ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 03 | March - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ROLE OF ADDING SAGITTAL T2 MAPPING SEQUENCE TO THE ROUTINE MRI IMAGING PROTOCOL IN THE ASSESSMENT OF ARTICULAR KNEE CARTILAGE

Radiology

Dr. Abha Sharad Yelne* Jr3, Radiodiagnosis, govt medical college and hospital, chh. Sambhajinagar, Maharashtra, India. *Corresponding Author

Dr. Varsha Rote Kaginalkar Prof & HOD, Department of Radiology, GMCH Chhatrapati Sambhajinagar Maharashtra, India.

Dr. Fadel Abdul Samed Jr3, Radiodiagnosis, govt medical college and hospital, chh. Sambhajinagar, Maharashtra, India.

Dr. Ajay Vare Associate professor, Department of Radiology, GMCH Chhatrapati Sambhajinagar Maharashtra, India.

Dr. Anjali Pawar Dahiphale Associate Professor, Department of Radiology, GMCH Chhatrapati Sambhajinagar Maharashtra, India.

ABSTRACT

Magnetic resonance imaging (MRI) has become the most important, non invasive medical imaging modality for assessment of pathological changes in the knee cartilage. The purpose of study was to determine the ability of MR T2 mapping to detect cartilage status in articular knee pathologies (traumatic/non traumatic) in addition to routine MRI sequencing & To compare the T2 relaxation values in subjects. This was observational cross sectional study carried over a period of 6 months from Jun 2023-Dec 2023 at department of Radiodiagnosis, tertiary care center after obtaining clearance from our Institutional Ethics Committee. Total 50 participants were enrolled in this study. Highest frequency (30%) observed in the 40-50 age group. About 56% were female (28 participants) and 44% are male (22 participants). Medial femoral condyle and medial tibia areas tend to have higher average T2 values, which could suggest more cartilage degeneration in these regions. The summary statistics for cartilage thickness (ct) across different knee regions show that the mean thickness values are relatively consistent, ranging from 1.5 (MFC and MT) to 1.8 (Patella). Osteoarthritis is the most prevalent condition. This study highlights the significant clinical value of incorporating T2 mapping into routine MRI for the assessment of knee cartilage in detecting early cartilage degeneration, crucial for timely diagnosis and management of conditions like osteoarthritis, chondromalacia patellae and osteochondral injuries.

KEYWORDS

MRI, MR T2 mapping, condyle (MFC), lateral femoral condyle (LFC), medial tibia (MT) and lateral tibia (LT) and patella (P).

INTRODUCTION:

Magnetic resonance imaging (MRI) has become the most important, non invasive medical imaging modality for assessment of pathological changes in the knee cartilage. The assessment of the cartilage is usually made by a set of traditional anatomical MRI images with different sequences, such as T1 and T2 weighted imaging. Newer emerging techniques, that map various in MRI parameters, have been developed and allows changes in an earlier stage of the disease. The visualization of articular cartilage and focal osteochondral injuries has been improved by the development and advancement of the MRI technology. One of these techniques is T2 mapping. Techniques to map various in MRI parameters had been developed and visualize the biochemical and biophysical changes of the cartilage. Compared to other methods, these newer techniques allow changes in an earlier stage of the disease. The goal of this thesis is to compare this newer technique, T2 mapping, with the standard MRI assessment for assessment of articular cartilage on distal femur in the knee.

Articular cartilage pathology may be the result of degeneration or due to acute injury. The articular cartilage is composed of cartilage cell and extracellular matrix including water, type II collagen, and proteoglycan. Currently, MRI is a powerful noninvasive tool for the evaluation of traumatic and degenerative changes in the articular cartilage of the knee because of its high sensitivity, specificity, high contrast, and multiplanar capability.

The aging population, obesity, infections, and joint stress all contribute to an increased incidence of osteoarthritis (OA). Preventive interventions for osteoarthritis (OA) must be observed and implemented, particularly in young individuals. It has been demonstrated that routine MRI is a useful technique for assessing articular cartilage. However, there is minimal sensitivity in identifying early cartilage degradation because of the limitations in morphologic cartilage imaging sequences. Quantitative T2 mapping exhibits broad usage of articular tissues, especially the cartilage. With advances in joint preservation surgery that are intended to alter the course of osteoarthritis by early intervention, there is a rising demand in developing accurate and reliable quantitative MRI techniques that are sensitive to early structural degeneration in articular cartilage.

