Spectroscopic Imaging of the Knee Using an Interleaved Ultrashort TE (UTE) Sequence

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INTRODUCTION
The human knee contains several tissues with short T2 relaxation times, such as menisci, tendon, and the deep radial and calcified layers of cartilage (1, 2). Ultrashort T2 (UTE) sequences have been used to image these tissues with high signal and contrast (2). It would be very useful to get information about the spectral composition of these short T2 tissues. UTE-CSI based on a variable TE Cartesian acquisition has been reported (3, 4). Here we report a novel technique for high spatial resolution spectroscopic imaging of the short T2 tissues in the knee utilizing multi-echo variable TE UTE acquisitions with fat suppression using a long adiabatic 90° pulse and dephasing.

MATERIALS AND METHODS
A multi-echo multi-slice variable TE UTE sequence combined with long T2 suppression (Figure 1) was implemented on a 3T Sigma TwinSpeed scanner (GE Healthcare Technologies, Milwaukee, WI) with a maximum gradient performance of 40 mT/m and 150 mT/m/ms. Fat signal was suppressed using a long adiabatic 90° pulse (26 ms duration) and dephasing to help reduce long T2 fat signal without saturating the short T2 water signals (5). Double half pulses were used to improve the slice profile by reducing their out-of-slice contamination (6). A total number of 1980 projections were sampled, and interleaved into 36 groups with each group having a different TE (TE delay interval = 140 µs). Each interleaved group of projections was used to generate one image. Two techniques were integrated into the reconstruction algorithm: (1), view sharing of high spatial frequency projection data from neighboring groups to suppress streak artifacts; (2), sliding window reconstruction which was used to reconstruct images for each interleaved group or TE. Other acquisition parameters include: FOV = 16 cm, TR = 150 to 200 ms, TE = 8 µs, 4 echoes, echo spacing = 5.0 ms, flip angle = 80°, BW = 61.25 kHz, readout = 512, number of slices = 2 to 8, slice thickness = 3 mm, scan time = 10 to 13 minutes.

RESULTS AND DISCUSSION
Figure 2 shows the UTE spectroscopic images of the knee at different resonance frequencies relative to water. The deep radial and calcified layers of cartilage and menisci are clearly demonstrated across a broad spectrum range, consistent with their short T2 values. Spectra from a single pixel from the calcified layer and a meniscus are depicted in Figure 3. The spectral of the calcified layer cartilage is shifted by 28 Hz from that of meniscus, probably due to greater diamagnetic susceptibility of the calcified layer cartilage (7). Future work will focus on multi-echo spin echo UTE spectroscopic imaging to provide more echoes and improve spectral resolution.

CONCLUSIONS
Multi-slice UTE spectroscopic imaging appears to be a useful technique for demonstrating spectral composition of the short T2 components in the knee.

REFERENCES