Fast T2 weighted imaging with PSIF in the abdomen at 3T

Chao Zou[1], Wensha Guo[1], Xin Liu[1], and Yiu-Cho Chung[1]

[1]*Paul C. Lauterbur Research Center for Biomedical Imaging, Shenzhen Key Laboratory for MRI, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong, China*

Introduction T_2 weighted (T2W) MR images are valuable in detecting various focal lesions in abdominal studies [1]. The long acquisition time of traditional T2W turbo spin echo (TSE) requires respiratory triggering or multiple breath-holds to suppress motion artifact. When patients cannot hold breath, HASTE (Half Fourier single shot turbo spin echo) is a popular alternative. However in high field (≥ 3T) system, B_1+ field inhomogeneity may introduce nonuniformity in images [2], and SAR constraint may limit the refocusing flip angle in HASTE for free breathing applications, reducing the SNR/CNR of the images. Time reversed FISP (PSIF or CE-FAST) has been used to provide good T_2 contrast in abdominal studies at 1.5T but the 3D acquisition is needed to improve SNR [3]. It is also used for interventional guidance at 0.2T where spatial resolution was compromised for SNR [4]. In light of the need for a low SAR sequence for free breathing T2W abdominal imaging at 3T, we investigate the feasibility of PSIF as an alternative to HASTE for this application. We hypothesize that the high SNR at 3T would improve the SNR of 2D PSIF so that it can be used for single shot T2W imaging for the abdomen.

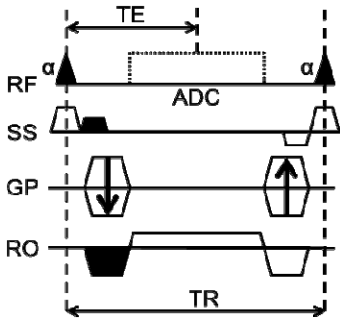

Figure 1: 2D PSIF sequence used in the study. The gradient in SS (filled in black) is used to crush FID. The readout gradients are balanced to reduce motion sensitivity.

Materials and Methods The revised PSIF sequence used in our study is shown in Figure 1 [4]. An additional spoiler gradient is applied along slice select direction to crush the FID component of the SSFP signal. The gradient in readout direction is fully balanced to reduce motion sensitivity. The PSIF signal equation [4] was used to investigate the optimal flip angle (FA) that gave the best SNR and spleen-liver contrast in this sequence. Parameters used in the simulation were: TR/TE = 5.0/3.2ms, T_1/T_2 of liver = 1000/40ms, T_1/T_2 of spleen = 1500/65ms. The signal curve was verified by a volunteer study conducted on a 3T system (TIM Trio, Siemens, Erlangen, Germany). Four volunteers (all with informed consent) were scanned by 2D PSIF and HASTE. The protocols used are listed in Table I. Body and spine matrix coils were used for signal reception. Fifteen slices were acquired within a single breath-hold (10s) for both sequences (to facilitate image comparison). For PSIF, TR was chosen as the shortest one in the given bandwidth to increase the signal available for collection, and FA varied from 10^o -70^o. The TR of HASTE was chosen so that the two sequences had the same acquisition time per slice (650ms). PSIF with 1-1 water excitation was also tested in the abdomen for its ability to suppress fat signal.

Table 1: protocols of HASTE and PSIF used in volunteer study.

	HASTE	PSIF
Voxel size	2.0×1.5×6.0 mm^3	
FOV	384 mm	
Slices	15	
Bandwidth	780 Hz/pixel	
Flip Angle	140^o	10^o -70^o
TR/TE (ms)	650/53	5.0/3.2

Results Figure 2 shows the relationship between signal intensity of liver and spleen (normalized) to FA from simulation and volunteer study. Simulation study shows that FA of around 20^o-30^o gives best liver SNR and spleen liver CNR, and the volunteer study agrees with the simulation. The SNR of liver is 16-18 for PSIF, and the CNR of spleen to liver is 16-19 in all four volunteers. Figure 3 shows typical 2D PSIF and HASTE images in one volunteer. The arrow indicates a hemangioma found in the volunteer that shows up well in all three images. Intra-hepatic vessels are usually dark in PSIF while they are most often bright in HASTE.

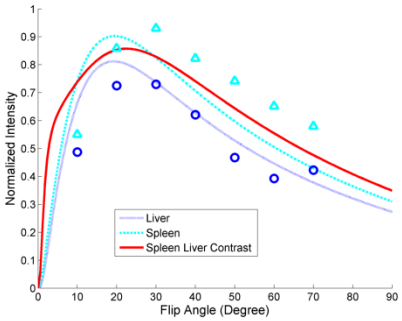

Figure 2: relationship of FA to signal intensity in simulation and volunteer study. Solid lines represent simulation results, blue circles and cyan triangles represent liver and spleen signal in volunteer study

Discussion The optimal FA that gives best CNR between spleen and liver in our study is different from the empirical finding from [3], which may be due to the different relaxation parameters of the organs at 1.5T and 3T. Volunteer study also confirmed that when FA is less than 15 degree, the signal is too sensitive to FA. FA between 20^o-30^o for PSIF would give images with better SNR/CNR at 3T. In contrast to the refocusing flip angle used in HASTE, which is usually 120^o or higher, the low flip angle that gives optimal contrast between liver and spleen is much less demanding on the performance of RF system and transmit coils and is highly desirable for 3T abdominal imaging. Also, the use of water excitation pulse in PSIF for fat suppression may help reduce SAR. The hypointensity of vessels in PSIF also may help the detection of small hepatic lesions. Quantitative analysis shows that though HASTE images have higher SNR and CNR, 2D PSIF images have sufficiently high SNR/CNR for diagnostic imaging of the abdomen at 3T (Figure 3). SNR can be increased by averaging. The speed advantage of 2D PSIF also makes it a useful tool for the assessment of tissue ablation during thermotherapy or interventional procedures.

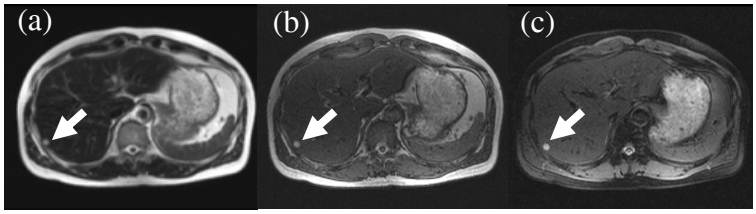

Figure 3: HASTE (a), PSIF (b) and PSIF with water excitation (c) in abdomen

Conclusion While both HASTE and PSIF are fast sequences suitable for free-breathing examinations, preliminary study here shows that PSIF offers good T_2 contrast in abdominal study at 3T with a much lower SAR compared to HASTE. The sequence may find more applications in higher field systems.

References [1] Klessen C et al., JMRI 21: 576, 2005; [2] Merkle EM et al., AJR 186:1524, 2006; [3] Taupitz M. et al., Radiology 194:439, 1995; [4] Chung YC et al., MRM 42: 335, 1999; [5] Hanicke W et al., MRM 49: 771, 2003;

Acknowledgement This research is supported by 973 Basic Research Program of China (No. 2011CB707903) and Guangdong Innovation Team.