TIDE bSSFP As A Fat-suppression Preparation

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Introduction

The Transition into Driven Equilibrium balanced steady-state free precession (TIDE bSSFP) sequence [1] has been shown to carry an intrinsic suppression of off-resonance signals after experiencing a certain number of RF pulses. Suppression of fat signals could thus be accomplished by just an appropriate choice of the timing passing through the *k*-space center [2][3]. The stopbands in TIDE bSSFP are shown to be wide in comparison to other fat-suppression schemes such as CHESS fat suppression [2][3]. Therefore, it should be possible to incorporate the intrinsic fat suppression property of TIDE bSSFP into other clinical routine techniques, by truncating the TIDE bSSFP up to the null point for off-resonance signals, followed by a connection with any other image readout sequences. In regions with strong susceptibility effects from air cavities such as the neck or the abdomen, where good shimming is harder to achieve, the wide stopbands of fat suppression using TIDE bSSFP preparation may be helpful. We evaluated this preparation method with both computer simulation and phantom studies.

Materials and Methods

The signal intensity evolutions were numerically computed with MATLAB software using the Bloch equations under various off-resonance frequencies, with the parameters set to those used in the experiments. For experiments, images of a oil-water phantom were acquired on a 1.5T system (Siemens Vision Plus, Erlangen, Germany) without and with fat suppression, followed by a spin-echo EPI image acquisition (TR/TE: 4000/103 msec, Matrix: 128x128, FOV: 350 mm). The fat suppression preparation employed either the TIDE bSSFP or the CHESS scheme. The RF flip angles of TIDE bSSFP prepared spin-echo EPI were $[90°\rightarrow\tau\rightarrow(180°\rightarrow\tau)_{\times 2}\rightarrow 158°\rightarrow\tau\rightarrow 135°\rightarrow\tau\rightarrow 113°]_{\text{TIDE bSSFP prep}}\rightarrow[90°\rightarrow 180°\rightarrow]_{\text{SE-EPI}}$ (τ = 6.46 msec in this study, but variable in principle), while for CHESS, we used a common 1-3-3-1 design of $[\theta\rightarrow\tau\rightarrow(-3\theta)\rightarrow\tau\rightarrow 3\theta\rightarrow\tau\rightarrow(-\theta)]$ (i.e., θ=90°/4 with RF phase angle alternation, τ =2.37 msec) followed by a spoiler gradient in three channels and the same spin-echo EPI readout.

Results

Figure 1 shows the signal intensity (*vertical axis*) plotted versus the off-resonance dephasing angles (*horizontal axis*) for TIDE bSSFP (solid line) and CHESS (dotted line), showing much wider stopband of TIDE bSSFP than that of CHESS when the TIDE bSSFP was truncated at the null point for fat signals [3]. **Figure 2** shows three EPI images without (a) and with CHESS (b) or TIDE bSSFP fat suppression (c). The one with TIDE bSSFP preparation shows a comparable fat suppression result with that using the CHESS preparation under well-shimmed conditions, while the EPI image without any fat suppression shows the well-known chemical shift artifacts far away from the water.

Discussion and Conclusion

Results from this study suggest that TIDE bSSFP preparation show at least a comparable fat suppression effectiveness to that of the conventional CHESS preparation, whenever the shimming condition is acceptably good. Nevertheless, since the stopband of TIDE bSSFP is much wider than that of CHESS, fat suppression performed with TIDE bSSFP preparation is anticipated to be superior in regions where good shimming is hard to maintain (for example, around the neck). Compared with relaxation-based fat suppression techniques such as STIR which is also insensitive to main magnetic field inhomogeneity but changes the image contrast, fat suppression by TIDE bSSFP preparation imposes a contrast closed to pure-T_2 weighting which is usually desirable clinically [3][4]. With the use of short TIDE bSSFP preparation schemes including a small number of preparatory RF pulses (i.e., one to two 180° RFs followed by a few RFs of linearly down-ramped flip angles), the specific absorption rate (SAR) concern could further be reduced. In conclusion, the TIDE bSSFP preparation can be used as an alternative for fat suppression preparation to be combined with any other common readout modules, and is particularly suitable for regions prone to susceptibility effects where good shimming is hard to achieve.

References

1. Hennig J, *MRM* 2002; 48: 801 **2.** Huang YC, *ISMRM* 2006 #633 **3.** Paul D, *MRM* 2006; 56:1328 **4.** Huang YC, *ISMRM* 2006 #2413.

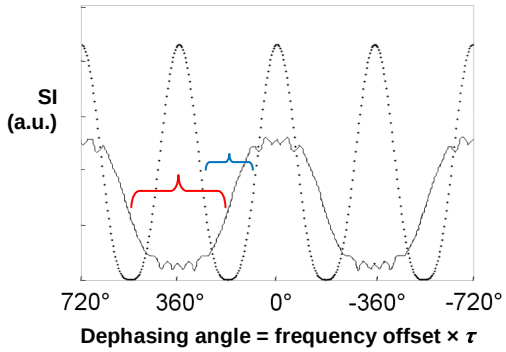

FIG. 1.
Signal intensity (SI) versus off-resonance dephasing angle for TIDE bSSFP preparation (solid line) and CHESS fat suppression scheme (dotted line), showing a much wider stopband of TIDE bSSFP (red bracket) than that of CHESS (blue bracket).

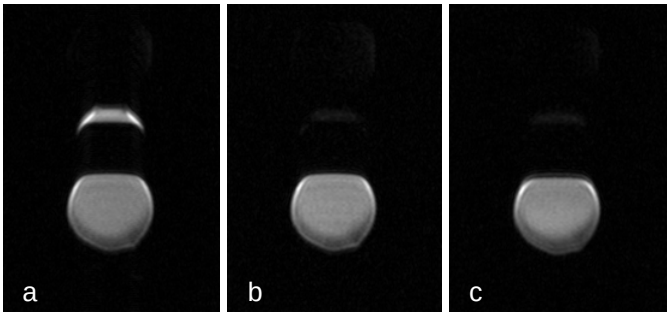

FIG. 2.
EPI images of a phantom of oil and water (a) without fat suppression (b) with CHESS preparation (c) with TIDE bSSFP preparation. As indicated by the images, (b) and (c) showed comparably effective fat suppression.