MORPHOLOGICAL AND QUANTITATIVE EVALUATION OF MENISCAL CALCIFICATIONS BY NOVEL 2D IR AND 3D UTE MR TECHNIQUES

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BACKGROUND/PURPOSE

The meniscus plays a central role in the transmission and distribution of load across the knee joint. Meniscal lesions have recently been established as a cause of knee joint degeneration[1]. Meniscal calcifications are frequent and likely alter the normal biomechanics of the meniscus. Although MR imaging is the non-invasive technique of choice for the evaluation of knee, and more specifically meniscal pathology, it does not allow the facile visualization of meniscal calcifications[2]. This is due, in part, to a lack of contrast between the meniscal tissue and calcifications, both with relatively short intrinsic T2 relaxation times. In addition, the lack of spatial resolution with standard clinical sequences provides an additional challenge for the visualization of small, punctuate calcifications. We describe novel MR imaging techniques based on 2D-UTE inversion recovery and 3D-UTE data acquisition to address these factors. We assessed the ability of these sequences to allow the visualization, characterization and quantitative evaluation of meniscal calcifications.

MATERIAL AND METHODS

Ten human menisci with documented calcifications at visual inspection and with Faxitron imaging were analyzed. The specimens were placed in Perfluorooctyl Bromide solution. Imaging was performed on a 3T clinical magnet, using a high-resolution custom-built quadrature birdcage coil with an inside diameter of 2cm and a length of 10cm was used. MR sequences to characterize meniscal morphology were performed and included: T1 SE (TR 500/ TE 16.2/ FOV 7 / Slice thickness: 1.7mm/ matrix: 512x512 /NEX 2); 2D SPGR (TR 300/ TE 12/ Flip angle 30/ FOV 7 / Slice thickness: 1.7mm / matrix: 384 x 384 /NEX 2) ; PDFS (TR 2000 / TE 13 / FOV 7 / Slice thickness 1.7/ 512 x 384 /NEX 1); UTE FS (TR 500/ TE 8 microsecs / FOV 7 / Slice thickness 1.7 / 512 x 511/NEX 2) . A novel morphological and quantitative 3D UTE sequence was performed, using a short duration (40 µs) hard RF pulse for signal excitation followed by dual echo 3D radial ramp sampling. In order to quantify T2* values of the meniscal calcification, the dual 3D UTE acquisition was repeated three times with paired TEs of 8/5122 µs, 500/5622 µs, and 2000/7122 µs. Subtraction images were obtained for each pair of TEs. Other acquisition parameters included an isotropic FOV of 6 cm, TR of 35 ms, flip angle of 8 °, readout of 256, 40000 projections for a total scanning time of about 20-25 minutes. The projection data was re-gridded onto a 384×384×384 matrix and was followed by 3D Fourier transformation to produce the final 3D UTE images. Another quantitative technique using an IR pulse was also performed. An adiabatic inversion pulse (8.64ms in duration) was employed to invert the longitudinal magnetization of normal meniscal tissue and fat, while leaving the short T2 calcification largely unaffected.

The images were viewed in the axial and sagittal planes. Menisci were divided into 3 thirds along their longitudinal axis, and the presence and absence of calcifications was noted. Whenever present, the calcifications were classified into punctuate or globular. The Faxitrons and MR sequences were analyzed independently by two musculoskeletal radiologists, in consensus. ROI placement on MR images was guided by comparison with Faxitron images of the menisci.

RESULTS/DISCUSSION

The conventional MR sequences and the 2D UTE FS sequences did not allow the visualization of the punctuate calcifications. The globular calcifications were visualized on the UTE FS and 3D acquisitions (Fig 1). With the IR technique, the T2* of the globular calcifications ranged from 0.131 to 0.157ms (Fig 2). However, that technique did not allow the visualization of punctuate calcifications. The 3D UTE sequence allowed the detection and classification of the calcifications, with a good correlation with Faxitron images (Fig 1). The T2* of the punctuate calcifications ranged from 3,03 to 6,54ms (mean: 4,6+/-0,99) (Fig 3). The mean T2* of the surrounding meniscal tissue ranged from 23 to 38ms, which is higher than the expected values of normal menisci. This finding is consistent with previous work stating that calcifications usually occur in degenerative areas of the menisci[3].

CONCLUSION

Calcifications within meniscal tissues are poorly visualized with conventional morphological sequences as well as with UTE FS sequences, but are unmasked with the IR UTE and the 3D UTE sequences. Globular calcifications are visualized on both sequences. Punctuate calcifications were only visible on the high-resolution 3D UTE sequence (Fig. 1-3).

Meniscal calcifications may have a range of T2* values based upon morphology. 2D UTE sequences can be used to quantify very short T2* values in globular calcifications, whereas 3D UTE techniques can be used to identify and quantify short T2* values in punctuate calcifications.

REFERENCES

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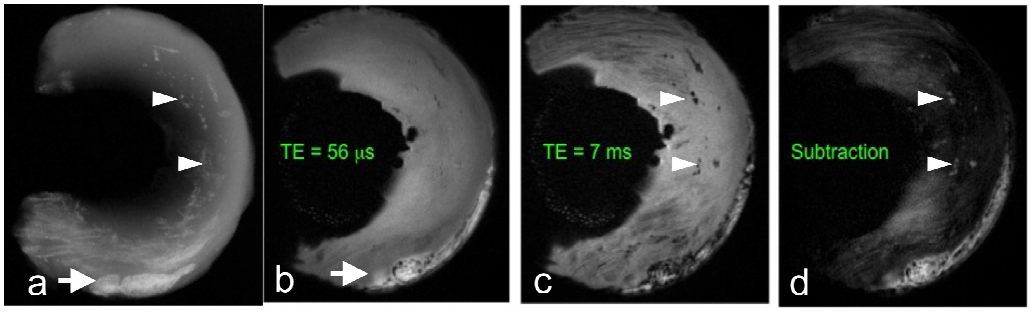

Fig. 1: Faxitron image (a) and axial 3D UTE images (two different TEs (b and c) with the corresponding subtraction image (d) of the same human meniscus specimen showing both globular (arrows) and punctuate (arrowheads) calcifications.

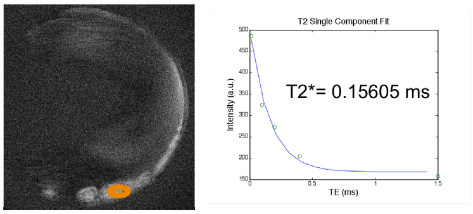

Fig 2.: IR UTE sequence with axial MR image showing globular calcifications and corresponding T2* fitting curve. The punctuate calcifications are not visible.

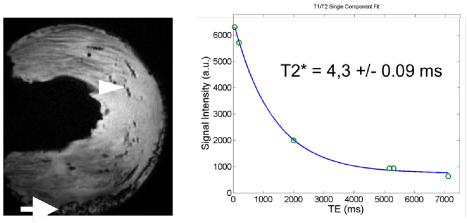

Fig. 3: 3D UTE sequence with axial MR image showing globular (arrow) and punctuate calcifications (arrowheads), and T2* fitting curve corresponding to a punctuate calcification (arrowhead).