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THE ROLE OF T2 MAPPING SEQUENCE IN ASSESSMENT OF ARTICULAR CARTILAGE IN OSTEOARTHRITIS OF KNEE - AN OBSERVATIONAL STUDY

Radio-Diagnosis

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ABSTRACT

Objectives: Osteoarthritis (OA) of the knee is a prevalent degenerative joint disease, significantly impairing quality of life. This study aims to evaluate the efficacy of T2 mapping sequences in magnetic resonance imaging(MRI) for assessing articular cartilage integrity in knee osteoarthritis. **Methods:** This prospective observational study was conducted in the Department of Radiodiagnosis at GMC Nagpur over a 24-month period, including a total of 31 cases and 31 controls.This observational study involved 62 individuals who were divided into two groups: cases and controls. The cases consisted of 31 patients with clinical and radiological evidence of osteoarthritis (OA), while the controls were 31 patients without any clinical or radiological evidence of OA. Both groups underwent MRI scans of their knees. The T2 relaxation times of the articular cartilage were measured and compared with clinical severity scores, specifically the Kellgren-Lawrence (KL) grading scale. **Results:** T2 mapping sequences demonstrated a significant correlation with the KL grading scale. Elevated T2 relaxation times were consistently observed in patients with higher grades of OA, indicating advanced cartilage degeneration. The use of T2 mapping provided detailed insights into the early biochemical changes in cartilage, which were not apparent on conventional MRI sequences. **Conclusion:** This study shows that T2 mapping, a non-invasive imaging technique, can improve the detection of early cartilage degeneration in osteoarthritis. By incorporating T2 mapping into standard MR imaging protocols, healthcare professionals can identify cartilage damage before it becomes visible on routine scans, allowing for early treatment and better management of the disease.

KEYWORDS

MRI knee, T2 mapping , osteoarthritis, cartilage mapping.

INTRODUCTION:

The knee joint is an essential weight-bearing joint in the body. It often experiences wear and tear, which creates various shearing forces within its components. The articular cartilage plays a crucial role in distributing loads to the bone, providing a low-friction surface that prevents direct bone-to-bone contact within the joint. When this cartilage gets damaged, it disrupts the joint's balance and can potentially lead to irreversible bone damage and deformities.

Articular cartilage is made up of chondrocytes and extracellular elements such as water, collagen fibers, and proteoglycans. Water makes up about 60-85% of the extracellular matrix. Proteoglycans, including hyaluronic acid and glycosaminoglycans, form the core protein within this matrix, which is arranged in a lattice-like structure that governs the cartilage's biomechanical properties.

The articular cartilage is divided into four zones based on collagen fiber orientation: 1.Superficial/tangential zone 2. Transitional/ intermediate zone 3. Radial/deep zone 4. Calcified zone. Each zone has different amounts of collagen, water, and proteoglycan content. The superficial zone has the highest water and collagen content, while the radial zone is richest in proteoglycans. Moreover, the biochemical composition of cartilage varies across different joint segments depending on the shearing forces in those areas.

As people get older, articular cartilage undergoes chronic degenerative changes that lead to osteoarthritis. These changes can be seen both biochemically and morphologically. Usually, thebiochemical alterations in the cartilage's components happen before visible morphological changes occur. With new treatment options available that may potentially modify the progression of osteoarthritis, there is an increasing need for early detection of these biochemical changes.

T2 mapping is an advanced MRI technique that can provide valuable information about the health of cartilage. It has the potential to be a useful tool for diagnosing and monitoring conditions such as osteoarthritis, where cartilage degeneration occurs. T2 mapping works by measuring the relaxation time (T2) of water molecules in the cartilage. When cartilage degenerates, there is an increase in the amount of water content, leading to prolonged T2 values. This change can be detected through MRI imaging.

Previous studies have shown that T2 values are sensitive to cartilage degeneration in knee osteoarthritis. However, it is important to note that T2 values may not always correlate with late-stage radiographic findings of osteoarthritis. This raises questions about the effectiveness of T2 mapping in assessing disease progression.

