INTRODUCTION: Traumatic meniscal injuries and degenerative tears often precede cartilage degeneration and accelerate the onset of osteoarthritis (OA)\(^1\). Detection of degenerative meniscal changes with MRI measurements is difficult due to the rapid T2 decay of the tissue. For articular cartilage, T\(_1\rho\) values have been found to inversely correlate with proteoglycan content and distribution, while T2 values have been found to correlate with collagen content and orientation\(^4\). However, while the meniscus has known heterogeneities in composition and mechanical properties, comparatively little is known about variations in meniscal T\(_1\rho\) and T2 values. In this study, we optimized a 3D spin lock spoiled gradient echo sequence to obtain short echo times (TE) and accurately measure the T\(_1\rho\) and T2 values in the inner and outer parts of the anterior, body and posterior sections of osteoarthritic human menisci.

METHODS: Nineteen menisci were obtained as incidental surgical waste from thirteen patients undergoing total knee replacement (TKR) surgery. Seven (7) menisci were obtained from patients with OA and 12 were from patients with degenerative tears. Menisci were stored in saline and scanned within 12 hours of the surgery. Each specimen was attached using cyanoacrylate to a plastic container filled with perfluorooctyl bromide, which eliminates susceptibility differences between the specimen and air but does not emit a signal detected by the MR scanner. To minimize “magic angle” effects, the specimens were oriented with the major collagen bundles perpendicular to the direction of the main magnetic field. T\(_1\rho\) and T2-weighted images were acquired using Magnetization-Prepared Angle-Modulated Partitioned k-Space Spoiled Gradient Echo Snapshots (3D MAPSS) sequence with a magnetization preparation followed by a spoiled gradient echo acquisition during transient signal evolution. Images were taken using a 3T GE MR scanner (GE Healthcare, Waukesha, WI) with an 8-channel wrist coil. Imaging parameters were TR 7.5ms, FOV 10cm, matrix 256X256, BW ±31.25kHz, number of excitations (NEX) 1, and 50 coronal slices with 1mm thickness.

RESULTS: The body region exhibited significantly shorter T\(_1\rho\) and T2 relaxation times than either the anterior or posterior regions (Fig 4), with no significant difference between anterior and posterior regions. Neither T\(_1\rho\) nor T2 significantly differed between medial and lateral menisci or between the (radial) inner and outer regions. For all regions pooled together, there was a strong, positive correlation (r=0.925, p<0.001) between T\(_1\rho\) and T2 relaxation times (Fig. 5).

DISCUSSION: This study provides a detailed examination of regional variations in short echo time T\(_1\rho\) and T2 relaxation times in OA human menisci. The T\(_1\rho\) and T2 values observed in this study were longer than values previously reported for menisci in patients\(^6\), perhaps because the menisci were retrieved from patients undergoing TKR surgeries and are thus likely to have severe degeneration. Volunteers with OA were found to have higher T\(_1\rho\) and T2 values in both cartilage and meniscus compared to healthy volunteers\(^7\). The ex-vivo specimens were stored in saline prior to imaging, which may have had impacted the level of signal. However, the trends among the different regions remains valid as all measurements were taken under the same conditions. The significantly higher relaxation times at the horns could indicate more advanced degeneration in those regions, but could also reflect inherent regional differences in tissue structure and composition. The lack of a significant difference between the inner and outer regions was unanticipated given the expected differences in composition, and subsequent histological and biochemical analyses will provide more insight into the relationship between MR measurements and the content and structure of the different meniscal regions. The high correlation between T\(_1\rho\) and T2 has been seen before in cartilage imaging\(^2\). While this strong correlation may indicate that proteoglycan and collagen contents vary consistently in the meniscus, it may also indicate that T\(_1\rho\) and T2 are sensitive to the same aspects of meniscal composition. Fully understanding this relationship will be essential to develop protocols for detection of early degenerative meniscal changes via MRI.

SIGNIFICANCE: Quantitative meniscal T\(_1\rho\) and T2 measurements can provide information on the degenerative state of the meniscus and has potential to serve as a diagnostic tool for early-stage OA. The regional variation of T\(_1\rho\) and T2 in the meniscus offers insight in understanding the physical meaning of these MR measurements.

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