Comparison of T1rho/T2 Imaging at 3 Tesla and 7 Tesla in Knee Cartilage of Healthy Volunteers

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Introduction –T1rho and T2 relaxation times have been used as markers for matrix changes in articular cartilage and elevated T1rho/T2 values have been associated with the proteoglycan loss in osteoarthritis[1-3]. While these mechanisms have been studied extensively at 3 Tesla, very few studies have been done at 7 Tesla, particularly for T1rho[4]. Kogan, et al. have studied T1rho relaxation using the proton transfer ratio at 7T, but have not performed T1rho mapping[5]. T1rho at 7T could provide improved sensitivity to proteoglycan content, as predicted by theory (indicated by the equation on the right). To our knowledge, no comparisons of the T1rho relaxation time have been reported between 3T and 7T in vivo. In this work, we present cartilage T1rho and T2 results at 3T and 7T in vivo.

$$T1_\rho = \frac{1}{\frac{1}{T2} + \frac{p_a p_b \delta^2 k}{\omega_1^2 + k^2}}$$

↑ δ with ↑ field strength
Results in ↓ $T1_\rho$
With ↑ sensitivity

Materials and Methods –Ten healthy volunteers (7 male, 3 female), ranging in age from 24 to 32 years, were recruited under an IRB approved protocol. Each volunteer underwent a single knee MR scan at 3T and 7T. The 3T used an 8-channel T/R knee coil (In Vivo, Gainesville, FL) while the 7T used a 28-channel T/R knee coil (QED, Mayfield, OH). Six left knees and four right knees were scanned.

Each scan consisted of a high resolution SPGR image used for segmentation. T1rho and T2 images were acquired with the 3D MAPSS sequence previously developed for T1rho/T2 imaging at 3T [6]. The T1rho/T2 sequences had the following parameters: FOV=14cm, 256x128 matrix, slice thickness=3mm, 30 slices, TSL=[0,2,4,8,12,20,40,60ms], spin lock frequency=500Hz, TE = [0 0,3.4,6.8,10.3,20.5,34.2,47.8,61.5ms], TR/TE=5.2/2.9ms. Composite tip-down and tip-up RF pulses were used to compensate for B0 and B1 inhomogeneities[7]. Also, the 3T exam used 2x phase ARC acceleration while the 7T exam used 2x phase and 2x slice acceleration in order to reduce scan time and SAR at the higher field strength. An additional set of TSL=0 images were acquired for accurate signal to noise (SNR) calculation. The SPGR images were segmented with in-house software and the T1rho/T2 relaxation maps were created using a 3 parameter fit (M0, T1rho or T2, constant). Mean values were calculated for six compartments of the knee cartilage and a one tailed paired t-test was performed between the 3T and 7T values for each compartment.

Results and Discussion – Example images of the T1rho and T2 relaxation maps in the left knee of a volunteer are shown in Figure 1. Mean values of T1rho and T2 in six compartments of the cartilage are shown in Figure 2. Results show significant decreases in T1rho and T2 as expected by theory. The T2 results are less consistent, but this could be due to B1/B0 inhomogeneities at 7T. SNR results showed mean SNR values across the entire knee of 39 and 47, for 3T and 7T respectively.

The results presented demonstrate the feasibility of T1rho and T2 imaging at 7T, and are the first reported results of in vivo human T1rho measurement at 7T to our knowledge. The results also confirm the relaxation model of T1rho, with reduction of T1rho at higher field strengths. However, this decrease should come with an increase in sensitivity to changes in proteoglycan or water content. Future work will involve imaging of additional subjects with and without osteoarthritis at 3T and 7T.

References – [1] Regatte, RR, Academic Radiology, 2002:9(12) [2] Stahl, R., Euro. Radiology. 2009:19(1) [3] Welsch, Euro. Radiology, 2010:21(6) [4] Chang, G. JMRI, 2012;35(2):441-8 [5] Kogan, F, MRM, 2012:68:107–119 [6] Li, X, MRM, 2008:59 [7] Chen, W, Mag Res Imag 2011:29

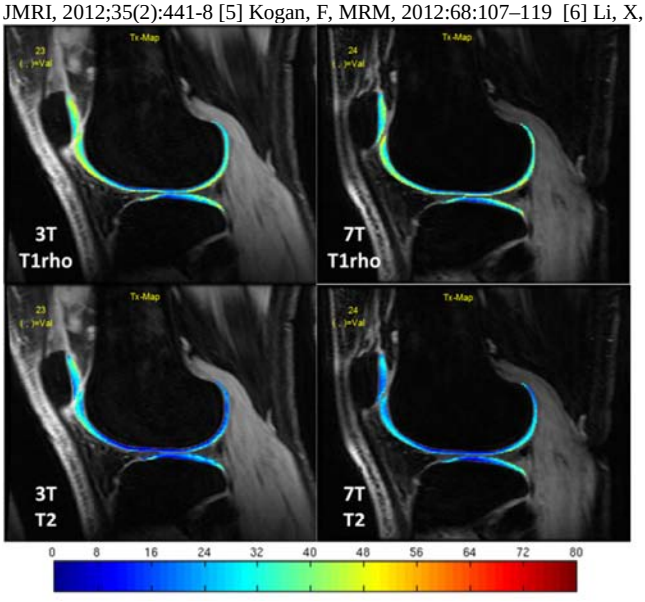

Figure 1: T1rho and T2 maps at 3T and 7T. Color bar in ms.

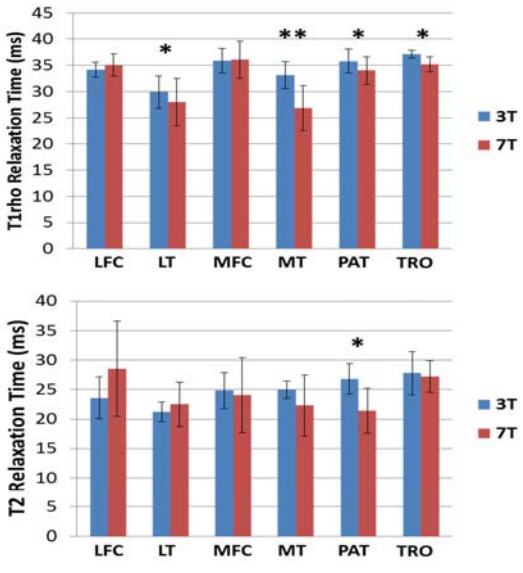

Figure 2: Mean differences between 3T and 7T for T1rho (top) and T2 (bottom) for six compartments (LFC=lateral femoral condyle, LT, lateral tibia, MFC=medial femoral condyle, MT=medial tibia, PAT=patella, TRO=trochlea. * - p<0.05 and ** - p<0.01