Quantitative VTE-T2* Imaging of the Hip Labrum

Cory Wyatt[1], Martin Kretzschmar[1], Deepak Kumar[1], Karupppasamy Subburaj[2], Thomas Link[1], Richard Souza[1], and Sharmila Majumdar[1]
[1]*Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, CALIFORNIA, United States,* [2]*Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, California, United States*

Purpose: Labral tears are commonly treated surgically [1]. However, recent reports using non-contrast MRI report high prevalence of labral tears in asymptomatic individuals [2]. Furthermore, labral tears have been shown to be not associated with pain and disability [3,4]. A labral tear is typically diagnosed with MRI using spin echo sequences with long echo times (20-30ms), where the presence of bright infiltrating fluid in the dark labrum is used to diagnose labral tears or injury. Even with contrast, only qualitative information can be obtained. Quantitative imaging with shorter echo times may provide greater sensitivity to early labral damage than is possible with standard clinical MRI. To our knowledge, the T2 or T2* of hip labrum has not been reported in vivo or ex vivo. It is assumed to be short, since conventional sequences obtain little to no signal in the labrum. Recently, variable echo time (VTE) sequences have been used to image short-T2 tissues such as meniscus and tendon[3]. These sequences provide high signal acquisition efficiency and are Cartesian. In this pilot study, a VTE sequence is used to determine the feasibility of acquiring quantitative T2* maps of the labrum in healthy volunteers and those with labral injury.

Methods: A 3D VTE sequence was developed which dynamically scales the length and amplitude of the phase and slice encode gradients to allow for acquisition of the minimum possible TE near the center of k-space (typically around 0.8-1ms when using partial k-space in the readout dimension). The echo time is then extended by 0.05ms increments as the position in k-space increases. Two echoes can be acquired within one TR due to a reverse readout gradient after the first echo. To obtain T2* maps of hip labrum, the left or right hip of 10 subjects [8 females, 2 males, mean age of 44±15 years (30-69), mean BMI of 22.8±3.7 kg/m^2 (19.4-29.4)] were scanned on a 3 Tesla MR scanner (MR750, GE Healthcare, Waukesha, WI). Consent was obtained for each subject under an IRB approved protocol. Scanning was performed with an 8-channel phased array cardiac coil positioned near the study hip. Subjects were scanned with 2D T2-weighted FSE sequences in the oblique coronal, oblique axial, and sagittal planes for clinical grading. The parameters were 288x244, slice thickness = 3mm, FOV = 14-20cm, BW=50kHz, NEX=3, TR/TE=3000/60ms. A board-certified radiologist scored the labrum of the ten volunteers on the sagittal images in the anterosuperior region, the coronal images in the superolateral regions, and on the axial images in the anterior and posterior regions. Labral tears were graded as 0 (normal or normal variant), 1 (fraying or signal abnormality), 2 (simple tear), 3 (labor-cartilage separation), 4 (complex tear) and 5 (maceration). The 3D VTE sequence was then acquired in the oblique axial plane using parameters of 320x320, FOV=16cm, slice thickness = 3mm, BW=62.50kHz, NEX=1, TR=15ms, Flip = 10°, TEs = [1.14,2.14,3.64,6.14ms]. Two acquisitions of the VTE sequence were needed to acquire the four echoes for a total scan time of approximately 9 minutes. The anterior and posterior portions of the labrum were segmented separately on the first echo of the VTE images. Comparisons between the first and last echo were used to distinguish labrum from the adjacent cartilage. A three parameter fit for T2* ($Ae^{\frac{-TE}{T2*}} + C$)was calculated using in house software in Matlab (Mathworks, MA).

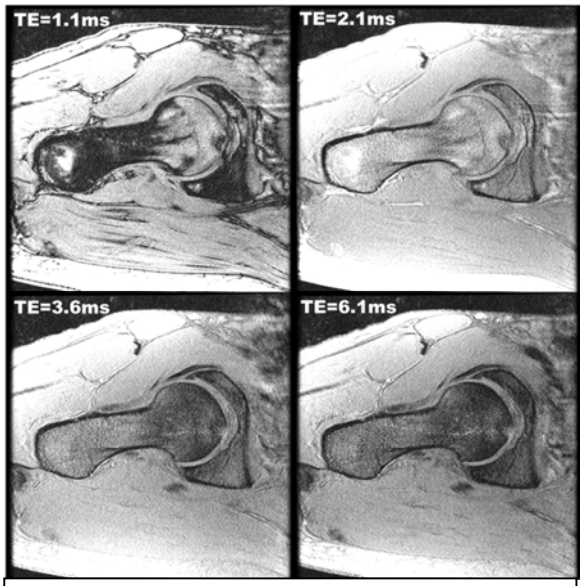

Figure 1: The four echo times acquired in the right hip of a volunteer with labral score = 0.

