RESEARCH PAPER

Effectiveness of T_2 Mapping Sequences Added to Routine MRI Protocol in Early Detection of Osteoarthritis of the Knee Joint

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ABSTRACT

Background: Osteoarthritis (OA) is one of the most common chronic degenerative joint disorders and a major cause of pain, disability, and impaired quality of life worldwide. Early osteoarthritic changes are primarily biochemical in nature and may not be detectable on routine radiographs or conventional MRI sequences until significant structural cartilage damage has occurred. Quantitative magnetic resonance imaging techniques such as T_2 relaxation mapping have emerged as promising tools for evaluating cartilage composition by assessing collagen fiber integrity and cartilage water content. Incorporation of T_2 mapping into routine MRI protocols may facilitate earlier diagnosis of osteoarthritis before irreversible morphological degeneration develops.

Aim: To evaluate the effectiveness of incorporating T_2 mapping sequences into routine MRI protocols for assessment of articular knee cartilage in osteoarthritis and to determine its role in identifying early degenerative cartilage changes.

Materials and Methods: This hospital-based cross-sectional study was conducted in the Department of Radiodiagnosis and Imaging at a tertiary care centre over a period of 18 months. A total of 50 participants were included, comprising 30 symptomatic osteoarthritis patients and 20 asymptomatic controls. MRI examinations were performed using a 3.0 Tesla SIGNA Pioneer MRI scanner with dedicated knee coil positioning. Routine MRI sequences included sagittal, coronal, and axial proton density fat-suppressed sequences along with T1-weighted and T2-weighted imaging. Quantitative T_2 mapping sequences were additionally acquired for compositional cartilage analysis. Cartilage T_2 relaxation values and cartilage thickness were measured in the medial femoral condyle, lateral femoral condyle, tibial plateau, patellar cartilage, and compartmental regions. Routine MRI findings including cartilage thinning, focal cartilage defects, meniscal degeneration, marrow edema, and joint effusion were also assessed. Statistical analysis was performed using unpaired t-test, chi-square test, and receiver operating characteristic (ROC) curve analysis.

Results: The overall mean cartilage T_2 relaxation value in symptomatic osteoarthritis patients was significantly higher than controls (63.9 ± 9.1 ms vs 39.3 ± 10.0 ms; $p<0.001$). Maximum elevation was observed in the patellar cartilage (67.5 ± 10.1 ms) and medial femoral condyle (65.4 ± 8.2 ms). Mean overall cartilage thickness was significantly reduced in OA patients compared with controls (1.6 ± 0.5 mm vs 2.0 ± 0.6 mm; $p=0.015$). Routine MRI alone demonstrated sensitivity of 73.3%, whereas incorporation of T_2 mapping improved sensitivity to 96.7%, with overall diagnostic accuracy of 93.2% and ROC AUC of 0.945. Elevated T_2 relaxation values were identified even in 26.7% of symptomatic patients with normal routine MRI morphology.

Conclusion:T_2 mapping significantly improves the early detection of osteoarthritis by identifying biochemical cartilage degeneration before overt structural abnormalities become evident on conventional MRI. Incorporation of T_2 mapping into routine knee MRI protocols enhances diagnostic sensitivity and overall accuracy and serves as a reliable non-invasive imaging biomarker for early osteoarthritis evaluation and disease monitoring..

Keywords Osteoarthritis; T_2 Mapping; Magnetic Resonance Imaging; Cartilage Degeneration; Quantitative MRI; Knee Osteoarthritis; Articular Cartilage; Compositional Imaging; Early Osteoarthritis Detection; Cartilage Relaxation Time

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INTRODUCTION

Osteoarthritis (OA) is one of the most prevalent chronic musculoskeletal disorders worldwide and represents a major cause of pain, disability, and functional limitation among adults. The disease is characterized by progressive degeneration of articular cartilage along with involvement of the subchondral bone, menisci, synovium, ligaments, and surrounding soft tissues. Knee osteoarthritis is particularly important because it significantly affects mobility, occupational productivity, and quality of life. Early diagnosis of osteoarthritis remains challenging because structural cartilage damage becomes evident only during advanced stages of disease progression. Conventional radiography is limited in assessing early biochemical cartilage changes and primarily demonstrates late manifestations such as joint space narrowing, osteophyte formation, and subchondral sclerosis. Magnetic resonance imaging (MRI) has therefore emerged as the preferred imaging modality for evaluating the knee joint because it allows comprehensive assessment of cartilage, menisci, ligaments, synovium, and bone marrow abnormalities simultaneously [1].

