Presence and Reduction of Off-resonance Ghosting in Magnetization Prepared TrueFISP

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Introduction: Magnetization preparation and storage during TrueFISP acquisitions using α/2 at TR/2 pulses has been used to introduce fat suppression (1) and to eliminate T1 contrast from bSSFP acquisitions (2-5). Magnetization storage was previously performed infrequently and/or with a time varying pattern. Here it is demonstrated that frequent regularly spaced magnetization preparation using α/2 pulses can lead to significant ghosting artifacts. We hypothesize that by slight randomization of the number of readouts between magnetization preparations it will be possible to decrease the amplitude of these ghosts.

Methods: Magnetization evolution as a function of off-resonance angle (-2π to 2π in steps of 0.1 radian) was simulated in Matlab (MathWorks, Natick, MA) for normal/uninterrupted TrueFISP (TR = 5.8 ms, FA = 50˚, T1 = 540 ms, T2 = 270 ms, 256 readouts), regularly prepared (16 readouts between preparations) and semi-randomly prepared (e.g., 16 + a uniformly distributed random number between 5 and -5) TrueFISP. An FFT was performed on the magnetization decay (readouts 21-256) for each off-resonance angle to generate the predicted point spread function (PSF) for all off-resonance angles for each technique. Actual experimental raw data was collected in a 1.5 T Espree magnet (Siemens, Erlangen, Germany) from a large doped water phantom (T1 = 540 ms, T2 = 270 ms) placed in a single channel knee coil with TrueFISP excitation (FA = 50˚, TR = 5.8 ms) with phase encoding turned off and a purposefully unbalanced readout gradient to induce off-resonance precession. Magnetization evolution was measured and the PSFs as a function of off-resonance angle were calculated for the regularly prepared and non-regularly prepared methods. Axial TrueFISP images were acquired in the neck of an asymptomatic human volunteer using both regular (16 readouts between preparations) and non-regular (using above randomization) magnetization preparation.

Results: Figure 1a demonstrates the magnetization evolution during TrueFISP as a function of off-resonance angle. Figure 1b provides the point spread function (PSF) associated with each off-resonant species. Figure 1c demonstrates the PSFs from the regularly stored TrueFISP. Note the presence of many ghosts with > ½ the amplitude of the main lobe. Figures 1d demonstrates the PSFs for the randomized TrueFISP acquisition. Note that the amplitude of the ghosts associated with the regularly prepared TrueFISP acquisition (1d) have been significantly reduced to below the level of unprepared TrueFISP imaging (1b). Figures 2a-b demonstrate the PSFs from regularly prepared and randomized TrueFISP. Note the presence of ghosts in 2a (arrows) and their reduction in 2b. Figure 3a is an axial image acquired in the human volunteer. Note the ghosting artifacts (arrows) which have been reduced in the non-regularly prepared TrueFISP image (3b).

Conclusion: This work is the first to identify a previously unreported artifact associated with magnetization prepared TrueFISP. A new method based on slight randomizations in the number of readouts between preparations is demonstrated to allow periodic magnetization preparation in TrueFISP while preventing these newly described off-resonance ghosting artifacts.

References:

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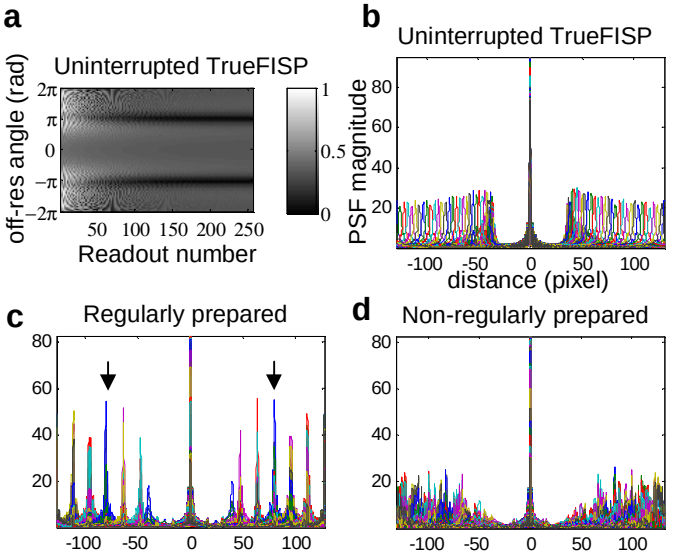

Fig. 1. Simulation results. (a) Simulated magnetization evolution during regular TrueFISP. **(b)** Point spread functions for all off-resonance species. **(c-d)** PSFs in presence of regularly spaced and non-regular magnetization preparation. Arrows point to ghosts in regularly prepared TrueFISP.

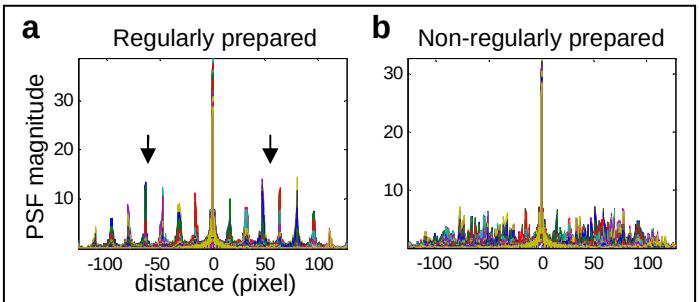

Fig. 2. Phantom results. Point spread functions for all off-resonance species for **(a)** regularly prepared TrueFISP and **(b)** non-regularly prepared TrueFISP.

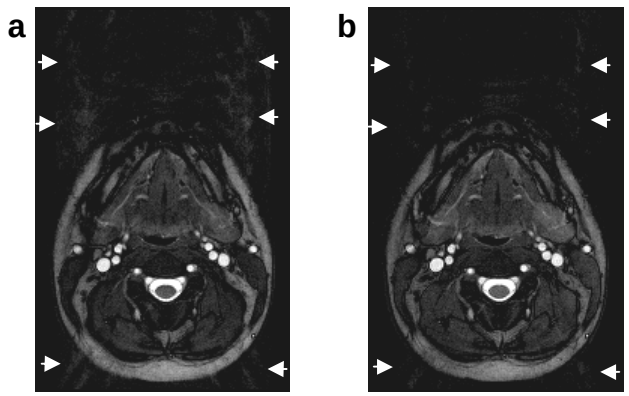

Fig. 3. In-vivo results. Human in vivo images of upper neck with **(a)** regular and **(b)** non-regular magnetization preparation. Note reduced ghosting artifacts (arrows) with non-regular magnetization preparation in (b).