Isotropic MRI of the Knee at 1.5T with 3D-FSE-XETA (Extended Echo Train Acquisition)

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INTRODUCTION: MRI with two-dimensional fast spin-echo (2D-FSE) requires multiple acquisition planes because of slice gaps and partial-volume artifacts. Volumetric acquisitions [1] with isotropic resolution overcome these limitations, allowing reformations in arbitrary planes. We developed a 3D isotropic fast spin-echo acquisition using an eXtended Echo Train Acquisition (3D-FSE-XETA) and compared it with conventional 2D-FSE in the knee at 1.5T.

METHODS: Ten knees of healthy volunteers were imaged in the coronal plane using a GE Signa 1.5T MRI scanner (GE Healthcare, Milwaukee, WI) and an 8-channel knee coil. 3D-FSE-XETA used variable flip angle refocusing to constrain T2-decay over a long echo train [2]. Partial Fourier and auto-calibrated parallel imaging [3] reduced echo train length by 3.4x (78 echoes encode 256 lines). With 1D acceleration, 184 coronal 0.7 mm sections were acquired in 8:40. Two-dimensional parallel imaging acceleration was then used to reduce scan time to 5:07 (104 TRs encode 184 slices). Image reconstruction took 90 seconds for 2D acceleration. Coronal 2D-FSE images were acquired with 2 mm slices and a 0.5 mm gap, 3 acquisitions, echo train length 8, and a scan time of 5:27.

All scans had the following parameters: TR/TE 3000/35ms, 256x256 matrix, 17 cm field-of-view, and bandwidth ±31 kHz. 2D-FSE was acquired in the axial plane for comparison with reformats of the 3D data, and both 2D-FSE and 3D-FSE-XETA were acquired with and without fat suppression. For each method, the signal-to-noise ratio (SNR) was measured in cartilage, muscle, and joint fluid. A paired t-test was used to compare SNR.

RESULTS: Cartilage SNR (Figure 1) was significantly higher using 3D-FSE-XETA with one-dimensional acceleration (52±9) than the 2D-FSE (30±10; $p < .01$). Muscle SNR (44±10) with 3D-FSE-XETA with one-dimensional acceleration was also significantly higher than 2D-FSE (22±3; $p < .01$). Fluid SNR was also higher using 3D-FSE-XETA(118±10) with one-dimensional acceleration then 2D-FSE (78±18; $p < .01$).

Cartilage, muscle, and fluid SNR using 3D-FSE-XETA with two-dimensional acceleration was not statistically different than 2D-FSE ($p > .07$). 3D-FSE-XETA allowed reformation of the images in arbitrary planes (Figure 2). The axial reformations of the 3D-FSE-XETA images were similar to the directly acquired 2D-FSE data, except the 3D-FSE-XETA had much thinner slices. Fat suppression was uniform on all sequences, and no significant blurring was seen on the 3D-FSE-XETA images.

DISCUSSION: Isotropic data from 3D-FSE-XETA allows for reformations in arbitrary planes, making multiple 2D acquisitions unnecessary. Slice thickness is up to 7 times less than 2D-FSE, decreasing partial-volume artifacts. 3D-FSE-XETA is promising high-resolution MR imaging technique which may improve depiction of complex knee anatomy.

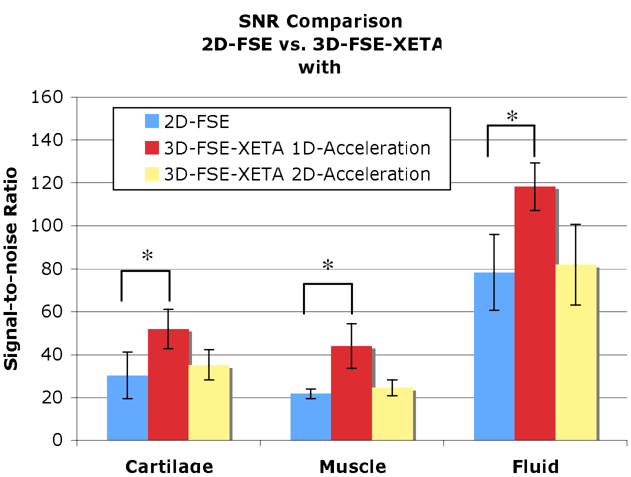

Figure 1: Comparison of SNR in cartilage, muscle, and fluid for one- and two-dimensional accelerated 3D-FSE-XETA and 2D-FSE. 3D-FSE-XETA with one-dimensional acceleration had significantly higher SNR in all three tissues (*$p < .01$) compared with 2D-FSE.

Figure 2: A) 3D-FSE-XETA coronal source image with one-dimensional acceleration, slice thickness 0.7 mm. B) Sagittal and C) Axial 3D-FSE-XETA reformats, slice thickness 0.7 mm. D) Oblique reformation showing the insertion of the ligament of Wrisberg on the posterior horn of the lateral meniscus (arrow).

ACKNOWLEDGMENTS: NIH (EB002524-04)

REFERENCES
1. Mugler et al., Radiology 216: 891-899, 2000.
2. Busse et al., Magn Res Med 55: 1030-1037, 2006.
3. Brau et al., Proc. 14th ISMRM p. 2462, 2006.