In order to distinguish normal and abnormal tissue in the T2-mapping, we used T2 relaxation time as a parameter. The T2 relaxation time is a function of the water content, collagen content and the collagen fibrils orientation in the extracellular matrix. By measuring the spatial distribution of T2 relaxation times through the cartilage, areas of increased or decreased water content can be identified. These changes correlate to cartilage damage and render T2 mapping to be a useful technique to depict early changes of articular cartilage.

T2 mapping provides both a visual evaluation with high image quality and quantitative analysis, by drawing ROIs on the map. The T2 map consists of a color map based on the T2 values. The T2 map provides an easy way to see variations within the cartilage and assess damage. Both the standard MRI assessment and the T2 map show changes in the knee cartilage. The outcomes were both a color map of the knee but also results in graphs and values.

This study shows similar results for both the standard assessment and the T2 map. Both methods could identify damage and is, therefore, useful for assessment of the knee cartilage. The outcomes of the different methods differ, and the assessment is therefore made in different ways. The best outcomes from the T2 mapping was when it only was changes within the cartilage and not when the cartilage lesion was adjacent to an underlying bone lesion. Based on what was examined in this work, the best result was when T2 mapping was used together with the anatomical images used in the standard assessment. The conclusion is that the standard assessment is necessary when it comes to make a damage assessment. The T2 mapping is, however, an interesting method and will be more useful with more applications in the future.

Methodology:

This was observational cross sectional study carried over a period of 6 months from Jun 2023-Dec 2023 at department of Radiodiagnosis, tertiary care center after obtaining clearance from our Institutional Ethics Committee. All patients with knee joint pathologies including

traumatic and non traumatic admitted in tertiary care center and referred to radiodiagnosis department for MRI knee were included in the study. The sample size was 50. All cases which satisfy inclusion criteria were included in the study. Informed consent was taken. Routine MRI Imaging of the concerned knee is done along with sagittal T2 mapping sequence. Relevant entries in the proforma for each patient were made after reviewing his/her case sheet & previous medical records. To avoid cartilage T2 variations by physical activity, loading of the knee, temperature, and diurnal alteration, all individuals had a resting time about 30 min.

Using a 15 channel knee coil and a 3 mm slice thickness, routine MRI tests were carried out in a 3 Tesla MRI scanner (GE Healthcare). The protocol comprises the following sequences: sagittal T1 weighted SE imaging (time of repetition (TR)/time of echo (TE) 575/9.1 ms, field of view (FOV): 140 mm, matrix: 256 x 256, number of excitations [NEX]: 1), sagittal and axial fat supressed (FS) proton density (PD) SE imaging (TR/TE: 3600/25 ms), sagittal PD space (TR/TE: 1200/28 ms, FOV: 160, NEX: 1), sagittal T2 anatomical (T2 mapping) sequence (TR/TE: 1000/14 ms, FOV: 160, NEX: 1). The additional T2 sagittal mapping sequence was taken covering the regions from top of the patellar cartilage to the femoro-tibial cartilage. The acquisition time for the sagittal T2 mapping sequence was 10 minutes. The total duration of the study was 25 minutes. A T2 colored-map is created using the default software settings and functions. It allows objective assessment of knee cartilage. The colour scale runs from red to blue, with high T2 relaxation values on the color-coded scale on at least two consecutive slices corresponding to green or blue colours. An elliptical ROI that was manually built and examined for each sequence was used to calculate the deep layer T2 relaxation value. Five compartments were defined in each subject: medial femoral condyle (MFC), lateral femoral condyle (LFC), medial tibia (MT) and lateral tibia (LT) and patella (P).

The MR images were analysed regarding cartilage lesions, joint effusion, popliteal cysts, ligaments and menisci and features of OA like reactive bone marrow changes, osteophytes, subchondral cysts and loose bodies.

