Improving Non-Invasive Diagnosis and Grading of Cartilage Defects in the Knee - Accuracy of Ultra High Field 7-Tesla MRI as Compared with Arthroscopy

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Introduction: Standard clinical MRI is commonly performed on a 1.5T or 3T machine. Ultra-high field (UHF) 7-Tesla(7T) magnetic resonance imaging (MRI) is a new technology that offers 2.3x improved signal-to noise ratio (SNR) compared to 3T MRI and 2.8x SNR compared to 1.5T-MRI. The purpose of this investigation was to evaluate the accuracy of 7T-MRI for the detection and grading of cartilage lesions in the knee. We hypothesized that 7T images would offer better detection and more accurate grading of chondral lesions than standard clinical grade MRI scans.

Methods: In this prospective, paired, blinded study, patients who had undergone a 1.5 or 3T standard of care (SOC) MRI and were scheduled for knee arthroscopy were enrolled (10/2019 to 08/2021) and a study intervention 7T-MRI was performed prior to surgery. Scans were reviewed by three independent radiologists (blinded to clinical and arthroscopic data). At the time of arthroscopy, each articular surface was graded by the operating surgeon according to a modified Outerbridge system. The surgeon was blinded to 7T images, although they had access to the SOC, which was necessary for patient care. Using arthroscopy as the gold standard, we calculated sensitivity and specificity of SOC and 7T. An Outerbridge grade of 0 was classified as negative, while a grade of 1-4 was classified as positive. A secondary analysis of sensitivity and specificity was performed on a per articular surface basis, with 6 articular surfaces per patient after correction. A Mann-Whitney U test was used to compare diagnostic scores and ratings between instruments (SOCvs.7T). Coefficients of variation between observers within each instrument were compared for each variable. Type-I error was set at alpha=0.05

Results: A total of 100 patients (43$\pm$14yr, 54F/46F) were enrolled. 7T resulted in improved sharpness (defined by visibility of nerve fascicles) and shading (based on artifacts) compared to SOC ($p<0.001$ for both). There was improved contrast between fluid and cartilage with 7T (using confidence rating at axial mid-patella, $p=0.003$). 7T had a higher sensitivity in detecting cartilage lesions for five of the six articular surfaces when using the arthroscopic gold standard, but with lower specificity for all surfaces. Finally, there was improved inter-observer reliability in detecting and grading cartilage defects with 7T compared to SOC ($p<0.05$).

Discussion/Significance/Clinical Relevance: Based on our findings thus far, 7T-MRI appears to result in improved measurement ratings, sensitivity, and inter-observer reliability compared to SOC in detecting cartilage lesions in the knee. These findings indicate that 7T-MRI may have greater clinical utility compared to current SOC.