Should hip dGEMRIC be performed early or late after the contrast injection?

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Introduction:

Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) is a molecular imaging technique that estimates glycosaminoglycan (GAG) distribution in articular cartilage by T1-mapping in the presence of Gd-DTPA^{2-} ($T1_{Gd}$). The "delay" refers to the time that is required for the contrast medium to diffuse into the cartilage after an intravenous (IV) injection. In knee cartilage, $T1_{Gd}$ was found to be relatively stable at 90-120 min post-injection, which has been the recommended window for dGEMRIC imaging of the knee [1, 2]. With regard to the hip joint, early data indicated no difference in signal intensity in T1 weighted images between 30 and 90 minutes post injection [2], and 30 minutes post injection has been used for in hip dGEMRIC studies [3]. The purpose of this study was to investigate the wash-in kinetics of Gd-DTPA^{2-} in the hip joint of asymptomatic individuals and those with early hip osteoarthritis (OA) due to hip dysplasia and to reevaluate the optimal window for hip dGEMRIC.

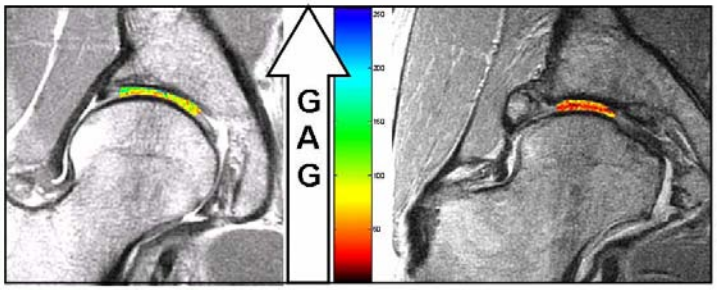
Materials and methods:

Eight asymptomatic volunteers (age 20-47 years) and four patients (age 25-58 years) with hip dysplasia but no or minimal joint space narrowing were injected IV with Gd-DTPA^{2-} (Magnevist, Berlex Imaging, Wayne, NJ) at 0.2 mmol/kg body weight (double dose). Following the injection, subjects walked during 10 minutes. At 30, 65, 100 and 135 minutes after the injection, the right hip in the healthy volunteers and the affected hip in the patients (3 right hips) were imaged at 1.5 T using the dGEMRIC-technique with a cardiac coil positioned on the front of the hip. Subjects walked for 5 minutes in-between each of the four scans. Images were 3 mm coronal slices; 256x256 matrix zipped to 512x512, and 14 cm FOV for an apparent 273 um in-plane resolution, TR: 1.8 s, TE: 14 ms, TI: 1650, 650, 350, 150 and 50 ms. dGEMRIC maps were generated with a pixel-by-pixel 3-parameter fit using Matlab (The MathWorks, MA). The dGEMRIC Index was calculated as the average $T1_{Gd}$ across all pixels in a region of interest (ROI) that included the weight bearing acetabular and femoral cartilage (mean ROI size: 755 pixels). One-way repeated measure of variance with the post-hoc Holm-Sidak method was used for comparison between different time-points. A two-way repeated measure of variance was used for the comparison between healthy volunteers and patients with osteoarthritis of the hip.

Results:

In all healthy volunteers, there was a decrease in $T1_{Gd}$ in the cartilage between 30 and 100 minutes (Figure 2). [Note: This decrease was not found in a previous study of two subjects who were immobilized in the scanner for the entire period (data not shown).] The dGEMRIC Index was on average 17% lower at 100 than at 30 minutes. No further decrease in $T1_{Gd}$ was observed between 100 and 135 minutes. In the patients with early OA due to hip dysplasia, the wash-in of the contrast medium was faster than in the healthy volunteers with little change in $T1_{Gd}$ between 30 and 135 min (Fig 2). At all time-points, the dGEMRIC Index was lower in the patients than in the healthy volunteers ($p<0.001$-$p=0.01$). The difference in $T1_{Gd}$ between the healthy volunteers and the patients with early OA was approximately 40% at 30 minutes and decreased to approximately 20% at 100 and 135 minutes (Fig 2).

