Review Paper:

Investigation of Knee Osteoarthritis by Magnetic Resonance Imaging

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Abstract

The structural causes of knee Osteoarthritis are not well understood. They involve a number of pathways that comprise changes in structure and function of the knee joint. The risk factors for knee Osteoarthritis include obesity and major injury. The intensive use of the knee in jobs requiring heavy labor and bending of the knee increases the risk of knee Osteoarthritis.

Magnetic resonance imaging (MRI) is a well-established imaging technique for visualizing the structural changes in the knees and it allows the investigation of knee osteoarthritis as well as the assessment of biochemical changes in the articular and periarticular tissues.

Keywords: Knee osteoarthritis, Magnetic resonance imaging, Obesity, Articular tissues, Periarticular tissues.

Introduction

Knee osteoarthritis (OA) is the most prevalent form of arthritis worldwide[9], posing a substantial socioeconomic burden. The estimated annual costs associated with medical care and productivity loss amount to billions of dollars[17]. The global prevalence of knee OA varies significantly, ranging from 3.8% to 70%, contingent upon the methodologies and diagnostic criteria employed in epidemiological studies[25,26]. Knee Osteoarthritis is also known as a degenerative arthritis (Figures 1a and 1b) since it involves the deterioration of the joints. The primary etiological factors contributing to osteoarthritis include limb misalignment and metabolic disturbances, which precipitate cartilage degradation and subsequent exposure of the underlying bone[2,15].

Technique of Magnetic Resonance Imaging (MRI): Magnetic resonance imaging (MRI) is a non-invasive diagnostic technique for the diagnosis and management of medical conditions. Unlike ionizing radiation-based imaging modalities, MRI utilizes a strong magnetic field, radiofrequency pulses and computer processing to generate high-resolution images of organs, soft tissues, bones and other internal structures. Its ability to noninvasively visualize hyaline cartilage *in vivo*[6] has made it a valuable tool for the early detection and quantitative assessment of cartilage lesions (Figure 2). Knee MRI (Figures 2 and 3) provides detailed visualization of intra-articular structures including bones, cartilage, tendons, ligaments, muscles and vascular components.

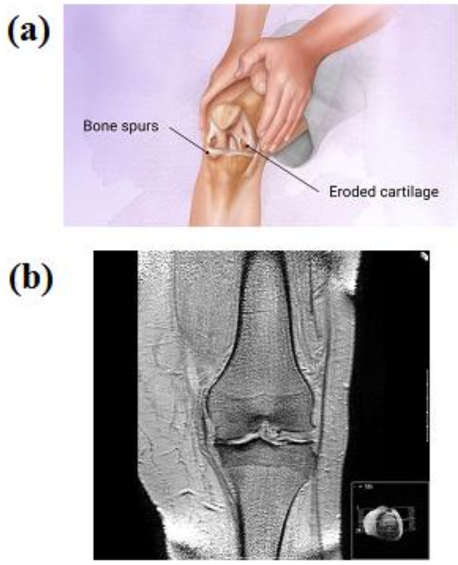


Figure 1: (a) Knee osteoarthritis occurs when flexible tissue at the ends of bones wears down (b) MRI of osteoarthritis in the knee showing characteristic narrowing of the joint space

Current State of MRI Technology for Knee Imaging: In the last two decades, MRI has become an important tool to assess knee Osteoarthritis. The semi-quantitative MRI techniques most commonly used are the Whole Organ MRI Score (WORMS), Boston Leeds Osteoarthritis Knee Score (BLOKS) and MRI OsteoArthritis Knee Score (MOAKS)[27]. In early Osteoarthritis, the condition of inflammation of the Synovial Membrane called Synovitis is present[19,24]. Synovitis is best imaged by MRI using the intravenous, paramagnetic contrast agent: Gadolinium (Figures 3 and 4)[21]. However, non-Gadolinium MRI can also be used to image Synovitis[23]. Quantification of Synovitis can be achieved by using a specific technique called dynamic-enhanced MRI (DEMRI)[23]. Dynamic-enhanced MRI (DEMRI) enables the study of pharmacokinetic and pharmacodynamic parameters[20,22].

Osteophytes are commonly observed in knee osteoarthritis and have been correlated with radiographic joint space narrowing, subchondral sclerosis[20] and pain[7]. Studies on osteophyte formation have provided valuable insights into the pathogenesis of osteoarthritis, contributing to a deeper understanding of disease progression and structural joint alterations[4,16].