Data was fed in MS excel. Data was analysed. The statistical significance of the relationship between independent variables and dependent variables are calculated using Chi-square test ; $p \leq 0.05$ was considered as statistically significant. All calculations were made using the SPSS V26.0 trial version.

RESULTS:

Total 50 study participants were enrolled in this study. Highest frequency (30%) observed in the 40-50 age group, followed by 24% in the 20-30 age group. About 56% were female (28 participants) and 44% are male (22 participants). The study reveals that 66% of the participants (33 out of 50) experienced non-traumatic events, while 34% (17 participants) had traumatic events. Non traumatic knee pathologies in female forms the largest group. (Table 1)

The T2 relaxation time values, which reflect cartilage composition and potential degeneration, increase with age, especially from the 40-50 age group onwards, indicating progressive cartilage degeneration. Conversely, cartilage thickness (CT) values show relatively minor fluctuations across age groups, with no clear trend of thinning. This indicates that while T2 values (indicative of cartilage quality) tend to worsen with age, cartilage thickness does not show a uniform pattern of change. Females have marginally higher T2 values across most regions (MFC, LFC, MT, LT, and PATELLA) compared to males, indicating a marginally greater degree of cartilage degeneration in females. In terms of cartilage thickness, both genders have similar values across all regions, with the average cartilage thickness being nearly identical (1.60 for females and 1.61 for males). (Table 2)

Medial femoral condyle and medial tibia areas tend to have higher average T2 values, which could suggest more cartilage degeneration in these regions. The summary statistics for cartilage thickness (ct) across different knee regions show that the mean thickness values are relatively consistent, ranging from 1.5 (MFC and MT) to 1.8 (Patella). (Table 3) Osteoarthritis is the most prevalent condition. (Table 4)

Table 1: Distribution Of Study Participants According To Demographic Parameter

Demographic Parameter		Total No. of patients	Traumatic	Non-Traumatic
Age Group	10-20	3(6%)	3(6%)	0(0%)
	20-30	12(24%)	9(18%)	3(6%)
	30-40	8(16%)	2(4%)	6(12%)
	40-50	15(30%)	3(6%)	12(24%)
	50-60	6(12%)	0(0%)	6(12%)
	60-70	6(12%)	0(0%)	6(12%)
Gender	Female	28(56%)	6(12%)	22(44%)
	Male	22(44%)	11(22%)	11(22%)

Table 2: T2 relaxation time values (T2 R) in milliseconds and cartilage thickness (CT) in millimeters according to Demographic Parameter

Five Compartment of Knee		Medial Femoral Condyle		Lateral Femoral Condyle		Medial Tibia		Lateral Tibia		Patella		Average	
		T2R	CT	T2R	CT	T2R	CT	T2R	CT	T2R	CT	T2R	CT
Age Group	10-20	27.3	1.9	22.5	1.3	22.1	1.5	24.1	1.47	23.9	1.3	23.9	1.49
	20-30	29.4	1.5	29.8	1.8	31.4	1.5	31.5	1.59	29.8	1.9	30.67	1.59
	30-40	27.5	1.5	28.9	1.6	27.4	1.5	26.7	1.64	26.1	1.5	27.29	1.56
	40-50	37	1.6	32.6	1.5	36.9	1.7	32.4	1.62	32.1	2.2	34.56	1.71
	50-60	41.3	1.3	37.9	1.7	45.5	1.4	36.4	1.77	37.5	1.7	37.33	1.56
	60-70	48.5	1.4	42.9	1.7	43.5	1.2	43.7	1.65	37.6	1.9	41.83	1.52
p Value	0.001	0.0020	0.0053	0.0100	0.0240	0.0000							
Gender	Female	36.2	1.5	33.5	1.6	35.9	1.5	34.1	1.64	31	1.9	33.1	1.6
	Male	33.4	1.5	31.5	1.6	33.9	1.5	30.7	1.61	31.9	1.8	32.93	1.61