Fig 1a **Fig 1b**



Figures 1a and 1b. Illustrations of ROIs in the weight bearing acetabular and femoral cartilage in one healthy volunteer (1a) and one patient with hip dysplasia (1b) at 65 min post contrast injection. $T1_{Gd}$, represented by the color scale, was lower in the patient, consistent with lower cartilage GAG content.

Fig 2

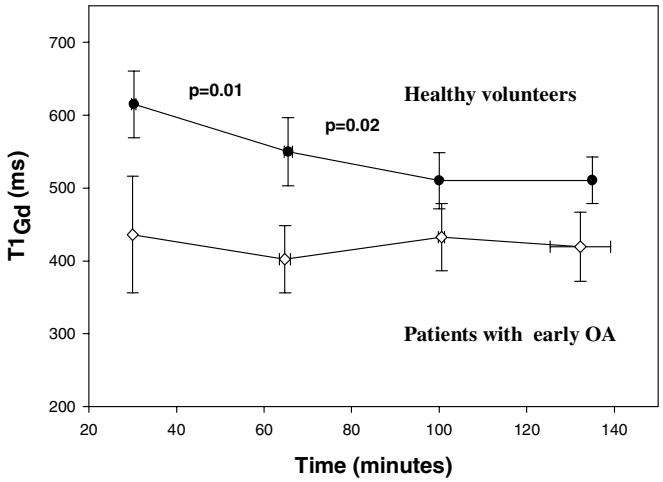


Figure 2. $T1_{Gd}$ (mean ± SD) over time (mean ± SD) in healthy volunteers and patients with early OA due to hip dysplasia after injection of Gd-DTPA^{2-}.

Discussion

- This study shows that the wash-in of Gd-DTPA^{2-} into healthy hip cartilage is similar to previously determined kinetics in the knee cartilage with a maximum concentration at approximately 90-120 minutes [1]. It is possible that the earlier study of hip cartilage [2] did not demonstrate the continued wash-in of Gd-DTPA^{2-} after 30 min because the volunteers were immobilized in the scanner after the initial 10 min of joint motion after injection.
- The wash-in kinetics appears to be faster in the diseased cartilage in the dysplastic hips. These results are consistent with a study of early knee OA, where $T1_{Gd}$ was approximately 30% lower in fibrillated compared with reference cartilage and the wash-out of the contrast medium was faster in the diseased cartilage [4].
- Due to this differential in wash-in kinetics, the earlier time point for imaging resulted in increased sensitivity to disease.
- The differential in $T1_{Gd}$ at 30 min would be due to a combination of transport (diffusion) differences and concentration differences due to charge (GAG) distribution. However, since water diffusivity tends to increase with GAG loss [5], the dGEMRIC Index might still reflect general GAG content.
- From a clinical point of view, imaging 30 minutes after the injection would be beneficial. However, measuring $T1_{Gd}$ during the early phase of wash-in may result in decreased reproducibility. An ongoing wash-in may be the reason for the relatively weak reproducibility that has been reported in hip dGEMRIC (C.V. in the order of 15%) [3]. Further data of both hip and knee cartilage are needed to evaluate the advantages and disadvantages of dGEMRIC already at 30 minutes post injection.
- The lower dGEMRIC Index in the patients with early OA due to hip dysplasia represents a lower GAG content and confirms previous findings [3]. In the patients, the radiographic changes of OA were absent or minimal whereas the dGEMRIC Index was decreased by 20-40%. This emphasizes that dGEMRIC is a sensitive measure of early cartilage pathology in the hip joint.

References: [1] Tiderius CJ et al. Magn Reson Med 2001;46(6):1067-1071. [2] Burstein D et al. Magn Reson Med 2001;45(1):36-41. [3]. Kim, YJ et al. J Bone Joint Surg Am 2003; 85-A: 1987-92. [4] Tiderius, CJ et al. Magn Reson Med 2003; 49: 488-92. [5] Burstein D, et al. J Orthop Res 1993; Jul; 11(4):465-78.