Does sub-regional analysis of dGEMRIC allow for improved sensitivity?

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INTRODUCTION

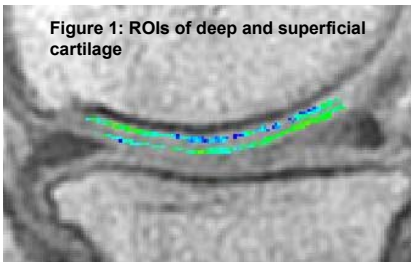
Post Gd-DTPA T1 relaxation time (T1Gd) is commonly used as a dGEMRIC index to determine relative glycoso-amino glycan (GAG) levels. This parameter is usually based on the analysis of regions of interest (ROIs) with full thickness of cartilage and has been argued to track changes in relaxation rate ΔR1 (= 1/T1Gd - 1/T1pre) *(Magn Reson Med 2007; 58:830-834)*. It was also shown that T1Gd and ΔR1 were similarly effective in differentiating knees with OA from those considered healthy *(J Magn Reson Imaging 2009; 29:494-97)*. A recent report (*Proc. Intl. Soc. Mag. Reson. Med. 17 (2009) p.3963)*, however, demonstrated a significant difference within sub-regions (deep and superficial layers) of the cartilage in terms of ΔR1. Specifically it was shown that the deep layer shows a much smaller ΔR1. This then begs the question, if the analysis would be more sensitive when only superficial cartilage was used instead of full thickness.
In this report, we have taken the opportunity to re-analyze data from a previous report, using both full thickness and sub-regional analysis. We specifically evaluated if sub-regional analysis could offer additional advantage, *e.g.* higher sensitivity in terms of differentiating knees with OA *vs.* healthy subjects.

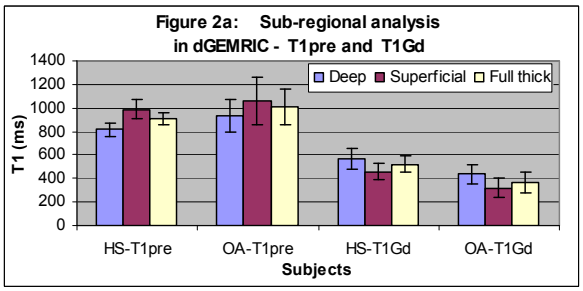
MATERIALS AND METHODS

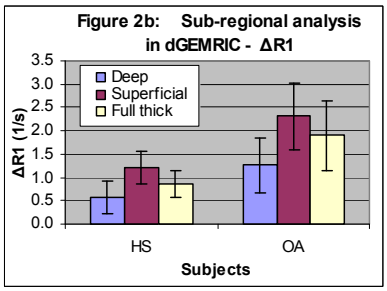
Subjects and imaging: Fourteen healthy subjects (HS) and 17 patients with osteoarthritis (OA) were included in this study. All subjects were part of a study reported previously. All subjects were imaged before and 90 min after double-dose Gd-DTPA^{2-} administration using a 1.5 T GE scanner (GE Healthcare, Waukesha) with transmit / receive extremity coils. 2D IR-FSE sequence was used for all post contrast exams and 20 pre-contrast exams (HS=9; OA=11), positioned sagittally through medial condyle. A three dimensional Lock-Locker (3D LL) sequence was used in the rest of 11 pre-contrast exams (HS=5; OA=6), positioned sagittally covering whole joint (only the matched slice through medial condyle was used for analysis). The detailed acquisition information can be found in previous report *(J Magn Reson Imaging 2009; 29:494-97)*.
ROI segmentation and Data analysis: ROIs for T1 mapping were segmented at deep, superficial, and full thickness of femoral cartilage separately. Attention has been paid to place the ROIs within the cartilage and to avoid partial volume effect. The spatial extent of the ROIs was similar to the previous reports based on full thickness covering the weight-bearing area as much as possible (Figure 1). If no more than one layer of ROI could be accommodated due to the limited thickness of the cartilage, only one ROI was defined and was counted as both superficial and full thickness ROI for the comparison purposes. T1 mapping was performed with a custom software analysis routine written in MATLAB (The Mathworks; Natick, MA). Two tailed paired t-Test and Regression were used for statistical analysis.

