique of shoulder MR arthrography (MRA)
2. Appreciate normal anatomy and variants of the labro-ligamentous complex.
3. Develop an approach to interpreting shoulder MRA and understand Bankart and SLAP lesions, their variants and mimics.

Shoulder MR arthrography (MRA) remains the reference imaging standard for assessment of the labro-ligamentous complex, but is complicated by many abbreviations and classification schemes. This presentation will first discuss the evidence-based indications, including the effect of patient age, and briefly review technique, imaging sequences and normal anatomy. However the majority of the session will illustrate common shoulder labro-ligamentous pathology, whilst proposing five easy steps for shoulder MRA interpretation.
Elbow fractures account for about 7% of all fractures. Plain radiography has been the mainstay for initial evaluation of the injury, and often their complexity and clinical significance go unrecognized.

1. Distal humerus fracture
Distal humerus fractures account for 2% of all fractures and exhibit a bimodal age distribution (12–19 years and over 80 years). In children, fracture of the humerus accounts for approximately 80% of elbow fractures. The distal humerus has been described as having two columns (medial and lateral columns) with bicolumn fractures being more common. Injury mechanisms include a direct elbow impact with resultant axial loading of the humerus during flexion of various degrees, as well as a FOOSH. The AO-ASIF system, which emphasizes articular and columnar involvement, is considered to enable more precise and reproducible classification with a potentially greater predictive benefit. Reporting the salient radiographic findings that guide treatment including column involvement, the direction and degree of displacement of epicondylar avulsion fractures and single-column fractures, and the presence of comminution or two-column injury are important. Inclusion criteria for surgical treatment include displaced epicondylar avulsion, displaced single-column fracture, and two-column fracture.

2. Medial epicondyle fracture
The mechanism of injury is avulsion injury from either valgus stress with fall on an outstretched arm. The medial epicondyle often gets trapped within the elbow joint.

3. Radius
Radial head and neck fracture account for 33–50% of elbow fractures and this is the most common elbow fractures in adults. FOOSH-type injury mechanism results from axial loading during forearm pronation with extension or relative flexion of 0°–80° and this causes the radial head to forcefully impact the capitellum of the humerus. The Mason-Johnston system is the one most commonly referenced in the literature. Surgery is usually recommended for type III and type IV injury with type II fractures that do not respond to conservative treatment.

4. Coronoid process fracture
Coronoid process resists varus stress. The mechanism of fracture is thought to relate to axial loading translating into shear stress on the coronoid process. Most coronoid process fractures occur in the context of elbow dislocation and are associated with comminuted proximal ulna fractures and radial head fractures. Fractures are associated with elbow instability and are difficult to treat.

II. Forearm
1. Monteggia fractures
Monteggia fractures reflect injury patterns that include ulnar fracture and radiocapitellar joint dislocation. Mechanisms of injury are direct blow to the ulna, or FOOSH with the forearm in pronation or hyperextension. Monteggia injuries are classified within the Bado system. Children tend to get injuries with anterior dislocation while adults tend to get posterior dislocation. All adult Monteggia fractures, and type 2–4 in children are treated surgically.

2. Essex–Lopresti Fracture–Dislocation
Dislocation of the distal radioulnar joint with an associated comminuted radial head fracture and interosseous membrane disruption. Mechanism is usually due to high-energy fall onto an outstretched hand. These nearly always require surgical treatment.
Goals and Objectives

1. Demonstrate an understanding of the technical and procedure-related considerations in MR imaging of the elbow.
2. Identify the normal anatomic structures within the four compartments of the elbow.
3. Diagnose common sports injuries of the elbow, using this compartmental approach.

The elbow is commonly injured in sports such as golf and judo, but especially in those involving throwing, such as baseball, javelin and cricket. This presentation will demonstrate the value of knowing compartmental anatomy and variants, and will review common pathologies such as common flexor and extensor tendinopathy, partial and full thickness tears of the UCL, including the reconstructed ligament, RCL, and lateral UCL. Triceps and bicipital tendon tears will be illustrated. Technique for MR arthrography, and the most clinically useful sequences will be delineated.
Evaluation of shoulder pathology: 3D enhanced T1-high resolution isotropic volume excitation MR versus 2D fast spin echo T2 fat saturation MR

Myung Sub Kim, Su Kim, Hee Jin Park
Kangbuk Samsung Hospital, Korea.
parkhiji@gmail.com

PURPOSE: To evaluate the diagnostic accuracy of three-dimensional (3D) enhanced T1-high resolution isotropic volume excitation (eTHRIVE) shoulder MR for the detection of rotator cuff tears, labral lesions, and calcific tendinitis of the rotator cuff in comparison to two-dimensional (2D) fast spin echo T2 fat saturation MR (T2 FS).

MATERIALS AND METHODS: This retrospective study included 73 patients who underwent shoulder MRI using the eTHRIVE technique. Shoulder MR images were interpreted separately by two radiologists. They evaluated anatomic identification and image quality of the shoulder joint on routine MR imaging sequences (axial and oblique coronal T2 FS images) and compared them to the reformatted eTHRIVE images. The images were scored on a four-point scale (0, poor; 1, questionable; 2, adequate; 3, excellent) according to the degree of homogeneous and sufficient fat saturation to penetrate bone and soft tissue, visualization of the glenoid labrum, and distinction of the supraspinatus tendon (SST). The diagnostic accuracy of eTHRIVE images compared to routine MR imaging sequences was evaluated in the setting of rotator cuff tears, glenoid labral injuries, and calcific tendinitis of the SST.

RESULTS: Fat saturation scores for eTHRIVE were significantly higher than those of the T2 FS for both radiologists. The sensitivity and accuracy of the T2 FS in diagnosing rotor cuff tears were greater than 90%, whereas sensitivity and accuracy of the eTHRIVE method were significantly lower. The sensitivity, specificity, and accuracy of both images in diagnosing labral injuries and calcific tendinitis were similar and showed no significant differences. The specificity of both images for the diagnosis of labral injuries and calcific tendinitis was higher than the sensitivities.

CONCLUSION: The accuracy of 3D eTHRIVE imaging was comparable to that of 2D FSE T2 FS for the diagnosis of glenoid labral injury and calcific tendinitis of SST. The 3D eTHRIVE technique was superior to 2D FSE T2 FS in terms of fat saturation. Overall, 3D eTHRIVE was inferior to T2FS in the evaluation of rotator cuff tears because of poor contrast between joint fluid and tendons.
Comparison of indirect MR arthrography and noncontrast MRI for the diagnosis of rotator cuff tears

Ji Hyun Lee, Young Cheol Yoon, Soyi Kwon
Samsung Medical Center, Korea.
youngcheol.yoon@gmail.com

PURPOSE: To compare the accuracy of indirect magnetic resonance arthrography and noncontrast magnetic resonance imaging for diagnosing rotator cuff tears.

MATERIALS AND METHODS: In total, 333 patients who underwent noncontrast magnetic resonance imaging or indirect magnetic resonance arthrography were assigned into groups A and B, respectively. Sensitivity for diagnosing articular-surface partial-thickness supraspinatus-infraspinatus and subscapularis tendon tears. The overall diagnostic performance was calculated using the arthroscopic findings as the reference standard. Statistical differences between the diagnostic performances of the two methods were analyzed.

RESULTS: Ninety-six and 237 patients who underwent noncontrast magnetic resonance imaging and indirect magnetic resonance arthrography were assigned into groups A and B, respectively. Sensitivity for diagnosing subscapularis tendon tear was slightly higher in group B than in group A. Statistical significance was confirmed by multivariate analysis using the generalized estimating equation (p = 0.046). The specificity for diagnosing subscapularis tendon tear (68% vs. 85%, p = 0.012) and grading accuracy (40% vs. 57%, p = 0.005) was higher in group B than in group A; the differences were statistically significant for one out of two readers. Univariate analysis using the generalized estimating equation showed that the accuracy for diagnosing subscapularis tendon tear in group B was higher than in group A (p = 0.042). There were no statistically significant differences between diagnostic performances of both methods for any other parameters.

CONCLUSION: Indirect magnetic resonance arthrography may facilitate more accurate diagnosis and grading of subscapularis tendon tears compared with noncontrast magnetic resonance imaging.

Actual measurement value in subacromial impingement: comparison with tomosynthesis and plain radiography

Yoonah Song, Seunghun Lee, Bong Gun Lee,
Young Bin Joo
Hanyang University Medical Center, Korea.
radsh@hanyang.ac.kr

PURPOSE: To evaluate acromio-humeral distance (AHD) in patients with subacromial impingement using a new modality, tomosynthesis.

