Fat suppression with Slice-Selection Gradient Reversal (SSGR) revisited;

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Introduction

Robust fat suppression is crucial for accurate evaluation of T2-weighted, post-contrast T1-weighted, and diffusion-weighted images. Nowadays, fat suppression is satisfactory in most of the cases. However, susceptibility induced field inhomogeneities as well as B_1 inhomogeneity increases substantially with increasing field strength, which makes homogeneous fat suppression challenging at high field (> 1.5T). The Slice-selective gradient reversal (**SSGR**) technique was reported more than 20 years ago [1]. This technique needs a relatively low bandwidth of the excitation pulses to obtain sufficient shift of the excited fat slice relative to the excited water slice at 1.5T. Its effectiveness at 1.5T is limited [2], and the method is not frequently used in clinical practice. Recently, Nagy et al. reported the effectiveness of this method at 3.0T, but did not compare it to that at 1.5T [3]. We therefore revisited this technique, hypothesized that SSGR works better at higher field strength thanks to larger chemical shift, and compared the effectiveness of SSGR in fat suppression among 7.0, 3.0, and 1.5T.

Methods

Theory: **Fig.1** shows the SE sequence with SSGR, which is characterized by an inversed slice-selection gradient for the 180 degree RF pulse. The displacement of the excited fat slice relative to the water slice (**Fig.2**) is $\sigma B_0/BW_{ex}*z$, with σ the chemical shift in ppm, B_0 is the main magnetic field, BW_{ex} the bandwidth of the excitation RF pulse, and *z* the slice thickness.. Since the maximum B_1 (and hence BW_{ex}) generally does not scale with B_0 because of technical challenges (RF amplifier power) and the SAR deposition, the shift of the fat slice will be larger at higher magnetic fields which is beneficial for effective fat suppression with gradient reversal.

Scan: Four volunteers underwent MR imaging at 7.0T, 3.0T, and 1.5T MRI systems after institutional review board approval and written informed consent were obtained. Both Turbo SE T1-weighted images (T1WI) and SE-EPI diffusion-weighted mages (DWI) were obtained as follows; 1) without fat suppression, 2) with "spectral pre-saturation with inversion recovery" (**SPIR**) based fat suppression, 3) with SSGR based fat suppression, and 4) with both SPIR and SSGR based fat suppression. The sequence parameters were: FOV of 24 x18 cm, slice thickness/gap of 5mm/1mm, matrix of 256x200. We used default RF excitation and refocusing bandwidths, given the maximum allowed *B1* amplitudes at the scanners. Simultaneously, we also performed an additional scan without any gradient to measure signal-to-noise ratio (SNR). SNR of the fat in intraconal region of the orbit and the calvarium was measured by means of free-shaped region of interest.

Fig.1. Sequence chart

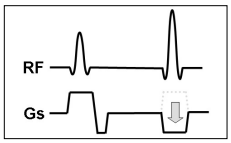


Fig.2. Expected split

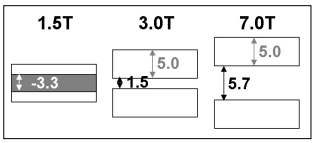


Fig.3. Bar graph showing relative SNR of fat using different suppression techniques compared to no fat suppression

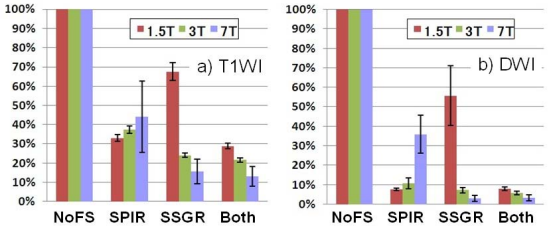
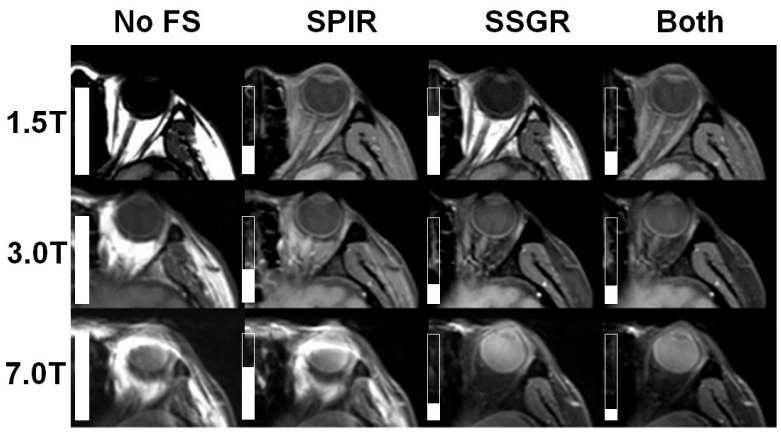


Fig.4. Comparison of fat suppression techniques on T1WI



Results: Comparison of relative SNRs of fat in different techniques is shown in **Fig.3**. A typical example of T1WI is shown in **Fig.4**. SSGR showed inferior results to SPIR at 1.5T, but yielded better fat suppression both at 3.0T and 7.0T. Combination of both SPIR and SSGR yielded superior fat suppression compared to SPIR or SSGR only, at all field strengths. The beneficial effect of SSGR based fat suppression for DWI is even more pronounced than for T1WI. (See Fig.3)

Conclusion: The SSGR technique is very effective for robust fat suppression, especially at high field strength (> 1.5T), and can be combined with SPIR for even better results. As the technique does not introduce any additional scan time or SAR, it should be used in spin-echo type sequences at high-field strength. Particularly for the application of whole body diffusion techniques (DWIBS) at high field, the improved fat suppression may substantially improve image quality.

References:

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