RESULTS

Average T1 and ΔR1 values for deep, superficial, and full thickness of femoral cartilage are summarized in the table below and Figure 2. The general trends of increased T1pre and decreased T1Gd in OA compared to HS were held irrespective of the specific ROI analysis method used. However, the magnitude of ΔR1did show differences within the sub-regions, and compared to full thickness analysis. ΔR1 in HS was higher in the superficial cartilage (1.21 ± 0.35) compared to the deep layer (0.57 ± 0.35, p<0.001) and full thickness analysis (0.86 ± 0.30, p<0.001), and so are in OA, with superficial layer ΔR1of 2.31 ± 0.73 compared to the deep layer (1.26 ± 0.59, p<0.001), and full thickness analysis (1.90 ± 0.75, P<0.01). T1Gd and ΔR1 were inversely correlated with R value of 0.94, p <<0.001.
In four cases of OA, no more than one layer of ROI could be accommodated due to the limited cartilage thickness. The average T1pre of the four subjects (1075 ms) was closer to the T1pre of superficial layer based on the rest of the subjects.







	T1pre-HS (ms)	T1pre-OA (ms)	T1Gd-HS (ms)	T1Gd-OA (ms)	ΔR1-HS (1/s)	ΔR1-OA (1/s)
Deep	814 ± 57	933 ± 139	570 ± 85	411 ± 82	0.57 ± 0.35	1.26 ± 0.59
Superficial	985 ± 82	1056 ± 202	458 ± 69	321 ± 79	1.21 ± 0.35	2.31 ± 0.73
Full thick	905 ± 52	1012 ± 149	517 ± 69	364 ± 88	0.86 ± 0.30	1.90 ± 0.75

DISCUSSION AND CONCLUSIONS

- For healthy subjects, our results (with ROIs covering large weight-bearing area) were consistent with the previous finding, which was based on small ROIs with specific location *(Proc. Intl. Soc. Mag. Reson. Med. 17 (2009) p. 3963)*. In both HS and OA, ΔR1 are higher in the superficial cartilage compared to full thickness analyses and the deep layer. This may reflect differences in regional GAG levels and transport of contrast to the respective regions.
- When comparing knees with OA *vs.* HS, the difference in average ΔR1 was slightly higher within the superficial region compared to full thickness (1.1 [2.31-1.21] *vs.*1.04 s^{-1} [1.90 – 1.86]), but did not reach statistical significance (p = 0.6). This suggests that sub-regional analysis did not improve the sensitivity compared to full thickness analysis in the present study. At this time it is not clear if the analysis of deep layer is necessary for routine use.
- Similar to previous reports with full thickness analysis, current study shows that T1Gd tracks ΔR1 for superficial region (R=0.94, P<<0.001), so the use of T1Gd measurements as dGEMRIC index may still be valid for routine use.
- In relatively advanced OA (Kellegren Lawrence score ≥ 2), as in this study, the sub-regional analysis is limited by the available thickness of the cartilage. Our preliminary analysis in this study suggests that the average T1pre of the four OA subjects with limited thickness of cartilage was closer to the superficial layer based on the rest of the subjects. This may suggest that the residual cartilage may be more representing superficial layer.

In conclusion, our preliminary experience supports the use of sub-regional analysis for the evaluation of dGEMRIC. In practice, we believe that superficial cartilage would be sufficient and may be potentially more sensitive compared to full thickness analysis. Since the sub-regional analysis is dependent on sufficient thickness of cartilage available, it may be restricted to healthy and knees with early degeneration. Sub-regional analysis could be more sensitive to partial volume effect.