Evaluation of Meniscal Abnormalities Using T2 Relaxation Time Mapping at 3T

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Purpose: Transverse relaxation time (T2) mapping is a parametric magnetic resonance imaging (MRI) technique used to study compositional and structural changes in cartilage related to tissue anisotropy, collagen concentration, and water content within the matrix.[1] In OA patients T_2 relaxation times provide a non-invasive means to detect early biochemical changes in cartilage prior to gross volume loss. The meniscus plays a primary role in shock absorption, load distribution, enhances stability and guides movement guiding, and help with joint lubrication[2] and a number of studies have shown an association between knee osteoarthritis (OA) and meniscal damage.[3,4,5] Therefore it is tempting to utilize the potential of T2 mapping to quantitatively evaluate meniscal abnormalities in OA. The purpose of this study was to investigate the feasibility of performing T2 mapping of menisci, to determine the potential to detect tears and ultimately to assist the radiologist in the grading of meniscal lesions.

Methods: MRI examinations of nine consecutive clinical patients with clinical symptoms of a meniscal tear and five healthy volunteers (seven males and seven females, mean age: 46.1 ± 14.0 years) were scanned on a 3T (Siemens; Verio) whole-body MRI scanner, equipped with a 15 Channel extremity (QED, Siemens) phased array coil. The clinical Aroutine protocol included TSE T2w FS and PDw sequences in the three major orthogonal planes. Relevant imaging sequence parameters were: Field of view (FOV) = 140mmx140mm, TR 2380-6520ms,TE=20-60ms,flip angle=145°-180°,bandwidth=181-257Hz/pixel, image matrix=384-448x75-85. MSME T2 mapping sequence (provided by the vendor) was implemented in the sagittal plane for full knee coverage. The se-mc imaging parameters for T2 mapping were: TR 3630ms, echo spacing (ESP) 13.8msec, 6 echoes (13.8msec to 82.8msec), FOV 150mm x 150mm, flip angle 180°, bandwidth 180 Hz/pixel, image matrix 256 x 100, acquisition time 6 minutes 55 seconds. T2 relaxation times were fitted by using a least squares fitting procedure from the six echoes and each meniscus was segmented manually based on T2 mapping. All segmentation and T2 mapping were processed offline using home-made software (FireVoxel). The standard TSE FS T2w / PDw and T2 mapping data sets were randomized and the reader was blinded re pat-ID for qualitative evaluation. An experienced musculoskeletal (MSK) radiologist scored the clinical images using the following modified WORMS grading system: 0 = intact, 1 = minor radial tear or parrot-beak tear, 2 = non-displaced tear, 3 = displaced or complex tear, and 4 = complete maceration of the meniscus[6]. We compared the WORMS score results to the clinical radiologic report. The patient's clinical reports were taken as the standard reference.

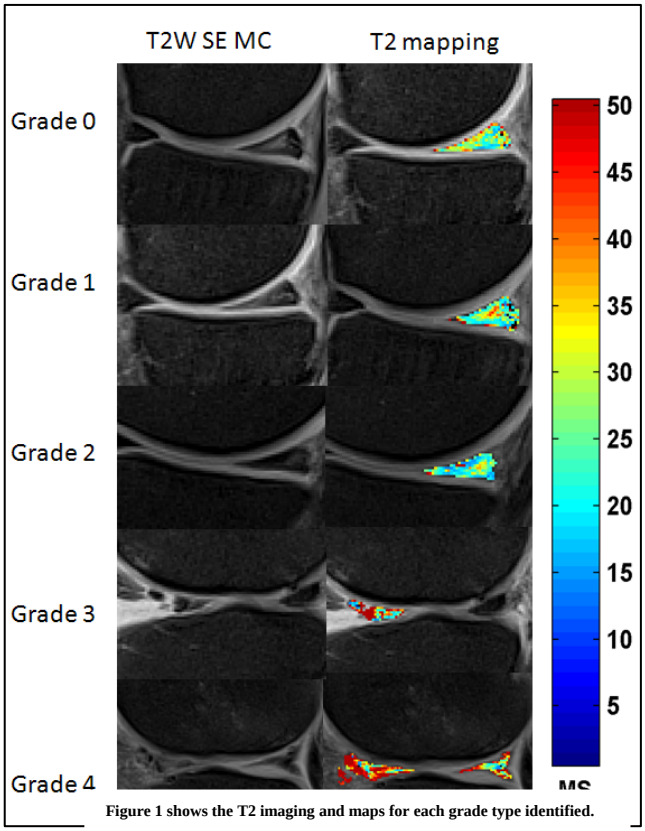

Figure 1 shows the T2 imaging and maps for each grade type identified.

Results: Out of the 8 cases, there are 3 cases for grade 1, 3 cases of grade 2, 1 case for grade 3, 1 case of grade 3/4. Representative examples of the T2 maps for each grade and corresponding clinical images are shown in Figure 1. Mean T2 relaxation times for each grade are shown in Table 1. Average T2 across the menisci increased with increasing grade of meniscal tear depicted by the clinical reading based modified WORMS scoring (Table 1). 56 menisci were sampled, seven tears were identified with WORMS, and one was not identified but was accounted for in the clinical reports. Eight menisci appeared to have increases in T2 signal on the parametric maps and seven had greater T2 signal than the other meniscal compartments within the same patient. All meniscal abnormalities seen in the routine imaging sequences could be detected using T2 maps. In (2/14) cases where the radiologist determined the WORMS score to be 0/1, the T2 map showed focally significantly prolonged T2 times and was hence helpful to suggest meniscal degeneration. In the normal subjects T2 fitting showed somewhat higher residuals, consistent with a lower meniscal SNR.

Conclusions: This study shows that T2 mapping of the menisci is feasible and that the approach has potential for the diagnostic workup of meniscal abnormalities in OA patients. T2 mapping may be used to help grade meniscal abnormalities. However, in view of the short T2 relaxation times of normal menisci, a shorter echo spacing may be beneficial for fitting accuracy. More studies are needed to confirm the effectiveness of this sequence as a clinical biomarker for meniscal lesions in OA patients.

Table 1 shows the graded patients increase in T2 signal per compartment. The highlighted blue area is the corresponding compartment with the tear vs. the normal contralateral compartment signal.

Table 1.	Mean_Meniscus_T2(MS)			
	AHLAT	PHLAT	AHMED	PHMED
Grade 1		22.9559		27.0449
Grade 2		26.1963		28.5263
Grade 3	32.3884		29.2451	
Grade 4	41.1414	33.7996	30.7464	34.8989

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