# Noncontrast cartilage assessment $(T_{1\rho})$ of the hip in femoroacetabular impingment: Can we predict early changes?

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**Introduction:** In degenerative articular disorders, pre-structural cartilage degeneration is important to diagnose, as these patients are most amenable to surgical as well as non-surgical interventions which may delay or prevent the onset of osteoarthritis. MR is the most promising test to assess for these early cartilage changes. Proposed techniques for biochemical interrogation of hyaline cartilage include $T_2$ mapping, dGEMRIC, and $T_{1\rho}$. $T_{1\rho}$ is sensitive to proteoglycan (PG) concentration as demonstrated by Wheaton *et al* [1] (inversely proportional to PG concentration) and has the important advantage, as $T_2$ measurements, of not requiring intravenous or intra-articular contrast combined with high sensitivity. In Femoroacetabular Impingement (FAI), intervention is most appropriately applied to those patients with pre-structural cartilage changes. Hence we sought to determine, via $T_{1\rho}$, if there are early changes in cartilage proteoglycan content in patients with unilateral symptomatic CAM type FAI (FAI SYMP), as compared to their asymptomatic CAM type FAI contra-lateral side (FAI ASYMP-C), normal volunteers (N), as well as a unique possibly transition group who have CAM deformity but who are asymptomatic (ASYMP).

**Methods:** This study was approved by the institutional research ethics board, with informed consent obtained. From February to October 2011, 22 individuals underwent $T_{1\rho}$ MRI of their hips: 8 with symptomatic cam FAI (FAI SYMP) (8M, age range 26-51 years), 5 of those underwent asymptomatic contra-lateral (FAI ASYMP-C) hip imaging (5M, age range 26-46), 8 with CAM deformity but asymptomatic (ASYMP) (7M, 1F age range 28-44 years) and 6 normal controls (N) (4M, 2F, age range 30-43 years) underwent $T_{1\rho}$ hip MRI. To be included in the symptomatic cam FAI group, patients had to fulfill the following selection criteria: both hips with cam deformity, but only one of them symptomatic. The $T_{1\rho}$ protocol was a turbo spin echo (TSE) sequence, acquired in an oblique sagittal plane parallel to the acetabular fossa opening, using the following parameters: field of view 180mm, 22 slices, slice thickness 3mm, 384 x 384 matrix yielding an in-plane resolution of 0.46 x 0.46 $mm^2$, TR/TE= 274/13 ms, bandwidth 130 Hz/pixel, 1 average, spin-lock amplitude ($B_1$) 400 Hz; variable times of spin locking(TSL) of 12/18/25/35/45 ms; with a total scan time of 21 minutes. A proton density (PD) TSE weighted sequence for anatomic depiction of the hip joint with matched plane, FOV, slice thickness, matrix and resolution was also performed, with parameters of TR/TE= 3090/24 ms, 2 averages, bandwidth 100 Hz/pixel, echo train length 7. Images were processed offline, using manual segmentation and custom routines written in MATLAB (MathWorks Inc.: Natick, USA). The $T_{1\rho}$ maps were calculated by fitting the images, on a pixel by pixel basis, to a mono-exponential function, using a Levenberg-Marquardt fitting algorithm. The center of the femoral head was found semi automatically and the joint was divided into four, 45 degree regions (I to IV, anterior to posterior), with respect to the center of the femoral head and an arbitrary line, (vertical through the center of the femoral head, parallel to $B_0$). The femoral head and acetabular roof cartilage were analyzed as a single bilayer. For each of the four groups, the mean $T_{1\rho}$ relaxation value and standard deviation within each individual region, and also for all four regions combined, were calculated. These mean $T_{1\rho}$ relaxation values for each of the four groups were compared using a two-tailed t-test.