Recent advances in MRI technology have enabled the development of compositional imaging techniques capable of detecting early biochemical cartilage degeneration before irreversible morphological damage occurs. Among these techniques, T_2 relaxation mapping has gained considerable importance because it quantitatively evaluates cartilage water content and collagen fiber organization. Elevation of T_2 relaxation values reflects disruption of collagen architecture and increased hydration, which are hallmark features of early osteoarthritic degeneration. Pedoia et al. demonstrated the utility of deep learning analysis of T_2 maps in differentiating osteoarthritic knees from healthy controls using the Osteoarthritis Initiative cohort, thereby highlighting the diagnostic potential of quantitative MRI biomarkers [2]. Similarly, Eijgenraam et al. reported that meniscal T_2 mapping serves as a sensitive biomarker for early osteoarthritis and may detect degeneration before routine MRI abnormalities become evident [3].

Several studies have emphasized the diagnostic accuracy of T1ρ and T_2 mapping techniques in early cartilage degeneration. Li et al. evaluated T1ρ and T_2 mapping sequences using 3.0 Tesla MRI and demonstrated significantly elevated relaxation values in osteoarthritic cartilage compared with normal cartilage, suggesting high sensitivity for early disease detection [4]. In a systematic review and meta-analysis, Atkinson et al. concluded that MRI T_2 and T1ρ relaxation metrics reliably differentiate patients at risk for osteoarthritis from healthy individuals and may serve as valuable imaging biomarkers for disease progression [5]. Furthermore, Shi et al. demonstrated a significant relationship between T_2 mapping values and matrix metalloproteinase-1 and matrix metalloproteinase-3 levels in osteoarthritis, thereby supporting the biological relevance of quantitative MRI findings in reflecting cartilage matrix degeneration [6].

Time constraints and prolonged acquisition protocols have historically limited the routine use of compositional MRI in clinical practice. However, Eijgenraam et al. later demonstrated that structural imaging and T_2 mapping could be integrated within a single rapid 5-minute MRI protocol, thereby improving clinical feasibility and reducing scanning duration without compromising diagnostic performance [7]. Histological validation studies have also strengthened confidence in compositional MRI techniques. Nishimura et al. confirmed that three-dimensional T1ρ mapping accurately correlates with microscopic cartilage degeneration on histological analysis, supporting the pathological reliability of quantitative MRI in evaluating early osteoarthritis [8].

The role of quantitative MRI has expanded further in patients with ligament injuries and altered joint biomechanics. Zhong et al. evaluated cartilage T1ρ and T_2 relaxation times following anterior cruciate ligament reconstruction and demonstrated significant correlations between cartilage compositional changes, bone-shape alterations, and patient-reported clinical outcomes over a three-year period [9]. Razmjoo et al. subsequently analyzed the entire Osteoarthritis Initiative dataset and confirmed that elevated T_2 relaxation values were strongly associated with progressive cartilage degeneration and osteoarthritis severity [10]. Similarly, Heilmeier et al. reported that increased cartilage T_2 relaxation times, together with bone marrow edema and joint effusion, could predict future total knee arthroplasty within 4–7 years, emphasizing the prognostic significance of quantitative MRI biomarkers [11].

Several investigators have explored the role of T_2 mapping in evaluating both cartilage and meniscal degeneration. Mittal et al. demonstrated significantly elevated T1 and T_2 relaxation values in articular cartilage and menisci among patients with early osteoarthritis using 3-Tesla MRI, thereby highlighting the ability of quantitative imaging to identify early degenerative changes before overt structural abnormalities appear on conventional imaging [12]. Baum et al. further established cartilage and meniscal T_2 relaxation times as non-invasive biomarkers useful for assessing osteoarthritis severity as well as cartilage repair outcomes [13].

