High Resolution UTE Imaging on Knee Patients at 3T

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INTRODUCTION

High resolution (HR) ultrashort echo time (UTE) imaging has been demonstrated to be feasible on healthy subjects on clinical MRI scanners at 3T (1). This study is further advancing HR-UTE imaging on patients to demonstrate its potential for visualizing micro defects and damages in articular cartilages in the knee. The challenges to this study are 1) the sensitivity of HR-UTE imaging to small cartilage defects and 2) the resolution of HR-UTE imaging for identifying micro cartilage damages such as fissures. We addressed these challenges by optimizing acquisition parameters and implementing test-run scans on patients with torn anterior crucial ligament (ACL). The outcomes showed promising potentials of HR-UTE imaging in non-invasively visualizing micro defects and damages.

METHODS AND EXPERIMENTS

Method. A customer-developed UTE pulse sequence, acquisition-weighted stack of spirals (AWSOS) (2), was used to acquire data for HR-UTE imaging. The acquisition parameters were optimized on subjects and patients using a trial-and-error approach under the restrictions of total scan time (TA ~10 min) and signal-to-noise ratio (SNR ~35). Slice thickness was gradually increased from 2mm to what a reasonable SNR was achieved at high resolution 0.14mm (matrix size 1024 at FOV 140mm). Repetition time (TR) and flip angle (θ) were optimized for minimizing TA and maximizing signal intensity. Verification of the findings on HR-UTE images was based on clinical arthroscopy grading of the cartilages. ***Experiments.*** HR-UTE imaging was performed on a clinical 3T scanner (Magnetom Trio Tim, Siemens Medical Solutions, Erlangen, Germany) with an 8-channel knee coil (Invivo Inc., Gainesville, FL). Five adult patients with torn ACL were scanned pre- or post-surgery of ACL reconstruction, under an approved IRB protocol. Data acquisition parameters were: sinc RF pulse (0.8ms duration and 1.5 cycles), fat saturation, TE/TR/θ=0.6/60ms/18º, slices=40 at thickness 3mm, FOV=140mm, matrix size=1024, resolution=0.14mm, in-plane spirals=256, spiral readout Ts=17.12ms, and total acquisition time TA=10.24min. An isocenter positioning of the knee joint and manual shimming were implemented. As a reference, dual-echo steady state (DESS) pulse sequence was also implemented on the same patient group with parameters: water excitation, TE/TR=4.9/16.44ms, θ= 25º, slices=160 at thickness=0.7mm, FOV=140mm, matrix size=320x256, resolution=0.44x0.55mm, bandwidth BW= 186HZ/Px, and TA=10.88min.

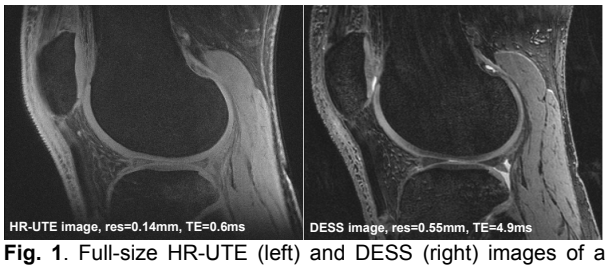

Fig. 1. Full-size HR-UTE (left) and DESS (right) images of a patient, pre-surgery baseline scan. Cartilages across entire thickness are hyper-intensity in the HR-UTE image while the intensity is varying in the DESS image (femoral/tibial cartilage).

RESULTS AND DISCUSSION

Results. A full-size HR-UTE image is shown in Fig. 1, illustrating overall contrast advantage on cartilages over the DESS image. Magnified HR-UTE image croppings are shown in Fig. 2, demonstrating representatives of the identified defects on anterior articular (AAC), posterior articular (PAC), femoral (FC), tibial (TC), and patellar (PC) cartilages. Contrast to noise of the defects in the AAC superficial (Fig. 2a), PAC middle (Fig. 2b) and PAC deep (Fig. 2c) layers has reached to a meaningful level in presenting the defects. Fissures across the patellar cartilage (Fig. 2d) are clearly visible, showing image resolution high enough in detecting small fissures of width 0.14mm. In the femoral/tibial cartilages (Fig. 2e) fissures are carefully visible. ***Discussion.*** Contrast of the defect to cartilage resulted from fluid/water that filled into defect regions and had longer T1 relaxation as the HR-UTE image was T1-weighted. The fissures were visible due to fluid/water accumulation as indicated in DESS images.

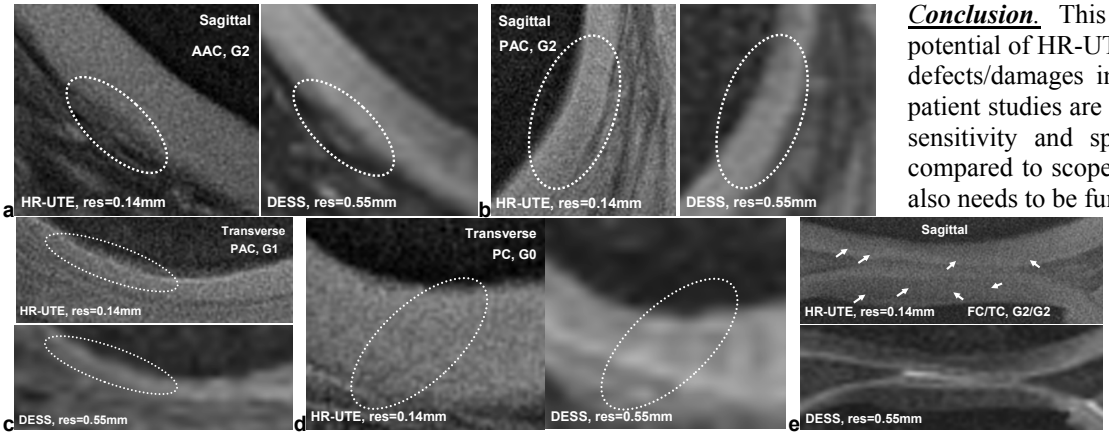

Fig. 2. Magnified croppings of HR-UTE and DESS images showing the defects in AAC superficial (**a**, sagittal), PAC middle (**b**, sagittal) and PAC deep (**c**, transverse) layers and the fissures in patellar (**d**, transverse) and femoral/tibial (**e**, sagittal) cartilages, with scope grades (G0-2) in Outerbridge scale.

Conclusion. This study has demonstrated the potential of HR-UTE imaging in visualizing micro defects/damages in cartilages in the knee. More patient studies are however needed to evaluate the sensitivity and specificity of the technique as compared to scope grades. Contrast to noise ratio also needs to be further improved in future.

REFERENCES: [1] Qian, *et al*. JMRI. 2011 (Epub, early view). [2] Qian Y, *et al*. US patent 7,750,632. 2010.