T1, T2 and dGEMRIC are not related to arthroscopic grade of articular cartilage

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TARGET AUDIENCE

Scientists and clinicians aiming to apply qMRI techniques for assessing cartilage degeneration.

PURPOSE

To determine the association of T2 relaxation time, pre-contrast T1 relaxation time and dGEMRIC to arthroscopic grading, considered to be the gold standard for OA diagnosis.

METHODS

Quantitative MRI (qMRI) at 3T (Siemens Skyra, Siemens Healthcare, Germany) was performed prior to arthroscopy in ten patients (8 female and 2 male, age range: 40-68 years) with persistent joint pain symptoms. The study protocol was approved by the local ethics committee and informed consent was obtained from all subjects. Pre-contrast T1 relaxation time and dGEMRIC was determined using an inversion recovery FSE sequence (TR = 4060 ms, TE = 8.6 ms, 8 TIs between 50 and 3900 ms; slice thickness 3 mm; FOV = 160*160mm^2; matrix = 384*384). T2 relaxation time was measured using a multi echo spin echo sequence (TR = 1680 ms, 5 TEs between 13.8 and 69 ms; same resolution than in T1 measurement). For dGEMRIC, T1 mapping was repeated 90 minutes after intravenous injection of 0.2 mM/kg of Gd-DTPA^{2-}, followed by flexion-extension of the knee and walking for 10 minutes. Relaxation times were determined at six different knee sites (medial and lateral tibia, medial and lateral femur, medial and lateral trochlea) for superficial, deep and bulk regions-of-interest (ROIs). Two to twelve weeks after imaging, arthroscopy was conducted and cartilage was graded according to the International Cartilage Repair Society (ICRS)[1] classification system at locations of MRI analyses. Data from different sites were pooled to test the association between qMRI parameters and arthroscopic grade using the non-parametric Kruskal-Wallis test. Correlation between ICRS grades and MRI parameters was tested using Spearman correlation analysis while the correlation between MRI parameters was tested using Pearson correlation analysis. Statistical analyses were performed using SPSS 19 software (SPSS Inc., USA).

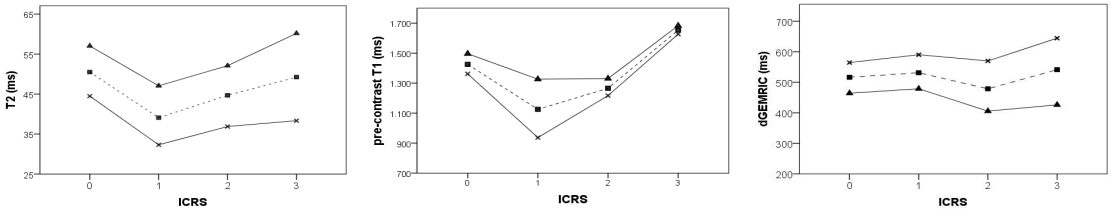

Figure 1: Mean T1 and T2 relaxation times and dGEMRIC in superficial (▲), bulk, (■) and deep (x) cartilage as a function of ICRS grading.

RESULTS

Arthroscopy revealed varying degree of cartilage degeneration (20 regions with ICRS grade 0 (ICRS0), 17 regions with ICRS1, 16 regions with ICRS2 and 2 regions with ICRS3). T1 and T2 revealed a trend towards shorter relaxation time values for ICRS1 as compared to ICRS0, while values showed an increasing trend towards higher grades (Fig. 1 and 2). Shortening of T1 and T2 between ICRS0 and ICRS1 was statistically significant (Fig. 2). Pre-contrast T1 showed a statistically significant ($p<0.01$) difference between superficial and deep ROI for ICRS0 while such a difference was not observed for ICRS2-3 cartilage. Broadening of T1 values for different cartilage depths was observed for ICRS1 as compared to other grades (Fig. 1). T1 and T2 relaxation times correlated statistically significantly ($r=0.45$, $p<0.01$). dGEMRIC values showed no significant difference between ICRS grades. Relaxation times were not linearly dependent on ICRS grade and the Spearman correlation coefficient was dependent on the ICRS grades included in the analyses (Table 1).