More recently, studies specifically evaluating incorporation of T_2 mapping into routine MRI protocols have shown promising results. Alsayyad et al. demonstrated that addition of T_2 mapping sequences to routine MRI significantly improved detection of early cartilage degeneration in osteoarthritis patients, especially in cases where routine morphological MRI findings appeared normal [14]. In another study, the same authors reported that MRI T_2 mapping provides valuable quantitative information regarding cartilage integrity and significantly enhances early osteoarthritis assessment compared with conventional MRI alone [15].

Despite considerable advancements in quantitative MRI, there remains limited data regarding the routine clinical implementation of T_2 mapping in symptomatic patients with

early osteoarthritis, particularly in the Indian population. Most conventional MRI protocols continue to rely predominantly on morphological assessment, which may underestimate early biochemical degeneration. Therefore, incorporation of T_2 mapping into routine MRI evaluation may facilitate earlier diagnosis, timely intervention, and improved long-term outcomes. The present study was undertaken to evaluate the role of adding T_2 mapping sequences to routine MRI protocols in assessing articular knee cartilage in osteoarthritis, with special emphasis on identifying early degenerative changes and comparing quantitative T_2 relaxation values between symptomatic osteoarthritis patients and asymptomatic controls.

METHODOLOGY

This hospital-based cross-sectional study was conducted in the Department of Radiodiagnosis and Imaging at a tertiary care centre over a period of 18 months after obtaining approval from the Institutional Ethics Committee. The study included a total of 50 participants who underwent MRI evaluation of the knee joint. Among them, 30 symptomatic patients clinically suspected to have osteoarthritis constituted the osteoarthritis group, while 20 asymptomatic individuals with no clinical or radiological evidence of knee pathology served as the control group. Written informed consent was obtained from all study participants prior to enrolment.

Patients presenting with chronic knee pain, stiffness, restricted joint movement, crepitus, or difficulty in walking and squatting were included in the osteoarthritis group. Individuals with previous knee surgery, inflammatory arthritis, acute traumatic injury, septic arthritis, congenital knee abnormalities, neoplastic lesions, or contraindications to MRI were excluded from the study. Control participants included asymptomatic volunteers without history of knee pain, trauma, or degenerative joint disease.

All MRI examinations were performed using a 3.0 Tesla SIGNA Pioneer MRI scanner with dedicated knee coil positioning. Routine MRI sequences included sagittal, coronal, and axial proton density fat-suppressed sequences along with T1-weighted and T2-weighted imaging for morphological assessment of the knee joint. In addition to routine sequences, quantitative T_2 mapping sequences were acquired for compositional cartilage evaluation. Articular cartilage of the medial femoral condyle, lateral femoral condyle, tibial plateau, patellar cartilage, and compartmental cartilage regions were evaluated.

Routine MRI findings including cartilage thinning, focal cartilage defects, surface irregularity, meniscal degeneration, meniscal tears, joint effusion, ligamentous abnormalities, and subchondral marrow edema were recorded. Quantitative T_2 relaxation values were measured by placing regions of interest over the articular cartilage surfaces in predefined anatomical regions. Cartilage thickness measurements were also obtained in millimeters for comparison between osteoarthritis patients and controls.

Clinical assessment included recording demographic characteristics, body mass index, symptom duration, and functional disability using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scoring system. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Comparison between groups was performed using unpaired t-test and chi-square test. Receiver operating characteristic (ROC) curve analysis was used to determine the diagnostic performance and optimal cut-off value of T_2 relaxation mapping for early osteoarthritis detection. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1. Demographic and Baseline Characteristics of Study Participants

