Free-breathing, fat-suppressed T1-weighted imaging using IR prepared dual-echo FGRE with MEDAL water/fat separation

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Introduction: Gradient-echo based techniques are very useful for T1-weighted imaging of abdomen both pre and post contrast agent injection. For effective minimization of motion-related artifacts, however, good breath-holding on the order of 15-30seconds is often required. In the clinical practice of our hospital, we find that a sizable portion of the patients, particularly those who are very sick or under anesthesia, are unable to perform such breath-holds. As an alternative to breath-holding, artifact-free T1-weighted images may also be acquired by using an inversion recovery (IR) prepared fast gradient echo (FGRE) technique [1,2]. In this technique, all 2D data for each slice are acquired with 2D FGRE in a single shot mode (≤1 second), thus effectively freezing the motion. Prior to the 2D FGRE acquisition, a non-selective inversion-recovery pulse is applied for enhanced T1 contrast. A major limitation of the technique is that it is not directly compatible with conventionally used fat suppression techniques. In this study, we modified the 2D IR-prepared FGRE technique with a dual echo acquisition (bipolar readout of two echoes after each RF excitation), and further incorporated a previously developed MEDAL algorithm [3] that requires only one in-phase image and one out-of-phase image for effective water and fat separation. We demonstrate that using our approach, motion artifact-free and fat-suppressed T1-weighted images of excellent quality can be readily acquired both pre and post contrast agent injection in patients who were not able to perform effective breath-holding.

Methods: An IR prepared FGRE sequence was modified to acquire two gradient echoes with bipolar readout gradients spaced 2.3 ms apart within each repetition time (TR) after a single RF excitation. Sequence parameters used for this study were: TR = 6.7 ms, TE = 2.1 and 4.4 ms, flip angle = 55^{o}, frequency FOV = 36-42 cm, slice thickness = 8 mm, matrix = 256x160, NEX = 1, acquisition time per slice = 1.5-2.0 sec and the total imaging time for whole abdomen coverage was < 1 min. FOV in the phase encoding direction was 70-100% of the FOV in the frequency direction. K-space was filled with a linear acquisition order, and the time from the inversion pulse to the time the center of k-space was acquired was approximately 800 ms. The sequence was applied to two patients who were referred for routine abdominal imaging. Partial parallel imaging with an acceleration factor of 2 was also implemented for possible further reduction of the acquisition time but was not used for the images shown below. All images using this technique were acquired during free breathing. Fat and water images were generated automatically on the scanner using the MEDAL water/fat separation algorithm [3].

Results: Images are shown in figure 1. No motion artifacts were observed in any of the images, and fat suppression was very even over all the water images.

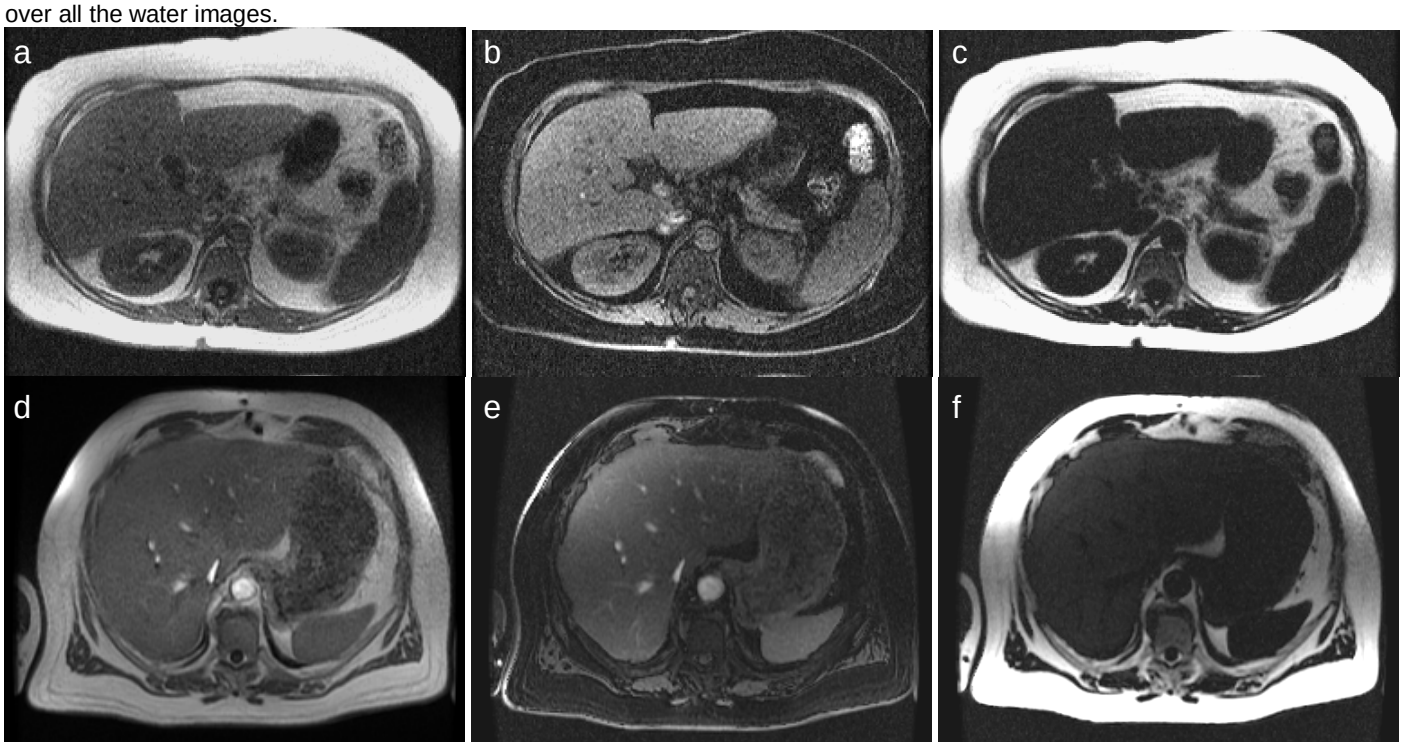

Figure 1: Non-contrast images from patient 1 (a-c) and post-contrast images from a patient 2(d-f). In-phase (a,d), water (b,e) and fat (c,f) shown.

Discussion: We present a fast, robust, free-breathing technique that provides artifact free T1 weighted images with excellent fat suppression. Since each slice is acquired with a single shot acquisition and enhanced T1 weighting is dependent on the IR preparation, STIR and chemical shift selective fat saturation techniques cannot be directly implemented for this free-breathing technique. Three major advantages of our technique are complete elimination of in-plane motion artifacts without breath-hold, good T1-contrast, and excellent fat-suppression. As in the original IR-prepared FGRE technique, slice misregistration may be noted. However, our radiologists find this much less objectionable for this group of patients than the severe motion artifacts that would otherwise be present on images acquired with the techniques that require good breath-hold. To minimize the slice registration with our technique, patients may be instructed to breathe slowly or a respiratory triggering scheme may be implemented at the expense of the total acquisition time.

References: 1. Mugler JP and Brookeman JR, MRM 1990; 15:152-157. 2. de Lange EE et al., JMRI 1991; 2:359-364. 3. Ma J, MRM 2004;52:415-419.