

Contrast Edited T₂ SSFSE: A Potential Alternative to Diffusion Weighted EPI for MRI Screening

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Introduction: In recent years, magnetic resonance imaging (MRI) has gained increased attention for whole-body screening of tumor metastasis (1). The most commonly used sequences for MR screening are short-tau inversion recovery (STIR) (2) and EPI based diffusion weighted imaging (DW-EPI) (3) or a combination of both (4). These methods exploit the increased T₂ and restricted diffusion typically found in metastatic tumors to generate contrast to visually separate these lesions from other tissues. However, both these sequences are SNR limited and thus require multiple signal averages increasing the total scan time. Further, DW-EPI images are subject to distortion when used with larger fields of view (FOV), particularly in the coronal plane.

The ideal sequence for whole-body screening would utilize a rapid acquisition with high SNR and negligible distortion, while simultaneously minimizing the background signal to increase tumor conspicuity. The suppressed background tissue is typically composed of fat, long T₁ material (such as fluid filled cysts) and blood vessels. Our hypothesis is that such a sequence can be developed using a single shot fast spin echo (SSFSE) approach by simultaneously suppressing signals from fat, fluid and blood vessels, offering the potential for time-efficient coronal acquisitions while preserving the spatial resolution typical of routine imaging.

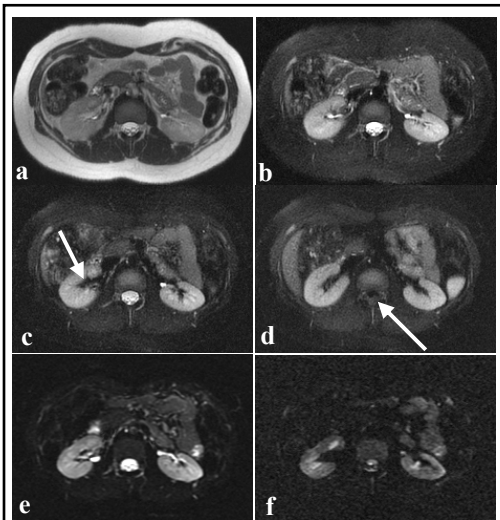
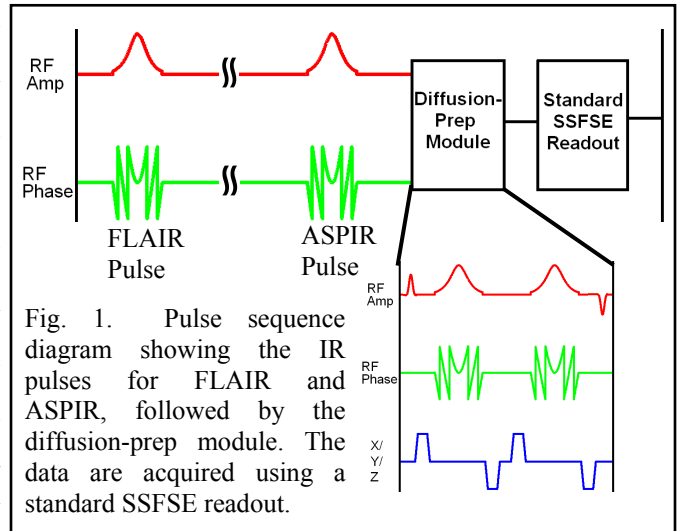


Fig. 2. Standard SSFSE (a), ASPIR-SSFSE (b), ASPIR-diff-prep SSFSE (c) and FLAIR-ASPIR-diff-prep-SSFSE (d) showing progressive suppression of different signals. For comparison, EPI ($b=0 \text{ s/mm}^2$) (e) and DW-EPI ($b=500 \text{ s/mm}^2$) (f) images are also shown.

Comparison images acquired with DW-EPI are shown in figs. 2e and 2f. SSFSE images were all acquired in a single excitation with higher spatial resolution, while the DW-EPI images required four signal averages with reduced resolution to achieve comparable SNR. Fig. 3 shows coronal images acquired with a) standard SSFSE, b) SSFSE with FLAIR, ASPIR, and diffusion-prep contrast and c) EPI using STIR for fat suppression. The comparison EPI image acquired using STIR (fig. 3c) shows distortion of the spinal canal (dashed arrow) and bright CSF (3c).

Discussion: The preliminary results in normal subjects show that our proposed method is capable of producing high SNR images using a single average while suppressing the undesired signals from fat, fluid and blood vessels. It is also compatible with time-efficient coronal plane acquisitions. The feasibility of the technique for improved conspicuity of the lesions needs to be validated in patients. This technique could provide an alternative to whole-body DW-EPI, which has been shown to detect malignant tumors similar to ¹⁸F-FDG PET/CT (5).

Reference: 1) Lauenstein et. al. JMRI 24: 489-498 (2006); 2) Hargaden et. al. AJR 180: 247-252 (2003); 3) Koh et. al. AJR 188: 1622-1635 (2007); 4) Takahara et. al. Radiation Medicine 22: 275-282 (2004); 5) Komori et. al. Ann Nucl Med 21: 209-215 (2007).

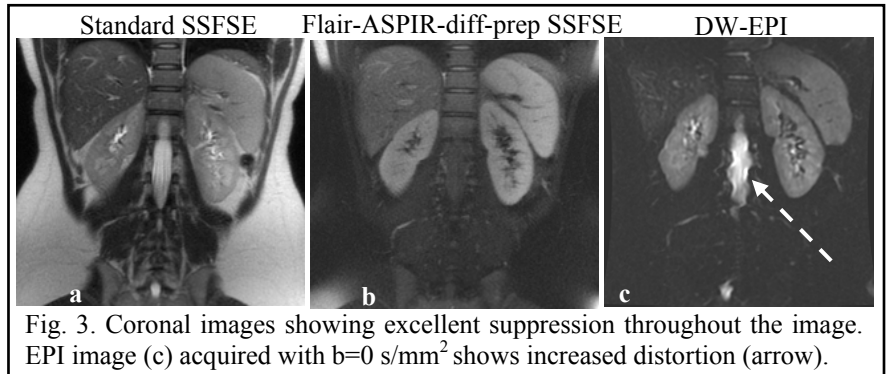


Fig. 3. Coronal images showing excellent suppression throughout the image. EPI image (c) acquired with $b=0 \text{ s/mm}^2$ shows increased distortion (arrow).

Methods: The pulse sequence diagram is shown in fig. 1. The sequence begins with an adiabatic inversion pulse (FLAIR) to suppress long T₁ fluid such as cysts, CSF etc. After an inversion time of 2700 ms, a spectrally selective adiabatic IR pulse (ASPIR) is applied to invert fat. 130 ms following ASPIR, a diffusion-prep module with weak diffusion gradients is applied to suppress moving tissue such as blood. This is immediately followed by an SSFSE readout. For initial feasibility studies, the sequence was tested on normal subjects (with IRB approval) in both axial and coronal planes using a 256x224 resolution and 70 ms TE. For comparison, DW-EPI with $b=0$ and 500 s/mm^2 using STIR were also acquired with 128x128 resolution and four signal averages with a TE of 80 ms.

Results: SSFSE images with progressive suppression of various background signals are shown in fig. 2. ASPIR-SSFSE shows uniform fat suppression (2b) compared to standard SSFSE (2a). Addition of the weak diffusion-prep module suppresses blood vessel (arrow, 2c). Finally, the addition of FLAIR suppresses the signal from long T₁ such as CSF (arrow, 2d).