

Towards a Whole-Joint MR Evaluation of the Knee: Cartilage, Bone and Marrow.

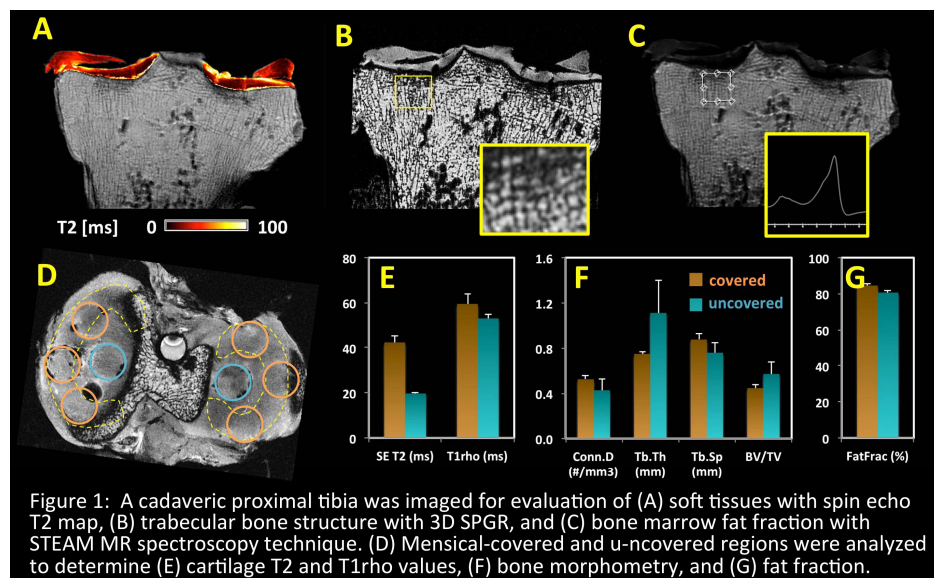
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Purpose: Knee injury and degeneration involve changes not only to the soft tissues (e.g., articular cartilage), but also bony components and the marrow. Simultaneous evaluation of multiple components enables broader understanding of the pathology and more sensitive and specific diagnosis of the condition. For example, osteoarthritis may initiate from cartilage degeneration¹ or bony changes such as osteoporosis and subsequent insufficiency fractures.² The goal of this study was to explore feasibility of a whole joint MR evaluation of the knee, to simultaneously evaluate articular cartilage, trabecular bone, and bone marrow. As an initial validation, we compared regional differences (meniscus-covered vs. -uncovered) in a specimen.

Methods: A proximal tibia was obtained from an aged female donor and imaged at 3T (GE Signa HDx) in the coronal plane: (Fig.1A) 2D spin echo multi-echo T2 (SE ME T2; TR=2000 ms, TE=10 to 80 ms, FOV=90 mm, matrix=320x320, slice=2 mm) and 2D spiral chopped magnetization preparation (2D SCMP; TR=1500 ms, TSL=0 to 30 ms) T1rho maps for soft tissue evaluation, (Fig.1B) 3D spoiled gradient echo (3D SPGR; TR=20 ms, TE=4.3 ms, FA=24 deg, FOV=70 mm, matrix=, slice=0.2 mm) without fat suppression for trabecular structure, and (Fig.1C) MR spectroscopy using stimulated echo acquisition mode (STEAM) for bone marrow evaluation. Eight regions (Fig.1D), corresponding to six meniscal-covered and two meniscal-uncovered regions, were selected to determine cartilage T2 and T1rho values and bone (subchondral 8 mm) morphometry and marrow fat fraction.

Results: The mean T2 values of articular cartilage (Fig.1E) in the covered region were significantly higher than that on the uncovered region (42.4 ± 7.7 ms vs. 19.7 ± 0.3 ms, $p < 0.01$, ANOVA). T1rho values were similar. Bone metrics (Fig.1F) suggested a trend of thicker trabeculae ($p = 0.07$), greater trabecular spacing, and greater bone volume fraction ($p = 0.16$) at the uncovered region. Consistently, the fat fraction tended to be lower at the uncovered region ($p = 0.16$).



Discussion: Using the present MR techniques, intrinsic variations and changes due to injury or disease can be evaluated quantitatively. Our findings are consistent with known regional differences in cartilage integrity⁴ and trabecular bone structure.⁵ This study shows feasibility of a comprehensive MR evaluation of major components of the knee. Future work will include validation of these MR properties using reference techniques such as biomechanical testing, biochemical assays, and micro CT.

Conclusion: Existing and novel MR techniques can be combined to simultaneously evaluate multiple major components of the knee, which provide a more complete picture of joint health.

References: ¹Buckwalter+ Adv Drug Deliv Rev 20:150, 2006. ²Sambataro+ PM&R 1:691, 2009. ³Hamilton+ NMR Biomed 24:784, 2011. ⁴Thambyah+ OAC 14:580, 2006. ⁵Johnston+ Skel Rad 40:1057, 2011.