Clinical Evaluation of Two- Point Dixon based fat-water separation with Conventional Fat Suppressed 2D Fast Spin Echo Imaging

D. W. Stanley[1], M. Saranathan[2], A. T. Vu[3], M. B. Wood[4], J. R. Bond[4], J. A. Skinner[4], and M. A. Frick[4]

[1]GE Healthcare, Rochester, MN, United States, [2]Global Applied Science Laboratory, GE Healthcare, Rochester, MN, United States, [3]GE Healthcare, Waukesha, WI, United States, [4]Department of Radiology, Mayo Clinic, Rochester, MN, United States

Introduction: Many pathologic, cystic or solid conditions involving the musculoskeletal system are detected on the basis of increased signal on T_2-weighted images. The ability to detect this increase without the confounding effect of signal from normal fatty structures is critical in accurate clinical diagnosis. Conventional fat suppression techniques such as chemical fat saturation are suboptimal at field strengths of 3T or higher due to B_0 and B_1 inhomogeneity issues leading to non-uniform fat signal across the imaged FOV. They also perform poorly at tissue-air interfaces or in the presence of metal. Inversion recovery based schemes are more robust to inhomogeneity effects but suffer from poor SNR and scan efficiency. We investigated the clinical performance of a two-point Dixon-based fat-water separation scheme [1] compared to conventional fat suppression techniques in 2D FSE imaging of the lower extremities.

Methods: All imaging was performed on a 3T Signa HDx MR scanner (GE Healthcare, Waukesha, WI) using an eight-channel phased array coil or a quad extremity surface coil (InVivo, Latham, NY). Twenty-two normal subjects (12 knee and 10 feet) with no known pathology were imaged after prior informed consent using chemical fat saturated (FS) FSE, Short Tau Inversion Recovery (STIR) FSE and a two-point Dixon (2PD) FSE pulse sequences. A 2PD based FSE sequence was developed that acquires two interleaved FSE images with in-phase and 180° opposed-phase water and fat signal respectively. The online image reconstruction algorithm uses a robust region-growing algorithm for phase correction [2] that exploits the intrinsic correlation between complex images from two neighbouring slices, generating "water-only" and "fat-only" images for each slice. The scan parameters for all three sequences were as follows: TR/TE 2817 ms/46 ms, ±32 kHz bandwidth, slice thickness 3 mm, slice gap 0.5 mm, 320x256 matrix, echo train length 12, 2 NEX, 16 cm/24 cm FOV (knee/foot), 15-20 slices. A TI of 180 ms was used for the STIR FSE sequence. The scan time for each sagittal plane acquisition was approximately 4 minutes. All images were evaluated and scored by three board certified radiologists trained in musculoskeletal imaging. Perceived image SNR, uniformity of fat suppression, and overall image quality were scored on a scale of 1 to 5 (1-worst, 5-best). Radiologist preference was also recorded. After pooling the results from the observers (checking for inter-observer variance), a Wilcoxon signed rank test was used to determine statistical significance with a p-value of less than 0.05 being deemed statistically significant.

Results: Mean scores for perceived SNR, uniformity of fat suppression, and overall image quality as well as radiologist preference are tabulated in Table 1 (2PD FSE vs. FS FSE) and Table 2 (2PD FSE vs. STIR FSE). Overall image quality was significantly better for 2PD FSE compared to FS FSE in the foot and better compared to STIR FSE both in the knee and in the foot. For uniformity of fat suppression, the 2PD FSE sequence performed significantly better than FS FSE and comparably to STIR FSE. Note that while STIR FSE suppresses fat uniformly, it suffers from poor SNR and poor overall IQ and radiologist preference. Figures 1-3 show a comparison of a sagittal slice obtained using fat suppressed FSE (A), 2PD FSE (B) and STIR FSE (C) for a normal knee (Fig 1), a knee with surgically implanted screws (Fig 2) and a foot (Fig 3). Note the non-uniform fat suppression of FS FSE in the foot (3A) or in the presence of metal (2A). For knee imaging, FS FSE (17/36) was slightly preferred over FSE 2PD (14/36) with STIR being the least preferred sequence (5/36). However, in the foot, the radiologist preference was overwhelmingly in favor of 2PD FSE (29/30) compared to both FS FSE (0/30) and STIR FSE (1/30).