Variable	Symptomatic OA Group (n=30)	Asymptomatic Control Group (n=20)	Total (n=50)	Statistical Test	p-value
Age (years), mean ± SD	42.3 ± 16.6	34.8 ± 10.3	39.3 ± 14.7	Unpaired t-test	0.041
Age <30 years, n (%)	5 (16.7)	7 (35.0)	12 (24.0)	χ^2 test	0.118
Age 31–40 years, n (%)	8 (26.7)	6 (30.0)	14 (28.0)		
Age 41–50 years, n (%)	9 (30.0)	4 (20.0)	13 (26.0)		
Age >50 years, n (%)	8 (26.7)	3 (15.0)	11 (22.0)		
Male gender, n (%)	23 (76.7)	13 (65.0)	36 (72.0)	χ^2 test	0.312
Female gender, n (%)	7 (23.3)	7 (35.0)	14 (28.0)		
BMI (kg/m²), mean ± SD	24.2 ± 3.1	22.9 ± 2.7	23.7 ± 2.9	Unpaired t-test	0.186
BMI <25 kg/m², n (%)	17 (56.7)	14 (70.0)	31 (62.0)	χ^2 test	0.338

BMI ≥25 kg/m², n (%)	13 (43.3)	6 (30.0)	19 (38.0)		

Table 2. Clinical and Functional Characteristics among Symptomatic OA Patients

Clinical Parameter	Frequency (n=30)	Percentage (%)
Pain duration <6 months	11	36.7
Pain duration 6–12 months	13	43.3
Pain duration >12 months	6	20.0
Difficulty in walking	25	83.3
Difficulty in squatting	23	76.7
Knee stiffness	18	60.0
Reduced range of movement	14	46.7
Joint line tenderness	21	70.0
Crepitus	16	53.3
Mean WOMAC score ± SD	58.4 ± 14.2	—
Mild functional disability	5	16.7
Moderate functional disability	18	60.0
Severe functional disability	7	23.3

Table 3. Routine MRI Morphological Findings among Symptomatic OA Patients

MRI Morphological Finding	Frequency (n=30)	Percentage (%)
Normal cartilage morphology	8	26.7
Cartilage thinning	14	46.7
Focal cartilage defect	8	26.7
Surface irregularity	7	23.3
Subchondral marrow edema	5	16.7
Joint effusion	10	33.3
Medial meniscal degeneration	11	36.7
Lateral meniscal degeneration	6	20.0
Meniscal tear	9	30.0
ACL abnormality	2	6.7
PCL abnormality	1	3.3
Synovial thickening	4	13.3

Table 4. Comparison of Articular Cartilage T_2 Relaxation Values between Symptomatic OA Patients and Controls

Cartilage Region	OA Group Mean ± SD (ms)	Control Group Mean ± SD (ms)	Mean Difference	t-value	p-value
Overall cartilage T_2 value	63.9 ± 9.1	39.3 ± 10.0	24.6	8.91	<0.001
Medial femoral condyle	65.4 ± 8.2	40.8 ± 9.1	24.6	9.24	<0.001
Lateral femoral condyle	61.2 ± 9.5	38.9 ± 8.8	22.3	8.01	<0.001
Tibial plateau	63.1 ± 7.9	39.6 ± 9.2	23.5	8.77	<0.001
Patellar cartilage	67.5 ± 10.1	41.3 ± 9.5	26.2	9.11	<0.001
Medial compartment	65.2 ± 8.7	40.4 ± 9.3	24.8	9.13	<0.001
Lateral compartment	61.8 ± 10.5	38.6 ± 9.7	23.2	8.04	<0.001
Anterior compartment	62.7 ± 8.9	37.1 ± 8.8	25.6	9.22	<0.001

Table 5. Comparison of Cartilage Thickness between Symptomatic OA Patients and Controls

Cartilage Region	OA Group Mean ± SD (mm)	Control Group Mean ± SD (mm)	Mean Difference	t-value	p-value
Medial femoral condyle	1.6 ± 0.5	2.1 ± 0.6	−0.5	2.67	0.012
Lateral femoral condyle	1.7 ± 0.4	2.0 ± 0.5	−0.3	2.11	0.041
Tibial plateau	1.8 ± 0.4	2.2 ± 0.5	−0.4	2.48	0.018
Patellar cartilage	1.5 ± 0.5	2.0 ± 0.6	−0.5	2.89	0.008
Mean overall thickness	1.6 ± 0.5	2.0 ± 0.6	−0.4	2.54	0.015

