

# Quantitative MRI T2 relaxometry of knee joint in early detection of osteoarthritis

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## ABSTRACT

**Background:** Magnetic resonance imaging (MRI) T2 is an advance modality for the early diagnosis of osteoarthritis. This study was performed to determine the MRI T2 relaxometry value of knee joint in early detection of osteoarthritis among suspected cases.

**Patients and methods:** This observational study was conducted at Department of Radiology, Jinnah Postgraduate Medical Centre (JPMC), Karachi, Pakistan from 20<sup>th</sup> September 2020 to 28<sup>th</sup> February 2021. All patients aged 20-60 years of either gender suspected of knee osteoarthritis were consecutively enrolled. Osteoarthritis was confirmed based on Kellgren & Lawrence (KL) radiographic grading of 2-5. MRI T2 relaxometry was performed in all patients.

**Results:** Of 102 patients, there were 67 (65.7%) males and 35 (34.3%) females. Mean age was 43.72 ±14.01 years. KL grading showed that KL grade 0 observed in 29 (28.4%), grade I in 13 (12.7%), grade II in 25 (24.5%), grade III in 30 (29.4%), and grade IV in 5 (4.9%) patients. The frequency of osteoarthritis was found in 60 (58.8%) patients. Mean MRI T2 value was found to be 94.12 ±16.32. Mean MRI T2 value was found significantly higher in patients with KL grade IV (109.89 ±5.38) followed by KL grade III (107.35 ±3.24), KL grade II (97.72 ±14.65), KL grade I (89.54 ±13.69), and KL grade 0 (76.65 ±10.56). (p-value<0.001) The findings of ROC curve showed that AUC was found to be 0.911 (0.85-0.97) (p-value<0.001).

**Conclusion:** MRI T2 relaxometry is highly recommended for the prediction of osteoarthritis in suspected cases.

## Keywords

Quantitative T2 Relaxometry, Magnetic Resonance Imaging, Osteoarthritis, Knee Joint

## INTRODUCTION

Diagnosis of knee disorders has dramatically improved over the last decade through better imaging techniques.<sup>1</sup> Plain radiography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Arthrography and state-of-the-art technology such as T2 Relaxometry, have all contributed to this improved knee imaging.<sup>1,2</sup> Knee x-rays are usually the initial imaging studies, especially when bone wear and tear are clinically suspected.<sup>3</sup> Knee joint is the body's biggest synovial joint with many articulating surfaces. Main constituents being the articulation between the femur and tibia, which is the weight carrier of the entire body weight and for the balance. This surface of the articulation has great chances of failure due to different causes.<sup>4,5</sup> MRI provides better imaging of the articular cartilage morphologically and compositionally in the knee using multi-planar capabilities, high spatial

resolution without ionizing radiation, and superior tissue contrast.<sup>6</sup> In regular knee joint clinical evaluations, most departments tend to apply a 2D quick SE multiplane sequence, alone or in conjunction with a 3D GRE sequence to enhance cartilage evaluation. The combined application of high-resolution morphological imaging techniques and techniques of compositional imaging will result in increased MR imagery sensitivity in the early cartilage detection and increased usefulness in cartilage repair assessments.<sup>7,8</sup> This study aims to determine how osteoarthritis among suspected cases is accurately and early identified by MRI T2 relaxometry. The study will facilitate treating physicians and patients to achieve better diagnosis and improve disease management in the future.

## PATIENTS AND METHODS

This descriptive cross-sectional study was conducted at Department of Radiology, Jinnah Postgraduate Medical Centre (JPMC), Karachi, Pakistan from 20<sup>th</sup> September 2020 to 28<sup>th</sup> February 2021. Ethical approval was obtained from the JPMC Committee and signed informed consent was obtained from all study participants prior enrollment in the study. All patients

**Conflict of interest:** The authors declared no conflict of interest exists.

**Citation:** Aneeta, Shoukat S, Kumar A, Baloch R, Kumar V. Quantitative MRI T2 relaxometry of knee joint in early detection of osteoarthritis. *J Fatima Jinnah Med Univ.* 2021; 15(3):127-131.

