JSMRM-KSMRM Joint Symposium (MSK): Recent progress of MSK MRI

SY19-1

Recent progress of MRI of the knee joint

Mamoru Niitsu

Department of Radiology, Saitama Medical University, Saitama, Japan

In this talk, recent topics about the MR imaging of the knee joint, as well as rare and not so popular pathologies are included.

The anterior cruciate ligament (ACL) tear is common ligamentous tear, due to the fact that ACL is more vulnerable to injury than PCL. The whole length of the ACL is visualized in sagittal MR images with the knee slight flexion (important point!). Imaging appearance of chronic ACL tear becomes variable, including, loss of ACL, discontinuous band, and continuous band with elongation. Ageing or accumulation of microtrauma may lead to mucoid degeneration within the ACL, including “celery stalk ACL”.

Complete disruption of PCL is quite rare, most PCL tear exhibits partial tear (intrasubstance injury): Continuity of the ligament is retained, there is intrasubstance hyperintensity. Only one of 2 major bundles, anterolateral bundle and posteromedial bundle may be torn and can be visualized on MRI. PCL tear may be accompanied by avulsion fracture of the deep layer of MCL. This is called “reverse Segond fracture”, and it occurs as a result of valgus and external rotation of the distal lower limb. Because of the proximity of the deep layer of MCL to the medial meniscus, reverse Segond fracture may be accompanied by medial meniscal tear.

Oblique meniscomeniscal ligaments (OMML) connect the lateral and medial menisci in the diagonal fashion. Medial OMML connects the anterior horn of the medial meniscus (MM) with the posterior horn of the lateral meniscus (LM). Lateral OMML connects the anterior horn of LM with the posterior horn of MM. Its prevalence is rare (1–4% for both medial and lateral combined). Its origin at the posterior horn can be mistaken as a meniscal tear.

Clinical diagnosis of traumatic patellar dislocation seems to be difficult; the dislocated patella is often naturally reduced, and the patient could not recall the accident precisely. Among the cases with traumatic patellar dislocation by MRI, 61% cases were not diagnosed as dislocation by clinical evaluation. Axial MR imaging with edema-sensitive sequences (FS-PDWI, FS-T2WI, STIR etc) is mandatory to demonstrate both the patella and the femoral condyle.

Patellar tendon-lateral femoral condyle friction syndrome is localized injury to the superolateral aspect of the Hoffa’s fat pad. It is said to be caused by impingement between the patellar tendon (patella) and the lateral femoral condyle. Chronic localized pain in the anterolateral aspect of the knee, which worsens on knee extension. It is relatively common in young women. The lesion located in the superolateral aspect of the Hoffa’s fat pad shows hypointensity on T1WI and hyperintensity on FS-T2WI. There may be associated signal abnormalities within the patellar tendon and patella.

Keywords : -

JSMRM-KSMRM Joint Symposium (MSK): Recent progress of MSK MRI

SY19-2

Recent Progress of Cartilage MRI

Yeo Ju Kim

Department of Radiology, Inha University Hospital, Incheon, Korea

Composition and microstructure of cartilage

Composition

- 70-80% fluid

- 20-30% solid extracellular matrix (ECM): collagen, proteoglycan complex

- 2% of chondrocyte

Collagen fibrils: far the most abundant macromolecule, accounting for about 20% of cartilage volume by weight; tissue structural framework; Principle source of tensile and shear strength

A proteoglycan (PG) unit: a protein core +glycosaminoglycans (GAG).

The negatively charged hydrophilic GAG , which within the collagen matrix, contribute to the mechanical stiffness of articular cartilage by creating an osmotic pressure that is related to the attraction of positive ions and their surrounding fluid

ultrastructure

The superficial or tangential zone

- 10–20 % of cartilage thickness

- collagen fibers running parallel to the articular surface

- the most cellular zone: ↑collagen, ↑water, ↓proteoglycan

The transitional or intermediate zone

- 60 % of cartilage thickness

random collagen fiber orientation with collagen fibers bending to form arcades

↓collagen, ↓water, ↑proteoglycan

The radial or deep zone

- 30 % of cartilage thickness

collagen, ↓water ↑proteoglycan (proteoglycan content is highest in the upper sector of the radial zone)

collagen fibers running perpendicular to the subchondral bone providing anchorage to the underlying calcified matrix

The calcified zone (cartilage–bone interface)

Regional differences in the composition and ultrastructure of articular cartilage

weight-bearing cartilage

a thicker radial zone, a thinner transitional zone

a higher GAG content compared with those regions that are not exposed to habitual loading

Compositional change of cartilage in osteoarthritis

Early change (even before morphologic change)

PGs and GAGs leak from the cartilage

the collagen fibers change in size and orientation

more water and less restricted water diffusion into the cartilage.