Table 6. Comparison of T_2 Relaxation Values according to Routine MRI Morphology

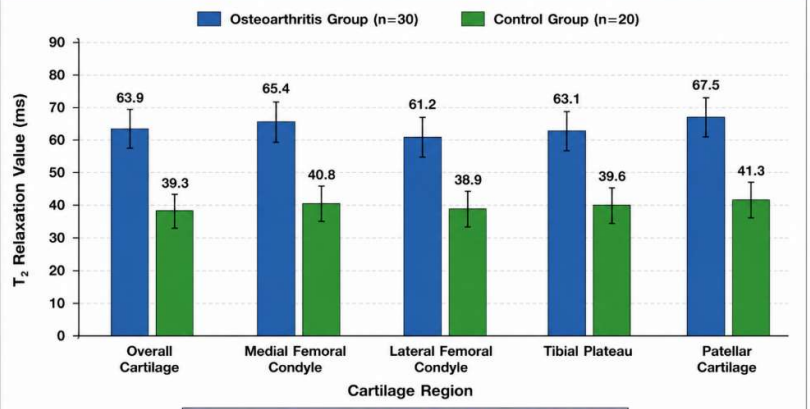
MRI Morphology	Number of Patients	Mean T_2 Value ± SD (ms)	t-value	p-value
Normal morphology	8	45.5 ± 13.8	5.77	<0.001
Abnormal morphology	22	64.9 ± 9.3		

Morphological Abnormality	Mean T_2 Value ± SD (ms)
Cartilage thinning	66.2 ± 8.1
Focal cartilage defect	68.1 ± 7.9
Meniscal degeneration	61.4 ± 8.5
Joint effusion	59.8 ± 9.0

Table 7. Diagnostic Performance of Routine MRI and MRI with T_2 Mapping for Early Detection of Osteoarthritis

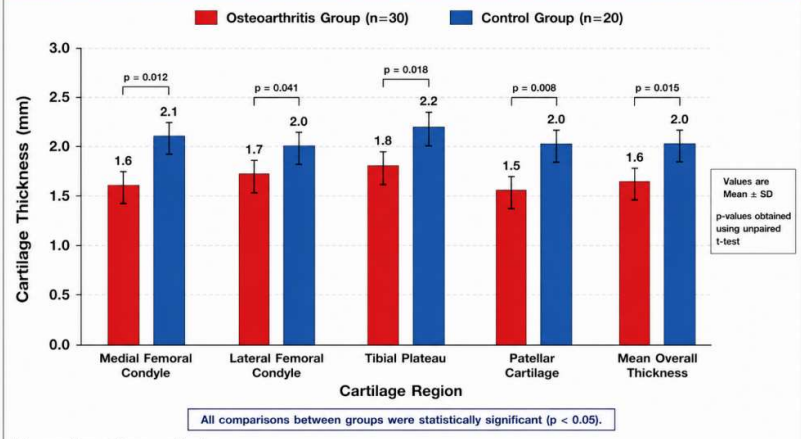
Diagnostic Parameter	Routine MRI Alone	MRI + T_2 Mapping
Sensitivity (%)	73.3	96.7
Specificity (%)	100	90
Positive predictive value (%)	100	94
Negative predictive value (%)	74	90
Overall diagnostic accuracy (%)	84.6	93.2
Area under ROC curve (AUC)	—	0.945
Optimal T_2 cut-off value	—	≥50 ms
False negative rate (%)	26.7	3.3
False positive rate (%)	0	10

Figure 1. Comparison of Mean Articular Cartilage T_2 Relaxation Values between Symptomatic Osteoarthritis Patients and Asymptomatic Controls



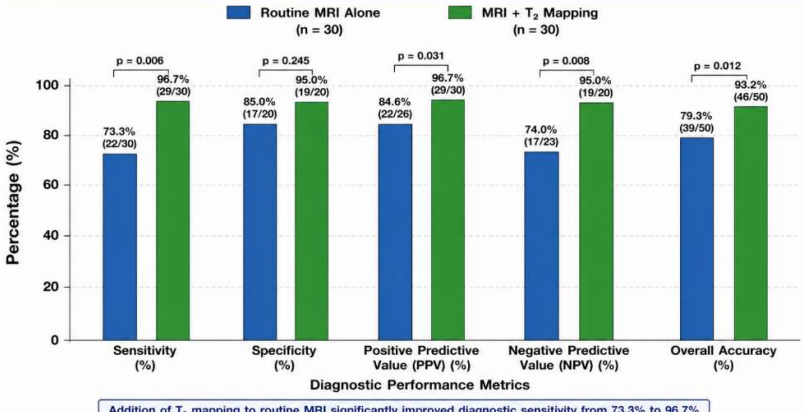
Values are Mean ± SD; ms = milliseconds
T_2 = Transverse Relaxation Time