**Results:** Mean $T_{1\rho}$ and their standard errors are plotted in Figure 1. Statistically significant differences were found between N and FAI SYMP groups in regions I and II (p=0.04 and p=0.004 respectively) and when comparing ASYMP and N (Figure 2) also in regions I and II (p<0.001, p<0.001). No statistically significant differences were found when comparing ASYMP and FAI SYMP. Statistically significant differences were found between the symptomatic hip (FAI SYMP) and contralateral asymptomatic hip (FAI ASYMP-C) in regions I, III and IV (p<0.001, p=0.004, p=0.004 respectively) [Figure 1].

**Discussion:** $T_{1\rho}$ values in CAM asymptomatic and symptomatic subjects are statistically higher than in controls subjects in the anterior (I) and anterior-superior (II) aspects of the hip suggesting that the cartilage degeneration process begins prior to onset of symptoms. Our results are in agreement with those of Pollard et al [2], their findings are similar in terms of normal and asymptomatic with cam deformity but this is the first study to discuss about findings in asymptomatic CAM type FAI contra-lateral side. The results indicate that $T_{1\rho}$ values obtained in the contra-lateral hip from symptomatic cam-FAI patients are shorter than those measured in the symptomatic hip in the anterior (I), posterior-superior (III) and posterior (IV) aspects of the joint. These patients may have become less active due to their symptomatic hip leading to a slowing of the degeneration process.

**Conclusion:** The results demonstrate $T_{1\rho}$ can differentiate between symptomatic cam-FAI and controls, and results are consistent with *expected* biochemical changes that occur during cartilage degeneration. Furthermore, changes in the $T_{1\rho}$ profile of subjects with asymptomatic CAM deformities suggest that biochemical degeneration of the hyaline cartilage can precede clinical symptoms. Thus $T_{1\rho}$ MRI has the potential to become a valuable, non-invasive quantitative biomarker in the early diagnosis of cartilage damage in FAI.

**References:**

[1] Magnetic Resonance in Medicine 54:1087–1093 (2005), [2] J Bone Joint Surg Am. 2010; 92:2557-69
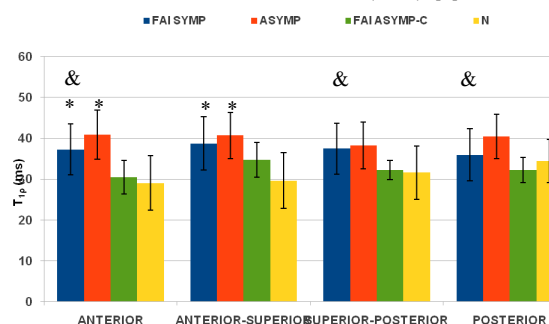
Figure 1: Bar plot showing the average $T_{1\rho}$ values and standard error of the different groups in the Anterior (I), Anterior-Superior (II), Superior-Posterior (III), Posterior (IV) aspects of the joint. Statistical significance compared to controls is shown as (*) and compared to asymptomatic contra-lateral is shown as (&)
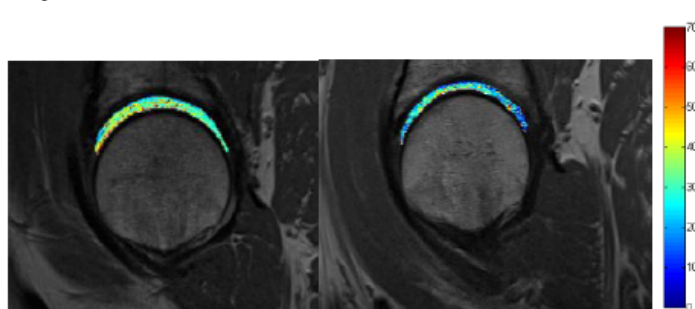


Figure 2: $T_{1\rho}$ values of articular cartilage superimposed on anatomical image. Bump patient on left with the following mean $T_{1\rho}$ values and standard deviations for each of the four regions: 41.06±16.50, 36.32±11.45, 33.94±9.32, 33.40±9.32 all in ms