Review Article

The diagnosis of early osteoarthritis of the knee using magnetic resonance imaging

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Contributions: (I) Conception and design: All authors; (II) Administrative support: None; (III) Provision of study materials or patients: K Nagai, FH Fu; (IV) Collection and assembly of data: K Nagai, T Nakamura; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: In consideration of the growing number patients with osteoarthritis (OA), orthopaedic surgeons and physicians have increasingly focused on the prevention of OA. If early OA can be diagnosed, it may be possible to intervene to prevent disease progression, in turn decreasing the treatment costs and increasing patient satisfaction. In the early diagnosis of OA, magnetic resonance imaging (MRI) is more sensitive and advantageous than plain radiograph, as the former offers several additional advantages, including the absence of radiation exposure. However, as the validated consensus criteria of early OA using MRI are lacking at present, its routine use in daily practice would not be recommended. In this chapter, we will highlight the recent studies on the evolving use of MRI to diagnose early OA.

Keywords: Early osteoarthritis (early OA); knee; magnetic resonance imaging (MRI)

Received: 14 November 2018; Accepted: 07 December 2018; Published: 21 December 2018.

doi: 10.21037/aoj.2018.12.05

View this article at: http://dx.doi.org/10.21037/aoj.2018.12.05

Introduction

Osteoarthritis (OA) of the knee is the most common joint disease, which is related to pain, disability (1). In 2012, the definition and classification of early knee OA was proposed by Luyten *et al.* (2); since then, the attention to early stage knee OA has increased, as identifying OA in its early stage would allow more optimal multimodal management to prevent or slow OA progression. More recently, international experts in OA have proposed classification criteria for early knee OA (3).

Magnetic resonance imaging (MRI) has advantage in the evaluation of structural changes during the progression of knee OA (4). MRI allows us to visualize all the tissues involved in OA pathology, such as cartilage, subchondral bone, meniscus, and soft tissue. Thus, MRI has great potential as a whole-organ imaging tool of the OA (5). In this chapter, we reviewed MRI assessments of early knee OA.

MRI and definition of early knee OA

In 2012, the definition and classification of "early" OA of the knee was proposed by Luyten *et al.* (2). According to this definition, early OA of the knee can be defined based on clinical and imaging findings, and should meet three criteria: (I) knee pain, (II) Kellgren-Lawrence (KL) (6) grade 0, I or II (osteophytes only) using plain radiographs, and (III) cartilage lesion confirmed by arthroscopy and/or OA-related MRI findings such as degenerations of cartilage and meniscus, and/or subchondral bone marrow lesions (BMLs).

MRI features of degenerative changes of the cartilage, BMLs, and/or meniscus are based on the Boston Leeds Osteoarthritis Knee Score (BLOKS), the Whole Organ Magnetic Resonance Imaging Score (WORMS) (7,8) and their comparisons (9,10). Specifically, at least two of the four following items need to be fulfilled (2):

(I) Cartilage morphology scores: at least grade 3 (WORMS grade 3–6) (7);
(II) Cartilage Score 1: at least grade 2 (BLOKS grade 2 and 3) (8);
(III) Meniscal tears: at least grade 3 (BLOKS grade 3 and 4) (9);
(IV) BML: at least WORMS grade 2 (7).

Related to this criteria of early knee OA, Hunter and his colleagues developed an MRI definition of structural knee OA (11) using the Delphi process (12,13). In this definition, definite osteophyte and/or full thickness cartilage lesion are essential for tibiofemoral OA definition on MRI. If the patient has only one out of these two features, two or more features out of four features (BMLs, meniscal lesions, partial thickness cartilage lesion, and/or bone attrition) should be fulfilled for the OA definition on MRI.

The definition of patellofemoral OA requires a definite osteophyte, and partial or full thickness cartilage lesion (11).

More recently, an expert group discussed potential classification criteria for early OA of the knee for use in a primary care setting, as consensus criteria for classifying early OA are lacking (3); however, MRI was not included in that draft proposal which consists of Knee Injury and Osteoarthritis Outcome score [Knee Osteoarthritis Scoring System (KOSS)], clinical examination, and plain radiograph (3). They provided consensus statements regarding MRI as follows, "*There was general agreement that MRI is a powerful technique that is needed in research on early OA. However, at present MRI is not recommended as an aid to identify or define early OA in routine clinical practice or primary care, in light of lack of validated consensus criteria, and the high population prevalence of structural joint changes detected by this method* (3)."

Semi-quantitative scoring system of knee OA using MRI

Semi-quantitative scoring of knee OA features using MRI has shown to be a valid method (4), and a couple of scoring systems have been reported. The WORMS was the first published scoring system, and it has been used extensively over a decade in the studies related to knee OA worldwide (7). Thereafter, three other knee scoring systems have been developed: the KOSS (14), the BLOKS (8), and the MRI Osteoarthritis Knee Score (MOAKS), which is a merger of the WORMS and BLOKS scoring tools (15-17). Plain MRI features are used in all these systems (18). The MOAKS was introduced by a panel of experienced OA researchers, and has shown very good to excellent reliability (15). The MOAKS refined the scoring of BMLs, articular cartilage, and the elements of meniscal morphology scoring, and consists of the scoring of seven sub-regions such as BMLs, cartilage, osteophytes, synovitis, meniscus, ligament/tendon and periarticular findings (15).