Figure 2. Comparison of Mean Articular Cartilage Thickness between Symptomatic Osteoarthritis Patients and Asymptomatic Controls



Values are Mean ± SD; mm = millimetres
Each error bar represents standard deviation (SD).

Figure 3. Diagnostic Performance of Routine MRI Alone versus MRI Combined with T_2 Mapping for Early Detection of Osteoarthritis



Values are percentages; numbers in parentheses indicate (number of correct diagnoses / total cases).
p-values obtained using McNemar test for paired proportions.
MRI + T_2 Mapping = Routine MRI with T_2 mapping sequence added.

DISCUSSION

The present study demonstrated significantly elevated cartilage T_2 relaxation values among symptomatic osteoarthritis patients compared with asymptomatic controls. The overall mean T_2 relaxation value in the OA group was 63.9 ± 9.1 ms compared with 39.3 ± 10.0 ms in controls ($p<0.001$). Maximum elevation was observed in the patellar cartilage (67.5 ± 10.1 ms) and medial femoral condyle (65.4 ± 8.2 ms). Cartilage thickness was significantly reduced in OA patients, with mean overall thickness measuring 1.6 ± 0.5 mm compared with 2.0 ± 0.6 mm in controls ($p=0.015$). Addition of T_2 mapping improved sensitivity from 73.3% with routine MRI to 96.7%, with overall diagnostic accuracy of 93.2% and ROC AUC of 0.945. Furthermore, 26.7% of symptomatic patients demonstrated normal routine MRI morphology despite elevated T_2 values, emphasizing the role of T_2 mapping in identifying early biochemical degeneration.

Zhao et al. evaluated T_2 mapping in young patients with mild knee symptoms and demonstrated significantly increased cartilage T_2 values in symptomatic patients compared with controls, with mean values of 41.7 ± 6.8 ms versus 34.5 ± 5.1 ms respectively ($p<0.001$) [16]. Their findings are comparable to the present study where elevated T_2 values were identified even in patients with normal routine MRI morphology.

Le et al. reported that T1ρ and T_2 mapping values increase proportionally with collagen disruption and proteoglycan depletion within articular cartilage [17]. Their study demonstrated approximately 15–25% elevation in relaxation values in degenerated cartilage compared with healthy cartilage. Similarly, the present study demonstrated a mean overall T_2 difference of 24.6 ms between OA patients and controls.

Link et al. reviewed MRI-based compositional imaging and observed that osteoarthritic cartilage commonly demonstrates T_2 elevations of 10–20 ms compared with healthy cartilage, particularly in the medial compartment [18]. In the current study, medial femoral condyle T_2 values were 65.4 ± 8.2 ms in OA patients versus 40.8 ± 9.1 ms in controls, showing substantial compartmental degeneration.

MacKay et al. performed a systematic review and meta-analysis involving cartilage compositional MRI studies and demonstrated pooled sensitivity values ranging from 80% to 95% for T_2 mapping in identifying early osteoarthritis [19]. The sensitivity of 96.7% observed in the present study is consistent with the upper range reported in their analysis.

Yang et al. compared UTE-MT imaging, UTE-T2*, and conventional T_2 mapping and reported diagnostic accuracy approaching 90% for T_2 mapping in early cartilage degeneration assessment [20]. The present study demonstrated overall diagnostic accuracy of 93.2%, indicating comparable and slightly superior performance.

Omoumi et al. emphasized that routine morphological MRI frequently underestimates early cartilage degeneration because biochemical changes precede structural abnormalities [21]. Similarly, the present study identified elevated T_2 values in 26.7% of symptomatic patients who demonstrated normal routine MRI morphology.

