Fast Multislice T_2-weighted Image Assessment of Brain with TIDE bSSFP Imaging

Y-C. K. Huang[1,2], C-J. Juan[2], H-C. Chang[3], H-S. Liu[2], T-Y. Huang[4], H-W. Chung[1,2], C-Y. Chen[2], and G-S. Huang[2]

[1]Department of Electrical Engineering, National Taiwan University, Taipei City, Taiwan, [2]Department of Radiology, Tri-Service General Hospital, Taipei City, Taiwan, [3]Applied Science Laboratory, GE Healthcare Taiwan, Taipei City, Taiwan, [4]Department of Electrical Engineering, National Taiwan University of Scienece and Technology, Taipei City, Taiwan

Introduction

In clinical routine, turbo or fast spin echo (TSE or FSE) sequence is used as the standard T_2-weighted imaging sequence [1]. The scan time usually takes several minutes for multislice imaging along any anatomical orientation. Obtaining all three-orientation (transverse, coronal, and sagittal) multislice information using TSE is not practical because of the long scan time. To acquire such images in a short period, a fast imaging technique is needed. Transition into Driven Equilibrium balanced steady-state free precession sequence (TIDE bSSFP, simply referred to as TIDE) [2] has been shown to carry T_2 weighting as well as intrinsic fat suppression [3, 4]. The scan time of TIDE is approximately one second for a single slice scan. For a slice number of 20, a set of three-orientation scans takes only one minute or so. In this study, we propose to use TIDE for fast three-orientation multislice T_2-weighted image assessment of the brain, as a supplement to the standard TSE examination along one anatomical orientation. We quantitatively compared the image quality of TIDE with two other T_2-weighted sequences, TSE and TGSE (GRASE) [5], by means of region of interest (ROI) analysis in brain tissues. The evaluations include signal intensity (SI), signal-to-noise ratio (SNR), and gray-white matter contrast-to-noise ratio (CNR).

Materials and Methods

Six volunteers (3 men & 3 women) as well as a female patient with stoke history were enrolled in this study. All images were acquired on a 1.5T system (Siemens Vision Plus, Erlangen, Germany). The sequences we used were T_2-TSE, T_2-TGSE, and TIDE bSSFP. TR/TE of TSE and TGSE were 3800/90 ms, while TR/TE of TIDE were 6.46/3.23 ms. TIDE-specific parameters were #180°-pulse = 1, #ramp-step = 4, and bSSFP flip angle = 90° [2, 3, 4]. Half-Fourier function was applied to acquire T_2 contrast as well as fat suppression of TIDE [3, 4]. To obtain similar image patterns, built-in fat-suppression (FS) was applied for the commercial TSE and TGSE sequences. The matrix size of TSE and TGSE is 256×250, locked by the vendor. The matrix size of TIDE is 256×256. Common parameters were: slice thickness = 4 mm, FOV ~ 240 mm. ROI analysis for image quality evaluation was performed off-line with MATLAB software. Two-tail t-test was used for statistical analysis with a *p*-value less than 0.05 regarded as statistically significant.

Results

Figure 1 demonstrates an axial image of a healthy man at the level of globus pallidus. The gray-white matter contrast was similar in all sequences except for the globus pallidus, of which the SI was much higher in TIDE bSSFP (**Fig. 1c**) that in FS-T_2-TSE (**Fig. 1a)** and FS-T_2-TGSE (**Fig. 1b**). **Table 1** showed the ROI evaluation of anatomical structures of six volunteers, including gray matter (GM; putamen and thalamus), iron-containing gray matter (ICGM; globus pallidus), and white matter (WM; centrum semiovale, corona radiata, and periventricular white matters). **Figure 2** shows an old infarction of the female patient at left corona radiata. The hyperintensity of the lesion is similar in FS-T_2-TSE, FS-T_2-TGSE, and TIDE bSSFP (**Fig. 2a, 2b, 2c**, respectively). **Figure 3** depicts a late subacute hematoma involving the right corpus striatum in the same patient. The hematoma was clearly demonstrated in both FS-T_2-TSE and TIDE bSSFP images.

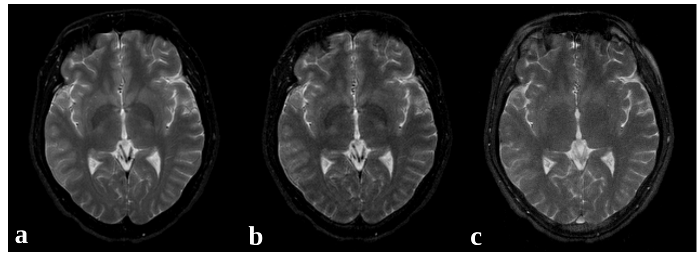

FIG. 1. Axial images of a healthy man at the level of the globus pallidus: (a) FS-T_2-TSE, (b) FS-T_2-TGSE, and (c) TIDE bSSFP.