DOI: <https://doi.org/10.37018/BGCG4108>

aged 20-60 years of either gender suspected of knee osteoarthritis were consecutively enrolled. Patients presented with deformity of the knee joint, total joint replacements, subchondral or stress fractures of the knee were excluded. Suspected cases were enrolled through Osteoarthritis Initiative (OAI) Incidence cohort criteria<sup>9,10</sup> and included at risk cases comprising: (i) Knee symptoms in the past 12 months, (ii) overweight or obesity, (iii) history of knee injury which would cause difficulty walking for at least a week, (iv) history of knee surgery, (iv) family history of osteoarthritis. The osteoarthritis was confirmed on the basis of Kellgren & Lawrence (KL) radiographic grading of 2-5. Epi info sample size calculator is used for the estimation of sample size taking confidence interval 95%, margin of error 9%, reported prevalence of osteoarthritis on MRI T2 relaxometry 30%<sup>8</sup>. The estimated sample size came out to be 102 suspected cases. The Canon MRI System<sup>®</sup> (1.5T) whole body magnetic resonance scanner was used with the gradient strength of 40 mT/m and with use of an eight-channel phased-array knee coil. No specific activity protocol was used prior to MRI. The MR examinations was scheduled so that there was no more than a 5–10-minute wait for the procedures. All patients were able to perform routine daily activities and walk to the MRI suite prior to imaging. The imaging protocol consisted of an axial T2-weighted, spin-echo multi echo sequence performed with the following parameters: Time of repetition (TR): 1200 msec, Time of Echo, 18 msec and 36 msec with a field of view (FOV) of 150 mm x 150 mm, matrix size 256 x 256, pixel size 0.58 mm, number of acquisitions (NAQ) per TR: 01, number of slices: 10, slice thickness: 3 mm, interslice gap of 0.6 mm and total acquisition time: 16 mins. Post processing was performed on Olea sphere workstation using relaxometry tool, 2-3 ROI's were drawn on a femoro-patellar cartilage depending on available cartilage tissue volume. Bony structures were well negotiated and ruled out from drawn ROI's (Figures 1 and 2).

SPSS version 24 was used for data analysis. Mean and standard deviation was calculated for quantitative variables like age, height, weight, BMI, and quantitative T2 relaxometry value. Frequencies and percentages were calculated for gender, Native knee symptoms in the past 12 months, Overweight or obesity, history of knee injury, family history of osteoarthritis, lifestyle factors such as occupational risk, and KL grading. Inferential statistics were explored using chi-square test and One-Way ANOVA test. A p-value  $\leq 0.05$  was considered as significant. Moreover, receiver operative

curve (ROC) was also applied to find out the diagnostic performance of MRI T2 in detection of osteoarthritis.

## RESULTS

Of 102 patients, there were 67 (65.7%) males and 35 (34.3%) females. Mean age of patients was  $43.72 \pm 14.01$  years. Mean height, weight and BMI of the patients was  $1.65 \pm 0.77$  m,  $68.72 \pm 5.49$  kg, and  $25.68 \pm 3.05$  kg/m<sup>2</sup> respectively. There were 47 (46.1%) overweight patients. While knee injury 37 (36.3%), family history of osteoarthritis 21 (20.6%), and lifestyle factors such as occupational risk was observed in 28 (27.4%) patients. KL grading showed that KL grade 0 was observed in 29 (28.4%), grade I in 13 (12.7%), grade II in 25 (24.5%), grade III in 30 (29.4%), and grade IV in 5 (4.9%) patients. Frequency of osteoarthritis was found in 60 (58.8%) patients. A significantly higher frequency of osteoarthritis was found among patients >45 years of age as compared to  $\leq 45$  years of age, i.e., 35 (79.5%) and 25 (43.1%) (p-value <0.001), among males as compared to females; 32 (47.8%) and 28 (80.0%) (p-value 0.002) and among patients with lifestyle risk factors such as occupational risk as compared to patients without lifestyle risk factors such as occupational risk; 23 (82.1%) and 37 (50.0%) (p-value 0.003) (Table 1). Mean MRI T2 value was found to be  $94.12 \pm 16.32$ . The mean MRI T2 value was found significantly higher in patients with KL grade IV ( $109.89 \pm 5.38$ ) followed by KL grade III ( $107.35 \pm 3.24$ ), KL grade II ( $97.72 \pm 14.65$ ), KL grade I ( $89.54 \pm 13.69$ ), and KL grade 0 ( $76.65 \pm 10.56$ ). (p-value <0.001) (Figure 3). Findings of ROC curve showed that AUC was found to be 0.911 (0.85-0.97) (p-value <0.001) (Figure 4).

