

Temporal dynamics of Gd-enhanced T1 relaxation time in deep and superficial femoral articular cartilage

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INTRODUCTION

dGEMRIC (delayed gadolinium-enhanced MRI of cartilage) technique has been developed to assess GAG content of articular cartilage [1]. Based on the previous studies, the ideal imaging time for knee joint after contrast agent injection has been assessed to be two hours [2]. However, the change in cartilage T1 has been observed from bulk regions of interest containing both deep and superficial cartilage. The aim of the current study was to investigate the temporal dynamics of the contrast agent over time in deep and superficial cartilage separately.

METHODS

Fifteen healthy (symptomless) volunteers were imaged using single-slice inversion recovery spin echo sequence (TR = 2000 ms, TE = 15 ms, TI = 50, 100, 200, 400, 800 and 1600 ms, ETL=5, matrix = 256x256, FOV = 12x12 cm, in-plane resolution 0.47 mm, slice thickness = 3 mm). A sagittal slice was localized to cover the middle part of lateral femoral condyle. Two regions of interest covering a layer of the most deep and superficial cartilage were segmented manually on the femoral condyle (Figure 1). The regions were segmented to include pixels completely inside the cartilage to avoid partial volume artifact. Triple dose (0.3 mM/kg) of Gd-DTPA²⁻ (Magnevist, Schering, Germany) was used, and the measurement was repeated after 1, 2, 3 and 4 hours after contrast agent injection, yielding altogether five time points. The mean value for each time point was calculated. To test the significance of the differences between the time points, the Wilcoxon signed rank test was used.

RESULTS

Both deep and superficial regions displayed lower T1 values after the contrast agent injection (Figure 2). The difference between pre-contrast T1 and Gd-enhanced T1 at all time points was statistically significant ($p < 0.01$). However, T1 of the deep cartilage kept lowering further. There is significant difference even between T1 obtained three and four hours after injection, whereas T1 of the superficial cartilage begins to rise again, suggesting the beginning of the wash-out.

DISCUSSION

For deep cartilage, T1 continuously gets lower, at least up to four hours after Gd-DTPA²⁻ injection. This could indicate that most of the contrast agent enters the cartilage from the synovial side, whereas the uptake from the bone is small or negligible. Based on the current results, the ideal time point to observe cartilage seems to be two hours after contrast agent injection, as previously reported, because the change in both superficial and deep cartilage is quite slow between one and three hours. However, the ongoing lowering of deep T1 could lead to an overestimation of the GAG content in the deep cartilage in vivo. Furthermore, the observed difference between superficial and deep pre-contrast T1 values suggests that the analysis of bulk cartilage regions of interest may not be the optimal way of estimating the GAG content, and that the post-contrast T1 alone doesn't provide all needed information for cartilage evaluation. The present results suggest that applying the dGEMRIC method for separate cartilage layers at different depths could provide additional information about the status of the cartilage.

REFERENCES

1. Bashir et al., Magn Reson Med 1999;41:857-865
2. Burstein et al., Magn Reson Med 2001;45:36-41

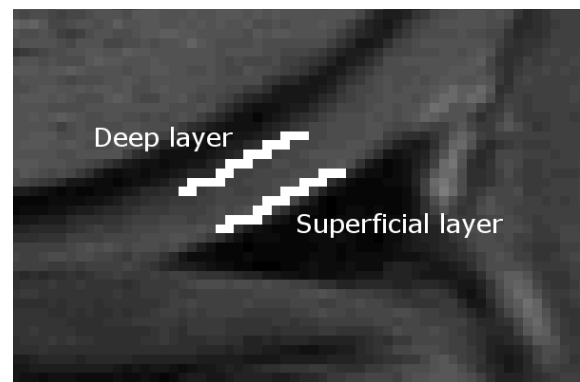


Figure 1. Selected regions of deep and superficial cartilage. Both regions were segmented to have a thickness of one pixel with particular consideration of the cartilage curvature and angle. Regions were segmented to consist of pixels completely within the cartilage to avoid partial volume artifacts.

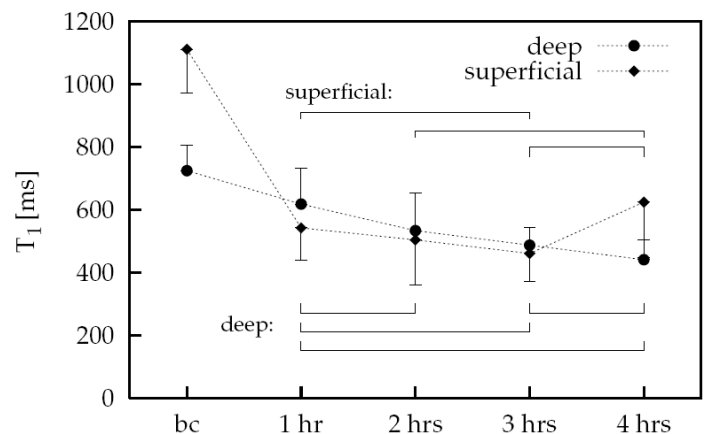


Figure 2. T1 relaxation times of medial condyle at five time points: before contrast (bc), and 1, 2, 3 and 4 hours after Gd-DTPA²⁻ injection. The difference between T1 values before and all time points after contrast agent injection were statistically significant. Statistically significant differences between time points after contrast agent injection are denoted by brackets opening up and down for deep and superficial cartilage, respectively.