Specifically, we focused on patients undergoing examination at 3 Tesla magnetic field strength. By comparing T2 values obtained from our study group with those observed in healthy individuals and established radiographic criteria, we hope to gain insights into the potential role of T2 mapping as a biomarker for early osteoarthritis diagnosis.

Aims And Objectives:

The aim of this study was to investigate whether incorporating quantitative T2 mapping into routine MRI protocols could enhance the diagnostic accuracy for detection of knee articular cartilage degeneration.

Materials And Methodology:

This prospective observational study conducted in the Department of Radiology at GMCH Nagpur, a tertiary care hospital, from June 2022 to December 2024, with institutional ethics committee approval.

MRI was performed using Siemens 3T MRI to evaluate the role of T2 mapping in assessing knee osteoarthritis. The study included 31 patients over 18 years old who were referred to the radiology department with symptoms of osteoarthritis (OA). These patients were diagnosed clinically and through X-ray imaging and agreed to undergo cartilage mapping as part of the study. Additionally, 31 healthy adult volunteers were included as controls. These volunteers were selected from the patients' relatives, hospital employees, or colleagues who also consented to participate in cartilage mapping. Using the study analyzed data with SPSS software, revealing significant differences between patients and controls.

RESULT & OBSERVATION :

In this study, the age distribution for cases and controls was as follows: 11 (35.5%) of both groups were in the 20-30 years age range, 11 (35.5%) cases and 9 (29.1%) controls were in the >30-40 years range, 4 (13%) cases and 5 (16.1%) controls were in the >40-50 years range, 3 (9.6%) cases and 5 (16.1%) controls were in the >50-60 years range, and 2 (6.4%) cases and 1 (3.2%) control were in the >60-70 years range. The mean age of participants was 39.4 years with a standard deviation of ±12.7 years. Gender distribution showed 16 (51.6%) males and 15 (48.4%) females among cases, and 14 (45.1%) males and 17 (54.9%) females among controls.

In our study, the Kellgren-Lawrence (KL) score distribution for the cases was as follows: 8 cases had a KL score of 1, 7 cases had a score of 2, 10 cases had a score of 3, and 6 cases had a score of 4. All individuals in the control group had a KL score of 0, indicating no osteoarthritis.

T2 Values Analysis,

In our study, we measured the mean T2 values for different regions of interest among both OA patients and healthy controls:

Region	Mean T2 Value (Cases)	Mean T2 Value (Controls)
Medial Femoral Condyle (MFC)	40.50 ± 9.3	29.25 ±1.9
Lateral Femoral Condyle (LFC)	35.21 ± 6.1	28.22 ±1.9
Medial Tibial Plateau (MT)	42.28 ± 7.7	27.54 ±1.7
Lateral Tibial Plateau (LT)	35.84 ± 4.8	27.66 ±2.0
Patella	35.59 ± 5 .6	27 .69±1 .9

There was a statistically significant difference between the T2 values of both groups with p <0 .0001. The mean cartilage thickness measurements among osteoarthritis (OA) patients were as follows: Medial Femoral Condyle (MFC): 1.56±0.34 mm, Lateral Femoral Condyle (LFC): 1.63±0.42 mm, Medial Tibial Plateau (MT): 1.56±0.33 mm, Lateral Tibial Plateau (LT): 1.68±0.44 mm, and Patella: 2.07±0.54 mm. For the control group, the measurements were: MFC: 1.69±0.23 mm, LFC: 1.62±0.17 mm, MT: 1.67±0.17 mm, LT: 1.61±0.17 mm, and Patella: 2.1±0.21 mm. There were no significant differences in mean cartilage thickness between the two groups.