## DISCUSSION

This study was conducted with the aim to determine the findings of quantitative MRI T2 relaxometry of knee joint in early detection of osteoarthritis. For this purpose, all patients with knee symptoms in the past 12 months, overweight or obesity, history of knee injury which would cause difficulty walking for at least a week, history of knee surgery, and family history of osteoarthritis, were enrolled. While osteoarthritis was confirmed on the basis of KL radiographic grading of 2-5. The findings of the current study demonstrate that KL grade 0 was observed in 28.4%, grade I in 12.7%, grade II in 24.5%, grade III in 29.4%, and grade IV in 4.9% patients. In particular, the findings the current study showed that KL grading of more than equal to 2 (osteoarthritis) was observed in 58.8% patients. Somewhat similar findings were observed in a previous

Table 1: Comparison of osteoarthritis with demographic and clinical characteristics (n=102)

Variables	Osteoarthritis		p-value*
	Yes n (%)	No n (%)	
Age, years			
≤45	25 (43.1)	33 (56.9)	<0.001
>45	35 (79.5)	9 (20.5)	
Gender			
Male	32 (47.8)	35 (52.2)	0.002
Female	28 (80.0)	7 (20.0)	
Overweight			
Yes	33 (70.2)	14 (29.8)	0.031
No	27 (49.1)	28 (50.9)	
History of Knee Injury			
Yes	26 (70.3)	11 (29.7)	0.076
No	34 (52.3)	31 (41.7)	
Family history of osteoarthritis			
Yes	13 (61.9)	8 (38.1)	0.747
No	47 (58.0)	34 (42.0)	
Lifestyle factors			
Yes	23 (82.1)	5 (17.9)	0.003
No	37 (50.0)	37 (50.0)	

\*Chi-square test applied, p-value ≤0.05 considered as significant

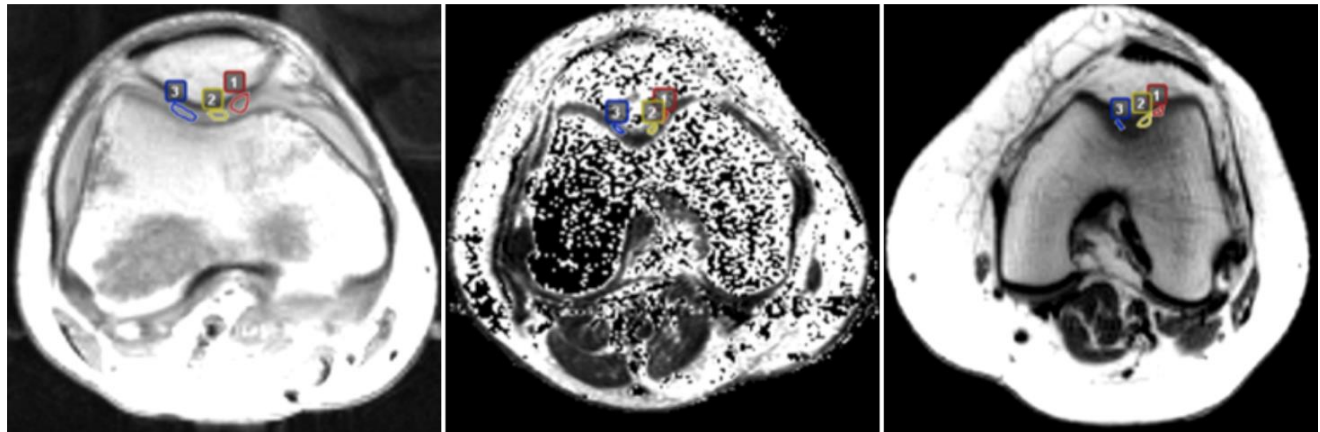


Figure 1. Dual Echo T2 Weighted Spin Echo sequence was performed and data was analyzed with Olea Sphere workstation for relaxometry analysis, images shown are of three patients in axial orientation with 3 ROIs on the femoropatellar cartilage.

