UTE MRI and Biomechanical Properties of Normal and Pathologic Human Menisci

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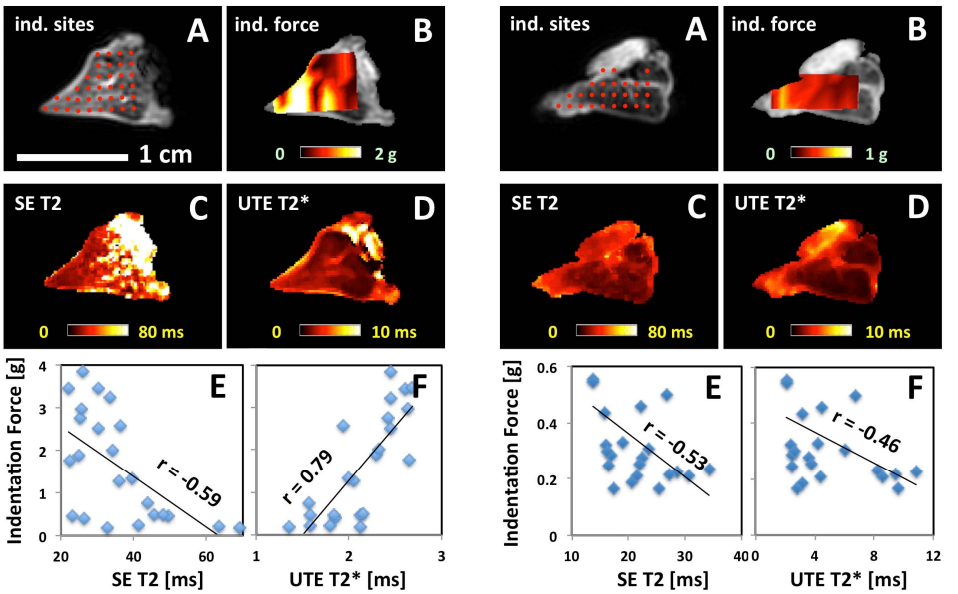
INTRODUCTION: Menisci of the knee are important for load bearing,[1,2] and injury or degeneration can contribute to knee osteoarthritis.[3] Conventional spin echo (SE) MR sequences are unable to detect any short T2 components (T2<10 ms) in the meniscus, which may change independent of longer T2 components (T2>10 ms). Ultrashort TE (UTE) MRI enables detection of short T2 components[4] in the tissue and enhances contrast of the fibrillar architecture.[5] It remains to be established how short and long T2 components change in disease, and with respect to biomechanical property of the tissue. Purpose of this study is to evaluate the sensitivity of conventional SE T2 (long T2) and UTE T2* (short T2) MRI properties to variations in biomechanical properties of grossly normal and pathologic human menisci.

METHODS: ***Samples:*** From cadaveric donors (n=5), three grossly normal (mean 61 yrs) and three grossly diseased menisci (mean 81 yrs; 1 degenerate, 2 tear) were obtained, and cut sagittally into ~5 mm thick triangular pieces. ***MR Imaging:*** GE 3T Signa HDx with a 1 cm diameter solenoid coil was used with the following sequences: **SE T2:** TR = 2000 ms, TE = 13 to 110 ms, matrix = 320x320, slice = 2 mm, FOV = 5 cm, FA = 90 deg, BW = ±31 kHz; **UTE T2*:** TR = 100, TE = 10μs to 40ms, NEX = 2, matrix = 256x256, slice = 2 mm, FOV = 5 cm, FA = 90 deg, BW = ±31 kHz. ***Biomechanics:*** Samples were placed into custom mold to hold and hydrate. Indentation testing was performed using 1 mm diameter tip. Cut-surface of each sample was tested in a 1 mm grid-pattern (Fig.1A and 2A). Each site was compressed 100 μm (over 1 s) while measuring the peak force (g). Photographs were taken for registration. ***MRI Analysis:*** Using MATLAB, 3-mm diameter regions of interest (ROI), centered about each indentation site, were used to determine SE T2 and UTE T2* properties. ***Statistics:*** Mean indentation force, SE T2, and UTE T2* between groups were compared using t-test. Relations between force vs. SE T2, and vs. UTE T2*, were determined using Pearson correlation.



Figs.1 and 2. Normal (Fig.1) and pathologic (Fig.2) menisci were indented along the cut surface (**A**) to determine peak force (**B**). Maps of SE T2 (C) and UTE T2* (**D**) values. Correlation of force vs. SE T2 (**E**) was similar in all samples, while that of force vs. UTE T2* (**F**) varied with sample pathology.

Gross Morphology	Normal	Pathologic	p-value
Indentation Force [g]	0.84 ± 0.66	0.56 ± 0.42	0.5
SE T2 [ms]	24 ± 9.4	26 ± 5.5	0.9
UTE T2* [ms]	2.5 ± 0.3	9.0 ± 3.9	0.04
R: force vs. SE T2	-0.47 ± 0.32	-0.45 ± 0.15	NA
R: force vs. UTE T2*	+0.66 ± 0.12	-0.42 ± 0.14	NA

Table 1. Summary of results.

RESULTS (Table 1): Indentation force was slightly higher for normal samples but overall similar (p=0.5). Mean SE T2 values of two groups were also similar at ~25 ms (p=0.9). In contrast, UTE T2* values were higher (p=0.04) in pathologic samples (9.0±3.9 ms) than normal samples (2.5±0.3 ms). For both normal and pathologic samples, correlation coefficient (R) between indentation force and SE T2 was negative (Fig.1E and 2E). In contrast, correlation between force and UTE T2* was dependent on pathology: normal samples showed a positive correlation (Fig.1F), while pathologic samples showed a negative correlation (Fig.2F).

DISCUSSION: These results suggest sensitivity of UTE T2* properties to pathology of human menisci. In this study, pathologic samples that had SE T2 values similar to those of normal samples had a markedly higher UTE T2* values. Results of correlation of analysis, while interesting, confounds interpretation of UTE T2* data and warrants further investigation. UTE T2* sequence may be useful for early evaluation of human meniscus involving biomechanical changes.

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