MATERIALS AND METHODS: The study was approved by the Institutional Review Board, and informed consent was waived. 77 patients with clinically suspected subacromial impingement (M:F = 36:41; mean age, 60 years; range, 40–72 years) and 11 healthy volunteers (M:F = 6:5; mean age, 32.3 years; range, 25–41 years) were included in this study. They underwent radiography, tomosynthesis, dynamic ultrasound (US), computed tomography (CT), magnetic resonance imaging (MRI) and physical examination of the most symptomatic shoulder on the same day. Two musculoskeletal radiologists independently analyzed images from variable modalities. We divided the subacromial distance as three compartments (anterior, middle, and posterior). Each AHD was measured on anteroposterior radiography, and tomosynthesis in standing position. And it was measured on CT, and MRI in supine position. Symptomatic 77 patients were correlated imaging findings with shoulder arthroscopy. Dynamic US was performed in healthy volunteers whether subacromial impingement or not.

RESULTS: In whole group, middle AHD showed the smallest diameter. AHD measurements of radiography and tomosynthesis showed excellent interobserver and intraobserver agreement (concordance correlation coefficient = 0.928 and 0.985). There was significant differences between radiographic AHD and anterior and middle AHD of tomosynthesis (p = 0.04). Other statistical data analysis revealed no significant correlation between radiography and tomosynthesis (p > 0.05). On the other hand, after correction of the patient’s age, the areas under the ROC curve (AUC) increased from 0.470 to 0.803.

CONCLUSION: AHD measurement using tomosynthesis in subacromial impingement is feasible. Unlike CT or MRI, tomosynthetic AHD measurement may be more meaningful to that found in terms of weight-bearing method.
RESULTS: Mean total time for performing additional series in ABER position (patient repositioning, localization and scanning sequences) was 12:15 minutes (SD ± 3:09 minutes). In 22 patients there was a benefit from additional ABER series concerning questions of the capsulolabral complex. In 4 cases there was benefit concerning pathologies of the rotator cuff. In another 4 cases there was diagnostic benefit regarding instability; in these patients ABER position led to subluxation which was not clinically evident before. As one patient could have more than one pathology, overall 24 of 42 patients (59%) had diagnostic benefit from additional ABER series.

CONCLUSION: In patients with suspected tear of the anteroinferior labroligamentous complex or tear of the rotator cuff additional series in ABER position should be performed, especially if there is no evidence seen on conventional MR arthrography.

CLINICAL RELEVANCE/APPLICATION: In all patients with suspected tear of the anteroinferior labroligamentous complex or tear of the rotator cuff additional ABER series should be performed, especially in the light of only moderate increase in examination time.

SS 06 MS-06
10:30
Disproportionate fluid sign: usefulness in diagnosis of high grade bursal-sided supraspinatus tendon tear misinterpreted as full-thickness tear
Seonji Jeong, Ja-Young Choi, Hye Jin Yoo, Yu Suhn Kang, Sae Hoon Kim, Sung Hwan Hong
Seoul National University Hospital, Korea.

PURPOSE: To determine the value of the disproportionate fluid sign for differentiating high-grade bursal-sided rotator cuff tears from full-thickness tears on conventional MRI.

MATERIALS AND METHODS: Preoperative shoulder MRI of 231 patients with arthroscopically confirmed high-grade bursal-sided tears and full-thickness tears were reviewed by two readers independently 4 weeks apart for the presence of high-grade bursal-sided tear by using tear depth alone and in combination with disproportionate fluid sign defined as the prominent subdeltidoid or subacromial-subdeltoid bursal fluid distension with a relative paucity of effusion in the glenohumeral joint. The sensitivity, specificity, accuracy, and the area under the receiver operating characteristic curve (AUCs) were calculated. Inter/intra-observer reliability was calculated.

RESULTS: For each reader, the sensitivity and accuracy of the diagnosis of high grade bursal-sided tear were significantly higher in combination with disproportionate fluid sign compared with using tear depth alone (p < 0.001). Interobserver agreement was excellent (κ = 0.832, p < 0.001). The AUCs were significantly higher in combination with the disproportionate fluid sign (reader 1: 0.859 to 0.936, p = 0.003; reader 2: 0.943 to 0.974, p = 0.032).

CONCLUSION: The disproportionate fluid sign could be an indication of the presence of a very high-grade bursal-sided tear misinterpreted as a full-thickness tear, and it significantly improved the diagnostic performance, being especially helpful for less experienced radiologists and orthopedic surgeons.

SS 06 MS-07
10:40
Pisotriquetral instability: assessment with 3D dual echo steady state (DESS)
Hee Dong Chae, Hye Jin Yoo, Ja-Young Choi, Hye Yeon Oh, Sung Hwan Hong
Seoul National University Hospital, Korea.
dairana3@gmail.com

PURPOSE: To determine if there is an association between pisotriquetral (PT) instability and trauma history or internal derangements of the carpal joint by using three-dimensional (3D) dual echo steady state (DESS).

MATERIALS AND METHODS: We evaluated 44 patients with distal radius fracture (patient) and other 44 patients without previous trauma history (control), who underwent 3T magnetic resonance (MR) imaging including 3D DESS sequence. To analyze PT instability, three parameters were measured on axial and sagittal images by two blinded-readers, independently: PT interval, PT angle and pisiform translation relative to triquetrum. The MR appearances of PT joint and ulnar-sided structures were also evaluated. The associations between PT instability and distal radius fracture, abnormality of ulnar-sided structures or osteoarthritic features of PT joint were calculated.

RESULTS: PT instability parameters measured by two radiologists showed good or excellent agreement (ICC = 0.628–0.965). Proximal translation of pisiform in relation to triquetrum was reduced in the patients with distal radius fracture (p = 0.028). However, there was no difference of other instability parameters between the two groups. ECU tendinopathy was associated with larger PT interval (p = 0.01) and with wider opening of sagittal PT angle (p = 0.021). Triangular ligament tear was also related to reduced proximal translation of pisiform (p = 0.031). Osteoarthritic features of PT joint and triangular fibrocartilage tear were not associated with PT instability.

CONCLUSION: Only pisiform translation was associated with distal radius fracture. Other instability parameters were not affected by distal radius fracture. ECU tendinopathy and triangular ligament tear were associated with PT instability.

SS 06 MS-08
10:50
Clinical significance of postoperative capsulitis of the shoulder on MRI
Jina Kim, Soon Tae Kwon, Kyung Cheon Kim
Chungnam National University Hospital, Korea.
stkwon@cnu.ac.kr

PURPOSE: To evaluated the clinical significance of postoperative capsulitis of the shoulder on MRI.

MATERIALS AND METHODS: Preoperative and postoperative MR images of 110 patients (M:F = 53:57; mean age, 57 years) underwent rotator cuff repair were enrolled. The T2 signal intensity and the thickness of articular capsule at the axillary pouch, the presence of the signal change of the subcoracoid fat, and the thickness of the coracohumeral ligament (CHL) and interval capsule (RIC) were analyzed in consensus by two readers. Clinical exam was assessed on same day underwent
Magnetic resonance (MR) imaging is fluoroscopy-guided shoulder arthrography (posterior and rotator interval approaches) of comparison between three techniques (anterior, at the axilla (65% vs. 57% improvement as measured by reduced in patients without T2 hyperintensity of capsule vs. 38 degrees, L2 vs. T12, p > 0.05). The pain was limited than that in patients with T2 hyperintensity of capsule at the axilla, and RIC on preoperative and postoperative MRI were 1.9 mm and 1.8 mm, 2.1 mm and 1.9 mm, respectively. In patients with T2 hyperintensity of capsule at the axilla, external rotation, internal rotation were limited than that in patients without T2 hyperintensity of the capsule (3.0 mm vs. 2.2 mm). Signal change of the subcoracoid fat before surgery as shown in 8 patients and newly developed signal change was shown in 18 patients. 13 of 70 patients with T2 hyperintensity of capsule at the axilla showed signal change of subcoracoid fat. Mean thickness of CHL and RIC on preoperative and postoperative MRI were 1.9 mm and 1.8 mm, 2.1 mm and 1.9 mm, respectively. In patients with T2 hyperintensity of capsule at the axilla, external rotation, internal rotation were limited than that in patients without T2 hyperintensity of capsule (34 degrees vs. 38 degrees, L2 vs. T12, p > 0.05). The pain was reduced in patients without T2 hyperintensity of capsule at the axilla (65% vs. 57% improvement as measured by the VAS, p > 0.05).

CONCLUSION: T2 hyperintensity and increased thickness of articular capsule at the axillary pouch are common postoperative MRI findings. Such changes are not related with the limitation of motion of the shoulder and the improvement of pain after surgery.

RESULTS: Excluding 1 case without data, total 101 patients were evaluated. Majority of patients was performed by 1-experience year radiologists (80 cases). There were only 6 failure cases in which 2 with anterior and 4 with posterior glenohumeral joint approaches without a difference between three techniques (p = 0.065). Number of puncture showed a range of 1–5 times without a difference according to the technique (p = 0.093). Average DAP was 943.74 Gy cm², without a significant difference (p = 0.440). However, procedure time of posterior glenohumeral joint approach was significantly long (mean, 95.79 seconds; range, 6–330 seconds), compared to others (p = 0.000). There was only one case with persistent pain at puncture site immediately after procedure using posterior glenohumeral joint approach.

CONCLUSION: All three techniques for fluoroscopy-guided shoulder arthrography are safe and easy without significant immediate side effect, in which posterior glenohumeral joint approach may need to more procedure time.

**SS 13 MS-01**
16:00

**Comprehensive assessment of acute ankle syndesmosis injury with 3D isotropic turbo spin-echo sequence-diagnostic performance compared with that of conventional and oblique MR imaging at 3.0T**

Minchul Kim, Yun Sun Choi, Min Sun Jeong, Jin Su Kim, Ki Won Young
Eulji Hospital, Eulji University, Korea

cys0128@eulji.ac.kr

**BACKGROUND:** Magnetic resonance (MR) imaging is an excellent tool in diagnosing injuries of the ligaments in ankle joint. However, additional 45° oblique plane imaging is needed to provide more accurate detection of syndesmosis injury of ankle.

**PURPOSE:** To compare the diagnostic performance of a 45° oblique 3D isotropic fat-suppressed (FS) turbo spine-echo sequence (TSE-SPACE) MRI in diagnosing ankle syndesmosis injury with that of conventional 2D and 45° oblique PD images at 3.0T.

**MATERIALS AND METHODS:** 50 patients (mean age, 34.5 years) underwent preoperative ankle MRI with subsequent ankle surgery were enrolled. Two readers evaluated the integrity of the ankle syndesmosis (AITFL, IOL, PITFL) using three sets of MR images (method 1: conventional 2D images with axial, coronal and sagittal sequences; method 2: 45° oblique plane PD TSE sequence; method 3: 45° oblique 3D isotropic FS PD TSE sequence). The integrity of the each ligament was...
classified as full thickness and partial thickness tears). The diagnostic efficacies of three methods for tears of the ankle syndesmosis ligaments were analyzed using arthroscopy as a reference standard.

**RESULTS:** Arthroscopy revealed 37 full-thickness tears and 2 partial thickness tears of ATFL, and 15 tears of IOL. No significant PIFTL tear was detected. For full-thickness and partial-thickness tears together, the mean sensitivity, specificity, and accuracy were 94, 63, and 78% on method 1, 99, 95, and 97% method 2 and 99, 93, and 96% method 3. Diagnostic performances of method 2 and 3 for syndesmosis tear were excellent, and method 1 was good. There was no statistical difference in the sensitivity and specificity between oblique PD sequence and 3D TSE-SPACE. Interobserver agreements were almost perfect for method 1 (k = 0.93), method 2 (k = 0.99) and method 3 (k = 0.98), respectively.

**CONCLUSION:** 45° oblique 3D TSE MR imaging showed comparable performance in diagnosing distal syndesmosis injury to 45° oblique plane PD imaging and was closer to diagnosis than conventional 2D sequences.

**SS 13 MS-02 16:10**

**Ankle joint: comprehensive assessment with 3D isotropic resolution fast spin-echo MR imaging-diagnostic performance compared with that of conventional MR imaging at 3.0T**

Jisook Yi, Jang Gyu Cha, Young Koo Lee

Soonchunhyang University Bucheon Hospital, Korea.
mj4907@schmc.ac.kr

**PURPOSE:** To determine the accuracy of a three-dimensional (3D) isotropic T2-weighted fast spin-echo (FSE) magnetic resonance (MR) sequence as compared with a conventional two-dimensional (2D) sequence in the diagnosis of anterior talofibular ligament (ATFL) tear, osteochondral lesion of talus (OLT), and os subfibulare/avulsion fracture of distal fibula (OSF).

**MATERIALS AND METHODS:** Between November 2013 and July 2014, thirty-five patients who had undergone ankle MRI with the 2D T2-weighted FSE sequence and the 3D isotropic T2-weighted FSE sequence and subsequent ankle arthroscopy were included. Each MR imaging sequence was independently scored by two readers retrospectively for the presence of complete or partial tear of ATFL, OLT and OSF. Diagnostic performance based on each sequence type was compared by the area under the receiver operating characteristic curve (AUC). Interobserver agreement was expressed as unweighted kappa value.

**RESULTS:** Arthroscopic findings enabled confirmation of the presence of 21 complete tear of ATFL, 14 partial tear of ATFL, 17 OLT, and 7 OSF. The AUCs for the readers using the 3D T2-weighted FSE sequence versus those obtained with the 2D sequence were fair versus moderate for ATFL tear, substantial versus moderate for OLT, and substantial versus substantial for OSF.

**CONCLUSION:** The accuracy of 3D isotropic FSE MRI may be comparable with that of conventional 2D MRI in the diagnosis of ATFL tears, OLT and OSF with a shorter imaging time.

**CLINICAL RELEVANCE/APPLICATION:** Three-dimensional isotropic T2-weighted FSE MRI of the ankle shows similar accuracy as more conventional imaging in the evaluation of ATFL tears, OLT and OSF of the ankle, with a faster imaging time.

**SS 13 MS-03 16:20**

**T2 values of femoral cartilage in porcine knee joint: comparison between fat-saturated T2 mapping and conventional T2 mapping**

Youngjin Ryu¹, Sung Hwan Hong¹, Hyoejin Kim¹, Ja-Young Choi¹, Hye Jin Yoo¹, Yusuhn Kang²

¹Seoul National University Hospital, ²Seoul National University Bundang Hospital, Korea.
dhong@snu.ac.kr

**PURPOSE:** To investigate reliability of fat-saturated (FS) T2 mapping of the articular cartilage for the elimination of chemical shift artifact.

**MATERIALS AND METHODS:** Eleven porcine knee joints were harvested en bloc with intact capsules and surrounding muscles. We performed FS T2 (FST2) and conventional T2 (cT2) mapping in sagittal plane with two frequency encoding directions: from superior to inferior (SI) and from inferior to superior (IS). Consequently, four types of T2 map were obtained: FST2-SI, FST2-IS, cT2-SI and cT2-IS. Two radiologists independently measured T2 values of the medial femoral condylar cartilage for four region-of-interest (ROI). In addition, depth-normalized line profiles for T2 values for each ROI were generated from cartilage/bone interface to cartilage surface.

**RESULTS:** Mean T2 value on FST2 mapping was significantly lower than that on cT2 mapping (97 ± 31 vs. 145 ± 84, p < 0.001). There was no significant difference of mean T2 values between FST2-SI and FST2-IS (96 ± 27 vs. 99 ± 36, p = 0.555). Mean T2 value of cT2-SI was, however, significant lower than that of cT2-IS (113 ± 28 vs. 178 ± 107, p < 0.001). There was a strong positive correlation between T2 values of FST2-SI and FST2-IS (rho-Pearson = 0.536), whereas T2 values between cT2-SI and cT2-IS showed weak positive correlation (rho-Pearson = 0.171). The 95% confidence interval was narrower between FST2-SI and FST2-IS than that between cT2-SI and cT2-IS (121.5 vs. 415.1). The interobserver reliability was almost perfect in all the four mappings (ICC range 0.942–0.989). Nevertheless, the 95% confidence interval of interobserver agreement was narrower between the two FS T2 mappings than that between the two conventional T2 mappings (21.0 vs. 78.1).

**CONCLUSION:** FST2 mapping of femoral condylar cartilage revealed higher reliability than cT2 mapping by reducing chemical shift artifact.
**T2 relaxation value of knee articular cartilage: six-month follow up after anterior cruciate ligament reconstruction**

Young Cheol Yoon, Soyi Kwon

*Samsung Medical Center, Korea.*
youngcheol.yoon@gmail.com

**PURPOSE:** To evaluate changes of T2 RV after injury and after double-bundle ACL reconstruction, and to correlate the changes of T2 RV to the meniscal status and other clinical information.

**MATERIALS AND METHODS:** Twenty-seven patients (M:F = 22:5; mean age, 28.56 ± 5.44) who underwent ACL reconstruction surgery using double bundle technique and had MR images obtained before and about six months after surgery were enrolled. Twenty-seven age, sex, and BMI matched subjects served as control group. T2 RV between control group and pre-operative MRI, T2 RV between pre-operative and post-operative MRI were compared. T2 RV change ratio between pre-operative and post-operative MRI was correlated to meniscal status and clinical findings.

**RESULTS:** T2 RV of pre-operative MRI significantly increased compared to that of control group in 4 compartments (MTP superficial, p = 0.0203; PMF superficial, p = 0.0072; PLF deep, p = 0.0051; PLF superficial, p = 0.0002) after adjusting for age, sex, knee laterality, and BMI. T2 RVs of post-operative MRI of 7 compartments were significantly higher than those of pre-operative MRI (MFP superficial, p = 0.045; MTA deep, p = 0.0103; MTC deep, p = 0.0038; LFA deep, p = 0.0020; LFA superficial, p = 0.0390; LFC superficial, p = 0.0081; PMF deep, p = 0.0392). Significant positive correlations of the change-ratio of pre- and post-operative T2 RVs were observed to injury-MRI interval in the posterior medial femur area ($r_s = 0.460$, $p = 0.0159$), to post-operative Lysholm score in the posterior lateral femur area ($r_s = 0.515$, $p = 0.0059$), and to the difference in anterior instability between injured and un-injured knee measured by KT-2000 arthrometer in the posterior medial femur ($r_s = 0.435$, $p = 0.233$). There was no significant correlation between meniscal status and change-ratio of pre- and post-operative T2 RVs of 6 areas. Inter- and intra-observer agreement of T2 RV measurement was moderate to excellent.

**CONCLUSION:** T2 RVs of tibiofemoral articular cartilage about six-month after anterior cruciate ligament reconstruction using double bundle technique are mainly increased in deep layers of both medial and lateral femoral condyles and medial tibial plateau. Such alteration was correlated to clinical scores and remaining instability at femoral posterior grooves.

**The wrisberg sign on MRI for PCL injury with arthroscopic correlation**

Jisook Yi¹, Jang Gyu Cha¹, Young Cheol Yoon², Jisun Hwang³

¹Soonchunhyang University Bucheon Hospital, ²Samsung Medical Center, Korea.

**PURPOSE:** The purpose of this article is to determine whether wrisberg signs on MRI are a marker for high grade (grade III) posterior cruciate ligament (PCL) instability.

**MATERIALS AND METHODS:** The study included 30 patients who had a knee injury and underwent both intra-operative posterior drawer test and arthroscopic surgery, between January 2011 and December 2014. All patients underwent 3-T MRI for the diagnosis of PCL injury. If MRI revealed ligament complete disruption (criterion 1) or adding the wrisberg sign to criterion 1 (criterion 2), the injury was considered to be high grade PCL instability. After MRI, knee arthroscopy was performed in all patients for a definitive diagnosis. MRI scans were independently reviewed by two experienced musculoskeletal radiologists (with 13 and 1 years of experience, respectively), who were blinded to the patients’ histories, outcomes, and operative findings. Receiver-operating characteristic (ROC) curves were plotted to estimate their diagnostic performance in detecting PCL instability. Interobserver agreement was expressed as unweighted kappa value.

**RESULTS:** Arthroscopy showed PCL complete disruption in 29 patients (intraoperative posterior drawer test, grade III) and partial tear in 1 patient (intraoperative posterior drawer test, grade II). When the MRI diagnosis was based on criterion 1, high grade PCL instability was diagnosed with a sensitivity of 20.7% and an accuracy of 23.3% in both of two readers. When the MRI diagnosis was based on both criteria 1 and 2, high grade PCL instability was diagnosed with a sensitivity of 73.3% and an accuracy of 72.4% in both readers. By adding wrisberg sign to the criterion 1 (criterion 2), 15 additional patients with high grade PCL instability were diagnosed, most of whom exhibited a complete tear of PCL on arthroscopy and grade III on posterior drawer test. Significantly higher AUC for detecting PCL instability when criterion 2 was added to the diagnosis compared with criterion 1 in both readers ($p < 0.05$). The interobserver agreement rate for PCL instability using criterion 1 and criterion 2 were fair ($k = 0.38$) and substantial ($k = 0.68$), respectively.

**CONCLUSION:** Whether partial or complete disruption of PCL on MRI, the morphological feature of wrisberg liga-ment embedded in the PCL (wrisberg sign) may assist to anticipate the high grade instability of PCL.
**SS 13 MS-06** 16:50 English

Comparison between 1.5T and 3.0T MR imaging of the oblique sagittal and oblique coronal planes of the knee in the evaluation of selective bundle injury of the anterior cruciate ligament

Hee Jin Park, Gyu Hong Lee, Mi Jeon Kangbuk Samsung Hospital, Korea.
parkhiji@gmail.com

**PURPOSE:** To evaluate the diagnostic usefulness of combining oblique sagittal and oblique coronal magnetic resonance imaging (MRI) views of the anterior cruciate ligament (ACL) with traditional orthogonal views for the evaluation of selective bundle ACL injury and to evaluate whether there is a statistical difference in diagnostic ability between 1.5T and 3.0T MRI.

**MATERIALS AND METHODS:** This retrospective study included 114 patients who underwent knee MRI (46 cases on 1.5T and 68 cases on 3.0T) and arthroscopy at our institution. Two radiologists evaluated orthogonal views and ACL views on 1.5T and 3.0T MRI in variable combinations. They diagnosed ACL views as normal, entire ligament tear, anteromedial bundle (AM) tear or posterolateral (PL) bundle tear. The surgeon then confirmed tears in the anteromedial or posterolateral bundle of the ACL arthroscopically, if a selective bundle tear did exist. The arthroscopically-confirmed diagnoses were used as the gold standard. The values were statistically analyzed.

**RESULTS:** Sixty-seven percent of patients showed an ACL tear on arthroscopy while 32% had a selective bundle tear; of these, 75% were AM bundle tears and 25% were PL bundle tears. On 1.5T MR, specificities of each view and combined views were the same (80%). The sensitivities and accuracies of the combined views were higher than the individual views; differences between individual views ranged from 4 percent to 15 percent. Reader 1 saw statistically significant differences between the oblique coronal and combined views. Although the performances of reader 2 showed similar results, the p values exceeded the critical value of statistical significance (0.063). On 3.0T MRI, differences of specificities between the orthogonal and combined views and between the orthogonal and oblique coronal views were statistically significant (p values 0.016 and 0.008, reader 1 and 2). There were no significant differences in the diagnostic performance of 1.5T MR and 3.0T MRI.

**CONCLUSION:** The oblique coronal view and the combination of the orthogonal view and both additional ACL views provide better diagnostic information with an improvement in specificity on 3.0T MR when compared to the orthogonal views alone in the diagnosis of selective bundle tears.

---

**SS 13 MS-07** 17:00 English

Distal semimembranosus abnormality on magnetic resonance (MR) image: capsular instability versus peel-back mechanism

Hyun Seok Shim, Joong Mo Ahn, Yusuhn Kang, Hunchool Lim, Eugene Lee, Joon Woo Lee, Heung Sik Kang

Seoul National University Bundang Hospital, Korea.
joongmoha@gmail.com

**PURPOSE:** To evaluate the signal intensity abnormality of distal semimembranosus tendon attachment at the proximal tibia on MR images and its association with capsular instability and/or peel-back mechanism.

**MATERIALS AND METHODS:** A retrospective study was performed on knee MR images of 185 consecutive patients from May 2014 to May 2015 (M:F = 98:87; mean age ± SD; 45.2 ± 16.7 years). Postoperative studies were excluded. Signal intensity abnormality of the distal semimembranosus tendon was defined as linear or curvilinear hyperintensity on T2-weighted sagittal images at the anterior/direct arm or common tendon of distal semimembranosus. Associated abnormalities were analyzed, including tears of anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), lateral collateral ligament (LCL), popliteus tendon, medial meniscus, lateral meniscus, and bone/chondral lesions.

**RESULTS:** The incidence of signal intensity abnormality of the semimembranosus tendon attachment was 11.4% (21/185). Among the patients with distal semimembranous tendon signal abnormality on MR imaging, 85.7% (18/21) had medial meniscal tears, 52.4% (11/21) had lateral meniscal lesions, 47.6% (10/21) had ACL tears, 38.1% (8/21) had lateral meniscal tears, 33.3% (7/21) had lateral chondral lesions, 19.0% (4/21) had bone contusions, 14.3% (3/21) had popliteus tendon tears, 9.5% (2/21) had PCL tears, 9.5% (2/21) had MCL tears, 4.8% (1/21) had LCL tear, and 4.8% (1/21) had subchondral fracture.

**CONCLUSION:** There appears to be an association between signal intensity abnormality on anterior/direct arm or common tendon of distal semimembranosus and medial meniscus tears, medial chondral lesions, ACL tears, lateral meniscus tears, and lateral chondral lesions in decreasing order of frequency. Capsular instability and/or peel-back mechanism could be proposed as the mechanical etiology of the signal intensity abnormality of the distal semimembranosus tendon.

