Direct Comparison of intra-articular versus intra-venous delayed Gadolinium Enhanced Magnetic Resonance Imaging of Hip Joint Cartilage

**INTRODUCTION:**

Sophisticated treatment modalities like the surgical hip dislocation or hip arthroscopy were developed to correct subtle anatomic deformities in femoroacetabular impingement (FAI) in an effort to halt or reverse cartilage damage in early stages. The MR arthrogram after intra-articular (ia) injection of gadolinium-based contrast agent has emerged as the standard method for the precise evaluation of labrum and cartilage. Delayed Gadolinium Enhanced Magnetic resonance Imaging of Cartilage (dGEMRIC) after the intravenous (iv) administration of gadolinium-containing contrast agent depicts cartilage quality in vivo. The feasibility of combining the MR arthrogram with the dGEMRIC technique has been proven recently. Aim of this present study was to directly compare ia with iv dGEMRIC in the assessment of hip joint cartilage quality at 3 Tesla in the same cohort of patients.

**METHODS:**

**Study Population**

The study group consisted of 35 symptomatic adult patients (14 males, 21 females) with symptomatic FAI. The mean age was 31.4 ± 11.0 years, range: 18 - 57 years. There were 14 males and 21 females with involvement of 24 right hips and 11 left hips.

**Magnetic Resonance Imaging**

Both, iv-MRI and ia-MRI were performed at a clinical 3 T system (Magnetom Trio, Siemens Medical Solutions, Erlangen, Germany) with a body-matrix phased-array coil and the subject being examined in supine position. For iv-MRI, FDA approved Gd-DOTA (0.4 mL/kg, 0.2 mmol Gd/kg, Dotarem, Bayer AG, Leverkusen, Germany) was injected intravenously 5 minutes prior to the MRI scan. For ia-MRI, 10-20 mL of a 2 mM solution of Gd-DTPA2- (1.88 mg/mL Artirem, Bayer AG, Leverkusen, Germany) was injected under fluoroscopic guidance 30 minutes prior to the MRI scan. The MRI were conducted for each patient with a time lag of 2 weeks. The MRI protocol for both iv-MRI and ia-MRI was similar and included a 3D double-echo steady state (DESS) sequence with water-excitation for morphological cartilage assessment. T1 maps were derived by an inline processing package (SyngoMapIt, Siemens Medical Solutions, Erlangen, Germany), which utilizes a nonlinear least square fitting routine. Geometric imaging parameters were similar for both DESS and T1 imaging.

**Image Analyses**

The 3D data sets of DESS and T1, which include the inline 3D T2* maps, were transferred to a Leonardo® workstation (Siemens Medical Solutions, Erlangen, Germany) in order to perform further processing. In order to obtain radial slices, seven reformats that were concentric within the center of the femoral head and perpendicular to the acetabulum were derived from the 3D data sets by using multi-planar reconstruction (MPR). Thus, hip joint cartilage could be analyzed in seven different zones: 1) anterior, 2) antero-superior, 3) supero-anterior, 4) superior, 5) supero-posterior, 6) postero-superior and 7) posterior. In order to be able to distinct femoral from acetabular cartilage, a slice thickness of 2 mm was chosen. Four regions of interest (ROIs) were analyzed within each radial slice: 1) peripheral acetabular cartilage, 2) central acetabular cartilage, 3) peripheral femoral cartilage, and 4) central femoral cartilage. In these regions, mean T1 values were assessed by using ROI analysis. The corresponding DESS reformats served as reference for the correct placement of the ROIs squares within cartilage bounds. Morphological cartilage damage was classified according to a modified Outerbridge score system: grade 0 = normal cartilage, grade 1 = signal changes and/ or minor surface irregularities, grade 2 = cartilage thickness loss up to 50 %, grade 3 = cartilage thickness loss of more than 50 % and grade 4 = total cartilage loss. Grade 4 lesions were excluded from the analysis.

**Statistical Analyses**

In this study, SPSS® software (Version 19.0; SPSS, Inc., Chicago, IL, USA) was used for all statistical analyses. Mean T1 values, standard deviation (σ) and value range were measured in various grades of cartilage degeneration. The one-way analysis of variance (ANOVA) including Bonferroni correction for multiple comparison was applied in order to identify statistically significant differences between the T1 values for independent samples was used to identify any statistically significant differences between the T1 values of the ia group and the iv group. In order to identify significant correlation between ROI size (as indicator for cartilage thinning) and T1, the Pearson correlation test was applied. Confidential intervals of 95% were measured for all assessments with p-values of < 0.05 being considered as statistically significant.

**RESULTS:**

Morphologically, on the acetabular site, 344 regions (75.1 %) were classified as grade 0, 63 regions (13.7 %) as grade I, 31 regions (6.7 %) as grade II and 20 regions (4.4 %) as grade III. On the femoral site, 395 regions (84.9 %) were classified grade 0, 18 regions (3.8 %) as grade I, 33 regions (7.1 %) as grade II and 19 regions (4.1 %) as grade III. The mean T1 values differed significantly between iv dGEMRIC (454.7 ms ± 137.2) and ia dGEMRIC (382 ms ± 154.1) (p-value < 0.001). The mean T1 values differed significantly with varying morphological grades of cartilage degeneration. On the acetabular site, both iv and ia dGEMRIC showed the same typical pattern with T1 time elevation superiorly, corresponding to a higher GAG-content in the main weight-bearing area. In contrast, on the femoral site, there is no such pattern.

**DISCUSSION:**

T1 mapping with ia- and iv-dGEMRIC demonstrated the typical damage pattern of acetabular cartilage consistent with a higher GAG content in the main weight-bearing area. T1 values for iv-dGEMRIC were significantly higher than those for ia-dGEMRIC. There were significant differences in both ia- and iv-dGEMRIC corresponding to the amount of cartilage damage. Intravenous contrast agent administration remains the standard procedure for the assessment of dGEMRIC. However, our study demonstrates that ia-dGEMRIC may be used as well for the assessment of cartilage status. Ongoing studies will further help us to decide when a direct MR arthrogram versus an indirect arthrogram is necessary.

**SIGNIFICANCE:**

The MR arthrogram is golden standard in the evaluation of hip joint cartilage and labrum. dGEMRIC for hip joint cartilage quality assessment may in the future enable the caregiver to monitor conservative or operative treatment modalities.