Imaging the collagen properties in the spinal disc and vertebra by combining DQF NMR and UTE MRI

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Introduction: Collagen is a major component of connective tissues such as tendons, and is responsible indirectly to the short T_2 relaxation time of the water molecules in these tissues, making imaging very difficult. The introduction of ultra-short TE pulse sequences (UTE)[1] solved the water short T_2 problem but did not give information about the nature of the collagen. In the preset work we show that a combination of the UTE with the double quantum and magnetization transfer filters (DQF-MT)[2,3] enables to obtain contrast that depends on the collagen contents and properties.

Materials and Methods: We conjoin a double quantum filter and magnetization transfer (DQF-MT) following by a UTE MRI sequence: 90°-τ-90°-t_{DQ}-90°-τ-90°-t_{LM}-UTE, where τ is the evolution period, and t_{DQ} and t_{LM} are the double quantum coherence and longitudinal magnetization evolution time intervals, respectively. MRIs were obtained using a 14T Bruker BioSpin μMRI system with an AVANCE III console. Discs and vertebrae were obtained from rat-tail of previously sacrificed animals and soaked in saline. Annulus was obtained from a spine of sacrificed pig.

Results: In Figs. 1 and 2 we show images of axial slices of discs and vertebrae in rat tail as function of τ. On a time scale of 30μs the intensities of the tendons, muscles, and annulus fibrosus decline by 1.3:2:1.9 respectively in disc. For the slice through the vertebrae the tendons, muscle, and vertebrae decay by 1.3:2.5:1.5 respectively. Preliminary studies of porcine annulus have shown gradual decline of collagen type I from outermost part towards innermost one. For τ=300μs only collagen type I containing tissues gave signal.

Discussion: The differences in the decay of the collage magnetization in the various compartments mentioned in the results section are consistent with the presence of different types of collagen (type I and II). In the tendon it is exclusively type I while in the annulus fibrosus there is gradual decline in the amount of type I from the outermost part to the innermost one with the opposite being valid for collagen type ii. This interpretation of the data is consistent with previous studies by methods other than magnetic resonance[4]

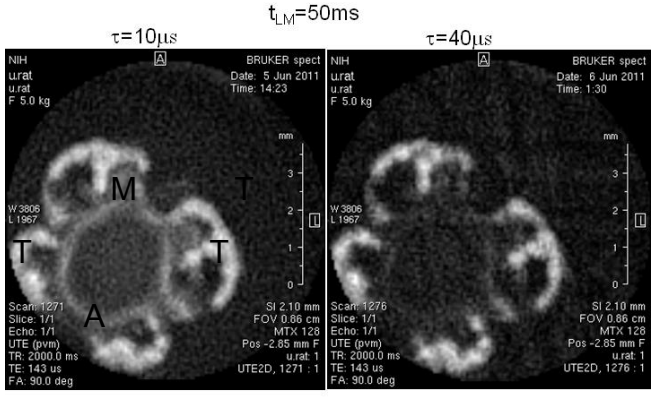

Fig. 1: An axial slice of rat-tail disc obtained by combining DQF-MT and UTE MRI. Slice thickness=2.1mm,TE=143μs. A-annulus fibrosus. T-tendon, M- muscle

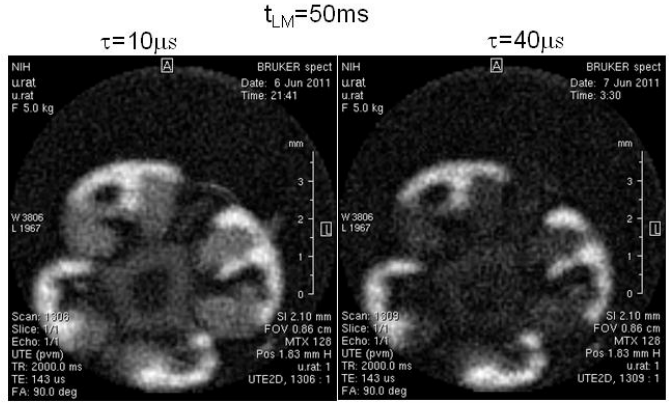

Fig. 2: An axial slice of rat-tail vertebrae obtained by combining DQF-MT and UTE MRI. Slice thickness=2.1mm,TE=143μs.

References:

(1)Gatehouse & Bydder, Clin Radiol 58 (2003) 1. (2) Eliav & Navon, JACS, 124 (2002) 3125 (3) Neufeld et al., MRM 50 (2003) 229 (4) Grynpas MD et al. Biochimica Et Biophysica Acta 626 (1980) 346-35.