---

**SS 13 MS-08** 17:10 English

“Patellar maltracking”: MRI spectrum of traumatic and nontraumatic cases

Anindita Sinha, Laxmikant Gupta, Mahesh Prakash, Niranjan Khandelwal

Post Graduate Institute of Medical Education and Research, India.
lkhunk@gmail.com

**PURPOSE:** The patellofemoral joint is a highly complex joint that relies on the patella and femoral trochlea coordination to meet the biomechanical demands of body movement. The joint is stabilized by extensor muscles,
ligament stabilizer (medial patellofemoral ligament and medial retinaculum) and bony stabilizer (high lateral trochlea and deep femoral sulcus). The disruption of the stabilizers can be secondary to trauma or can be nontraumatic including anatomical variation and other factors.

**MATERIALS AND METHODS:** We present 16 cases of patellar instability with 9 cases of traumatic and 7 of nontraumatic instability. Different qualitative and quantitative parameters were assessed for the diagnosis. The qualitative MRI features were disruption of the medial ligament stabilizer, marrow edema of the inferomedial patella and the lateral condyle, osteochondral and cartilage defect of the patella, edema of the vastus medialis oblique muscle and superolateral Hoffa fat pad. Quantitative parameters were used to evaluate trochlear dysplasia, patella alta and lateralization of tibia tuberosity.

**RESULTS:** The mean age of the patients was 22.37 years with male:female ratio of 11:5. Four cases of the nontraumatic instability were involving the bilateral joints. Medial stabilizers injury was seen in 9 patients with 7 cases being traumatic. 9 patients had edema in the lateral femoral condyle and in the inferomedial patella. Patella alta (Insall salvati index >1.3) was seen in 4 patients. 4 patients had lateral inclination angle <11° and 5 patients had the trochlear depth <3 mm suggestive of trochlear dysplasia. Tibial tuberosity and trochlear groove incongruence (TT-TG distance >15 mm) was found in 3 patients. 3 patients had osteochondral defect. Additional findings like condylar fracture and meniscal tear were noted in three patients each. Lipohemarthrosis, bifid patella and dysmorphic trochlea found in one patient each. Two patients with traumatic patellar instability were missed clinically and were diagnosed subsequently on MRI.

**CONCLUSION:** It is important to diagnose patellar maltracking early as it requires nonarthroscopic surgical repair. Early repair prevents chronic healing by fibrosis leading to recurrent instability. MRI is an indispensable tool for the diagnosis of the etiology and effect of the patellar instability. Every radiologist should be aware of the MRI features of the patellar maltracking.

**SS 13 MS-09 17:20**

**Patellofemoral instability (PFI) in children part I: T2 relaxation times of the patellar cartilage in patients with and without PFI, and correlation with morphologic grading of cartilage damage**

Chang Ho Kang1, Hee Kyung Kim2, Dong Hoon Kim3
1Korea University Anam Hospital, Korea. 2Korea University College of Medicine, Asan Medical Center, Korea
3Korea University Anam Hospital, Korea. Cincinnati Children’s Hospital Medical Center, USA. Korea University College of Medicine, Korea.
Hee.Kim@cchmc.org

**PURPOSE:** Patellofemoral instability (PFI) is one of the most common causes of cartilage damage in teenagers. Our purpose was to quantitatively evaluate the patellar cartilage in patients with PFI using T2 relaxation time maps (T2 maps), compare the values to those in subjects without PFI, and correlate them with morphologic grades in subjects with PFI.

**MATERIALS AND METHODS:** 53 patients with PFI (mean age, 15.9 ± 2.4 years) and 53 age and gender matched subjects without PFI were included. Knee MR with axial T2 map was performed. Mean T2 relaxation times were obtained at the medial, central and lateral zones of the patellar cartilage and compared between the two groups. In the PFI group, morphologic grading of the patellar cartilage (0–4) was performed and was correlated with T2 relaxation times.

**RESULTS:** Mean T2 relaxation times were significantly longer in the group with PFI as compared to the control group across the patellar cartilage (Student’s t-test, p value <0.05) with the longest time at the central area. Positive correlation was seen between mean T2 relaxation time and morphologic grading (Pearson correlation coefficient, p < 0.05). T2 increased with severity of morphologic grading from 0 to 3 (Mixed model, p value <0.05), but no statistical difference was seen between grades 3 and 4.

**CONCLUSION:** In PFI, patellar cartilage damage occurs across the entire cartilage with the highest T2 values at the apex. T2 relaxation times directly reflect the severity in low grade cartilage damage, which implies an important role for T2 maps in differentiating between normal and low grade cartilage damage.

**Chairperson(s)**
Wook Jin Kyung Hee University Hospital at GangDong, Korea
Hye Won Chung University of Ulsan College of Medicine, Asan Medical Center, Korea

**SS 13 MS-10 17:30**

**Patellofemoral instability (PFI) in children part II: correlation between risk factors and injury patterns and severity of cartilage damage**

Chang Ho Kang1, Hee Kyung Kim2, Dong Hoon Kim3
1Korea University Anam Hospital, Korea. 2Cincinnati Children’s Hospital Medical Center, USA. Korea University College of Medicine, Korea.
Hee.Kim@cchmc.org

**PURPOSE:** Patellofemoral instability (PFI) is major cause of cartilage damage in teenagers and has characteristic MR findings. The purpose of this study is to compare the MR findings between groups with PFI and without PFI and to correlate the MR findings with the severity of patellar cartilage damage.

**MATERIALS AND METHODS:** Fifty three children with PFI and 53 age and gender matched children without PFI (mean age, 15.9 ± 2.4 years; ranges, 8–21 years) were included. Knee MR with T2 mapping was performed. On MR, evidence of femoral trochlear dysplasia, patellofemoral malalignment, medial retinaculum injury or bone marrow edema was documented. The degree of patellar cartilage damage was evaluated on MR using a morphologic grading scale (0–4) and on T2 mapping with mean T2 values at medial, central and lateral facets. MR findings were compared between the two groups. In the PFI group, MR findings were correlated with the severity of cartilage damage at each region.

**RESULTS:** The trochlear morphology and alignment were significantly different between two groups (Wilcoxon, p < 0.0001). In the group with PFI, a high riding patella was associated with central patellar cartilage damage with higher morphologic grading and T2 value
(Spearman, $p < 0.05$). The severity of medial retinaculum injury and presence of bone marrow edema either at the medial patella or lateral femoral condyle were associated with a higher grade of medial patellar cartilage damage (Wilcoxon, $p < 0.05$). None of the other findings correlated with the severity of patellar cartilage damage.

**CONCLUSION:** Patients with PFI have significantly different trochlear morphology and alignment, which are known risk factors for PFI. However, the only risk factors or injury patterns that directly correlated with the severity of patellar cartilage damage were patella alta, medial stabilizer injury and bone marrow edema.

**SS 13 MS-11 17:40**

**Efficacy of double inversion recovery MR imaging in the evaluation of the synovium without contrast enhancement**

Ye Na Son¹, Wook Jin³, Geon-Ho Jahng¹, Jang Gun Cha¹, Yong Sung Park¹, Hye Soo Koo¹, So Young Park¹, Ji Seon Park², Kyung Nam Ryu² ¹Kyung Hee University Hospital at Gangdong, ²Soonchunhyang University Bucheon Hospital, ³Kyung Hee University Medical Center, Korea.

**PURPOSE:** To investigate the efficacy of double inversion recovery (DIR) in evaluation of the synovium at the knee joint without contrast enhancement.

**MATERIALS AND METHODS:** A total of 26 knees from 25 patients (M:F = 9:16; mean age, 41.7 years) was included in the study. Both MR sequences – contrast-enhanced T1-weighted fat-saturated imaging (CET1FS) and DIR imaging – were performed at all knee MRI. Paired MR images from DIR and CET1FS at each five level were selected for MR evaluation. The visualization and distribution of the synovium on DIR and CET1FS at each level was rated on a four-point visual scale for consistency. This scaling was independently performed by two radiologists. And then, if visual scaling was concordant by two reviewers, the location of the thickest synovium and the maximum synovial thickness on each sequence were evaluated based on the consensus of two reviewers. Also, the synovium-to-effusion signal ratio (SER), the synovium-to-bone signal ratio (SBR), and the CNRs for DIR and CET1FS were assessed at each level. Inter-observer agreement for a four-point scale was assessed by calculating weighted $k$ statistics. Inter-sequence agreement for the location of the thickest synovium on DIR and CET1FS was calculated with McNemar-Bowker test. Paired t-tests were performed for comparison of DIR and CET1FS on the maximum synovial thickness, SER, SBR, and CNRs.