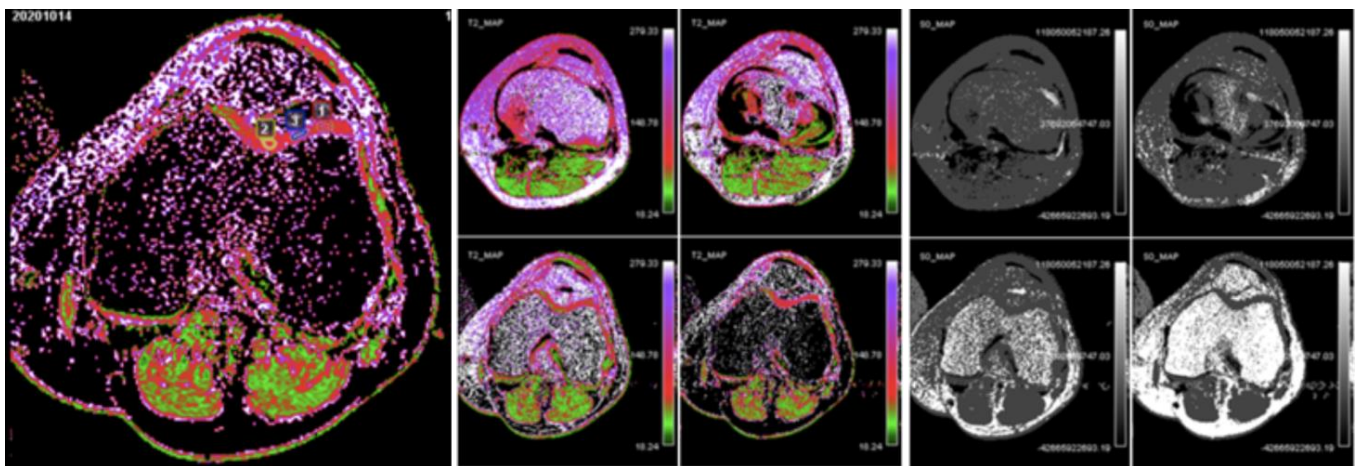


Figure 2. Dual Echo T2 Weighted Spin Echo sequence was performed and data was analyzed with Olea Sphere workstation for relaxometry analysis, images show axial color map with 3 ROIs on the femoropatellar cartilage, and corresponding color coded and grey scale images of the same patient.

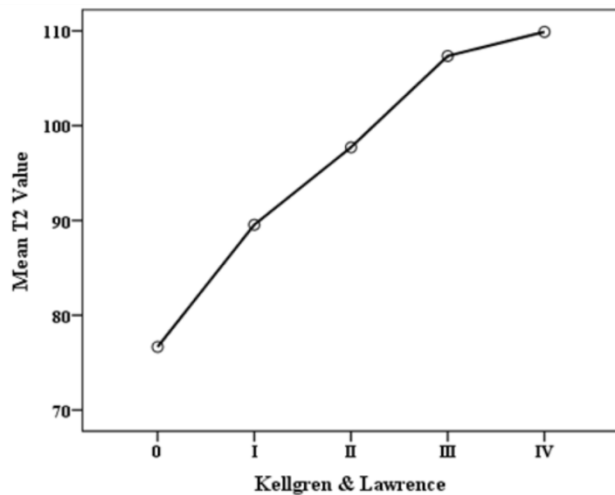


Figure 3. Mean difference of MRI T2 value with respect to KL grading (N=102)

