

Modified T₂-TIDE Sequence: A Preliminary Result

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Introduction

Transition into driven equilibrium (TIDE) for balanced steady-state free precession (bSSFP) imaging has been shown to possess several advantages [1]: TIDE sequence shows less banding artifacts due to off resonance than half-angle-half-TR (HAHT) bSSFP [2]; TIDE suffers less from point-spread-function blurring and exhibits lower RF specific absorption rate (SAR) than HASTE [3]. A recent study further shows that T₂ weighting could be achieved by placing a series of 180° pulses before the TIDE preparation (T₂-TIDE) [4]. In this study, we aim at a comparison of the effectiveness of three T₂-weighting schemes for bSSFP imaging: HAHT bSSFP (T₂/T₁-weighting largely similar to T₂-weighting), T₂-prepared HAHT bSSFP (T₂-bSSFP), and T₂-TIDE.

Materials and Methods

The T₂-TIDE sequence used in this study employed a series of eight 180° pulses, followed by a four-step preparation from 180° to 90° which corresponded to the final flip angle in bSSFP readout. Hence the scheme was [90° 180°×8 150° 120° 90°]_{prep}[90°...]_{acq} with phase alternation every other pulse [1,4]. In T₂-bSSFP, we used [90° 180° 90° (TE: 36ms) spoiler 45°]_{prep}[90°...]_{acq}, again with phase alternation every other pulse. A schematic illustration of the two pulse sequences is shown in Fig.1. Half Fourier was chosen with HASTE-type phase encoding order in both techniques to enhance the function of preparation by acquiring data in the transient state [5]. For HAHT bSSFP, the T₂-bSSFP was used with full k-space coverage such that the contrast was dominated by T₂/T₁-weighted steady-state signals.

Coronal abdominal images were acquired on a 1.5T system (Siemens Vision Plus, Erlangen, Germany) using TR/TE: 6.46/3.23 msec. The matrix size was chosen as 256×256. Flip angle was 90°. Subjects volunteering participations gave written informed consent.

Results

Figures 2a-2c show the images of human abdomen obtained in coronal orientation using T₂-TIDE, T₂-bSSFP, and HAHT bSSFP, respectively. The image acquired using T₂-TIDE has the best intensity homogeneity throughout the entire field-of-view. The T₂-bSSFP image shows prominent presence of noise from ghosting in the background regions (open arrows) and wavy banding pattern at the upper abdomen (arrow). These two sequences both possess image contrast close to being T₂-weighted, as can be seen by clear distinction of the renal cortex from the renal medulla. In contrast, the T₂/T₁-weighting seen in HAHT bSSFP imaging does not provide a clear contrast between renal cortex and medulla. The fat suppression seen in Figs.2a and 2b is discussed in a separate abstract.

Discussion and Conclusion

The contrast of conventional HAHT bSSFP becomes T₂/T₁-weighted as the signals approach steady state. Although it is mainly T₂-like, this contrast does not provide clear soft-tissue distinction between, say, renal cortex and medulla or gray versus white matter in the brain. HAHT bSSFP with T₂ preparation partially remedies this situation, which however is prone to the B₁ imperfections [4] leading to undesirable image artifacts in addition to ghosting from oscillatory off-resonance spins. As experimentally shown in this study, the T₂-TIDE technique is superior to HAHT bSSFP and T₂-bSSFP in the aforementioned aspects, and is therefore suitable for obtaining fast T₂-weighted images especially on high-field systems where SAR could be a major concern hampering fast spin-echo imaging.

References

1. Hennig J, *MRM* 48: 801 2. Deimling M, *SMR* 1994 3. Paul D, *ISMRM* 2005 4. Huang TY *ISMRM* 2004 5. Huang TY *MRM* 48: 684

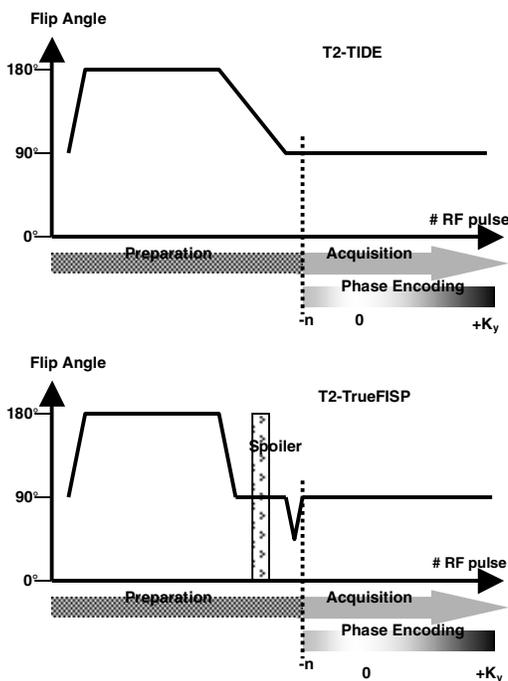


FIG. 1. Schematics for T₂-TIDE and T₂-bSSFP, both implemented with half Fourier option using HASTE-type phase encoding. For full k-space coverage, T₂-bSSFP becomes HAHT bSSFP due to contrast dominance by steady-state signal behavior.

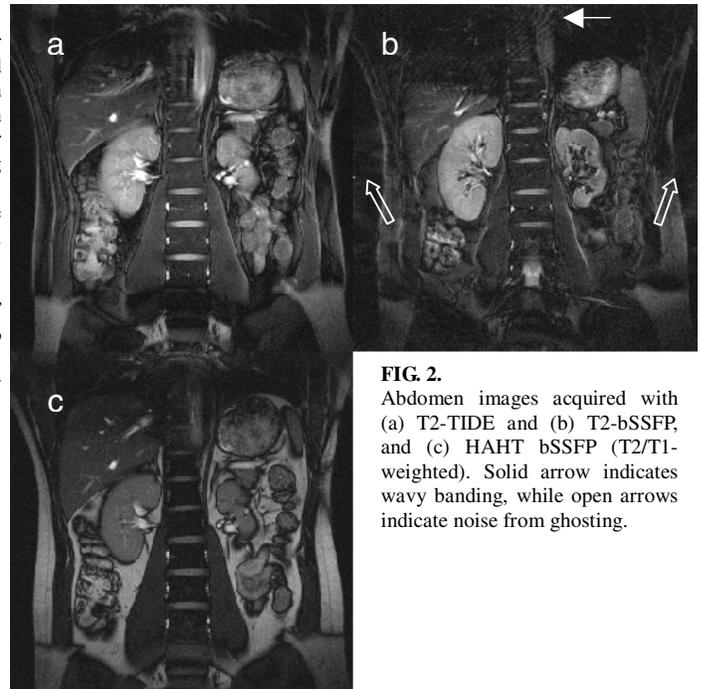


FIG. 2. Abdomen images acquired with (a) T₂-TIDE and (b) T₂-bSSFP, and (c) HAHT bSSFP (T₂/T₁-weighted). Solid arrow indicates wavy banding, while open arrows indicate noise from ghosting.