

Role of Adding T2 Mapping Sequence to the Routine Mr Imaging Protocol in the Assessment of Articular Knee Cartilage in Osteoarthritis

Research Article

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Abstract

Introduction: Osteoarthritis (OA) of the knee is characterized by early biochemical cartilage changes that may precede visible morphological damage. Conventional 1.5 Tesla MRI provides detailed anatomy but may be less sensitive to early matrix alterations. T2 mapping quantifies T2 relaxation and is sensitive to changes in collagen organization and tissue water content.

Methods: A prospective observational study of 50 participants (25 OA and 25 controls) was performed over two years at SSIMS & RC, Davangere. All participants underwent routine 1.5 Tesla knee MRI with an additional T2 mapping sequence. T2 relaxation values and cartilage thickness were assessed at the medial and lateral femoral condyles, medial and lateral tibial plateaus and patella. Statistical significance was set at $p < 0.05$.

Results: Mean T2 relaxation values were significantly higher in OA patients than in controls across all assessed compartments ($p < 0.001$). Cartilage thickness did not differ significantly between the groups at the femoral condyles or tibial plateaus. However, patellar cartilage was significantly thicker in the OA group than in the control group (1.88 ± 0.55 mm vs. 1.57 ± 0.36 mm; $p = 0.025$).

Conclusion: T2 mapping demonstrated biochemical and microstructural cartilage abnormalities before consistent morphological thinning and can be incorporated into routine 1.5 Tesla knee MRI as a quantitative adjunct for early OA assessment.

Keywords: Knee osteoarthritis; T2 mapping; Quantitative MRI; Articular cartilage; Cartilage degeneration; 1.5 Tesla MRI

Introduction

Knee osteoarthritis (OA) is characterized by progressive biochemical and structural cartilage deterioration. Compositional

changes in collagen organization and cartilage water content may occur before appreciable morphologic cartilage loss. Conventional MRI is well suited to structural assessment, whereas T2 mapping provides a quantitative measure that is sensitive to changes in cartilage

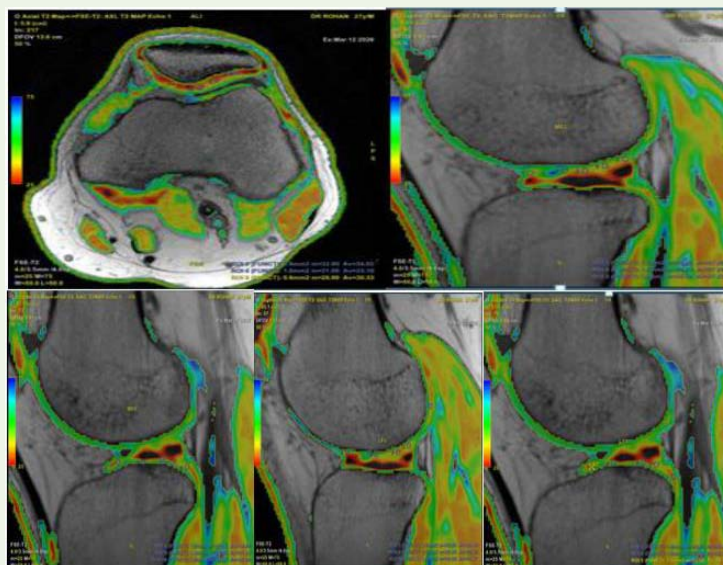


Figure 1: 50-year-old male without symptoms: T2 values approximately 28–30 ms.

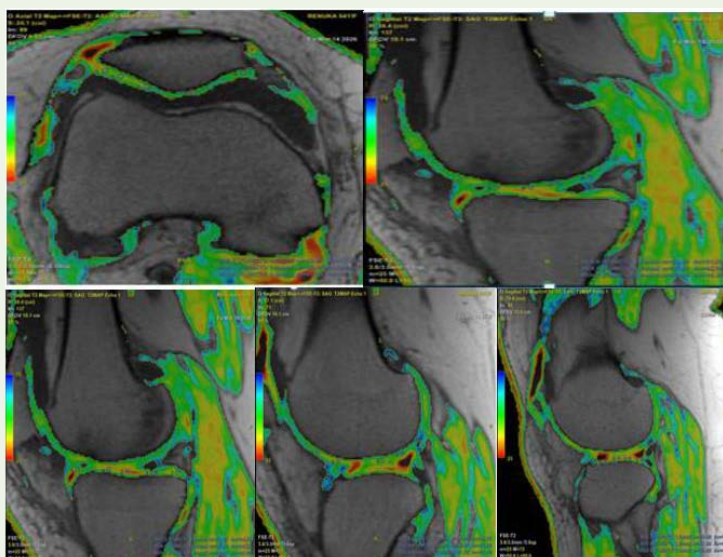


Figure 2: 56-year-old female without symptoms: T2 values approximately 33–34 ms.

