T1rho dispersion and T2 measurements of cartilage and muscle in guinea pig knees at 7 Tesla

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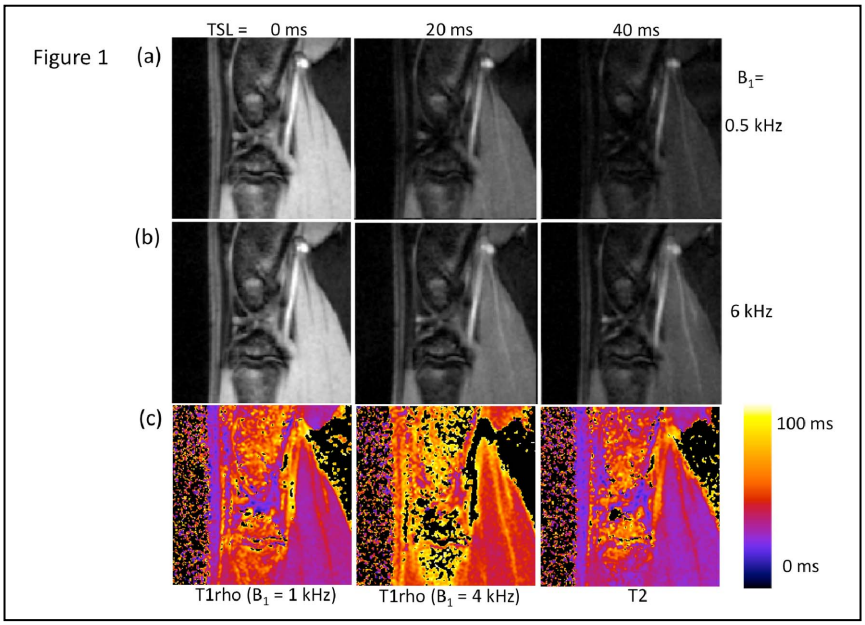
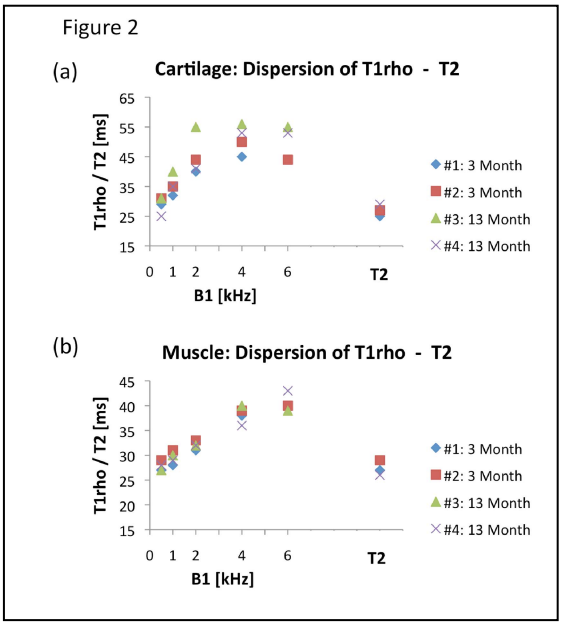
Introduction: Osteoarthritis (OA) affects over 20 million people in the United States and is highly prevalent in the aging population [1]. The disease is characterized by destruction of the articular cartilage and changes in the subchondral bone. It was shown that quantitative MRI methods, such as T1rho and T2 mapping sequences, have the potential to evaluate changes in concentration and structure of macromolecules within cartilage matrix in OA [2-4]. Higher field strengths will improve the signal to noise ratio of the MRI measurements, however, these quantitative parameters are less reviewed at high field strengths (7T or higher). Further, the dispersion behaviour of T1rho at different spin locking fields strength is important to understand and interpret T1rho values when T1rho mapping sequences should be applied on animal and human studies at high magnetic field strengths. Dunkin-Hartley guinea pigs can be used as an animal model to study cartilage degeneration; it was shown that they develop OA at three-four months of age [5-7]. The aim of this study was to establish and implement a quantitative MR imaging protocol for T2 and T1rho dispersion analysis to evaluate these parameters *in vivo* on the articular cartilage of a guinea pig OA model at 7T.

Material and Methods: The right hind stifle joint of four male Dunkin Hartley guinea pigs (two with an age of 3 month and two with an age of 13 month) were imaged in a 7T Agilent horizontal MR scanner equipped with a 400mT/m gradient system. The right legs of the animals were sprawled out in the homogenous center of a short-length linear birdcage resonator (diameter = 40 mm, length = 30 mm), which was used for signal excitation and reception. A nominal 1kW HF-amplifier was connected to the coil to achieve high B_1-spin-locking-frequencies (up to 6 kHz). T1rho imaging was performed using a T1rho preparation scheme in combination with a 3D gradient-echo readout module (previously published by Li et al. [8]). Six different Spin-Lock-Times (TSL = 0, 2, 5, 10, 20, 40 ms) were used to acquire T1rho weighted 3D-datasets at five different B_1-field strengths (B_1 = 0.5, 1, 2, 4, 6 kHz). T2 mapping was performed using a T2-preparation module (six TEs = 0, 4.5, 9, 18, 27, 36 ms) with the same readout scheme used for T1rho imaging. The FOV for the T1rho- and T2-mapping was 32 x 32 x 24 mm^3, the matrix-size = 192 x 128 x 24, resulting in a resolution of 0.17 x 0.25 x 1 mm^3. Additionally a high-resolution 3D multi gradient echo acquisition with the same FOV but higher resolution (= 125 x 125 x 375 μm^3) (matrix = 256 x 256 x 64) was performed for anatomical reference. The length of the complete imaging protocol was 3h. The T2- and the T1rho-weighted datasets were fitted to an mono-exponential decay model ($S=S_0 \cdot \exp(-t/T2)$ and $S=S_0 \cdot \exp(-t/T1rho)$) to obtain quantitative relaxations time maps.

Results: Representative T1rho-weighted images of a 3-month old guinea pig stifle joint acquired at two different B_1-fields strength can be seen in Fig.1a and b. With increasing B_1-field strength from 0.5 kHz to 6 kHz, an increase in signal intensity in the images acquired at longer TSLs is visible. Fig. 1c shows the T1rho-maps for different spin-lock field strengths and the T2-map. Fig. 2 shows the results of the T1rho and T2 values from ROIs in the cartilage and the muscle. While T1rho of the muscle and cartilage is increasing with increasing B_1-field similar in all four animals, T1rho values differ between the 3- and the 13-month old guinea pigs. For both ages T1rho increases with the strength of the applied B_1-field in the muscle and in the cartilage, resulting in maximum values when fields of 4 kHz or 6 kHz are used.





Discussion: This preliminary data confirms that T1rho can be used to study changes in biochemical concentration and structure of macromolecules in OA of the guinea pig knee [7]. Theses experiments using different spin-locking-field strengths show that with increasing B_1-field T1rho is increasing in cartilage and in the muscle tissue of the guinea pigs *in vivo*. Further, there is the evidence that a more sensitive interpretation of the cartilage status can be achieved when higher B_1-fields (4 kHz or above) are applied for *in vivo* T1rho mapping. More data will be acquired to confirm these results. On the other side – especially when T1rho mapping experiments should be applied on humans – the SAR values using high B_1-locking-fields should be considered.

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