Combined T1-T2 mapping of articular cartilage at 1.5T

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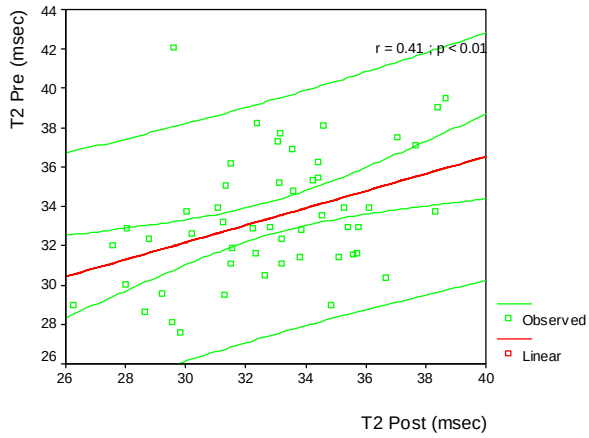
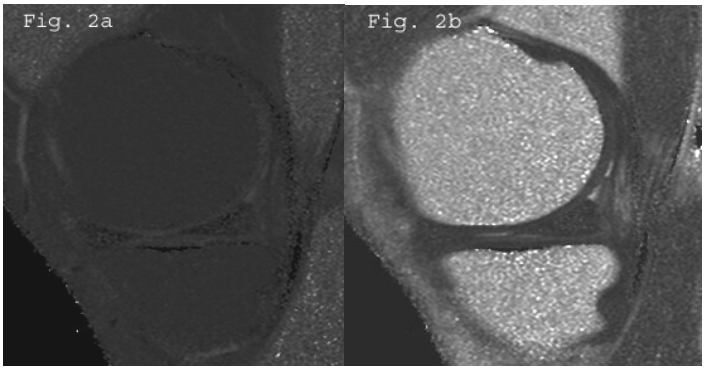
Introduction
Two MR imaging techniques that have demonstrated promise in the evaluation of early structural damage in articular cartilage are quantitative T2 mapping and T1 mapping after Gd-DPTA^{2-} administration (dGEMRIC). Existing research suggests these techniques are complimentary (1,2). In this study, we use a turbo-mixed imaging technique on a 1.5T MR imaging system (3), which combines T1 and T2 mapping of femoro-tibial articular cartilage in healthy adult volunteers. We evaluate the influence of Gd-DTPA^{2-} on T2 relaxation values of cartilage obtained with this technique and determine the range of T1 relaxation values after Gd-DTPA^{2-} administration.

Methods and materials
A turbo mixed T2-IR fast spin-echo sequence was implemented with a 1.5T MR imaging system (Gyroscan; Philips Medical Systems). This sequence simultaneously generates T1 and T2 maps using a built-in calculation tool. The sequence parameters were: repetition time/echo time (first echo - second echo) of the SE part 630 msec/ 4 – 64 msec; repetition time/echo time (first echo - second echo) of the IR part 910 msec/ 4 - 64 msec; IR delay time 280 msec; turbo factor 12; matrix 304 x 304, 75% scan resolution, reconstructed to 512 x 512; field of view 14 x 14 cm. Twelve slices in an oblique sagittal direction were obtained with a slice thickness of 3 mm and a 0.01 mm slice-gap, covering one femoro-tibial compartment. Four signals were acquired within a total acquisition time of 11min 51sec.
20 healthy adult volunteers (male/female ratio: 12/8) without history of knee trauma or surgery (age range, 18 – 39 year) underwent MR imaging of either the left or right knee after informed consent was obtained. The volunteers were positioned supine with the femoro-tibial joint space placed at the gradient isocenter of the coil. A standard quadrature receive only knee coil was used for all measurement. tMIX imaging was performed on the medial and lateral femoro-tibial compartment, followed by intravenous injection of 0.2 mMol/kg Gd-DTPA (Magnevist®, Schering). A rest period of 120 minutes was respected followed by post-contrast scanning of the medial and lateral femoro-tibial compartment with the same tMIX sequence. T1 and T2 maps of all measurements were displayed using the built-in software tools based on least square algorithms. 4 ROIs were determined in the centro-central segments of the femoral and tibial parts of both the medial and lateral knee compartments in each volunteer and means are calculated per segment. The T1 relaxation range as well as mean T1 was determined on the post-contrast calculated T1 maps. T2 relaxation values before and after gadolinium administration were statistically analysed.

Results
Mean T1 relaxation value is 356,6 msec ± 63,9 msec (SD), with the T1 relaxation range between 258 msec and 577 msec. Interactive graph plotting of the T1 relaxation values revealed a few outliers (1,5%), which were left out in the relaxation range determination. Mean T2 relaxation value before contrast is 33,4 msec ± 3,2 msec (SD) and after contrast is 32,9 msec ± 3,0 msec (SD). Paired sample T-test analysis is not significant (p = 0,25; 95% C.I. [-0,40;1,58]), meaning no significant influence of contrast on T2 map calculations. There is a significant correlation between pre- and post-contrast T2 relaxation values (r=0,41; p<0,01). Linear regression analysis gives a curve estimate of $T2_{pre}$=0,44 * $T2_{post}$ + 19,09 given a $T2_{post}$ value (R^2=0,17; 95% C.I. for B [0,16;0,72]; p<<0,01; Figure 1).

Fig. 1: Curve estimate for T2 pre





A typical example of a cartilage T1 map is shown in figure 2a; a typical cartilage T2 map (after Gd administration) is shown in figure 2b.

Discussion
Our study shows that combined T1-T2 mapping of cartilage with the tMIX sequence is possible. Correction for obtained T2 relaxation values after contrast administration is not necessary, but if performed, increases correlation. Calculation of both T1 and T2 from a single measurement is not only a very efficient approach. It reduces problems of misregistration between T1 and T2 weighted images and integrates its information. This sequence would lead to a drastic reduction in overall scan time compared to high resolution imaging of both T1 and T2 maps. The lengthy scan time for both maps is an important drawback for routine application of cartilage mapping. The clinical usefulness of this sequence however further needs to be determined.

References
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