**RESULTS:** The readers demonstrated good inter-observer agreements ($k = 0.708$) for a four-point scale, and there was no difference between the locations of the thickest synovium on DIR and CET1FS images ($p = 0.096$). There were significant differences between thicknesses, SERs, and SBRs for DIR and CET1FS (all $p < 0.000$). The mean thicknesses of the synovium, mean SERs, and mean SBRs were 3.16 mm on DIR and 2.81 mm on CET1FS; 3.52 and 2.17; and 14.75 and 3.90, respectively. However, there were no differences between CNRs of DIR and CET1FS (all $p > 0.05$).

**CONCLUSION:** DIR revealed thicker synovium, higher SER, and higher SBR in knee MR, comparing with those of CET1FS. Also, in the evaluation of the synovium at the knee joint, DIR sequence showed good agreement for visual scaling comparing with CET1FS, and was not inferior to CET1FS. Therefore, DIR may be one of useful MR techniques for evaluating the synovium of the knee joint without contrast enhancement.

**SS 13 MS-12 17:50**

**Focal defect at the lateral patellar retinaculum on knee MRI: a normal variant or pathologic lesion?**

Ji Su Kim¹, Wook Jin¹, Gou Young Kim¹, Yong Sung Park¹, Hye Soo Koo¹, So Young Park¹, Ji Seon Park², Kyung Nam Ryu² ¹Kyung Hee University Hospital at Gangdong, ²Kyung Hee University Medical Center, Korea.

**PURPOSE:** We experienced several, clinical cases of infrapatellar fat herniation through a focal defect of the lateral patellar retinaculum in pre-school age. These patients had no traumatic or surgical history. Therefore, we tried to investigate the incidence of the lateral patellar retinaculum (LPR) on knee MRI and to evaluate the significant factors relating with the size of the defect.

**MATERIALS AND METHODS:** A total of 99 knee MRIs from 90 patients (M:F = 37:53; age range, 10–86 years; mean age, 41 years) were included in the study. Two radiologists retrospectively reviewed the knee MRI independently for presence (group I) or absence (group II) of a focal defect of the LPR. In knee MR with concordant results by reviewers, BMI, Kellgren-Lawrence grade (KL grade), the subcutaneous fat thickness, the infrapatellar fat pad area, and the amount of joint effusion were evaluated based on the consensus of two reviewers. Also, in group I, the size of the defect and the distance from the patella were measured. Inter-observer agreement was assessed by calculating weighted Kappa statistics. Pearson’s chi-squared test was used for nominal variables and independent t-tests were performed for continuous variables. Also, in group I, Pearson’s correlation coefficient and Spearman’s correlation coefficient were calculated for assessing relations of the variables.

**RESULTS:** The readers demonstrated excellent inter-observer agreement ($k = 0.923$) for the presence or absence of focal defect at the LPR. Of the 96 knees (showing concordant results), 25 knees (26 %) showed a focal defect at the LPR. There was no significant difference of sex, age, side, body weight, height, BMI, KL grade, the subcutaneous fat thickness, and the amount of joint effusion between group I and II (all $p > 0.05$). Only the infrapatellar fat pad area was significantly different between group I and II ($p = 0.033$). In group I, there was no relationship between the size of the defect and other variables (all $p > 0.05$).

**CONCLUSION:** A focal defect of the LPR was not an uncommon finding on the knee MRI. This was not related to patient’s age, BMI, or KL grade, but related to the infrapatellar fat pad area. Therefore, a focal defect of the LPR may be a normal variant rather than pathologic change from trauma or degeneration. Also, we guess that this can be a route of infrapatellar fat herniation in childhood.
Localized resolution enhancement of QCT images for investigating trabecular architecture in proximal femur

Jung Jin Kim, Young Han Lee, In Gwun Jang
Korea Advanced Institute of Science and Technology, Severance Hospital, Korea.

**PURPOSE:** In vivo high-resolution (HR) skeletal images are vital for accurate diagnosis of bone diseases. However, obtaining clinical HR images has technical difficulties to be resolved such as high radiation doses, low signal-to-noise ratio, and long scan times. To overcome these issues, this paper proposes a novel method that can enhance the resolution of QCT images of volume of interest (VOI).

**MATERIALS AND METHODS:** A proximal femur of a 62-year-old healthy female was scanned by using LightSpeed VCT (GE Healthcare, USA) with 625 μm resolution. Three VOIs which contain characteristic trabecular patterns were selected: femoral head, femoral neck, and intertrochanter. First, the resolution up scaling to 62.5 μm was performed through dividing each voxel into 10 × 10 × 10 subvoxels, while preserving original BMD distribution. Second, inspired by Wolff’s law which states the self-optimizing capabilities of bone, topology optimization was performed for compliance minimization under daily loads. A constraint for the BMD deviation was implemented to maintain the patient-specific BMD distribution obtained from the QCT scan.

**RESULTS:** Trabecular architecture in the VOIs was successfully reconstructed from the LR QCT data. As the characteristic features in the femoral head, the reconstructed trabeculae were aligned along the direction of the hip joint load and were primarily composed of trabecular plates with the highest bone volume fraction (BV/TV = 0.34). The reconstructed femoral neck near the Ward’s triangle, where the lowest bone volume fraction was presented (BV/TV = 0.07), contained fewer trabeculae that are thinner than those in other VOIs. Finally, the orthogonal intersection was observed in the intertrochanteric region.

**CONCLUSION:** The proposed method enhanced the QCT images at the 625 μm resolution to those at the 62.5 μm resolution, which is suitable to investigate trabecular architecture. For three VOIs, the reconstructed bone microstructures included the representative features. These results demonstrate the feasibility of the proposed method, which requires further clinical validation such as a cadaver study with microCT scan.
patients who had no visible metastasis in the lumbar spine and had recent T-score results derived from dual energy X-ray absorptiometry (DXA). Patients were divided into three groups; patients without underlying malignancy (Benign group, n = 27), patients with underlying primary malignancy but without vertebral metastasis (Malignancy group, n = 7), and patients with underlying primary malignancy and vertebral metastasis other than the lumbar spine (Metastasis group, n=5). Region-of-interests were drawn at continuous five-slice sagittal MRI in each lumbar vertebrae (from L1 to L4). Fat fractions were calculated in a total 156 vertebrae of 39 patients using the formula: fat fraction = fat/(fat + water) × 100. Fat fractions of each vertebra as well as T-scores were compared among the three groups using Student’s t-test. RESULTS: Fat fraction was averaged as 66.83% in the Benign group, 57.65% in the Malignancy group, and 58.84% in the Metastasis group. The mean T-score of DXA was −0.8 in the Benign group, −1.3 in the Malignancy group, and 1.2 in the metastasis group. Fat fraction of vertebral body significantly discriminated the Benign group from the Malignancy group, and the Metastasis group (p < 0.01) while T-score did not (p = 0.16). T-score significantly distinguished the Metastasis group from the Malignancy group (p < 0.01) while fat fraction did not (p = 0.23). CONCLUSION: Fat fraction measurement using dual-echo, multi-peak T2*-corrected spin-echo mDixon MRI of morphologically non-metastatic lumbar vertebrae in patients with underlying malignancy, regardless of vertebral metastasis, shows significantly lower fat fraction than that of patients without underlying malignancy. This mDixon MRI is expected to play an important role in elucidating the alteration of bone architecture and marrow fat in cancer patients.

SS 35 MS-05
16:40
Comparison of diagnostic performances of conventional MR imaging findings and apparent diffusion coefficient (ADC) values in differential diagnosis of benign and malignant soft tissue tumors
Yoonah Song1, Young Cheol Yoon2
1Hanyang University Medical Center, 2Samsung Medical Center, Korea.
youngcheol.yoon@gmail.com

PURPOSE: To compare the diagnostic performance of conventional MR findings and ADC values for differentiating benign and malignant soft tissue tumor (STT) in whole group and subgroup of non-myxoid non-hemosiderin STTs.

MATERIALS AND METHODS: 123 patients (70 malignant and 53 benign STTs; 66 of myxoid STT, 6 STT with hemosiderin deposition and 51 non-myxoid non-hemosiderin STT) who underwent pre-operative MR imaging including DW images with ADC map were enrolled. Two musculoskeletal radiologists analyzed conventional MR imaging findings by a consensus: maximum diameter, deep compartment involvement, central necrosis, signal heterogeneity in T1W image. These two readers measured mean and minimum ADC values independently. Statistical analyses were done; to evaluate the difference of frequency of each parameter in benign and malignant STTs; to determine the cut-off values of mean and minimum ADC values, and maximum diameter for calculating sensitivity, specificity, accuracy, and AUC; to calculate the OR and AUC; to compare the size of AUC of each parameter. The same analyses were performed in subgroup
RESULTS: There were significant differences of frequency of conventional MR findings and mean and minimum ADC values except deep compartment involvement between the benign and malignant STTs. The order of AUC and OR was maximum diameter (AUC/OR, 0.73/9.29; cut-off value of 31.5 mm), min ADC (AUC/OR, 0.70/5.68; cut-off value of 805.4 mm$^2$/sec), mean ADC (AUC/OR, 0.68/4.33; cut-off value of 1348.15 mm$^2$/sec), T1 heterogeneity (AUC/OR; 0.65/3.58), and central necrosis (AUC/OR; 0.59/5.36). Regarding the subgroup analysis of non-myxoid non-hemosiderin STTs, mean ADC, min ADC, and T1 heterogeneity showed significant differences between benign and malignant STTs. The order of AUC and OR was mean ADC (AUC/OR, 0.83/21.25; cut-off value of 1132.45 mm$^2$/sec), min ADC (AUC/OR, 0.78/10.51; cut-off value of 630.75 mm$^2$/sec) and T1 heterogeneity (AUC/OR, 0.63/4.38).