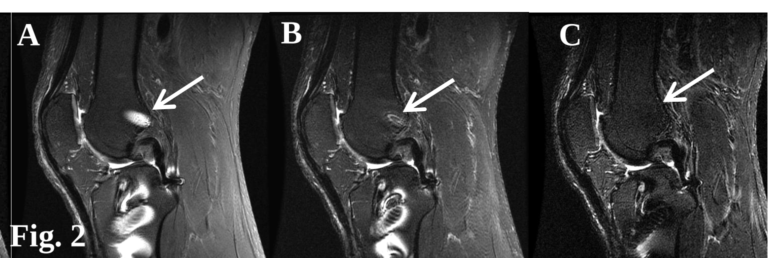
Conclusions: Preliminary results are promising using the 2-Point Dixon FSE in MSK exams especially in areas like the foot where conventional fat suppressed FSE performs poorly due to susceptibility issues and inversion-recovery prepared FSE sequences suffer from poor SNR. It appears to combine the robust fat suppression quality of the STIR FSE sequence with the high SNR of the FS FSE sequence as evidenced by the overall image quality scores and radiologist preference. The addition of parallel imaging would further reduce scan times and make the sequence more immune to motion artifacts.

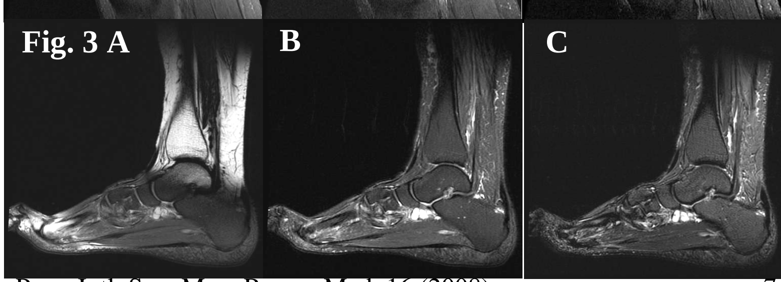
Table 1	Sequence	SNR	Uniform fat suppression	Overall IQ	Preference
Knee	2PD FSE	3.83±0.56	4.31±0.75*	3.75±0.65	14/36
	FS FSE	4.08±0.73	3.33±0.86	3.81±0.79	17/36
Foot	2PD FSE	4.03±0.32	4.63±0.49*	4.27±0.52*	29/30
	FS FSE	3.80± 0.48	1.03±0.18	2.27±0.69	0/30

Table 2	Sequence	SNR	Uniform fat suppression	Overall IQ	Preference
Knee	2PD FSE	3.83±0.56*	4.31±0.75	3.75±0.65*	14/36
	STIR	3.19±0.71	4.39±0.60	3.31±0.89	5/36
Foot	2PD FSE	4.03± 0.32*	4.63±0.49	4.27±0.52*	29/30
	STIR	3.27 ± 0.56	4.60±0.50	3.50±0.57	1/30

*Significantly different $p<0.05$; Table elements show Mean ± SD

References: [1] Ma et al. MRI. 23:977-82 (2005). [2] Ma et al. MRM. 52:415-9 (2004).





Fat suppressed FSE [A] compared to 2-Point Dixon FSE [B] and STIR FSE [C] for a knee (Fig 1), a knee with surgically implanted screws (Fig 2) and a foot (Fig 3). In the case of the normal knee (Fig 1), all techniques performed similarly. Note the non-uniform fat suppression using the FS FSE sequence in the presence of metal (Fig 2A) or in the foot (Fig 3A). In the presence of metal, STIR FSE produced more uniform fat suppression (Fig 2C) but had the worst SNR (Table 1,2). In the foot, 2PD FSE (Fig 3B) produced very uniform fat suppression with higher SNR than STIR or FS FSE.