	FS-T_2-TSE	**FS-T_2-TGSE**	**TIDE bSSFP**	***p*-value TSE&TIDE**
Scan Time (sec)	193	193	24	
SI GM	562.6 ± 17.3	524.5 ± 21.2	870.5 ± 33.5	<0.05
SI ICGM	448.5 ± 7.0	417.6 ± 3.9	782.8 ± 6.7	<0.05
SI WM	504.0 ± 22.1	465.4 ± 21.0	702.8 ± 49.2	<0.05
Noise	18.4 ± 1.6	32.5 ±3.6	38.9 ± 4.8	<0.05
SNR GM	57.6 ±1.8	30.1 ± 1.2	30.7 ± 1.2	<0.05
SNR ICGM	46.1 ± 0.7	24.1 ± 0.2	27.7 ± 0.2	<0.05
SNR WM	51.6 ± 2.3	26.7 ± 1.2	24.8 ± 1.7	<0.05
CNR GM-WM	6.0 ± 2.7	3.4 ± 1.6	5.9 ± 2.0	**>0.05***
CNR ICGM-WM	-5.5 ± 2.3	-2.7 ± 1.2	2.9 ± 1.7	<0.05

TAB. 1. Results of the ROI evaluation of anatomical structures of the six volunteers using FS-T_2-TSE, FS-T_2-TGSE, and TIDE bSSFP. The scan time, SI, noise, SNR, and CNR are listed (means ± S.D.). The abbreviations: GM, (common) gray matter; ICGM, iron-containing gray matter; WM, white matter. *p*-values between TSE and TIDE are also listed, in which CNR between GM and WM is equivalent in both sequences. *, the *p*-value is 0.91.

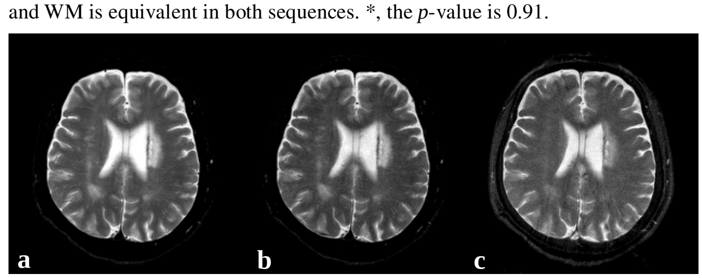

FIG. 2. Axial images of a female patient with stroke history: (a) FS-T_2-TSE, (b) FS-T_2-TGSE, and (c) TIDE bSSFP. A similar hyperintense lesion at left corona radiata shows up in all three images.

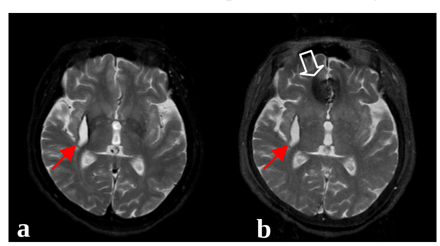

FIG. 3. The image results of the same patient in Fig. 2 showing a late subacute hematoma (red arrow): (a) FS-T_2-TSE, (b) TIDE bSSFP. An artifact (open arrow) can be seen in TIDE bSSFP due to magnetic susceptibility.

Discussion and Conclusion

Results from this study suggest that TIDE bSSFP is capable of acquiring fat-suppressed T_2-weighted multislice images at a much shorter scan time than TSE or TGSE sequences. The SNR of TGSE and TIDE is about half of that in TSE, similar to the results in Ref. [5]. Lower SNR of TIDE can result from the use of Half-Fourier function and a higher receiver bandwidth. The CNR between GM and WM, however, is equivalent in TSE and TIDE. The CNR of ICGM subtracting WM is somewhat different: the value of TIDE is positive while those of the other two are negative. This may result from that bSSFP pulsing brings along some T_1 relaxation effect, which makes TIDE less influenced by iron compounds. Intrinsic fat suppression of TIDE is not as good as the built-in FS function in this study, possibly due to sampling center *k*-space slightly earlier than the off-resonance signal null [4]. Also in this study, it is found that TIDE is prone to magnetic susceptibility effect from air sinuses of inferior slices, showing an artifact of local signal drop. This is suspected to come from its gradient-echo nature. Nevertheless, considering that TIDE has a short scan time and its ability to detect pathological changes, this technique is still beneficial as a fast brain imaging. In conclusion, TIDE bSSFP can be used as a fast image assessment tool to screen pathological changes in the brain in supplement to the standard TSE examination.

References

1. Hennig J, *MRM* 1986;6:823 **2.** Hennig J, *MRM* 2002;48:801 **3.** Huang YC, *ISMRM* 2006 #2413 **4.** Huang YC, *ISMRM* 2006 #633 **5.** Fellner F, *EJR* 1995;19:171