CONCLUSION: Conventional imaging findings such as maximum diameter, signal heterogeneity on T1W image, and presence of central necrosis and ADC values were useful to differentiate malignant and benign STTs. On the other hand, ADC values and signal heterogeneity on T1W image were much powerful parameters to do that in non-myxoid non-hemosiderin STTs.

**SS 35 MS-06 16:50**

Detection of Soft tissue sarcoma recurrence: use of additive diffusion-weighted MR imaging to standard MR imaging at 3.0T

Borim Park¹, Won-Hee Jee¹, So Yeon Lee², Joon-Yong Jung³, Chan Kwon Jung³, Seung Han Shin³, Yang-Guk Chung³

¹The Catholic University of Korea, Seoul St. Mary’s Hospital, ²Kangbuk Samsung Hospital, Korea. whjee12@gmail.com

PURPOSE: To retrospective determine the added value of diffusion-weighted imaging (DWI) to standard magnetic resonance imaging (MRI) to detect recurrent soft tissue sarcoma after surgical resection at 3.0T.

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study and informed consent was waived. From June 2009 through April 2014, 75 patients were referred for postoperative surveillance of soft tissue sarcoma in our institute. Among them, 30 patients who underwent 3.0T MRI including DWI and no residual tumor after surgery were included in this study. Two independent musculoskeletal radiologists first scored standard MRI. Then, they assessed a combination of standard MRI and qualitative and quantitative DWI. Interobserver agreement for apparent diffusion coefficient (ADC) measurement in recurrent soft tissue sarcoma was assessed using intraclass correlation coefficient (ICC). The receiver operating characteristic (ROC) curve with areas under the curve (AUC) was obtained for diagnostic performance.

RESULTS: There were 13 histologically proved recurrent soft tissue sarcoma in nine patients. In qualitative analysis of DWI, all recurrent soft tissue sarcoma revealed hyperintensity relative to skeletal muscle. In quantitative analysis of recurrent soft tissue sarcoma, median ADCs of two readers were 1025 (774–1092) μm$^2$/sec and 996 (801–1126) μm$^2$/sec, respectively, showing excellent interobserver agreement (ICC = 0.900). Sensitivity, specificity and accuracy of each reader were 69%, 81%, and 77%; 92%, 57%, and 71% on standard MRI alone, whereas 100%, 95%, and 97%; 92%, 95%, and 94% on standard MRI combined DWI, respectively. AUCs of a combination of standard MRI and DWI were higher than those of standard MRI alone: 0.824 versus 0.969 (p = 0.029), and 0.866 versus 0.958 (p = 0.127) for each reader, respectively.

CONCLUSION: The addition of DWI to standard MRI improves the detection of recurrent soft tissue sarcoma at 3.0T.

CLINICAL RELEVANCE STATEMENT: DWI should be added to standard MRI protocols to help detect the recurrent soft tissue sarcoma.
SS 035 MS-07 17:00
Correlation between diffusion-weighted MR imaging parameters and MR perfusion parameters in patients with bone metastasis from non-small cell lung cancer at 3.0T
Na Hye Han¹, Won-Hee Jee¹, So Yeon Lee², Joon-Yong Jung¹, Yohan Son¹, Mun Young Paek³, Jin Hyoong Kang¹
¹The Catholic University of Korea, Seoul St. Mary’s Hospital, ²Kangbuk Samsung Hospital, ³Siemens Healthcare, Korea.

PURPOSE: To retrospectively investigate whether intravoxel incoherent motion (IVIM) diffusion-weighted imaging (DWI) parameters correlate with dynamic contrast-enhanced (DCE) magnetic resonance imaging (MRI) perfusion parameters in patients with bone metastasis from non-small cell lung cancer (NSCLC) at 3.0T.

MATERIALS AND METHODS: The Institutional Review Board approved this retrospective study and informed consent was waived. Thirty-two patients (M:F = 16:16; mean age, 61 years; range, 46–89) with 37 bone metastases from NSCLC prior treatment underwent 3T MRI including IVIM DWI with nine b values (0–800 sec/mm²) and DCE-MRI. Following IVIM parameters including apparent diffusion coefficient (ADC), true diffusion coefficient (Dslow), pseudodiffusion coefficient (Dfast), and perfusion fraction (f), DCE MRI perfusion parameters including volume transfer constant (Ktrans), rate constant (Kep), extravascular extracellular volume fraction (Ve), and initial area under the time-signal intensity curve at 60 seconds (iAUC) were calculated. The Spearman rank correlation was performed for statistical analysis.

RESULTS: Median Ktrans, Kep, Ve, and iAUC were 138 (107–213) 10⁻³/min, 506 (319–647) 10⁻³/min, 334 (236–513) 10⁻³, and 16 (11–27), respectively. Median ADC, Dslow, Dfast, and f were 973 (849–1198) µm²/sec, 898 (786–1128) µm²/sec, 274 (224–311) µm²/sec, and 98 (59–118), respectively. Ktrans demonstrated a significant inverse correlation with Dslow (r = -0.405, p = 0.013). Kep revealed a significant inverse correlation with ADC and Dslow (r = -0.370, p = 0.024; r = -0.352, p = 0.033, respectively). There was a significant inverse correlation of iAUC with ADC and Dslow (r = -0.434, p = 0.007; r = -0.486, p = 0.002, respectively). However, there was no significant correlation between Ve and IVIM parameters.

CONCLUSION: Ktrans inversely correlates with Dslow, while Kep and iAUC inversely correlate with ADC and Dslow in patients with bone metastasis from NSCLC at 3.0T.

CLINICAL RELEVANCE STATEMENT: IVIM DWI could help assume DCE MRI perfusion in patients with bone metastasis from NSCLC, particularly when DCE MRI cannot be performed.

SS 35 MS-08 17:10
How reliable is the DW-SSFP compared to the DW-EPI in terms of Differential diagnosis of osteoporotic vertebral fractures from the neoplastic pathological fractures?
Jae Ho Shin, Jeongmi Park, Soh Yong Jeong, Jung Hyun Lim
The Catholic University of Korea, Yeouido St. Mary’s Hospital, Korea.
ciprofloxashin@hotmail.com

PURPOSE: We evaluated the diagnostic strength and reliability of DW-SSFP (Steady State Free-Precession) by correlating its results with the DW-EPI (Echo Planar Imaging).

MATERIALS AND METHODS: Total of 41 patients with confirmed vertebral fractures (25 benign and 16 malignant fractures) were evaluated via DW-SSFP and DW-EPI. The normalized signal intensities at the fractured site on DW-SSFP and the degree of diffusion restriction (ADC values) on DW-EPI were measured by matching the coordinates from the conventional MR sequences. Mann-Whitney U test was performed in order to compare the normalized signal intensities on DW-SSFP and ADC values on DW-EPI for both malignant fractures and benign fractures. Linear regression was utilized to correlate normalized signal intensities on DW-SSFP with the ADC values on DW-EPI to test the reliability of DW-SSFP.

RESULTS: There was a distinct DW-SSFP normalized signal intensity difference in the malignant fracture and
the benign fracture. That is, the malignant fracture had higher median normalized signal intensity (5.24) than the median benign fracture normalized signal intensity (1.26) \( (p < 0.05) \). Likewise, DW-EPI ADC values were significantly different between the two groups such that the benign fractures had higher median ADC values (1.40) than the median ADC values of malignant fractures (0.86) \( (p < 0.05) \). When DW-SSFP and DW-EPI data were analyzed in the linear regression, both data well correlated to each other for both malignant and benign fractures \( (R^2 = 0.32, 0.25 \text{ respectively}) \).

**CONCLUSION:** DW-SSFP sequence and DW-EPI sequence are useful in the differentiation between the benign osteoporotic and pathological vertebral fractures and that DW-SSFP sequence well correlated with the DW-EPI sequence, thereby proving DW-SSFP’s diagnostic strength and reliability.