DISCUSSION:

In our study, mean T2 values among osteoarthritis (OA) cases for MFC, LFC, MT, LT, and Patella were 40.50±9.3, 35.21±6.1, 42.28±7.7, 35.84±4.8, and 35.59±5.6 respectively. In controls, they were 29.25±1.9, 28.22±1.9, 27.54±1.7, 27.66±2.0, and 27.69±1.9 respectively, showing significant differences (p <0.0001). Mean cartilage thickness among OA cases for MFC, LFC, MT, LT, and Patella were 1.56±0.34, 1.63±0.42, 1.56±0.33, 1.68±0.44, and 2.07±0.54 respectively, while in controls they were 1.69±0.23, 1.62±0.17,1.67±0.17, 1.61±0.17, and 2.1±0.21, showing no significant differences (p >0.05).

Similarly, Alsayyad et al. (2021) found that adding T2 mapping to 1.5 T MRI significantly improved sensitivity from 73.3% to 96.7%. Their study included 50 participants (30 OA patients, 20 controls) and revealed higher mean T2 values in OA patients compared to controls with significant differences (p <0.05).

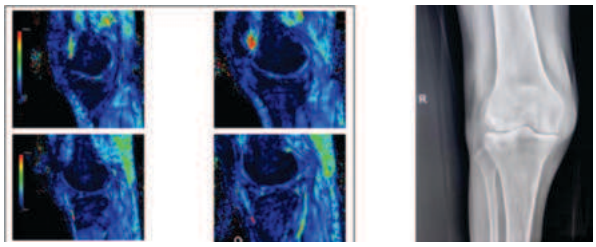
Khandelwal et al. (2022) observed significant regional differences in T2* values across various knee joint segments. Dunn et al. (2004) reported increased T2 values in OA patients compared to healthy controls, correlating with clinical symptoms and cartilage morphology.

Mamisch et al. (2010) noted higher T2 values in cartilage repair tissue compared to control cartilage, with significant differences at late unloading.

Jungmann et al. (2013) found an inverse correlation of longitudinal T2 changes with baseline T2 values and cartilage defects indicating limited evaluation of further degradation once morphological defects occur. These studies underscore the value of T2 mapping in early detection and comprehensive assessment of cartilage degeneration in osteoarthritis.

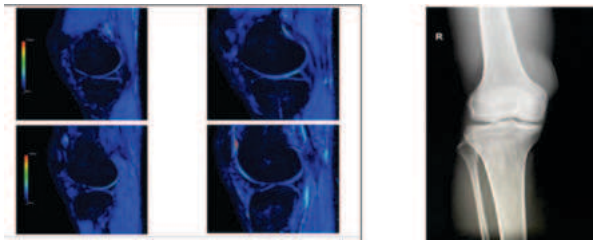
CONCLUSION:

The study concludes that integrating T2 mapping sequences into routine knee MRI significantly enhances the sensitivity for detecting cartilage lesions. This non-invasive imaging technique improves the detection of early cartilage matrix degeneration, particularly at the initial stages of osteoarthritis pathogenesis, such as collagen network disruption. Identifying cartilage damage before it becomes apparent in routine imaging, which typically identifies morphological lesions after irreversible damage, is crucial for initiating early treatment and monitoring disease progression. Incorporating T2 mapping into standard MR protocols increases sensitivity for detecting cartilage lesions, assists in evaluating cartilage status in patients with unexplained knee pain without meniscal tears, and assesses cartilage following repair or arthroscopic surgery. Thus, T2 mapping is a valuable tool for early detection of cartilage lesions, informing treatment strategies and potentially reducing osteoarthritis morbidity in the elderly.



Case 1: 65 year old female with knee pain Figure 1- Sagittal T2 mapping images shows increased T2 values indicated by colour scale & loss of cartilage in medial femoral condyle & medial tibial plateau (upper row). Also in lateral femoral condyle & lateral tibial plateau (lower row)

Figure 2 - X ray knee joint AP showing joint space narrowing, osteophytes– KL score – 4.



Case 2 : 29 yr old male with right knee pain Figure-1 Sagittal T2 mapping images shows no evidence of significant cartilage loss. No evidence of increased T2 values noted in medial and lateral femoral and tibial condyles and in patella

Figure 2 - X ray knee joint AP and lateral view shows no joint space narrowing or osteophytes, bony deformity – KL score – 0.

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