Results: The four echoes of an axial VTE slice from one volunteer with no visible labral tears is shown in Figure 1 to demonstrate the T2* decay of the labrum and the overall signal quality. T2* maps for the same subject are shown in Figure 2 compared to a slice from another volunteer with a labral tear visible in the VTE images. A plot of the signal across echoes along with the fit of the T2* in one pixel of the healthy volunteer is shown in Figure 2. The average T2* values for all ten of the volunteers were 3.70±0.58ms for the anterior labrum and 3.50±0.67ms for the posterior labrum. Three patients had a labral score of 0 for both labral sections while seven volunteers had a score of 2 in the anterior labrum and a score of 0 in the posterior labrum. No significant differences were found between the two groups. The mean values for the healthy volunteers were 3.68±0.16ms for anterior labrum and 3.25±0.89ms for posterior labrum. The mean values of the volunteers with a labral score > 0 were 3.71±0.70ms for anterior labrum and 3.60±0.60ms for posterior labrum.

Discussion: Figure 1 shows substantial signal decay in the labrum with all images maintaining good image quality and signal to noise ratio. The T2* relaxation values obtained in the labrum are similar to those of tendon or ligament (2-4ms[4]), which are fibrocartilagenous tissues with a similar composition to hip labrum. There were no correlations with labral score, but the distribution and number of subjects may not be large enough to see differences. However, two of the higher T2* values were seen in subjects that were either recovering from a labral injury or had obvious tears in the images. Additionally, the mean T2* values were calculated for the entire anterior or superior labrum, whereas the clinical score was also divided by superior and inferior tears. Hence, sub-regional analysis of T2* may be needed to detect differences. However, the lack of significant difference between populations may demonstrate that even with a simple tear, the majority of the labrum may be healthy and functioning.

Conclusions: This study demonstrates the feasibility of VTE and T2* imaging of the hip labrum. Signal in the labrum was obtained with good signal to noise ratio and reasonable T2* values were calculated. While no correlations with clinical score were seen, this technique may allow for investigation into the nature of labral injury and the effect of injury on the biochemical nature of the labral tissue. Further work will be focused on the acquisition of additional subjects and correlation with specific areas of labral injury.

References: [1]Groh, Curr Rev MSK Med 2:2, pp 105-117 [2] Register, Am J Sports Med, 2012 vol. 40 no. 12 [3]Deligianni, MRM, 2013 Nov;70(5):1434-9 [4] Juras, Eur Radiol (2013) 23:2814–2822

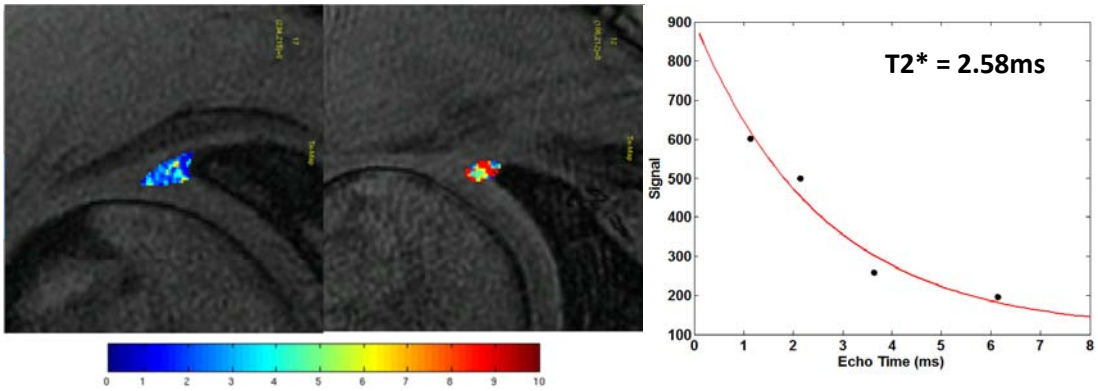

Figure 2: T2* map (in ms) of the anterior labrum of a healthy volunteer (left image) vs. T2* map of labral tear in another volunteer (right image). A plot of the signal in a pixel of the healthy volunteer is shown with the T2* fit.