Late change

progression of collagen network degeneration

proteoglycan depletion

the cartilage water content eventually decreases

Compositional assessment of cartilage

T2 mapping

$T2^*$ mapping

T1ρ

dGEMRIC

Others: Sodium, gagCEST, Diffusion MRI

T2 mapping

measures water content and collagen integrity, zonal variation reflecting the biochemical composition of cartilage

knee, hip, ankle (many joints)

Spatial resolution: Adequate

Clinical feasibility: high

Suited as a biomarker: high (++++)

Strength: clinically useful, validated, robust technique, many prior studies, commercially available on clinical MRI scanners

Drawback: 2D technique; relatively long scan time; less sensitive in early stages of cartilage degeneration; T2 variations related to diurnal effects and imaging parameters; magic angle effect

Reproducibility: high

cutoff values, a reference database for diagnosis of OA: not yet defined

Clinical application: diagnosis of early OA and monitoring of intervention

T2* mapping

measures water content and collagen integrity

Keywords : Cartilage, MRI, Osteoarthritis

JSMRM-KSMRM Joint Symposium (MSK): Recent progress of MSK MRI

SY19-3

Recent progress of hip joint MRI

Tsutomu Inaoka

Department of Radiology, Toho University Sakura Medical Center, Sakura, Japan

New concepts in the biomechanics of the hip joint and the rapid development of arthroscopic surgery have changed the way we image the hip joint during the past several years. Although plain radiography is still the basis of any imaging of the hip joint, MR imaging has been the most important imaging modality for the assessment of the hip joint. In clinical practice, osteoarthritis (OA), femoroacetabular impingement (FAI), and acetabular labral tears are very important disorders of the hip joint. FAI is a widely accepted abnormality of the hip joint, but the concept of FAI still remains controversy. Acetabular labral tears are often associated with bone abnormalities such as OA, FAI, and hip dysplasia. MR imaging is useful for the evaluation of morphological abnormalities of the acetabulum and femoral head and neck and damages of the articular cartilage and labrum. Furthermore, MR imaging of the hip joint often shows unexpected causes of hip pain that may be originating from other nearby structures such as the sacroiliac joints, pubic bones, or even the lower lumbar spine. Regardless of age of patients, stress fractures have to be kept in mind. In this lecture, technical advances of MR imaging of the hip joint and new insights and common pitfalls in hip joint abnormalities will be discussed.

Keywords : MRI, Hip

JSMRM-KSMRM Joint Symposium (MSK): Recent progress of MSK MRI
SY19-4

Recent Progress of Muscle MRI

Min a Yoon

Department of Radiology, Korea University Guro Hospital, Seoul, Korea

1. Considerations in evaluation of skeletal muscle

Largest organ in body

Numerous conditions with similar MR imaging features

Muscle fiber type : type I, Type IIa/b

Blood flow

Age-related changes

- Loss of muscle mass

- Structural and perfusion changes

- Sarcopenia

2. Advanced quantitative MRI techniques

1) Diffusion tensor imaging (DTI)

2) Intravoxel incoherent motion (IVIM) MRI

3) Chemical shift based fat-water imaging

4) MR elastography

3. DTI

1) Information on directional properties of diffusion

- Greatest water diffusion in direction parallel to the dominant muscle fiber

- Sensitive to changes in muscle microstructure, architecture

- $\lambda 1$: local muscle fiber orientation ($\lambda 2$ and $\lambda 3$: less clear relation)

2) Technique

- Multiple diffusion sensitizing directions

- Diffusivity described by 3x3 tensor

- Diagonalization of tensor by eigenvector and eigen value analysis

3) Applications

- Trauma, inflammatory myositis, denervation, exercise

- ↑ mean diffusivity, ↑ fractional anisotropy (cell swelling, increased ECF)

4) Challenges of muscle DTI

- Need for sufficient SNR

- Dependence on hardware, acquisition parameters

- Artifacts : susceptibility induced, motion, chemical shift, shimming over large FOV, geometric distortion from off-center location

- Voxels with non-muscular tissue (fat and connective tissue)

- Dependence on demographic and transient factors : age, gender, BMI, sex, exercise, position

4. IVIM MRI

1) Information on microvascular blood flow and true molecular diffusion

2) Technique

- Acquisition of DWI at multiple b-values

3) Applications

- Quantification of perfusion and diffusion effects at rest and following exercise

- Dynamic blood flow change after specific muscle work

- Future : PAOD, DM, inflammatory myopathy

4) Challenges of muscle IVIM

- Organ-specific b-value threshold

- Higher temperature in muscle after exercise

- Anisotropic diffusion/pseudodiffusion in muscle fiber

- Field inhomogeneity, sensitivity to motion in EPI

5. Chemical shift based fat-water imaging

1) Quantification of fat content in muscle

- More spatial information and coverage than single-voxel MRS

- Good agreement with single voxel MRS

2) Technique

- Separation of water and fat signals based on chemical shift differences

3) Applications

- Quantification of early fatty infiltration in rotator cuff muscles

- Evaluation of disease progression in muscular dystrophy

4) Challenges of muscle fat quantification

- Spectral complexity of fat

- Difference in T1, $T2^*$ values of fat and water

- Noise bias

- B0 magnetic field inhomogeneity

6. MR Elastography

1) Noninvasive quantification of mechanical properties of skeletal muscle such as stiffness

2) Technique

- Oscillating motion-sensitizing gradient, synchronized to mechanical vibration

- Induction of measurable phase shift

- Inversion of data to estimate shear modulus in soft tissue

3) Applications

- Stiffness of relaxed and contracted muscles

- Prediction of muscle behavior

- Correlation with functional exam (EMG)

- Assessment of pathologic muscle

4) Challenges of muscle MR elastography

- Acquisition time

- Inversion algorithm for muscle

- Mechanical properties affected by joint position, loading

- Position of pneumatic driver, frequency used

Keywords : Muscle, Diffusion tensor imaging, Intravoxel incoherent motion, Chemical shift based fat-water imaging, MR elastography