Intra-articular dGEMRIC: Contrast concentration in joint cavity may impact cartilage T1 measurements

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INTRODUCTION

Recently, intra-articular delayed gadolinium-enhanced MRI of cartilage (*ia*-dGEMRIC) has been demonstrated to be feasible for assessing cartilage changes in symptomatic patients with femoroacetabular impingement (FAI) *(Magn Reson Med 2010t;64:1200-7)*. It was also reported that the information and dGEMRIC indices obtained by the *ia*-dGEMRIC were similar to those using intravenous (*iv*)-dGEMRIC (*Invest Radiol 2010;45:538-542)*. Based on the logistical advantage of the *ia*-dGEMRIC over the *iv*-dGEMRIC approach, we conducted a preliminary trial using *ia*-dGEMRIC to assess biochemical changes in cartilage in subjects who underwent MR-arthrography at our institution. We used a variable flip-angle fast three-dimensional (3D) acquisition with isotropic spatial resolution for T1 mapping. This could enable biochemical assessment of articular cartilage in any arbitrary plane through the hip joint *(J. Magn. Reson. Imaging 2009;30:896–900; Magn Reson Med 2011; 65:1377-83)*. Because with *ia*-dGEMRIC technique, the transport of Gd-DTPA^{2-} to cartilage is only from the articular surface, the contrast concentration in articular cavity would influence the cartilage T1 measurements. Hence, we estimated the variance in the fluid T1 values and evaluated whether the cartilage T1 values were correlated with the fluid T1 values.

MATERIALS AND METHODS

Subjects: 39 patients with hip pain (male = 13, mean age = 37 ± 13) who underwent hip arthrography prior to MR imaging were included in this study. The mean body weight was 72.5 ± 19.4, ranged 51.8 – 122.7 kg. **Arthrography:** For each case, 10 ml of diluted Gd-DTPA^{2-} (Magnevist, Schering AG, Berlin, Germany) with concentration of 2.5 mM was injected intra-articularly under fluoroscopic guidance and sterile precautions. 1% Lidocaine was injected into superficial and deep soft tissues surrounding the hip joint space. Most subjects also received Ropivacaine (1-4 ml) based on pain assessment. Proper position was confirmed using 1-5 ml Omnipaque. **MR imaging:** All cases had MR imaging post arthrography randomly on either a 1.5 T scanner (Magnetom Avanto, Siemens; n= 17, male = 7, mean age = 36 ± 14), or a 3.0 T scanner (Magnetom Verio, Siemens; n= 22, male = 6, mean age = 39 ± 12). Body matrix coils were used. The variable flip-angle based 3D sequence (fl3d_vibe) was used for T1 mapping, at a mean time of ~ 50 min following the contrast injection. The parameters of the sequence at 1.5 T scanner were axial slab with 96 slices, TR/TE = 25/1.64 ms, duel flip-angle = 7° & 38° (estimate T1 = 600 ms), FOV = 200mm, voxel size = 0.8 × 0.8 × 0.8 mm, PAT = 2, acquisition time = 8:45 min. B1-correction was applied *(Magn Reson Med 2011; 65:1377-83)*. The parameters used at the 3 T were identical with 1.5 T except for a longer TE (1.83ms). Morphological imaging included PD, T1 and T2 weighted images, all obtained with FATSAT.

ROI segmentation and Data analysis: 3D T1 maps were calculated inline. In each 3D data set, six radial cuts perpendicular to axial plane with 0.8 mm slice thickness and 30° apart were reformatted (sag -30°, sagittal, sag +30°, cor -30°, coronal, cor +30°), which cover superior-anterior-lateral portion of the hip joint (fig. 1, top row). ROIs for cartilage, which included both acetabular cartilage and femoral head cartilage, were segmented peripherally in each reformatted cut. The average T1 of the six reformatted cuts was considered as the cartilage T1 value of the case. ROIs for joint fluid were also segmented in two of the six reformatted slices (fig. 1, bottom row), and the average T1 of the two was considered as the joint fluid T1 value. Two tailed t-test and Regression were used for statistical analysis.