Quantitative measurements of articular cartilage using MRI

Articular cartilage is the main tissue that is involved in the OA process (15). The cartilage compositional MRI techniques such as T1rho (T1ρ) (19-23), T2 (22,24-26), and delayed gadolinium enhanced MRI of cartilage (dGEMRIC) (27-30) are sensitive to the alteration in cartilage extracellular matrix (ECM) composition, and allow us to detect these molecular changes before gross morphological changes become apparent (31,32).

T2 reflects the movement of free water proton molecules inside the cartilage matrix (22). The damage to collagen-proteoglycan (PG) matrix and increased water content in degenerated cartilage may increase T2 relaxation times (22), and elevated T2 values were observed in patients with OA (22,24,33). T1rho was introduced as an alternative parameter to assess biochemical changes in cartilage (19-23,32,34,35). The changes to the ECM (i.e., loss of PG) would be reflected in T1rho measurements (22). It has been shown that T1rho values were elevated in OA patients (20-22,36). Even though both T1rho and T2 investigate slow motion of water protons, these measure different MR relaxation mechanisms; thus, these parameters can provide complementary information about macromolecular changes in articular cartilage (22). A recent systematic review and meta-analysis showed that these cartilage compositional MRI techniques are reliable, and can distinguish between subjects with OA and healthy cartilage in the case of T1rho and T2 MRI (31).

Association between MRI findings and incident OA

It has been shown that MRI-detected structural changes (i.e., osteophytes, meniscal damage, BMLs, and/or synovitis) may represent early OA in people without radiographic OA, and are associated with the incident OA. MRI may identify bone structure changes more sensitively than radiographic findings (37). Schiphof *et al.* compared the findings between MRI and plain radiograph in a population-based study, and concluded the definition of knee OA based on MRI more sensitively detected structural knee OA than the definition based on plain radiograph (37). Zhu *et al.* performed a prospective cohort study of 895 participants, and showed that 85% had MRI-detected osteophytes at baseline while only 10% were detected by radiographs (38).

It is widely known that meniscal extrusion due to meniscal injuries or degeneration can accelerate the initiation and progression of knee OA. Even absent a discrete tear, meniscal extrusion has shown to be associated with the incidence of knee OA; therefore, meniscal extrusion on MRI would suggest risk for developing knee OA (39-42). In patients age 50–90 years old with asymptomatic knees, Englund *et al.* found the prevalence of meniscal tear was 60% on MRI, yet 23% of patients had no radiographic evidence of OA (43). Others also reported that meniscal lesions were frequently observed in MRI even in the knees from 50 to 90 years old asymptomatic subjects without radiographic findings of OA (44,45).

From the Multicenter Osteoarthritis Study (MOST), Javaid *et al.* have reported that MRI features of OA in only a few specific locations occurred prior to clinical symptoms in the knees without significant symptoms or radiographic OA, suggesting that bony changes may be associated with early knee pain development (46). Using the MOST data, Felson *et al.* also reported that a substantial volume of synovitis in the knee was an independent cause of the incident OA (47). Moreover, several studies from the Osteoarthritis Initiative have showed the associations between MRI findings and incident OA (48-51). Roemer *et al.* reported that the presence of synovitis and medial meniscal lesion in MRI 2 years prior to incident radiographic OA increased the risk for incident radiographic OA (48). Liebl *et al.* showed that increased baseline T2 values in articular cartilage, which was assessed when radiographic changes are not yet apparent, may be useful in predicting the development of radiographic tibiofemoral OA. Sharma *et al.* showed that worsening MRI findings were associated with concurrent incident radiographic OA and subsequent symptoms (50). Katsuragi *et al.* reported that the knees with osteophyte formation at the intercondylar notch, even those of KL grade 0 or 1 in radiographic assessments, had a risk for the radiographic OA development within 4 years.

Conclusions

MRI is a tool that provides useful information for early OA diagnosis. Although MRI is not recommended for now to diagnose early knee OA in daily clinical practice, because of lack of validated consensus criteria and the frequent prevalence of structural knee joint changes with MRI, the literature suggests that such MRI-detected lesions may represent early knee OA, and add support for the investigation of intervention effectiveness at the early stage of OA. Further investigations using MRI will be warranted.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Yuji Uchio) for the series "Early Osteoarthritis: Definition, Pathogenesis, Diagnosis, Management and Prevention" published in *Annals of Joint*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/aoj.2018.12.05). The series "Early Osteoarthritis: Definition, Pathogenesis, Diagnosis, Management and Prevention" was commissioned by the editorial office without any funding or sponsorship. FHF serves as an Editor-in-Chief of *Annals of Joint* from Mar 2016 to Aug 2019. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/aoj.2018.12.05
Cite this article as: Nagai K, Nakamura T, Fu FH. The diagnosis of early osteoarthritis of the knee using magnetic resonance imaging. Ann Joint 2018;3:110.