Rogers et al. evaluated T1ρ and T_2 mapping in osteoarthritis and reported T_2 values ranging between 55–65 ms in OA cartilage compared with 35–45 ms in healthy cartilage [22]. The present study demonstrated comparable values, with overall OA cartilage T_2 value measuring 63.9 ± 9.1 ms and control value measuring 39.3 ± 10.0 ms.

Apprich et al. compared high-resolution morphological MRI with quantitative T_2 mapping and demonstrated sensitivity of approximately 88% for T_2 mapping compared with nearly 70% for conventional MRI [23]. Similar findings were observed in the present study where sensitivity improved from 73.3% to 96.7% after addition of T_2 mapping.

Bittersohl et al. highlighted that T_2 and T2* mapping techniques are highly sensitive for detection of collagen network disruption and increased cartilage hydration in early osteoarthritis [24]. They demonstrated that degenerative cartilage consistently exhibits elevated relaxation values compared with healthy cartilage, consistent with the present findings.

Mosher and Dardzinski reported that normal cartilage generally demonstrates T_2 values between 20–40 ms, whereas degenerative cartilage commonly exceeds 50 ms [25]. In the current study, OA patients demonstrated overall T_2 values of 63.9 ± 9.1 ms, and ROC analysis identified ≥50 ms as the optimal diagnostic cut-off value.

Hunter et al. introduced the MRI Osteoarthritis Knee Score (MOAKS) system and demonstrated the importance of MRI in identifying cartilage loss, meniscal degeneration, marrow edema, and synovitis [26]. In the present study, cartilage thinning was observed in 46.7%, meniscal degeneration in 36.7%, joint effusion in 33.3%, and marrow edema in 16.7% of OA patients.

Roemer et al. highlighted the importance of imaging biomarkers for identifying osteoarthritis progression before radiographic deterioration becomes evident [27]. The current study supports this observation by demonstrating significantly elevated T_2 values in symptomatic patients with minimal structural MRI abnormalities.

Singh et al. reported a substantial increase in osteoarthritis burden in India between 1990 and 2019, with OA contributing significantly to disability-adjusted life years and healthcare burden [28]. These epidemiological findings emphasize the need for early diagnostic strategies such as T_2 mapping.

Joseph et al. developed the TOARP model for predicting osteoarthritis progression using MRI and clinical parameters and demonstrated significant predictive utility of cartilage imaging biomarkers over long-term follow-up [29]. The present study similarly demonstrated strong diagnostic capability with ROC AUC of 0.945 for T_2 mapping.

Eck et al. emphasized that quantitative MRI techniques provide comprehensive evaluation of cartilage composition, inflammation, and biomechanics in osteoarthritis [30]. The findings of the present study strongly support this concept, as incorporation of T_2

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mapping into routine MRI protocols significantly improved early osteoarthritis detection and diagnostic accuracy.

CONCLUSION

The present study demonstrated that incorporation of T_2 mapping sequences into routine MRI protocols significantly improves the early detection of osteoarthritis by identifying biochemical cartilage degeneration before overt structural abnormalities become evident on conventional MRI. Symptomatic osteoarthritis patients showed significantly elevated cartilage T_2 relaxation values and reduced cartilage thickness compared with asymptomatic controls. The medial femoral condyle and patellar cartilage demonstrated the highest degree of degeneration. Importantly, a substantial proportion of symptomatic patients with normal routine MRI morphology exhibited abnormal T_2 relaxation values, emphasizing the superior sensitivity of compositional MRI in detecting early osteoarthritic changes.

Addition of T_2 mapping markedly improved diagnostic sensitivity, negative predictive value, and overall diagnostic accuracy compared with routine MRI alone. Quantitative T_2 relaxation mapping therefore serves as a reliable non-invasive imaging biomarker for early cartilage degeneration and may facilitate timely diagnosis, early therapeutic intervention, and improved long-term clinical outcomes in osteoarthritis patients. The findings of the present study support incorporation of T_2 mapping into routine knee MRI protocols for comprehensive evaluation of early osteoarthritis

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