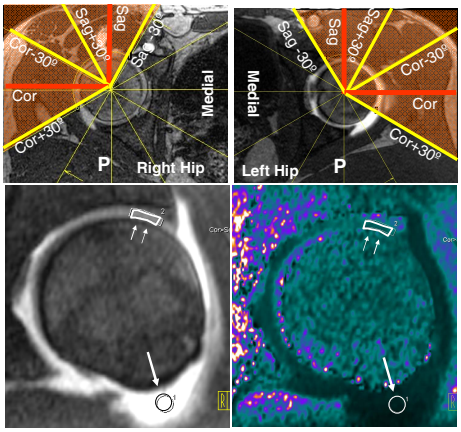

Fig 1: Top – Reformatted radial cuts and the coverage; **Bottom** - ROIs for articular cartilage (small arrows) and joint fluid (large arrows).

RESULTS

Arthrographic and MR morphological findings suggested 14 cases of FAI (cam=12, pincer=2; 9 at 1.5T, 5 at 3T), 19 cases of tear and/or cartilage damages (chondromalacia, degeneration…; 6 at 1.5T, 13 at 3T), and 6 cases of others (post surgical changes…; 2 at 1.5T, 4 at 3T). T1 measurements of cartilage and hip-joint fluid are shown in the table below and Fig 2. The T1 of articular cartilage are moderately correlated with T1 of joint fluid at both 1.5 T (R=0.49, p<0.05) and 3 T (R=0.47, p<0.05) (Fig 3a, b). The mean T1of cartilage in coronal & oblique coronal (cor -30°, cor +30°) cuts were statistically lower than the mean T1of sagittal & oblique sagittal (sag -30°, sag +30°) cuts for both 1.5 T (p<0.01) and 3 T (p<0.01).

Table - T1 measurements of cartilage and hip-joint fluid

	Cart. / FAI	Cart. / Lesions	Cart. / Other	Cart. / Total	Joint Fluid
1.5 T (n)	361± 149 (9)	344 ± 91 (6)	251 ± 25 (2)	342 ± 122 (17)	219 ± 105 (17)
3.0 T (n)	479 ± 267 (5)	372 ± 133 (13)	468 ± 232 (4)	414 ± 185 (22)	195 ± 129 (22)

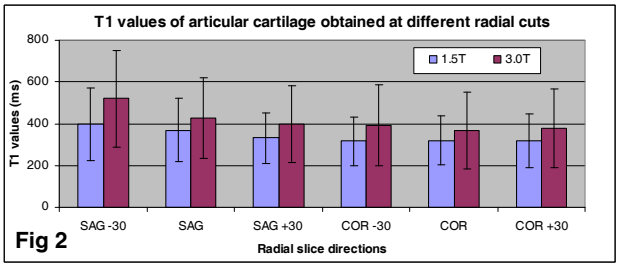

Fig 2

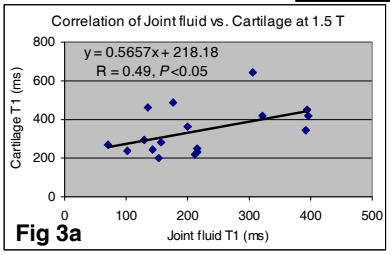

Fig 3a

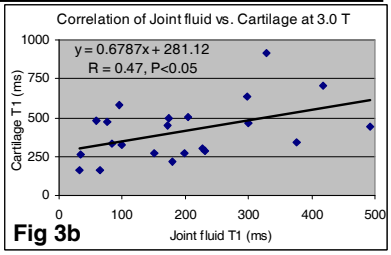

Fig 3b

DISCUSSION AND CONCLUSIONS

The T1 measurements of joint fluid, which reflect the contrast concentration in articular cavity of the hip, were very diverse with a SD of ~48% at 1.5T & 66% at 3T. This is probably related to the fact that a fixed volume of contrast was injected without any normalization to the body weight (or joint size). Further the administration of additional drugs (Lidocaine, Ropivacaine and Omnipaque) could also lead to further dilution. Similarly, there was also large disparity in cartilage T1 measurements, with SD of ~36% at 1.5T & 45% at3T. We did observe a moderate correlation between T1 of articular cartilage and T1 of joint fluid for both 1.5 T and 3 T. This finding suggests that in *ia*-dGEMRIC, the cartilage T1 measurements may not be specifically related to the proteoglycan (PG) content in the cartilage, but may also reflect the contrast concentration (input function) in articular cavity. This will impact the interpretation of T1 values observed. However, for each individual subject, the relative T1 at different regions of the joint can still be compared and the differences could be interpreted to be primarily related to the PG content. Further studies may be necessary to evaluate whether normalized T1 values (*i.e.* cartilage T1 / fluid T1) could be used as *ia*-dGEMRIC index to allow inter-subject comparisons. This would be important to define any threshold values to differentiate healthy from diseased cartilage.