

Standard deviation of T_{1ρ} and T₂ relaxation times show regional changes in hip articular cartilage of patients with FAI

Stephen J. Matzat¹, Emily J. McWalter², Weitian Chen³, Marc R. Safran⁴, and Garry E. Gold^{2,5}

¹Stanford University, Stanford, CA, United States, ²Department of Radiology, Stanford University, Stanford, CA, United States, ³MR Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, ⁴Department of Orthopaedic Surgery, Stanford University, Stanford, CA, United States, ⁵Department of Bioengineering, Stanford University, Stanford, CA, United States

Introduction: Femoroacetabular impingement (FAI) is thought to cause early development of osteoarthritis (OA) in the hip [1], but conventional MR techniques are not sensitive to early physiological degradation of cartilage. Quantitative MR methods, such as delayed gadolinium enhanced MRI, and T_{1ρ} and T₂ relaxation times, show promise in detecting these physiological changes in the hip [2,3,4] and thus may be used to identify patients at risk for early cartilage breakdown and confirm the benefits of FAI surgery in preventing progressive chondral damage. In the knee, early progression of OA is associated with elevated relaxation times and elevated heterogeneity of relaxation times within a region of cartilage [5]. In patients with FAI, the anterosuperior region of the acetabular cartilage is most prone to damage [1], so these quantitative indications of change may be found in acetabular rather than femoral articular cartilage. The present study aims to determine if regional means and standard deviations (SD) (as a surrogate for heterogeneity) of T_{1ρ} and T₂ relaxation times capture differences between femoral and acetabular cartilage in patients with FAI.

Methods: Acquisition: 9 patients (3M, 6F, age 33±10yrs) with FAI were recruited after referral for MR arthrography as part of their standard clinical management. All images were acquired in a GE MR 750 3.0T MRI scanner (GE Healthcare, Milwaukee, WI) with a 16-channel coil (NeoCoil, Pewaukee, WI) after injection of 0.2cc gadolinium in 7cc saline. No patients had significant morphologic cartilage defects seen on conventional sequences.

T_{1ρ} and T₂ relaxation time maps were created from sagittal plane images acquired using the CubeQuant sequence [6]. Imaging parameters were FOV: 18x18cm², matrix: 384x256, BW: ±62.5kHz, and slice thickness: 3mm. T_{1ρ} images were obtained at four spin-lock time intervals (1, 10, 30, and 60ms) with TR: 1324ms, spin-lock frequency: 500Hz, and scan time: 7:15. T₂ images were obtained at four echo times (6, 12.4, 25.3, and 38.1ms) with TR: 1862ms and scan time: 10:09.

Analysis: T_{1ρ} and T₂ relaxation times were calculated using a mono-exponential fit and mapped on three sagittal slices of the joint using OsiriX. Within each slice, femoral and acetabular cartilage were segmented into anterior and posterior regions of interest (ROIs) and the mean and SD of the estimated T_{1ρ} and T₂ values were calculated. Mean and SD values were compared between femoral and acetabular cartilage in the anterior and posterior regions using paired t-tests.

Results: Significant differences were between SD in the anterior region of femoral and acetabular cartilage for both T_{1ρ} and T₂ (Table 1). No other significant differences were observed. Figure 1 demonstrates the quantitative maps obtained.

Discussion: SD of both T_{1ρ} and T₂ detected differences between femoral and acetabular cartilage in the anterior region. This suggests that patients with FAI have increased heterogeneity of

| | T _{1ρ} | | | | T ₂ | | | |
|------------|-----------------|-----------|---------------|-----------|----------------|-----------|---------------|-----------|
| | Mean | | SD | | Mean | | SD | |
| | Anterior | Posterior | Anterior | Posterior | Anterior | Posterior | Anterior | Posterior |
| Femoral | 45.2±5.5 | 45.8±4.4 | 13.5±4.1 | 15.2±3.8 | 36.9±4.5 | 37.8±3.8 | 13.3±3.5 | 16.9±3.3 |
| Acetabular | 45.8±5.0 | 43.9±3.2 | 15.0±3.8 | 14.9±2.7 | 36.1±4.2 | 38.2±5.1 | 15.7±3.7 | 16.6±2.8 |
| p-value | 0.5874 | 0.1126 | 0.0332 | 0.7319 | 0.2205 | 0.6114 | 0.0004 | 0.6816 |

acetabular cartilage, and is consistent with clinical findings that cartilage of the anterior acetabulum is

Table 1: Mean relaxation time values and standard deviation (SD) of relaxation time values are compared between femoral and acetabular cartilage.

commonly damaged. One limitation of this study is that T_{1ρ} and T₂ relaxation times were measured in the presence of injected fluid with a small amount of gadolinium (done for clinical reasons), which may distribute into the cartilage. Imaging with no exercise was done immediately after arthrography to minimize this effect. Additionally, low SNR may contribute to increases in SD of relaxation times, although this effect should be uniform throughout and does not explain the differences in anterior acetabular cartilage.

Mean T_{1ρ} and T₂ relaxation times did not detect differences between the two layers of cartilage in either region. This alternate finding may result from several factors: isolated pockets of cartilage with physiological change may be grouped with unaffected cartilage, diluting T_{1ρ} and T₂ changes; or changes in T_{1ρ} and T₂ may happen in either direction in early disease.

Conclusion: Analyzing heterogeneity of cartilage via quantitative MR methods can be a useful tool in tracking early degenerative changes in the hip. Patients with FAI exhibit signs of early progression of OA in articular cartilage of the anterior acetabulum.

References: [1] Ganz et al. (2003) Clinical Orthop Relat R 417:112-120 [2] Bittersohl et al. (2010) Skeletal Radiol 40(5):553-561 [3] Bittersohl et al. (2012) Invest Radiol 47(7):392-397 [4] Cardenas-Blanco et al. (2012) ISMRM Abstract p.3307 [5] I. Joseph et al. (2011) Arthritis Res Ther 13(5):R153 [6] Chen et al. (2011) ISMRM Abstract p.231

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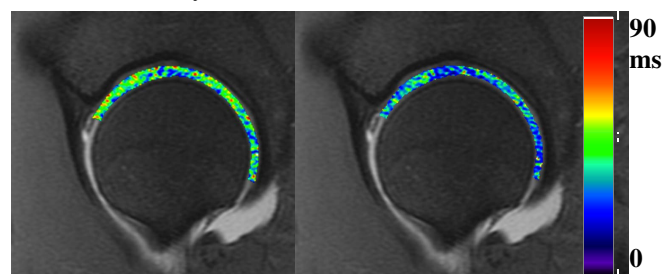


Figure 1: T_{1ρ} (left) and T₂ (right) maps for a patient with FAI.