T1rho and T2 relaxation times in patients with knee osteoarthritis at 3 Tesla and 7 Tesla

Cory Wyatt[1], Aditi Guha[1], Anand Venkatachari[1], Xiaojuan Li[1], Roland Krug[1], Douglas A.C. Kelley[2], Thomas M. Link[1], and Sharmila Majumdar[1]
[1]Radiology, University of California San Francisco, San Francisco, California, United States, [2]GE Healthcare Technologies, San Francisco, California, United States

Introduction –T1rho and T2 relaxation times have been used as markers for extracellular matrix changes in articular cartilage, with elevated T1rho/T2 values associated with the proteoglycan and collagen loss in osteoarthritis (OA)[1-3]. While these mechanisms have been studied extensively at 3 Tesla, few studies have been done at 7 Tesla, particularly for T1rho[4]. Kogan, et al.[5] have studied T1rho relaxation using the proton transfer ratio at 7T, while Singh et al. have performed in vivo preliminary studies on T1rho at 7T.[6]. However, T1rho and T2 studies at 7T to date have focused on healthy volunteers, with no studies focused on patients with knee OA. Studies with OA patients are needed to assess the potential of 7T quantitative imaging to provide improved sensitivity to proteoglycan and collagen changes, as predicted by theory. Additionally, comparisons are needed to 3T imaging, which is currently the gold standard for quantitative T1rho and T2 imaging. In this work, we present cartilage T1rho and T2 results at 3T and 7T in vivo in patients with knee OA.

Materials and Methods –Twenty volunteers (11 females, 9 males), ranging in age from 37 to 72 years, were recruited under an IRB approved protocol. Seven of the volunteers were healthy controls (Kellgren-Lawrence (KL) score =0) and the remaining 13 volunteers had OA (KL=2,3). Each volunteer underwent a single knee MR scan at 3T and 7T, with exams performed within three months of each other, so little progression of disease should have occurred between scans. 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). T1rho and T2 images were acquired with the 3D MAPSS sequence previously developed for T1rho/T2 imaging at 3T [7]. The T1rho/T2 sequences had the following parameters: FOV=14cm, 256x128 matrix, slice thickness=3mm, 28 slices, TSL=[0,2,4,8,12,20,40,60ms], spin lock frequency=500Hz, TE = [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[8]. Modified WORMS scores were calculated for each compartment on high resolution CUBE images. Additionally, cartilage segmentations were performed on the CUBE images with in-house software and the T1rho/T2 relaxation maps were created using a 2 parameter fit (M0 and T1rho or T2). Mean values were calculated for six compartments of the knee cartilage. These include the lateral femoral condyle (LFC), medial femoral condyle (MFC), medial tibia (MT), lateral tibia (LT), patella, and trochlea. Lastly, a two-tailed student's t-test was performed between control and OA groups for each compartment.

Results and Discussion – Example images of the T1rho and T2 relaxation maps in the medial side of the left knee of an OA patient are shown in Figure 1. The patient had WORMS=3 in the MFC and MT compartments. Increased T1rho and T2 values are more obvious at 7T compared to 3T. When looking at the mean values between controls and radiographic OA subjects, shown in Figure 2, significant differences in the LFC and trochlea were found in the 7T relaxation values but not 3T values. The MFC and patella were approaching significance. The results presented demonstrate the potential increased sensitivity of T1rho and T2 at 7T compared to 3T. The results show more significant differences at 7T, which suggests that 7T quantitative imaging could be used to detect changes in cartilage composition using smaller cohorts compared to 3T. The increased sensitivity seen in this study is most likely a result of increased chemical exchange and signal to noise ratio at 7T compared to 3T.

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] Singh, A, PLOS ONE 2014 [7] Li, X, MRM, 2008:59 [8] Chen, W, Mag Res Imag 2011:29 [8] Peterfy, C.G., 2004, 12:177-190

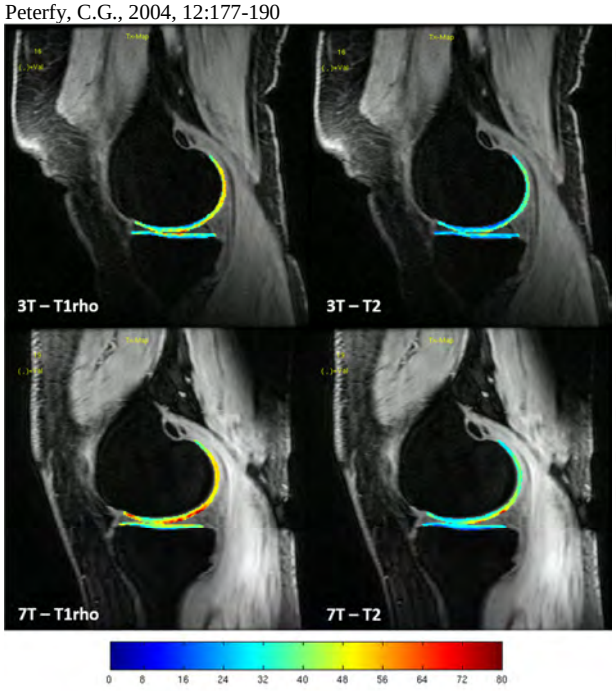

Figure 1: T1rho and T2 maps at 3T and 7T in patient with WORMS=3 in the MFC. Color bar in ms.

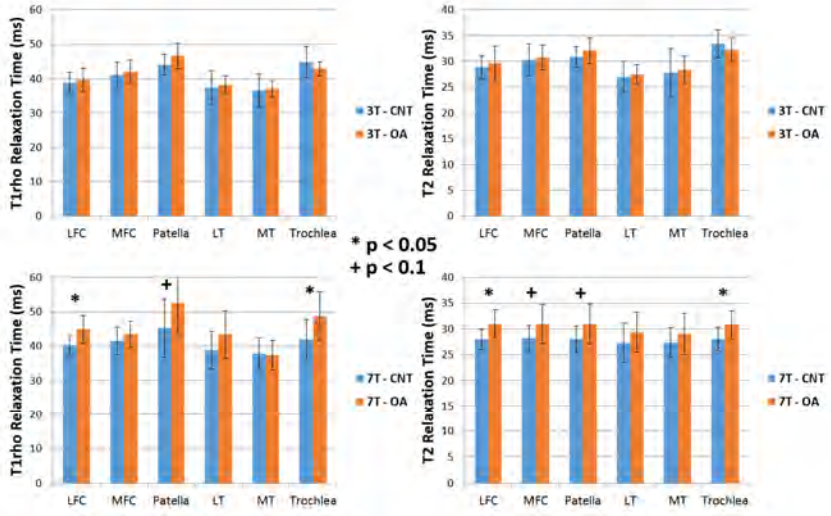

Figure 2: Mean differences of T1rho and T2 (bottom) between healthy controls and OA patient at (top) 3T and (bottom) 7T for six compartments (LFC=lateral femoral condyle, LT, lateral tibia, MFC=medial femoral condyle, MT=medial tibia. * = p<0.05 and + = p<0.1