Imaging of the Deep Radial and Calcified Layers of the Cartilage Using Ultrashort TE (UTE) Sequence at 3T

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INTRODUCTION

Magnetic Resonance (MR) imaging of cartilage injury and osteoarthritis (OA) has focused on detection of cartilage loss (1). Much less attention has been paid to less obvious features of injury and degeneration including changes to intact deep radial and calcified layers of the cartilage. Calcified cartilage is very difficult to detect with conventional MR imaging sequences because it is thin and has very short T2 (~1ms). Ultrashort echo time (UTE) imaging sequences can detect short T2 relaxation tissues (2-4). Here we report two-dimensional (2D) UTE imaging of the knee cartilage at 3T. Results show that this sequence can demonstrate the previously undetectable deeper layers of the cartilage, which may be of critical importance in the pathogenesis of OA. Comparison is made between several fat saturation pulses, including asymmetric Sinc and adiabatic pulses.

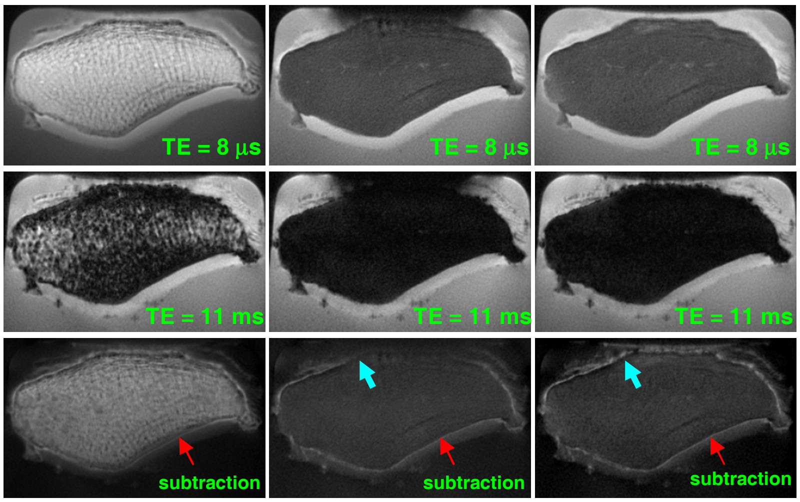

Figure 1. Dual echo and subtraction images for patella sample without fat saturation (1st column), with asymmetric Sinc (2nd column) and adiabatic (3rd column) fat saturation pulses. Fat saturation improves contrast of the deeper layers of cartilage (red arrow). Adiabatic pulse produces slightly higher SNR and fewer artifacts (blue arrow) compared with the Sinc pulse. FOV = 8 cm, readout = 512, projections = 511, 2 mm thick, 3 inch coil, scan time = 8 minutes.

MATERIALS AND METHODS

A multiecho UTE sequence with minimal TE of 8 µs was developed at a 3T Signa TwinSpeed scanner (GE Healthcare Technologies, Milwaukee, WI). No fat saturation, as well as asymmetric Sinc and adiabatic fat saturation were investigated on three patella samples and two healthy volunteers. The patella samples were imaged using a 3-inch coil with FOV = 8 cm, matrix = 512×511, 2 mm thick, TR = 500ms, 62.5 kHz bandwidth. A single channel and an eight-channel knee coil were used for human knee imaging with FOV = 16cm, matrix = 512×511, 2.5 mm thick, TR = 500ms, 62.5 kHz bandwidth. Echo subtraction was used to reduce long T2 fat and superficial cartilage signals.

RESULTS AND DISCUSSION

Figure 1 shows the dual echo images and subtraction images of a patella sample without, and with fat saturation. Figure 2 shows the corresponding images of the knee from a healthy volunteer. Both images show higher contrast for the calcified layer cartilage after fat saturation. Adiabatic pulse produces 15% higher signal and fewer artifacts than sinc pulse. However, higher signal of the calcified layer is preserved without fat saturation. Figure 3 shows the multi-slice subtraction images of the femoral-tibial cartilage without fat saturation. High signal is preserved in the deep radial and calcified layers of the cartilage and meniscus, although their contrast with trabecular bone marrow is limited.

CONCLUSIONS

The UTE sequence can depict the deep radial and calcified layers of the cartilage with high signal and contrast after fat saturation. Higher signal is present with the deeper layers of cartilage without fat saturation.

REFERENCES

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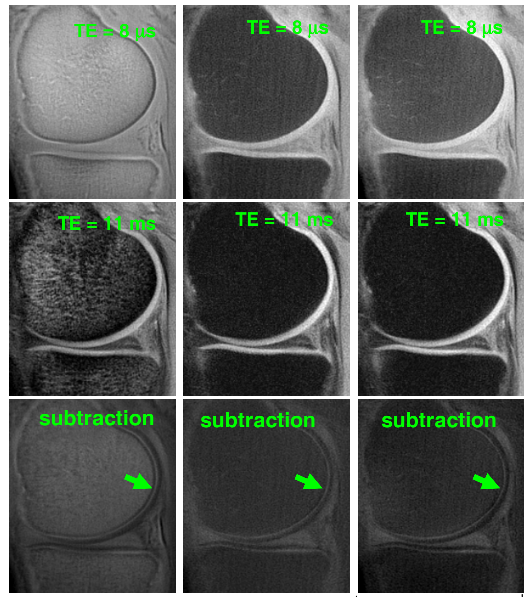

Figure 2. Comparison of non-fat sat (1st column), Sinc (2nd column) and adiabatic (3rd column) fat sat for the knee of a volunteer using a single channel knee coil. Fat saturation improves contrast but reduces signal of the deeper layers of the cartilage. Adiabatic fat saturation (26ms) gives 15% higher signal over asymmetric Sinc fat saturation (8 ms).

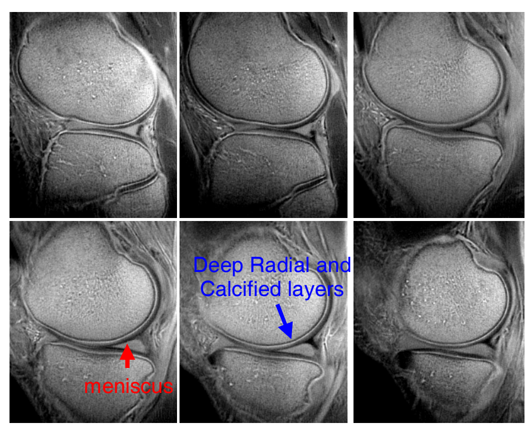

Figure 3. Multi-slice subtraction images of the femoral-tibial cartilage from a healthy volunteer using an 8-channel knee coil. Fat sat was not used to help preserve the short T2 signals of the deeper layers cartilage. Echo subtraction suppressed signals from the long T2 superficial layers cartilage, creating high contrast with the deep radial and calcified layers (long arrow) and meniscus (short arrow).