Experimental Investigation into the Relationship between T2* and T2 in Cartilages at 3T

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INTRODUCTION

Compared with T2 relaxation time determined by internal Brownian motion of spins in tissue, T2* time is affected by both internal events (Brownian motion of spins and local change of tissue microstructures) and external fields (main field B0 and encoding gradients). An equation has been established to connect T2* to T2 by including field effects via a quantity T2' (1): 1/T2* = 1/T2 + 1/T2'. It is supposed that T2* value approaches to T2 value when the external effects are minimized. However, T2* may not do so when the local field effect is much larger than the effect of Brownian motion. This is usually the case in osteoarthritis (OA) cartilages where collagen disorganization is expected to have much larger effect on local field than in normal cartilage. In this work we show that T2* value is dominated by internal events in cartilage once external field effects are minimized. T2* time is then an independent quantity and might be more sensitive to cartilage degeneration than T2.

METHODS AND EXPERIMENTS

**Methods** As 1/T2* = 1/T2 + γΔB in a voxel with field inhomogeneity ΔB = ΔBex + ΔBin. It has been known that reducing voxel size (or increasing spatial resolution) will reduce the magnitude of total field inhomogeneity ΔB across the voxel and thus push T2* value closer to T2 if ΔB is dominated by the external field inhomogeneity, ΔBex (1). Otherwise, the ΔB is dominated by internal field inhomogeneity, ΔBin. We implemented T2 and T2* mapping at different spatial resolutions to determine which inhomogeneity (ΔBex or ΔBin) affects T2* more. The T2* mapping was implemented at two distinct resolutions: a low resolution of 0.71mm at matrix size 128 and a high resolution of 0.36mm at matrix size 256, while the T2 mapping was implemented only at the low resolution.

**Experiments** An tibial cartilage explant of human knee (asymptomatic adult) was scanned on a 3T MRI scanner (Magnetom Trio Tim, Siemens Medical Solutions, Erlangen, Germany) with an extremity coil. For T2 mapping, multi-contrast spin echo sequence (se mc) was used with 11-TEs (8.8-96.8ms), TR=3500ms, slice thickness = 1mm, resolution = 0.71mm, and BW=326 Hz/pix. For T2* mapping, AWOSOS sequence was used (2), with 13-TE acquisitions (0.3-70ms), TR=100ms, slice thickness =1mm, resolution= 0.71/0.36mm. **Data Processing** Mono-exponential fitting was employed for T2 and T2* mapping. For T2* mapping two TE groups were used: one is normal TEs matching that for T2 mapping but the other is UTE having all the 13-TEs. Alignment of the T2* map to T2 map was performed before comparing them at individual voxels.

RESULTS AND DISCUSSION

**Results** Fig. 1 shows the maps of T2* and T2 times, demonstrating visible distinction between them across the cartilage. Quantitative correlations between T2* and T2 at individual voxels are shown in Fig. 2. Increasing spatial resolution from 0.71mm to 0.36mm did not improve the correlation significantly: 10% at low resolution and 14% at high resolution for normal TE mapping (Fig. 2a-b), and 5.2% to 1.5% for UTE mapping (Fig. 2c-d). The ratio of the internal to external field inhomogeneity (ΔBin/ΔBex) at an individual voxel was estimated as 41.6, showing that ΔBin was much larger than ΔBex. [Details: γΔB = (1/T2* - 1/T2) ≈ (1/37ms - 1/58ms) = 9.8Hz, across a voxel. The measured shim linewidth was <60Hz, leading to γΔBex < 60Hz across FOV, and thus γΔBex < 60/256 = 0.23Hz across a voxel. Consequently, ΔBin/ΔBex ≈ (9.8-0.23)/0.23 = 41.6]. **Discussion** The reason for low correlation between the T2* and T2 (Fig. 2a-b) might be microstructures in the cartilage that make local magnetic field inhomogeneous at any voxel sizes and thus can not be reduced through increasing spatial resolution. Lower correlation of the UTE T2* to T2 (Fig. 2c-d) may reflect short-T2* component of dominative impact on resultant T2* values, leading to UTE-T2* values more distinct from T2 values. In conclusion, both the very low correlation between the T2* and T2 and the very large ratio of ΔBin to ΔBex clearly showed that the T2* value was an independent quantity relative to T2 value in the cartilage explant studied. The UTE-based T2* further enhanced this independency.

REFERENCES: