Fat Suppressed FSE Pelvic MR Imaging with Two New FSE Based Dixon Pulse Sequences: A Comparison of IDEAL FSE and FSE Triple Echo Dixon

R. N. Low[1,2], and N. Panchal[1,2]

[1]Sharp and Children's MRI Center, San Diego, CA, United States, [2]San Diego Imaging Medical Group, San Diego, CA, United States

Purpose: To compare two new FSE based Dixon pulse sequences and conventional fat suppressed FRFSE T2-weighted imaging for fat suppressed pelvic MRI.

Background: Fat suppressed FSE T2-weighted imaging is an integral part of an MR pelvic examination. However, fat suppression by conventional technique can be degraded by inhomogeneities of the magnetic field. The problem can be exacerbated when a typical large FOV is used for abdominal and pelvic imaging. Techniques that provide fat-suppressed T2-weighted imaging that is insensitive to field inhomogeneity would be clinically useful for pelvic MR imaging. In this work we report our initial clinical evaluation on the performance of two new FSE-based Dixon pulse sequences that generate water-only and fat-only images:

1. FSE Triple-Echo Dixon (FTED) is a prototype fast spin echo (FSE) based Dixon pulse sequence [1]. The sequence replaces each FSE readout gradient with three readout gradient pulses of alternating polarity. The length of these gradients is adjusted such that their respective echoes occur when fat and water are -180°, 0°, and $+180^o$ relative to each other. After data acquisition, a host computer based two-point Dixon image reconstruction program commercially known as FLEX (or MEDAL) uses the three echoes as input and automatically generates separate water-only and fat-only images for each slice [2]. Since the pulse sequence acquires multiple echoes within a single pass, breath-hold acquisition of fat-suppressed T2-weighted images is possible even without parallel imaging.

2. IDEAL FSE is an FSE based three-point Dixon technique [3]. It requires three input images that have different and asymmetric phase angles between water and fat. The different phase shift is achieved by shifting the readout gradient with a corresponding increase in FSE echo spacing and the three input images are acquired in interleave. An iterative phase correction algorithm (IDEAL) is then applied to generate water-only and fat-only images from the input images.

Materials and Methods: Fifteen patients referred for pelvic MRI were imaged with axial FTED (TR 2000, TE 90, ETL 17, matrix 320 x 192, Nex 1, rFOV 0.8, slice thickness 7 mm, 24 slices, bandwidth 64 kHz, and time = 1:12). Patients were also imaged with axial IDEAL FSE (TR 2400, TE 90, ETL13, matrix 320x192, Nex 1, rFOV 0.8, slice thickness 7mm, 24 slices, bandwidth, 31.25 kHz, and time = 3:22 or 1:56 using an ASSET factor of 2). For comparison patients also were imaged with fat suppressed T2-weighted FRFSE (TR 2060, TE 90, ETL 12, matrix 320x192, NEX 2, rFOV 0.8, slice thickness 7mm, 24 slices, bandwidth 32 kHz, ASSET factor = 2, and time = 42 sec). Two radiologists independently compared the FRFSE, FTED, and IDEAL FSE images for overall image quality, homogeneity of fat suppression, image sharpness, anatomic detail, phase artifact, susceptibility, and other artifacts. Areas of fat and water swapping on the FTED and IDEAL FSE images were noted. Depiction of normal anatomic structures and disease was compared.

Results: FTED and IDEAL FSE images successfully reconstructed water-only and fat-only images from the raw images in all 15 cases. Water and fat separation was perfect with no areas of fat and water swapping. Compared to FRFSE images homogeneity of fat suppression was superior on the FTED and IDEAL FSE images in all 15 cases. The three image types demonstrated similar depiction of normal anatomic structures including muscles, subcutaneous fat, bones, uterus, bladder, and vasculature. Anatomic detail was equal on the FRFSE and FTED images in 7 of 15 cases and superior on the FTED images in 8 cases. IDEAL FSE images received the lowest score for anatomic detail 12 of 15 cases. Image sharpness was equal on the FRFSE and FTED images in 7 of 15 cases and superior on the FTED images in 8 cases. Image sharpness was least on the IDEAL FSE images in 14 of 15 cases, probably due to its increased echo spacing and the substantially longer acquisition time required. Vascular pulsation and susceptibility artifacts were equivalent for the three image types in all cases. Overall, image artifacts were rated as least on the FTED images in 14 of 15 cases. For overall image quality FTED images were rated highest in 9 cases, FRFSE and FTED images were equal in five cases, and the FRFSE image superior in 1 case. Depiction of pelvic diseases including uterine fibroids, ascites, osseous metastases, and lymphadenopathy was equal on the three image types.

Conclusions: FTED and IDEAL FSE are robust sequences that provide T2-weighted images with superior separation of fat and water signal compared to conventional T2-weighted FRFSE imaging. The efficiency of the FTED pulse sequence and its inherent anatomic sharpness make it the preferred sequence for fat suppressed T2-weighted pelvic MR imaging.
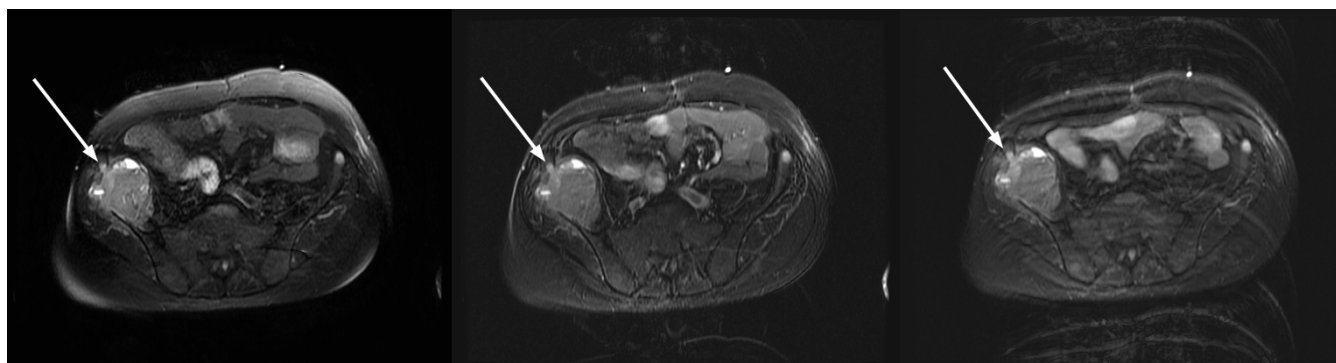

Figure 1: The FRFSE image (left) shows inhomogeneous fat suppression in this patient with a right iliac bone metastasis (arrow).
FTED (middle) and IDEAL FSE (right) images show homogeneous fat suppression with perfect separation of fat and water signal on all images.
Compared to the IDEAL FSE image the FTED image shows sharper image quality and fewer artifacts from respiratory motion.

References [1]. Ma J, Son JB, Zhou Y, Le-Petross H, Choi H. Magn Reson Med 58:103, 2007. [2] Ma J. Magn Reson Med 52:415, 2004. [3] Reeder SB, Pineda AR, Wen Z, Shimakawa A, Yu H, Brittain JH, Gold GE, Beaulieu CH, Pelc N. Magn Reson Med 54:636, 2005.