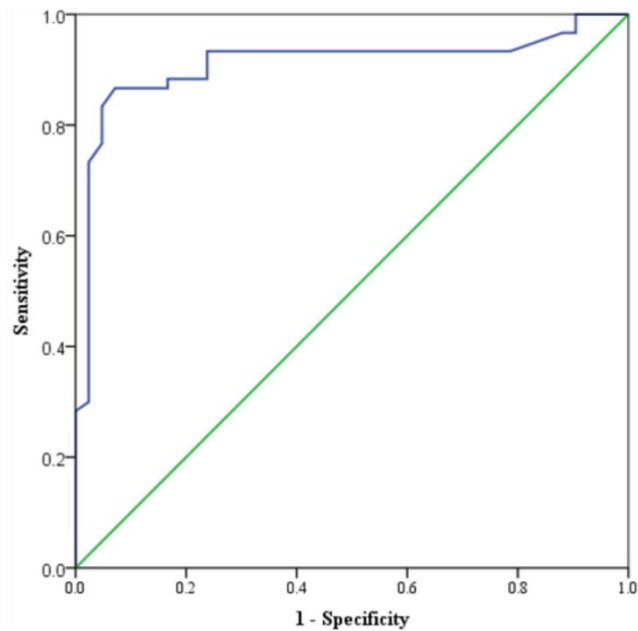


Figure 4. ROC curve showing the diagnostic performance of MRI T2 in detection of osteoarthritis

study as well in which more than equal to 2 KL grading was observed in 44.2% of the patients.<sup>11</sup> However, a considerably low number of patients with KL 2 gradings were reported in a study by Joseph and coauthors.<sup>12</sup> Significantly higher frequency of osteoarthritis was found among patients with more than forty-five years of age as compared to less than equal to forty-five years of age patients in this study. Similarly, significantly higher frequency of osteoarthritis was found among males as compared to females, i.e., 47.8% and 80.0% and significantly higher frequency of

osteoarthritis was found among patients with lifestyle risk factors such as occupational risk as compared to patients without lifestyle risk factors such as occupational risk, i.e., 82.1% and 50.0%.

According to the current study findings, the mean MRI T2 value was found to be approximately ninety-four. The mean MRI T2 value was found significantly higher in patients with KL grade IV followed by KL grade III, KL grade II, KL grade I, and KL grade 0. Padoia and coworkers reported higher frequency of osteoarthritis is males than that of females.<sup>11</sup> However, other variables like age, BMI, and KL gradings were found to be non-significant. Liebi and colleagues conducted a study on predictive ability MRI T2 in early diagnosis of knee osteoarthritis.<sup>13</sup> Their findings revealed that baseline T2 values in all compartments except the medial tibia were significantly higher in knees that developed OA compared with controls and were particularly elevated in the superficial cartilage layers in all compartments. There was an increased likelihood of incident knee osteoarthritis associated with higher baseline T2 values, particularly in the patella, medial femur, lateral femur, and lateral tibia. Further studies also reported that higher MRI T2 values has high efficacy of predicting degenerative changes of osteoarthritis.<sup>14-16</sup> A previous report observed that T2 measurements are sensitive to the earliest changes in the biochemical cartilage composition that are precursors to the development of radiographic disease and through early diagnosis may play a role in efforts to support a paradigm shift from palliation of late osteoarthritis towards prevention of disease.<sup>13</sup>

The findings of current study could be highlighted in the light of number of limitations. Firstly, this was carried out in a single centre with limited number of sample size. As this study was carried out during the coronavirus disease (COVID)-19 pandemic, the inclusion of the patients was very challenging. Secondly, this study included all clinically suspected knee osteoarthritis patients. Earlier majority of the studies were conducted analytically or longitudinally to assess the degenerative changes in knee osteoarthritis.<sup>17,18</sup> Lastly, previous study has reported findings on the basis of different anatomical locations.<sup>8</sup> However, current study failed to provide findings of various anatomical locations. Despite of these limitations, this study is of great importance because as per our knowledge, this is a first kind of study from Pakistan that has reported how osteoarthritis among suspected cases is accurately identified by MRI T2 relaxometry. MRI T2 measures

early degenerative changes in knee cartilage that occur prior to macroscopic cartilage defects and thinning.<sup>19</sup> Thus, a composite model consisting of clinical risk factors and imaging data may help identify subjects at high risk for osteoarthritis. Further large scale longitudinal studies are needed to assess the MRI T2 relaxometry at multiple time duration to monitor the sequence of pathological events in cartilage and other tissues leading to onset of osteoarthritis. Such studies are highly recommended in our part of the world as due to social and financial constraints, most of the people present late. Early diagnosis will eventually help in improve patient management and prognosis.

### CONCLUSION

MRI T2 relaxometry may be recommended for the prediction of osteoarthritis in suspected cases. In addition, this modality could be used for the early diagnosis of knee osteoarthritis in high-risk patients such as older age, overweight, and/or lifestyle risk factors.

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