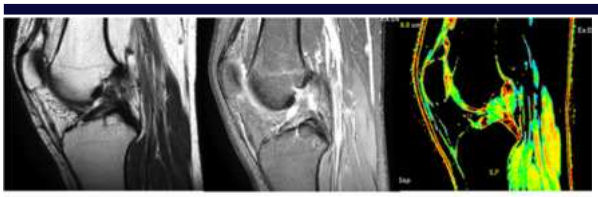
Table 3: T2 Relaxation Values & Cartilage Thickness Across Different Knee Cartilage Regions

Different regions of the knee cartilage		Mean	S.D	Range
T2 relaxation Value (ms)	MFC	35	8.7	56-24.5
	LFC	32.6	6.7	48.5-19.2
	MT	35	9	53.1-20.1
	LT	32.6	6.8	46.2-22.0
	Patella	31.4	7	55.4-21.1
	Average	33.03	6.99	50.42-21.30
Cartilage Thickness (mm)	MFC	1.5	0.4	2.7-0.8
	LFC	1.6	0.4	2.8-1.2
	MT	1.5	0.3	2.3-0.9
	LT	1.63	0.36	2.9-1.1
	Patella	1.8	0.6	3.6-1.1
	Average	1.6	0.26	2.32-1.18

Table 4: Distribution Of Study Participants According To MRI Diagnosis

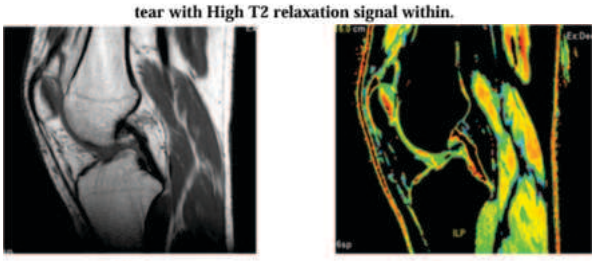
MRI Diagnosis	Total no. of patients	Additional cartilage pathology on T2 mapping Sequence
ACL Pathologies	12	3(25%)
Meniscal Tear	7	1(14%)
Osteoarthritis	15	2(13%)
Chondromalacia Patellae	5	1(20%)
Bone Contusion	3	1(33%)
Lateral Patellar Subluxation	1	1(100%)
Patellar Tendinopathy	1	0(0%)
Baker's Cyst	1	0(0%)

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr



T2WI T2/PD Sagittal T2 mapping

T2/PD Sagittal image with mapping sequence showing partial thickness ACL tear with High T2 relaxation signal within.



T2WI SAG T2 mapping

T2WI showing mild buckling of PCL.

DISCUSSION:

In this study, the age distribution in this study showed the highest concentration of participants (30%) in the 40-50 age group, which is commonly associated with the onset of cartilage degeneration. This aligns with findings from Kijowski et al. (1) and Shawky et al., (2). These findings reinforce the value of T2 mapping in middle-aged and older adults, where early degenerative changes are often missed by conventional MRI. The study's gender distribution, with 56% female and 44% male participants, revealed that females exhibited slightly higher T2 values across most regions, consistent with previous research. Alsayyad et al. (3) found higher T2 values in females, particularly in the medial femoral condyle, indicating early osteoarthritic changes. Youssef and Abdelwahab (4) also noted that T2 mapping detected subtle cartilage degeneration in females that routine MRI missed. In the study, 66% of the participants experienced non-traumatic knee conditions, emphasizing the utility of T2 mapping in evaluating degenerative changes beyond trauma-related injuries. Non-traumatic conditions, such as osteoarthritis, showed a significant increase in T2 values, suggesting early degenerative changes that did not show structural abnormalities on routine MRI. This is consistent with the findings of Alsayyad et al. [3] & Kijowski et al. [1]. The study revealed a consistent increase in T2 relaxation values with age, particularly from the 40-50 age group onwards, reflecting progressive cartilage degeneration. However, cartilage thickness values showed no uniform pattern of change, remaining relatively stable across age groups. These findings are supported by Dunn et all (5) which showed increased T2 relaxation time between diseased and healthy knee. In this study, statistically significant differences in T2 mapping values across different age groups, with all p-values below 0.05. This finding underscores the sensitivity of T2 mapping in detecting age-related changes in knee cartilage. Kijowski et al. [1] reported similar results. The study found statistically significant differences in T2 mapping values between genders, particularly in the lateral tibia (LT) and patella regions, with females showing slightly higher T2 values. This suggests a marginally greater degree of cartilage degeneration in females, which aligns with the findings of Alsayyad et al. [3]. The distribution of knee pathologies in our study highlighted osteoarthritis as the most prevalent condition, affecting 30% of participants, followed by ACL pathologies (24%) and meniscal tears (14%). These findings are consistent with those of Kijowski et al. [1] Apprich et all (6) also suggested detection of degenerative disease with comparison between high resolution morphologic MRI and quantitative T2 mapping.