matrix organization and water mobility. The clinical interpretation of T2 values may also be influenced by patient-related factors, including body mass index (BMI), because increased mechanical loading may affect cartilage composition and degeneration. Similarly, the relationship between T2 relaxation and symptom duration or disease chronicity is clinically relevant, as a quantitative marker that changes with longer-standing disease could provide information beyond a simple OA-versus-control comparison. The present study therefore primarily compared cartilage T2 relaxation times and thickness between patients with knee OA and controls. Where participant-level BMI and symptom-duration data are available, their associations with

compartmental T2 relaxation should be assessed using correlation or regression analysis rather than inferred from the group comparison. [4,7,9–11]

Materials and Methods

Study design and setting. This was a prospective observational study conducted in the Department of Radiodiagnosis, S. S. Institute of Medical Sciences and Research Centre, Davangere, over a period of two years. Participants were recruited from the Orthopaedics outpatient service and referred for knee MRI. Participants. Fifty participants were included in the study: 25 patients

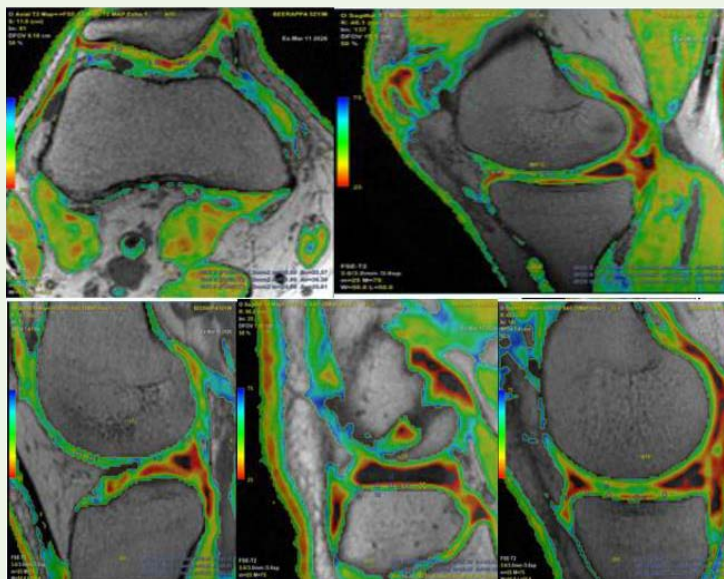


Figure 3: 58-year-old male without symptoms: T2 values approximately 40–42 ms.

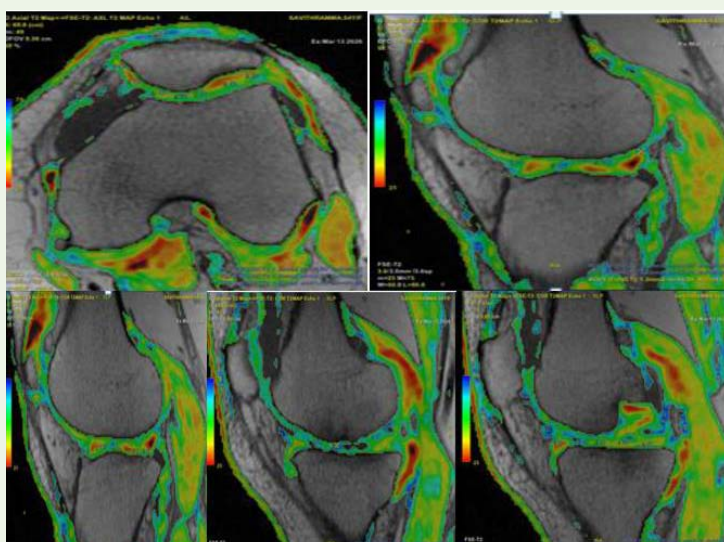


Figure 4: 60-year-old female with knee pain: T2 values approximately 52–54 ms.

