Improved Reliability of Cartilage T2 Measurements using a Leg Positioning Device

T. J. Mosher[1,2], Y. Liu[1], M. B. Smith[1]

[1]Center for NMR Research, Radiology, Penn State Milton S. Hershey Medical Center, Hershey, PA, United States, [2]Orthopaedics and Rehabilitation, Penn State Milton S. Hershey Medical Center, Hershey, PA, United States

Introduction: Application of MR image markers of cartilage damage to longitudinal clinical trials on osteoarthritis requires a measure that is valid (score is a true measure of the observed pathology), responsive (able to differentiate between differing degrees of severity), and reliable (able to consistently produce the same score). Prior preliminary studies on reliability of cartilage T2 measurements indicated variation in patient position was the major cause of random error, with pooled coefficients of variation (CV_T) ranging from 10% to 15% for femoral tibial cartilage T2 profiles (1). To reduce variability in knee cartilage T2 measurements, our laboratory has developed a leg-positioning device to improve reproducibility in leg position between imaging sessions. The purpose of this study was to determine the impact of this device on test-retest variability in cartilage T2 profile measurements of the femoral tibial joint.

Methods: The MRI compatible leg positioning device shown in **Figure 1**, was constructed of Delrin and nylon components, and attaches directly to the MRI gradient/rf coil insert used for knee cartilage T2 mapping studies. In addition to firmly stabilizing the leg during the examination, the device allows for fine adjustment of translational position on three axes, as well as internal and external rotation of the leg.

Reliability of cartilage T2 profiles was determined through a test–retest evaluation of 6 young healthy volunteers. Cartilage T2 maps were obtained using a Bruker 3T MR spectrometer, a 24 cm gradient insert, and 15 cm linear Litz coil (Doty Scientific). Sagittal T2 maps of the femoral tibial joint were calculated from a 6 section, 12 echo sequence with TR/TE = 1500/9-106 ms, 4 mm section thickness, 384 x 384 matrix and a 12.75 cm field of view (FOV). The subject was then removed from the MRI scanner, repositioned using the leg holder, and a second data was then obtained using identical imaging parameters.

Cartilage T2 maps and profiles of articular cartilage were generated for each data set using automated subroutines in CCHIPs/IDL software (2). Pooled T2 profiles of weight-bearing femoral and tibial cartilage were normalized to 1.0 for thickness, and divided into 20 segments for analysis. The two data sets were compared by calculating a pooled coefficient of variation (CV_T) for each segment. This allowed variation of the cartilage T2 measurement to be determined as a function of normalized distance from bone.

Figure 1: Knee gradient and leg holder. (A) Foot holder can be rotated in 5° increments. (B) Screw adjustment controls position along the z- axis

Results: Representative cartilage T2 maps shown in **Figure 2** demonstrate reproducible spatial variation in cartilage T2, with longer values occurring near the articular surface. As demonstrated in **Figure 3** CV_T is less than 5% for all locations on the cartilage T2 profile, ranging from 1% to 3%. Slightly greater variation is observed at the bone/cartilage interface (0.0) and articular surface (1.0).

Figure 2: Color T2 maps obtained from the same individual at two different sessions demonstrating reproducible appearance of the femoral/tibial joint

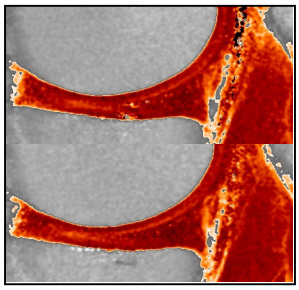
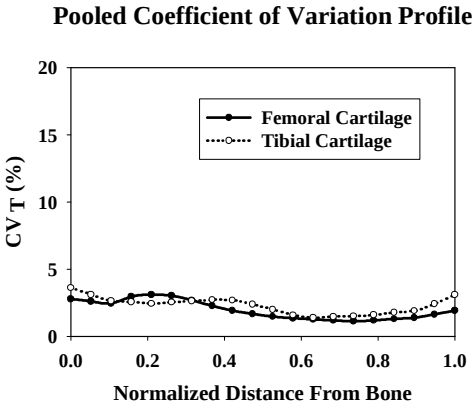


Figure 3: Pooled coefficient of variation (CV_T) in mean T2 values as a function of normalized distance from bone. CV_T values range from 1% to 3% with slightly higher variation at the cartilage boundaries, likely due to artifact from volume averaging.



Discussion: For all individuals, cartilage T2 maps had reproducible spatial dependency of T2 similar to that previously reported (3), with CV_T in the range of 1% to 3%. The use of a dedicated extremity holder and control for diurnal variation substantially improved reliability in cartilage T2 profiles compared to that previously reported (1). Historically, positioning templates have been used to provide reproducible positioning of the leg for clinical trials on osteoarthritis using radiographic techniques. Based on results of this study, it is recommended that similar dedicated positioning devices be used to provide greater reliability for longitudinal MRI studies of osteoarthritis.

References:

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