The comparison between standard MRI and T2 mapping findings in our study revealed that T2 mapping identified additional lesions in conditions like early changes of osteoarthritis, chondromalacia patellae and osteochondral injuries, which could not be appreciated on routine MRI. Similarly, Kijowski et al. [1] found that T2 mapping significantly enhanced the detection of cartilage softening and superficial partial-thickness cartilage defects, with sensitivity improving from 74.6% to 88.9%. Our study also found that T2 mapping was particularly valuable in detecting early degenerative changes, such as increased T2 signals indicative of early osteoarthritic changes and stage I osteochondral injuries that can be subtly missed on routine MRI especially in traumatic knee in young population. Bazaldua et all (7) also showed evaluation of articular knee cartilage using T2 mapping. The ability of T2 mapping to detect subtle changes in cartilage composition highlights its role as a complementary tool to routine MRI, providing additional insights that can inform treatment decisions and improve patient outcomes, particularly in the early stages of degenerative joint diseases.

CONCLUSION:

This study highlights the significant clinical value of incorporating T2 mapping into routine MRI for the assessment of knee cartilage in detecting early cartilage degeneration, crucial for timely diagnosis and management of conditions like osteoarthritis, chondromalacia patellae and osteochondral injuries. The study found that T2 relaxation values increase with age, revealing progressive cartilage degeneration, especially in older adults, and noted slight gender differences, with females showing higher threshold T2 relaxation values. T2 mapping also proved valuable in young traumatic cases, improving the sensitivity of detecting early osteochondral injuries.

REFERENCES:

1. Evaluation of the Articular Cartilage of the Knee Joint: Value of Adding a T2 Mapping Sequence to a Routine MR Imaging Protocol ; Richard Kijowski, MD ; Donna G. Blankenbaker, MD ; Alejandro Munoz del Rio, PhD ; Geoffrey S. Baer, MD ; Ben K. Graf, MD : Radiology: Volume 267: Number 2—May 2013 ; 503 – 513.
2. Shawky MS, El-Sharkawy MG, Sakr H, Mansour MG. Comparison of a routine magnetic resonance imaging & T2* mapping of articular cartilage in knee osteoarthritis. QJM: An International Journal of Medicine. 2023. doi:10.1093/qjmed/hcad069.743
3. Alsayyad MAI, Shehata KAA, Khattab RT. Role of MRI T2 mapping in assessment of articular knee cartilage in osteoarthritis. Ain Shams Medical Journal. 2020;71:441-455. doi:10.21608/asmj.2020.125675
4. Youssef M, Abdelwahab UM. T2 Mapping Sequence in the Assessment of Articular Cartilage of Knee Joint. Is There Added Value? Medical Journal of Cairo University. 2020;88:1089-1095. doi:10.21608/mjcu.2020.110845
5. Dunn TC, Lu Y, Jin H, Ries MD, Majumdar S (2004) T2 relaxation time of cartilage at MR imaging: comparison with severity of knee osteoarthritis. Radiology 232(2):592–598
6. Apprich S, Welsch GH, Mamisch TC, et al. Detection of degenerative cartilage disease: comparison of high-resolution morphological MR and quantitative T2 mapping at 3.0 Tesla. Osteoarthritis Cartilage 2010; 18(9):1211–1217.
7. Bazaldua-Cheda HM, Onofre-Castillo JJ, Torres-Gómez E (2019) Evaluation of articular cartilage of the knee using T2 mapping sequence in magnetic resonance. Anales de Radiología México 18:99–107