with clinically and radiologically diagnosed knee osteoarthritis (OA) and 25 clinically normal controls. Participants were recruited using consecutive sampling. Exclusion criteria included MRI-incompatible implants, orthopnea or claustrophobia, knee implants, previous trauma or knee surgery, and other contraindications to MRI. Imaging protocol. MRI was performed on a GE Signa HDxt 1.5 Tesla system using a knee coil. Routine knee MRI sequences were followed by a T2 mapping sequence for quantitative assessment of articular cartilage. T2 relaxation values and cartilage thickness were assessed at the medial femoral condyle (MFC), lateral femoral condyle (LFC),

medial tibial plateau (MT), lateral tibial plateau (LT), and patella. Statistics and ethics. Quantitative variables were summarized as mean $\pm$ standard deviation and qualitative variables as frequencies and percentages. Data were analyzed using SPSS version 25.0, with $p < 0.05$ considered statistically significant. Institutional ethics approval was obtained and written informed consent was obtained from all participants.

Results

The study population had a mean age of 68.4 ± 9.47 years. The

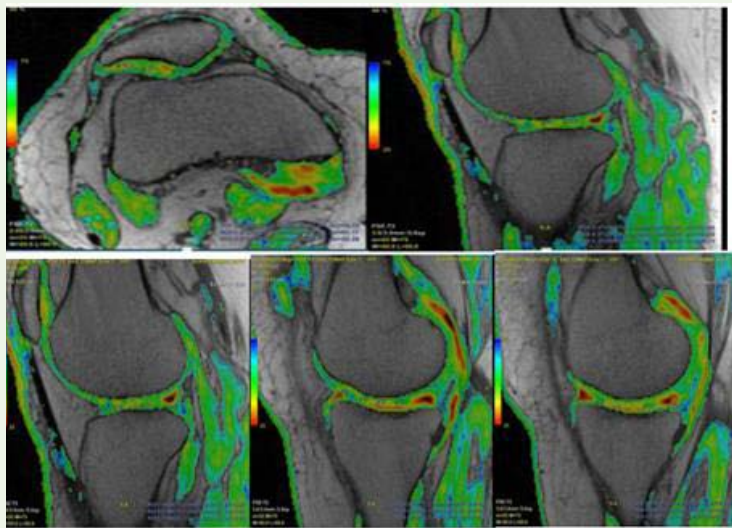


Figure 5: 57-year-old female with knee pain: T2 values approximately 43–45 ms.

Table 1: Comparison of T2 relaxation values and cartilage thickness between OA and control groups.						
Compartment	OA T2 (ms)	Control T2 (ms)	p	OA thickness (mm)	Control thickness (mm)	p
MFC	36.90 ± 7.20	27.60 ± 2.10	<0.001	1.69 ± 0.54	1.58 ± 0.20	0.349
LFC	37.66 ± 8.69	27.85 ± 1.86	<0.001	1.56 ± 0.49	1.65 ± 0.31	0.472
MT	33.95 ± 5.79	26.86 ± 1.33	<0.001	1.66 ± 0.55	1.61 ± 0.28	0.670
LT	37.84 ± 6.22	26.85 ± 1.96	<0.001	1.62 ± 0.43	1.62 ± 0.25	0.994
Patella	36.09 ± 7.24	28.10 ± 2.28	<0.001	1.88 ± 0.55	1.57 ± 0.36	0.025

OA group had a mean age of 68.60 ± 10.19 years and the control group 68.20 ± 8.91 years. Females constituted 62% of the overall cohort (31/50). Across all five evaluated cartilage compartments, T2 relaxation values were significantly higher in the OA group. In contrast, cartilage thickness showed no statistically significant group difference at the MFC, LFC, MT or LT; the only significant thickness difference was at the patella, where cartilage was thicker in the OA group. The available manuscript does not provide participant-level BMI or symptom-duration data. Therefore, the relationship between BMI and T2 relaxation, and the relationship between T2 relaxation and duration of symptoms or OA chronicity, could not be statistically evaluated from the supplied dataset.

Discussion

The principal finding of this study was a consistent elevation of T2 relaxation values in OA cartilage across the medial and lateral femoral condyles, tibial plateaus and patella, despite largely preserved cartilage thickness. This supports the concept that compositional cartilage abnormalities can be detected before consistent morphologic thinning. Prolonged T2 relaxation is compatible with disruption of the collagen network and increased water mobility within the cartilage extracellular matrix. The magnitude of the between-group differences