DISCUSSION

Previously, cartilage degeneration has been associated with a prolonged T1 and T2 relaxation times and a lower dGEMRIC index as compared to normal cartilage [2-4]. Elevated T2 has been attributed to progressive collagen network disruption, while prolonged T1 relaxation time has been related to increasing water content. A lower dGEMRIC index has been associated with proteoglycan loss. In the present study, arthroscopic grading of cartilage was not associated with qMRI parameters. Moreover, the anomalous finding of shortened T1 and T2 relaxation times at early degeneration as well as the broadening of T1 values for different cartilage depths at ICRS1 reveals a more complex pattern of disease progression. T2 shortening in early degeneration has been previously reported [3,5]. Three explanations can be proposed for the current findings. First, arthroscopic evaluation assesses the degree of tissue loss while qMRI probes the quality of the remaining tissue. Consequently, a significant correlation may not be expected. Second, the anomalous behaviour of T1 and T2 relaxation times may reflect a more complex pattern of disease progression than anticipated. The changes in T1 and T2 may reflect the early attempts of articular cartilage to repair itself prior to gross degeneration. Finally, T1 and T2 relaxation times of deep cartilage are shorter than at the surface and the wear-out of the more superficial tissue may give rise to shortened relaxation time values supposing the remaining tissue is intact. Even though this study is based on a small population, its findings suggest that a more complex pattern may occur at early stages of the disease with a different trend compared to advanced stages. Since such changes are detected in MRI but are not visible during arthroscopy together with the lack of correlation between MRI and arthroscopy, further investigations are required.

CONCLUSION

qMRI parameters are not related to arthroscopic grading of cartilage. qMRI may detect changes in cartilage quality more sensitively as compared to arthroscopic grading which merely evaluates the loss of cartilage.

Table 1: Spearman's correlation coefficients between MRI parameter means in superficial, bulk and deep cartilage and ICRS grading 0-3 and 1-3 (* $p < 0.05$, ** $p < 0.01$).

	pre-contrast T1			dGEMRIC			T2		
	sup	bulk	deep	sup	bulk	deep	sup	bulk	deep
ICRS 0-3 (N=49-55)	-0.26	-0.19	-0.12	-0.30*	-0.19	-0.06	-0.19	-0.25	-0.26
ICRS 1-3 (N=30-35)	0.13	0.44*	0.46**	-0.48**	-0.24	0.05	0.32	0.33	0.20

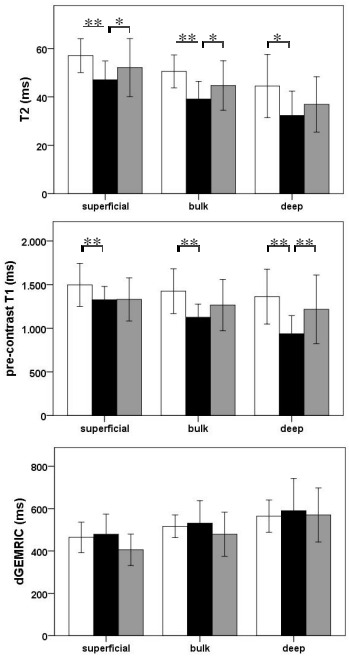

Figure 2: T1, T2 relaxation times and dGEMRIC means and SD at 0 (white), 1 (black) and 2 (white) ICRS grading (* $p < 0.05$, ** $p < 0.01$). Grade 3 was excluded from the comparison due to the small amount of regions (2).

REFERENCES

1. Brittberg and Winalski, J.Bone Joint Surg.Am. 2003; 85-A:58-69. 2. Lammentausta et al., Osteoarthritis Cartilage 2007; 15:1149-1157. 3. Nissi et al., J Orthop Res 2004; 22:557-564. 4. Hannila et al., Acta Radiol 2007; 48:444-448. 5. Chu et al., Arthritis Rheum 2010; 62:1412-1420.