

T2 Mapping Sequence for Detecting Cartilage Lesion within the Knee Joint at 3.0T: Diagnostic Performance in 114 Patients with Surgical Correlation

Richard Kijowski¹, Donna Blankenbaker¹, Arthur De Smet¹, Geoffrey Baer², and Ben Graf²

¹Radiology, University of Wisconsin, Madison, Wisconsin, United States, ²Orthopedic Surgery, University of Wisconsin, Madison, Wisconsin, United States

Purpose: T2 mapping of articular cartilage can detect changes in water content and collagen matrix ultra-structure associated with early cartilage degeneration (1). T2 mapping sequences have been used extensively for cartilage assessment in osteoarthritis research studies (2-5). However, few previous studies have investigated the ability of a T2 mapping sequence to evaluate articular cartilage in clinical practice. Thus, this study was performed to determine whether adding a T2 mapping sequence to a routine magnetic resonance imaging (MRI) protocol could improve diagnostic performance for detecting cartilage lesions within the knee joint at 3.0T.

Methods: The IRB approved prospective study was performed on 114 patients with knee pain who were evaluated with MRI and arthroscopy. A routine MRI protocol consisting of multi-planar two-dimensional fast spin-echo (2D-FSE) sequences and a commercially available sagittal T2 mapping sequence (Cartigram, GE Healthcare, Waukesha, WI) were performed on all patients using the same 3.0T scanner (Signa HDx, GE Healthcare, Waukesha, WI) and 8-channel phased-array extremity coil (InVivo, Orlando, FL). The T2 mapping sequence was acquired using the following imaging parameters: TR of 1500ms, TE of 8.8, 17.6, 26.5, 35.3, 44.1, 52.9, 61.8, and 70.6ms, 31.3kHz bandwidth, 90° flip angle, 16cm field of view, 320 x 192 matrix, 3 mm slice thickness with 1.0mm to 1.5mm gap between slices, one signal average, and 5 minute scan time. Two musculoskeletal radiologists reviewed all MRI examinations in consensus prior to arthroscopy to determine the presence or absence of cartilage lesions on each articular surface of the knee joint first using the routine MRI protocol alone and then using the routine MRI protocol along with the T2 maps. When a partial-thickness cartilage lesion was identified on the routine MRI protocol, the radiologists determined whether the lesion showed increased, normal, or decreased T2 relaxation time on the T2 maps. All articular surfaces were evaluated at arthroscopy by two sports medicine specialist who documented all cartilage lesions and in particular carefully assessed all areas noted as abnormal on the MRI examinations. McNemar's tests were used to compare sensitivity and specificity of the routine MRI protocol alone and the routine MRI protocol and T2 maps for detecting surgically confirmed cartilage lesions.

Results: There were 255 cartilage lesions within the knee joint identified at arthroscopy. The sensitivity and specificity for detecting cartilage lesions was 72% and 98% respectively for the routine MRI protocol alone and 88% and 92% respectively for the routine MRI protocol and T2 maps. Differences in sensitivity and specificity were statistically significant ($p < 0.05$). Identification of areas of increased cartilage T2 relaxation time on the T2 maps allowed for detection of 12 areas of cartilage softening, 12 areas of cartilage fibrillation, 10 superficial partial-thickness cartilage defects, and 2 deep partial-thickness cartilage defects which were not detected using the routine MRI protocol (Figures 1-3). However, 24 areas of increased cartilage T2 relaxation time on the T2 maps were found to represent normal articular cartilage at arthroscopy (Figure 4). False positives were most common in the patellar ($n=10$), lateral tibial plateau ($n=10$) and trochlea ($n=3$). Two-hundred eight of the 220 partial-thickness cartilage lesions identified on the routine MRI protocol and confirmed at arthroscopy showed increased T2 relaxation time on the T2 maps, while 10 cartilage lesions showed normal T2 relaxation time and 2 cartilage lesions showed decreased T2 relaxation time.

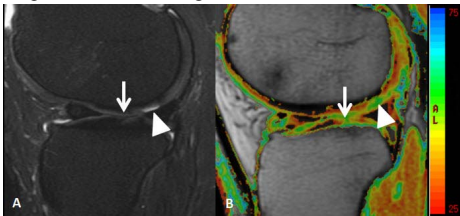


Figure 1: Patient with surgically confirmed cartilage fibrillation on the lateral tibial plateau and a deep partial-thickness cartilage lesion on the lateral femoral condyle. (A) 2D-FSE image shows normal appearing cartilage on the lateral tibial plateau (arrow) and a deep partial-thickness cartilage lesion on the lateral femoral condyle (arrowhead). (B) Corresponding T2 map shows increased cartilage T2 relaxation time on the lateral tibial plateau (arrow). Also note the increased cartilage T2 relaxation time on the lateral femoral condyle in the area of the partial-thickness cartilage lesion (arrowhead).



Figure 2: Patient with surgically confirmed cartilage softening on the femoral trochlea and a deep partial-thickness cartilage lesion on the patella. (A) 2D-FSE image shows normal appearing cartilage on femoral trochlea (arrow) and a partial-thickness cartilage lesion on the patella (arrowhead). (B) Corresponding T2 map shows increased cartilage T2 relaxation time on the femoral trochlea (arrow). Also note the increased cartilage T2 relaxation time on the patella in the area of the partial-thickness cartilage lesion (arrowhead).

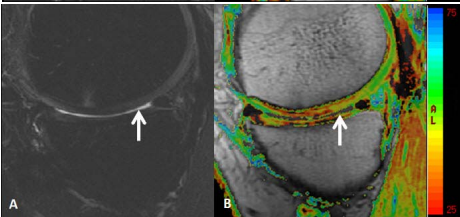


Figure 3: Patient with surgically confirmed cartilage fibrillation on the medial femoral condyle. (A) 2D-FSE image shows normal appearing cartilage on the medial femoral condyle (arrow). (B) Corresponding T2 map shows increased cartilage T2 relaxation time on the medial femoral condyle (arrow).

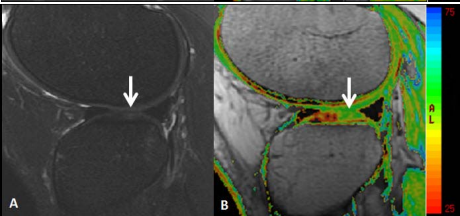


Figure 4: Patient with surgically confirmed normal articular cartilage on the lateral tibial plateau. (A) 2D-FSE image shows normal appearing cartilage on the lateral tibial plateau (arrow). (B) Corresponding T2 map shows increased cartilage T2 relaxation time on the lateral tibial plateau (arrow).

Conclusions: Adding a commercially available T2 mapping sequence to a routine MRI protocol at 3.0T improved sensitivity for detecting cartilage lesions within the knee joint from 72% to 88% with only a moderate reduction in specificity. The lower specificity of the T2 mapping sequence may be due to spurious increases in cartilage T2 relaxation time secondary to the magic angle effect or regional variations in the collagen matrix ultra-structure or due to early cartilage degeneration which was unable to be detected using arthroscopy.

References: (1) TJ Mosher, et al. *Semin Musculoskeletal Radiol.* 8:355, 2004. (2) J Pan, et al. *Radiology.* 261:507, 2011. (3) ZA Zarins, et al. *Osteoarthritis Cartilage.* 18:1408, 2010. (4) C Stehling, et al. *Radiology.* 254:509, 2010. (5) TJ Mosher, et al. *Osteoarthritis Cartilage.* 18:358, 2010.