was substantial in all five compartments (approximately 7–11 ms), with $p < 0.001$ for each comparison, indicating a statistically robust group separation in this cohort. However, statistical significance should not be equated with an established diagnostic threshold or with clinical severity, because the study was small and cross-sectional and no longitudinal clinical outcome was assessed. BMI is a potentially important modifier of cartilage T2 values. Higher body mass may increase mechanical loading across the knee and may be associated with cartilage degeneration, which could in turn influence T2 relaxation. Accordingly, an observed BMI–T2 association would need to be distinguished from the effect of OA itself, ideally by using participant-level data and multivariable regression adjusting for age, sex and OA status. Such an analysis was not possible in the present manuscript because participant-level BMI measurements were not included in the available dataset. Therefore, the current results should not be interpreted as demonstrating either a positive or negative association between BMI and T2 relaxation. Symptom duration and disease chronicity are also relevant to interpretation. T2 mapping reflects tissue composition rather than symptom duration directly, and patients with similar symptom duration may have different structural and biochemical stages of OA. Conversely, prolonged disease may be associated with progressive

matrix disruption and potentially higher T2 values, although this relationship cannot be established from the present cross-sectional group comparison. Because individual symptom duration, disease-onset timing or a formal chronicity classification was not available in the supplied dataset, no valid correlation, trend analysis or acute-versus-chronic comparison could be performed. Importantly, the representative images in the manuscript illustrate a range of T2 values in individuals with and without symptoms, but these examples are descriptive and cannot substitute for participant-level statistical analysis. The lack of significant thickness differences at most compartments, despite consistently elevated T2 values, further emphasizes the complementary role of compositional imaging. The higher patellar thickness observed in the OA group may reflect early cartilage swelling or measurement variability, but this finding should be interpreted cautiously because the study was not designed to establish the mechanism of thickness increase. Absolute T2 values should also be interpreted in the context of field strength, sequence parameters, ROI placement, loading state and other technical and biological sources of variation. Overall, the study supports the feasibility of adding T2 mapping to routine 1.5-T knee MRI, while the associations of T2 with BMI and disease duration remain important questions for adequately powered studies with detailed clinical metadata. [4,7,9–11] [4,7,9,10] [7,9,10]

Limitations

Limitations included the single-centre design, relatively small sample size, use of a 1.5 Tesla scanner, lack of longitudinal follow-up, absence of histopathological or arthroscopic correlation, possible biological and technical variability in T2 measurements, and potential segmentation or partial-volume effects in cartilage thickness measurements. Most importantly, participant-level BMI and symptom-duration/chronicity variables were not available in the dataset supplied for this manuscript, preventing valid secondary analyses of BMI–T2 association and T2 variation according to symptom duration or disease chronicity. These relationships should be evaluated in future studies using participant-level clinical data and appropriate multivariable statistical methods. Other quantitative techniques such as T1rho and dGEMRIC were not evaluated extensively.

Conclusion

T2 mapping demonstrated significantly higher cartilage T2 relaxation values in OA than in controls across all five evaluated compartments, while cartilage thickness was largely preserved. These findings support T2 mapping as a complementary compositional technique for detecting cartilage abnormalities that may precede consistent morphologic loss. The present dataset does not permit conclusions regarding BMI-related variation or the effect of symptom duration/disease chronicity on T2 relaxation; these associations

require participant-level clinical data and dedicated statistical analysis.

Learning Points

1. T2 mapping can detect cartilage biochemical and microstructural abnormalities before consistent morphological thinning becomes apparent.
2. In this cohort, T2 values were significantly higher in OA cartilage at all five assessed compartments.
3. Cartilage thickness was not significantly different at the femoral condyles or tibial plateaus; patellar thickness was higher in OA.
4. BMI and symptom duration are clinically relevant potential modifiers of T2 relaxation, but their associations could not be tested because participant-level data were unavailable in the supplied dataset.
5. Interpretation of absolute T2 values should account for field strength, acquisition parameters, ROI technique and biological variability.
6. Adding T2 mapping to a routine 1.5 Tesla knee MRI protocol is feasible and provides quantitative information complementary to morphology.
7. In this cohort, T2 values were significantly higher in OA cartilage at all five assessed compartments.
8. Cartilage thickness was not significantly different at the femoral condyles or tibial plateaus; patellar thickness was higher in OA.
9. Interpretation of absolute T2 values should account for field strength, acquisition parameters, ROI technique and biological variability.
10. Adding T2 mapping to a routine 1.5 Tesla knee MRI protocol is feasible and provides quantitative information complementary to morphology.

Ethics and Consent

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Ethics Review Board of S. S. Institute of Medical Sciences and Research Centre, Davangere, Karnataka, India. Written informed consent was obtained from all participants.

Conflict of Interest

To be confirmed by the authors before submission.

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