---

**SS 35 MS-09 17:20 **

**Differentiation of benign and malignant musculoskeletal tumors: multiparametric MR imaging with standard, diffusion, and dynamic contrast-enhanced imaging at 3.0T**

Yoon-Soo Kim, Won-Hee Jee, So-Yeon Lee, Na Hye Han, Joon-Yong Jung, Yohan Son, Mun Young Paek, Yang-Guk Chung

1 The Catholic University of Korea, Seoul St. Mary’s Hospital, 2 Kangbuk Samsung Hospital, 3 Siemens Healthcare, Korea.

whjee12@gmail.com

**PURPOSE:** To investigate whether multiparametric (MP) magnetic resonance imaging (MRI) could improve the diagnostic performance of standard MRI in differentiation of benign and malignant musculoskeletal tumors.

**MATERIALS AND METHODS:** The Institutional Review Board approved this retrospective study and informed consent was waived. From December 2013 through March 2015, 71 patients underwent 3T MRI including consent was waived. From December 2013 through March 2015, 71 patients underwent 3T MRI including 34 patients (M:F = 15:19; mean age, 45 years; range, 14–83) with histopathologically proved primary musculoskeletal tumor were included. One musculoskeletal radiologist interpreted MRI for the presence of malignancy in two steps: standard MRI alone and MP MRI including standard MRI, IVIM DWI, and DCE MRI with quantitative analysis. Areas under the receiver operating characteristic curve (AUC), sensitivity, specificity and accuracy were calculated.

**RESULTS:** There were 19 benign and 15 malignant musculoskeletal tumors. Sensitivity, specificity and accuracy of standard MRI alone and MP MRI for diagnosis of malignancy were 100%, 53%, 74% and 93%, 90%, 91%, respectively. Specificity of MP MRI was significantly greater than that of standard MRI alone \( (p = 0.016) \). AUC was higher in MP MRI \( (0.944) \) than standard MRI alone \( (0.872) \) without significant difference \( (p = 0.146) \). Median apparent diffusion coefficient (ADC), true diffusion coefficient (Dslow), and efflux rate constant (Kep) were significantly different between malignancy and benignity: ADC, 1600 (1427–2109) versus 901 (588–1563) \( \mu m^2/sec, p = 0.006; \) Dslow, 1499 (1368–1971) versus 834 (575–1683) \( \mu m^2/sec, p = 0.016; \) Kep, 307 (267–552) versus 737 (434–1070) \( \times 10^{-3}/min, p = 0.011 \).

**CONCLUSION:** The addition of DWI and DCE MRI to standard MRI can help differentiate benign from malignant musculoskeletal tumors.

**SS 35 MS-10 17:30 **

**T1ρ and T2 relaxation mapping for lumbar disc degeneration and morphology: a correlation study at 3.0-Tesla MRI**

Min A Yoon, Suk-Joo Hong, Chang Ho Kang, Kyung-Sik Ahn, Baek Hyun Kim, Seun Ah Lee

1 Korea University Guro Hospital, 2 Korea University Anam Hospital, 3 Korea University Ansan Hospital, Korea.
hongsj@korea.ac.kr

**PURPOSE:** To evaluate correlation between \( T1ρ \) \( (T1ρ) \), T2 values and disc degeneration and morphologic changes in the lumbar intervertebral discs.

**MATERIALS AND METHODS:** Twenty-two subjects \( (M:F = 8:14; \text{mean age, 55.5 years; range, 26–84 years}) \) with 109 lumbar intervertebral discs (from L1–2 to L5–S1) were examined at 3.0T MRI. Disc degeneration was evaluated using the 5-level Pfirrmann grading system and the disc morphology was categorized into five groups: normal, bulging, annular tear, protrusion, extrusion. For \( T1ρ \) and T2 quantification, regions of interest (ROIs) were drawn on the three mid-sagittal images at nucleus pulposus (NP), posterior annulus fibrosus (AF), and junction of the NP and posterior AF for each disc on \( T1ρ \) and T2 maps. Quantitative measurements for herniated discs were made within the protruded or extruded portion. Statistical analysis was performed using Spearman rank correlation and partial correlation.

**RESULTS:** The Pfirrmann grades showed strong correlations with the \( T1ρ \) values at the NP \( (r = 0.800, p < 0.001) \), T2 values at the NP \( (r = 0.792, p < 0.001) \), and T2 values at the junction \( (r = 0.784, p < 0.001) \). Disc morphology was moderately correlated with T2 values at the junction \( (r = 0.697, p < 0.001) \), and \( T1ρ \) values at the NP \( (r = 0.509, p < 0.001) \). After correction for effects of patient age and disc level, there was strong to moderate correlation between the Pfirrmann grades and \( T1ρ \) values at the NP \( (r = 0.750, p < 0.001 \text{ after correction of age effect and } r = 0.697, p < 0.001 \text{ after correction of disc level effect}) \).

**CONCLUSION:** \( T1ρ \) and T2 mapping, especially \( T1ρ \) values at the NP and T2 values at NP and junction, provided quantitative measurements of the progression of the intervertebral disc degeneration with strong correlations. T2 values at the junction proved good relationship in the assessment of the disc morphologic changes.
SS 35 MS-11 17:40
T2 Relaxation values of the ankle cartilage: comparison between patients with lateral instability and healthy volunteers
Soyoun Park, Young Cheol Yoon
Samsung Medical Center, Korea.
youngcheol.yoon@gmail.com

PURPOSE: To evaluate the difference in T2 relaxation values (T2 RV's) of the talar trochlear cartilage (TTC) between patients with lateral instability of the ankle joint and healthy volunteers.

MATERIALS AND METHODS: The study was approved by our Institutional Review Board. We retrospectively assessed 13 ankle MRIs with T2 mapping from 12 patients who underwent lateral ankle ligament repair with an arthroscopically proven normal TTC. A total of 13 ankle MRIs from 12 healthy age- and sex-matched volunteers were prospectively obtained. Two radiologists independently measured the T2 RV's of the TTC [two layers (superficial and deep) and six compartments (medial and lateral; anterior, middle, and posterior: M1, M2, M3, and L1, L2, L3)]. We compared T2 RV's between patients and healthy volunteers. Intra-class coefficient analysis was performed for inter- and intra-observer agreement.

RESULTS: The mean T2 RV's of all 6 compartments of the superficial layer were significantly higher among patients than among controls as per both Reader 1 and 2 (p < 0.05). For the deep layer, the mean T2 RV's of M2 (p = 0.004) and M3 (p = 0.046) as per Reader 1 and M2 as per Reader 2 (p = 0.041) were significantly higher in patients than controls. Intra- and inter-observer variability were excellent with the exception of inter-observer variability for M1 deep (0.79) and L1 deep (0.75).

CONCLUSION: T2 RV's of arthroscopically proven normal TTC of patients with lateral instability were higher than those of normal volunteers, especially in the superficial layer and the medial middle compartment of the deep layer.

Musculoskeletal(SP)
08:00-09:30 208 B
Imaging of spine

Chairperson(s)
Joong Mo Ahn Seoul National University Bundang Hospital, Korea
Jong Won Kwon Samsung Medical Center, Korea

SS 26 MS(SP)-01 08:00
Added value of SEMAC in the diagnosis of postoperative complications in patients receiving lumbar inter-body fusion and pedicle screw fixation surgery
Sol Bee Han, Young Cheol Yoon, Jong Won Kwon Samsung Medical Center, Korea.
youngcheol.yoon@gmail.com

PURPOSE: To compare the visibility of anatomical structures between FSE and SEMAC sequences and to evaluate the additional value of SEMAC in the diagnostic confidence of the post-operative complications in patients who had lumbar spine surgery.

MATERIALS AND METHODS: This retrospective study protocol was approved by Institutional Review Board and informed consent was waived. 54 postoperative MR imaging sets obtained from 54 patients with titanium alloy were enrolled (age range, 23-85 years; mean age, 62.0 ± 12.93 years; M:F = 18:36). For the semi-quantitative evaluation, visibility of six anatomical structures was evaluated with FSE T2W and SEMAC T2W images in sagittal plane (neural foram, bone-inter-body cage interface) and Gd-TIW and SEMAC Gd-TIW images in axial plane (central canal, nerve root in epidural space, back muscle, and bone-pedicle screw interface) by two radiologists. For the qualitative evaluation, both reviewers evaluated conventional FSE sequences and FSE+SEMAC sequences independently, and recorded their confidence level for the diagnosis of the post-operative complications (central canal stenosis, neural foraminal stenosis, and non-union of inter-body cage, epidural lesion, and para-spinal lesion) with positive, inconclusive, or negative grading system. We additionally readjusted original grading system into group 0 (grade 2, 3, 4) and group 1 (grade 1 and 5) for the evaluation of diagnostic confidence.

RESULTS: Scores of all 6 imaging findings with SEMAC sequences were significantly higher than them of FSE