

IMPROVED 3D-FSE ISOTROPIC IMAGING OF THE KNEE USING ENHANCED FLIP ANGLE MODULATION AND CRUSHER GRADIENT OPTIMIZATION

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Introduction: 3D-FSE sequences can be acquired with isotropic resolution and without slice gaps in less than 6 minutes, allowing multi-planar reformations (1-2). 3D-FSE methods utilize variable flip angles that constrain T2 decay over long echo trains. Because of the predominance of short T2 tissues in the knee, blurring can be a problem with 3D-FSE. Two modifications may improve this: a reduced minimum flip angle to flatten the signal profile across the echo train, and a reduction of the crusher gradient to decrease echo spacing, which results in an overall shorter echo train length. The purpose of this study was to compare conventional 3D-FSE to modified 3D-FSE with different flip angle modulation and crusher gradient strengths for isotropic 3D-FSE imaging of the knee.

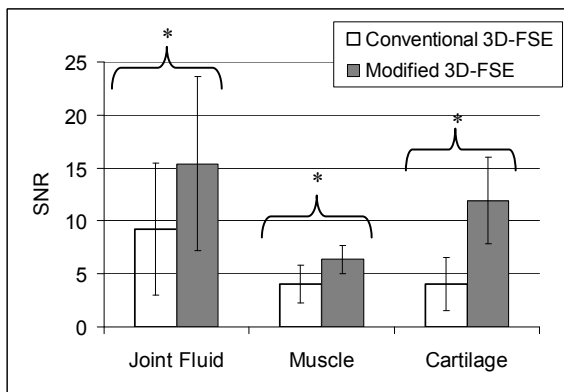


Fig 1: SNR for conventional compared to modified flip angle modulation (* = significant results)

Materials and Methods: Images were acquired from 6 volunteers and 14 patients using a Discovery MR750 3T scanner (GE Healthcare, Waukesha, WI) and 8-channel knee coil (Invivo Inc., Gainesville, FL). Conventional flip angle modulation and modified flip angle modulation and crusher gradients were used with a prototype of the 3D-FSE-Cube sequence to acquire images in the coronal plane with isotropic 0.6 mm resolution. Imaging parameters were: TR/TE 1500/35 ms, BW 41.67 kHz, 256 x 256, 17 cm FOV, 0.6 mm slice thickness. Conventional 2D FSE images were also acquired in multiple planes.

Signal-to-noise ratio (SNR) in cartilage, bone, and joint fluid was measured in the volunteers using the subtraction method developed by Reeder et al. (3). Blur was analyzed by measuring full width half maximum of the signal intensity at the edges of an agar-water phantom with different T2 relaxation times. A musculoskeletal radiologist with fifteen years of experience performed comparison of conventional and modified flip angle modulation diagnostic images in 14 patients.

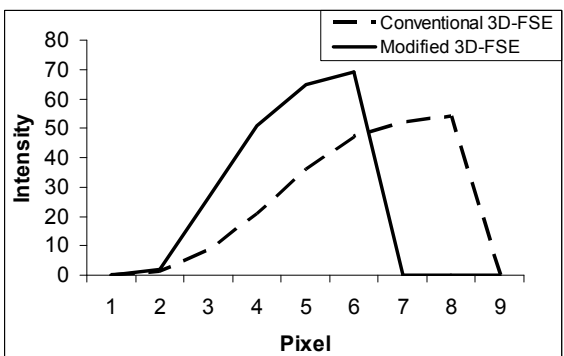


Fig 2: Full width at half maximum for conventional (a) and modified 3D-FSE (b)

Results: In volunteers, SNR for muscle, joint fluid, and cartilage was significantly higher with modified compared to conventional flip angle modulation ($p < 0.01$, Figure 1). Pixel full width at half maximum of one edge of the phantom was significantly narrower for modified compared to conventional flip angle modulation ($p < 0.01$, Figure 2). In 14 patients, all pathologies diagnosable with 2D fast-spin echo images were seen using modified flip angle modulation. Qualitative comparison of conventional versus modified flip angle modulation images in the patient group with a range of pathologies did not show a significant difference in image quality and blur. However, in selected pathologies such as complex meniscal tears, modified flip angle modulation sequences offered superior detail resolution compared to conventional flip angle modulation (Figure 3).

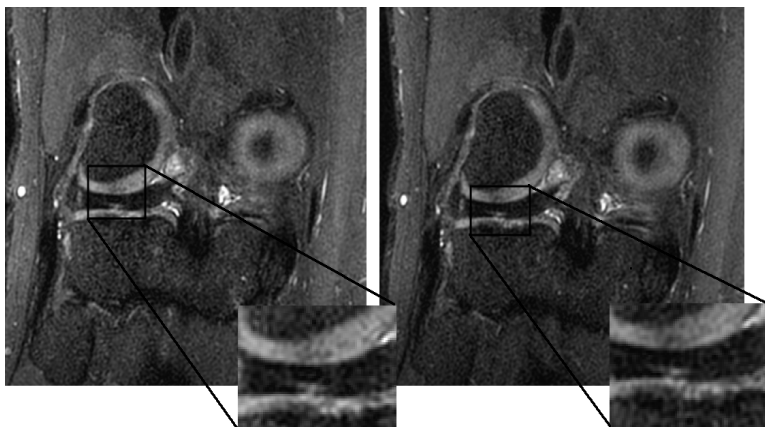


Fig 3: Modified (left) and conventional 3D-FSE (right) images demonstrating a meniscal tear with extension into articular surface appreciable with 3D-FSE.

Conclusion: Flip angle modulation with flatter signal profile and crusher gradient strength modification improves conventional 3D-FSE imaging in the knee with significant improvement in the SNR and decrease in edge blur, without loss of image quality or increase in imaging time. 3D isotropic FSE sequences have the potential to acquire a complete diagnostic knee MR dataset in less than 6 minutes, with comparable and possibly superior diagnostic accuracy to standard FSE images in a variety of knee pathologies.

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References: 1. Busse RF, et al. Magn Reson Med. 2006;55(5):1030-1037. 2. Gold GE, et al. AJR Am J Roentgenol. 2007;188(5):1287-1293. 3. Reeder SB, et al. Magn Reson Med. 2005;54(3):748-754.