**T2* Mapping of Acetabular and Femoral Hip Joint Cartilage at 3 T: A Prospective Controlled Study**

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**INTRODUCTION:**

With the increasing advances in hip preservation surgery, accurate assessment of joint cartilage status that includes detection of biochemical changes is becoming increasingly important. Magnetic resonance imaging (MRI) methods sensitive to collagen network structure, water content (T2 mapping), and the charge density of cartilage contributed by glycosaminoglycans (i.e. T1rho mapping with delayed gadolinium-enhanced MRI of cartilage (dGEMRIC)) have been studied. While there are several studies reported on dGEMRIC, literature on T2* mapping is fairly limited. While comparing the logistics of imaging techniques in these two modalities, dGEMRIC is limited due to its need for contrast medium requiring additional time waiting for contrast uptake followed by image acquisition. Therefore, the purpose of this prospective control group study was to explore the pattern of T2* values in acetabular and femoral cartilage in both morphologically normal and abnormal cartilage.

**METHODS:**

**Study Population**

The study group consisted of 40 symptomatic adult patients with suspicion of cartilage damage. There were 17 males and 23 females with involvement of 25 right hips and 15 left hips. The mean age of the study group was 33.4 ± 10.3 years with a range of 18.3 - 57.2 years. The control group included 35 healthy, asymptomatic young adults with no history of any hip diseases or abnormalities. There were 14 males and 21 females in whom 18 right hips and 17 left hips were imaged. The mean age of the control group was 24.9 ± 2.1 years with a range of 21.2 - 28.9 years.

**Magnetic Resonance Imaging**

MRI was performed using a 3 T system (Magnetom Trio, Siemens Medical Solutions, Germany) with a body-matrix phased-array coil. The MRI protocol for both study and control group was similar and included a 3D double-echo steady state (DESS) sequence for morphological cartilage assessment and a 3D multi-echo data image combination (MEDIC) sequence using six echoes in order to assess the T2* decay. Geometric imaging parameters were similar for both DESS and MEDIC imaging: field of view = 192 mm², slice thickness = 0.6 mm, in-plane resolution = 0.6 mm x 0.6 mm.

**Image Analyses**

The 3D data sets of DESS and T2* were transferred to a Leonardo® workstation (Siemens Medical Solutions, Germany) in order to perform further processing. From each 3D data set, seven identical radial reformats that were concentric within the center of the femoral head and perpendicular to the acetabulum, were created by using multi-planar reconstruction. This was done in order to assess hip joint cartilage in different zones including: 1) anterior, 2) anterior-superior, 3) superior-anterior, 4) superior, 5) superior-posterior, 6) posterior-superior, and 7) posterior. Within each radial slice, four regions were analyzed: 1) peripheral acetabular cartilage, 2) central acetabular cartilage, 3) peripheral femoral cartilage, and 4) central femoral cartilage. In these regions, mean T2* values were assessed by using ROI analysis. The corresponding DESS reformats served as reference for accurate placement of the ROIs squares within cartilage bounds. Morphological changes of cartilage damage were classified according to a modified Outerbridge score system where grade 0 indicates normal cartilage, grade 1 indicates signal changes and / or minor surface irregularities, grade 2 indicates cartilage thickness loss up to 50 %, and grade 3 indicates cartilage thickness loss of more than 50 %. Areas of total cartilage loss (grade 4 lesions) could not be mapped and were, therefore, excluded from this analysis.

**Statistical Analyses**

SPSS® software (Version 19.0; SPSS, Inc., USA) was used for all statistical analyses. Mean T2* values, standard deviation (±) and value range were measured in various grades of cartilage degeneration. The one-way analysis of variance (ANOVA) was applied in order to identify statistically significant differences between the T2* values of various grades of cartilage. The Student’s t-test for independent samples was used to identify any statistically significant differences between the T2* values of the study group and the control group. Confidential intervals of 95% were measured for all assessments with p-values of < 0.05 being considered as statistically significant.

**RESULTS:**

The mean T2* values differed significantly with varying morphological grades of cartilage degeneration in both symptomatic patients and asymptomatic volunteers (p < 0.001) ranging from 25.1 ± 4.5 ms (grade 0) to 14.2 ms ± 2.5 ms (grade III) in the study cohort, and 26.0 ± 5 ms (grade 0) to 13.8 ± 3.2 ms (grade III) in the control group (ANOVA). Student’s t-test revealed a statistically significant difference between T2* values of the study group and the control group for morphologically normal-appearing cartilage (p-value < 0.001). The intergroup comparisons of T2* values in morphologically grade I- (p-value = 0.592), grade II- (p-value = 0.859), and grade III changes (p-value = 0.776), however, were not statistically different.

**DISCUSSION:**

We noted a statistically significant drop in T2* values with increasing morphologic damage in both symptomatic patients and asymptomatic volunteers (Figure). The largest drop of T2* numbers occurred between morphologically normal-appearing cartilage and grade I changes. Furthermore, for morphologically normal-appearing cartilage, we noted statistically significant differences between T2* values in the study group and control group of asymptomatic volunteers indicating the possibility of early biochemical changes in symptomatic patients that may have been missed with standard MRI. Based on our results we consider T2* mapping a reliable tool for assessing the status of hip joint cartilage. T2* mapping can add relevant information in certain cases where normal (or abnormal) cartilage cannot be accurately specified based on the traditional morphological MR image.

**SIGNIFICANCE:**

In the era of joint preservation and cartilage transplantation, T2* mapping for hip joint cartilage assessment in combination with a 3 T system holds great promise as it offers unique advantages such as fast imaging and the prospect of 3D biochemically-sensitive cartilage evaluation without the need for contrast medium, high image resolution and optimal independent characterization of acetabular and femoral cartilage.