IDEAL-FSE Imaging of the Ankle: Initial Clinical Experience

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Introduction: Fast spin echo (FSE) imaging with and without fat saturation is commonly used in ankle MR imaging. Achieving uniform fat suppression with fat-suppressed FSE (FS-FSE) is difficult due to the presence of Bo and B_1 inhomogeneities, both of which worsen with increasing field strength. Short tau inversion recovery (STIR) techniques necessitate additional time for inversion pulses, and suffer from low signal-to-noise (SNR) ratios [1]. Spectral-spatial pulses [2] are also relatively sensitive to magnetic field inhomogeneities.

We have previously described an iterative, least-squares Dixon water-fat separation method (IDEAL) [3] in combination with FSE that allows superior fat saturation, and comparable signal to noise (SNR) and contrast to noise (CNR) ratios in comparison with traditional FSE techniques in evaluating the knee. This work compares the IDEAL-FSE method with conventional FS-FSE in the ankles of 22 patients.

Methods: Twenty-two ankles were imaged using a GE Signa LX/I 1.5T scanner and a quadrature extremity coil. Informed consent was obtained prior to imaging. IDEAL-FSE imaging was performed in the coronal plane using TR/TE 4600/22ms and three echoes. Conventional FS-FSE images were also obtained in all ankles with TR/TE 4600/17ms and two signal averages. For both IDEAL and conventional FSE imaging, the following parameters were employed: BW=$\pm$20 kHz; echo train length=8; FOV=12; slice thickness=3 mm; 24-27 coronal images; 512 x 192 matrix. Total scan time for one ankle was 5:45 for IDEAL-FSE, and 3:46 for FS-FSE. The TE values used for the two sequences differed due to slight differences in echo spacing between the two sequences. Images were reconstructed with an on-line implementation of the IDEAL algorithm, combined with a robust reconstruction method [4].

For each method, SNR was measured from regions of interest in articular cartilage on the talar dome, and contrast-to-noise ratio (CNR) between cartilage and joint fluid was measured. Images were scored by consensus of two experienced musculoskeletal radiologists on four-point scales (0-poor; 1-fair; 2-good; 3-excellent) for both fat suppression and diagnostic quality. A paired student *t*-test was performed to compare quantitative measurements (SNR, CNR). Qualitative fat suppression and diagnostic quality scores were compared with a Wilcoxon paired signed rank test. *P* values <.05 were considered significant for both quantitative and qualitative analyses.

Results: Figure 1 contains an example of IDEAL-FSE images in an ankle containing a metallic fibular fixation plate, and FS-FSE images are shown for comparison. Superior fat-suppression performance is seen with IDEAL-FSE. Articular cartilage SNR was very similar using both sequences (Table 1). Fluid SNR and CNR were significantly better using IDEAL-FSE as compared to FS-FSE ($p < .05$). Diagnostic quality was higher ($p < .05$) using IDEAL-FSE (2.9) as opposed to FS-FSE (2.5). Fat saturation was scored as fair to good on FS-FSE (1.9) images, it was deemed excellent on all IDEAL-FSE (3.0) images, which was statistically significant ($p < .05$).

	Cartilage SNR	Fluid SNR	Fluid/Cartilage CNR	Diagnostic quality	Fat Suppression
IDEAL-FSE	**36.6 +/- 8.0**	**84.6 +/- 20.2***	**47.5 +/- 17.5***	**2.9***	**3.0***
FS-FSE	**37.0 +/- 7.7**	**73.4 +/- 13.7**	**36.7 +/- 11.3**	**2.5**	**1.9**

Table 1: SNR, CNR, Diagnostic Quality, and Fat suppression results for IDEAL-FSE and FS-FSE. The IDEAL-FSE images were significantly better in fluid SNR, fluid-to-cartilage CNR, diagnostic quality, and fat suppression ($P < .05$).

Discussion: The IDEAL-FSE method yielded outstanding fat saturation in all cases evaluated. This held true in areas corresponding to consistent failure of fat saturation on the FS-FSE images: near the medial and lateral malleoli, in the distal tibia, and in the calcaneus. The IDEAL method even achieved excellent fat saturation despite the presence of metallic hardware that caused failure of fat saturation on traditional FS-FSE images (Figure 1). An additional benefit of IDEAL imaging is that in addition to fat-suppressed images, fat-only and combined water/fat images are generated, and combined images are corrected for chemical shift artifact [5]. Preliminary observations suggest that the combined images demonstrate similar superiority in CNR and diagnostic quality as compared to T2-weighted images without fat saturation. Although the scan time of IDEAL-FSE was longer, the addition of fat and combined images allowed us to eliminate the coronal T1-weighted images from our protocol, resulting in a net exam time reduction of approximately two minutes. IDEAL-FSE is a promising technique for ankle MR imaging.

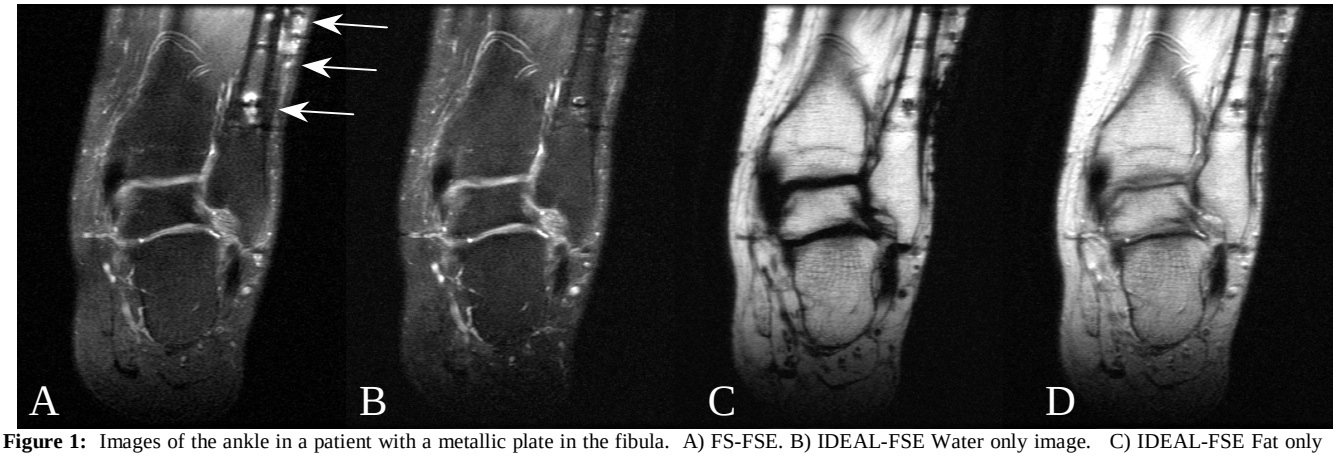

Figure 1: Images of the ankle in a patient with a metallic plate in the fibula. A) FS-FSE. B) IDEAL-FSE Water only image. C) IDEAL-FSE Fat only image. D) Combined fat-water IDEAL-FSE image. Note the superior fat saturation of IDEAL-FSE image (B) in the region of a metal plate compared with the FS-FSE image (arrows).

References:

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