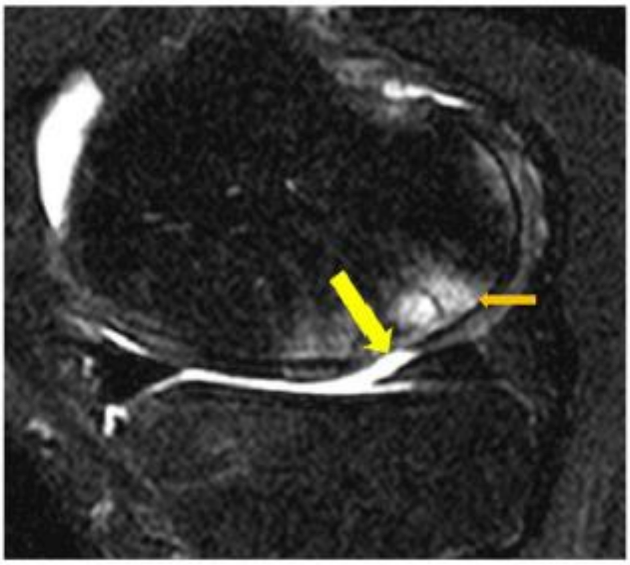
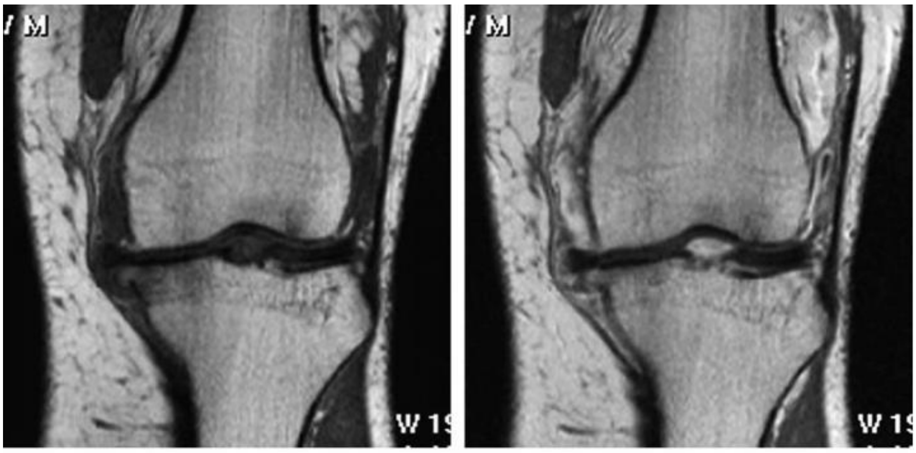


Figure 2: Sagittal section MRI image showing the tear of the cartilage of the medial femoral condyle

Figure 3: Knee MRI image showing horizontal tear of the posterior part of the meniscus of the knee



Coronal T1 Coronal T1 + Gd

Figure 4: Coronal section MRI images of an Osteoarthritic knee (with and without use of Gadolinium contrast agent)

Table 1
Tabulation of Kellgren-Lawrence (KL) radiology scores[18]

Grade of Osteoarthritis	Description
0	No cartilage injury with appearance of zero or minimal Osteophytes (<5mm)
1	Cartilage injury grade1 and at least one of the following: Osteophytes >5 mm, BME>10mm, sub-chondralcyst>10mm
2	Cartilage injury gradeII and at least one of the following: Osteophytes>5 mm, BME>10mm,sub-chondralcyst>10 mm
3	Cartilage injury grade III and at least one of the following: Osteophytes>5 mm, BME>10mm,sub-chondralcyst>10 mm
4	Cartilage injury grade III and meniscal injury grade III

Use of Radiography versus MRI to characterize Osteoarthritis: Three radiographic grading scales have been established for assessing knee osteoarthritis: The Kellgren–Lawrence (KL) scale (Table 1), the Ahlbäck scale and the Brandt scale[1,5,15]. Among these, the KL scale has been recognized by the World Health Organization (WHO) as the reference standard for epidemiological studies. However, the KL scale is limited in its ability to characterize cartilage degradation and marrow changes within bony structures[10]. In contrast, semi-quantitative MRI scoring offers valuable insights into the pathogenesis of osteoarthritis and the structural-functional relationships within the joint. Additionally, MRI facilitates the exclusion of alternative diagnoses and provides a detailed evaluation of chondral surfaces and bone edema associated with osteoarthritis[11].

Correlation of MRI and Histopathological Data: The studies conducted to evaluate the comparison of MRI findings with histopathology in hip arthritis have shown good correlation. The grading of the disease performed by a radiologist uses the scores: absent, mild, moderate and severe. These scores are based on the appearance of Osteophytes and joint narrowing[14]. The correlation studies involving histopathologic data with radiographs have suggested the use of Osteoarthritis Cartilage Histopathology (OACH) assessment system for the grading, staging and scoring while for radiographs Kellgren-Lawrence (KL) radiology scores can be used.

The OACH system takes into account the surface of cartilage by assigning scores between 0-6[8]. Correlation studies between radiology and pathology assessment for facet joint degeneration have shown moderate accuracy, thereby providing evidence that a more reliable technique is needed to assess joint damage before planning surgery[28]. The studies conducted using MRI as a method to estimate joint cartilage damage have been convincing. Hence, the efficacy or superiority of MRI as an investigative tool can be confirmed or reinforced by comparing MRI findings with histopathologic changes.

Conclusion

MRI is not routinely recommended for the diagnosis of knee osteoarthritis, as it may not significantly alter treatment planning. Instead, weight-bearing radiographs remain the preferred imaging modality for assessing joint space narrowing. MRI has limitations, including prolonged image acquisition times, which contribute to higher costs, increased susceptibility to motion artifacts and radiofrequency (RF) power deposition concerns. For a reliable MRI evaluation, a minimum of two tissue contrast RF sequences is required to ensure accurate assessment of joint structures.

Future Perspectives

The advancements in MRI technology have helped to expand the accuracy of diagnosis of knee Osteoarthritis. MRI-based investigation of non-cartilaginous parts of the knee joint has increased our understanding of the progression of the disease. Some novel techniques for the quantitative analysis of knee joint surface size and curvature have recently been introduced[12]. Additionally, whole-organ assessment of the knee is now possible through semi-quantitative scoring systems. High-resolution imaging studies conducted by Beuf et al[3] have demonstrated a reduction in trabecular bone volume fraction and an increase in spacing.

The use of biomarkers alongside MRI data also holds promise and can provide insight into both the disease pathology and the dynamic progression of the joint degeneration. The recent research has identified some potential biomarkers for the early diagnosis of Osteoarthritis[13]. However, variability in the findings of the studies remains a challenge. This mandates further standardization and validation before new biomarkers can reliably be used in clinical practice.

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