REMEMBER PSIF? A 2-SECOND IMAGING METHOD FOR T2 CONTRAST AT 7T

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Introduction Ultrahigh field imaging at 7T can offer higher SNR, improved contrast, and enables better diagnosis of diseases like multiple sclerosis and brain tumors [1]. However, two important issues are hampering clinical applications requiring T2 contrast. Firstly, SAR increases with field strength in a quadratic way and patient safety limits the flip angles of RF pulses in SE based sequences, especially T2 weighted TSE. Secondly, B1+ field inhomogeneity at 7T produces signal and contrast non-uniformity in images [2], making clinical diagnosis challenging. Local heating may even occur at high flip angles. Here, we propose to use PSIF (aka CE-FAST) [3, 4] for T2 imaging at 7T. The technique uses short TR and low flip angle. It is therefore faster and more importantly, much less demanding than conventional TSE in terms of SAR limits and B1+ field homogeneity. Our first results showed that without any hardware improvement, the technique gives T2 weighted images with submillimeter spatial resolution in about 2 seconds. It robustness makes it well suited for clinical imaging at 7T.

Materials and Method Sequence PSIF is a SSFP technique where only the spin echo part in the steady state signal is collected [3]. Its T2 contrast comes from the long T2 decay extending over multiple TR cycles. The sequence has low SNR, and so would benefit from the high SNR at 7T. Fig.1 shows the sequence implementation used [4].

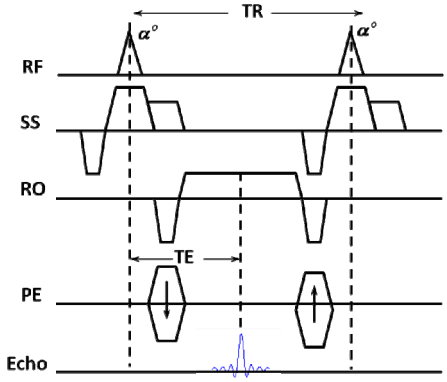

Fig.1: The 2D PSIF sequence used in this study.

Volunteer study A 7T system (MAGNETOM 7T, Siemens, Erlangen, Germany) equipped with a head coil (1 quadrature transmit and 24 parallel receive channels, from Nova Medical Inc., MA, USA) was used. The sequence was first tested on phantoms, and then on 3 healthy volunteers (all with informed consent) in two different sessions (A and B) where interleaved 2D TSE (iPAT 2) and multislice 2D PSIF were compared (9 slices of 4mm thick were acquired). SNR of white matter (WM) and CNR between grey matter (GM) and WM for the central 3 slices were measured (signals normalized by voxel size when spatial resolutions differ). Table 1 shows the imaging parameters.

Table 1: Imaging parameters used in 2DPSIF and 2DTSE comparison (sessions A and B). In session B, interpolation was used in selected 2DTSE scans.

	TR/TE	Scan time	Bandwidth	Flip angle	Resolution
PSIF (A)	4.6/2.4ms - 4.8/2.5ms	1.5-2s per slice	558-579Hz/px	23°	256x256
PSIF (B)				36°-40°	256x256 / 320x320
TSE	6s/92ms	1min	220Hz/px	120°	320x320

Results In session A of the experiment, a 180s delay was needed so that a 120° refocusing pulse in 2DTSE could be used. In session B, the system failed to set the transmit voltage. It was therefore manually set to ~250V, and a higher flip angle was used. Fig.2 shows 2 typical images from 2DTSE and 2DPSIF from the study. Vessels appeared slightly different in the 2 images In session A, average SNR of WM from 2DPSIF and 2DTSE were 32 and 97.55 respectively. The CNR between GM and WM for 2DPSIF and 2DTSE were 19 and 70.7 respectively. In session B, average SNR of WM from 2DPSIF and 2DTSE were 29.7 and 60.3 respectively while the CNR between GM and WM for 2DPSIF and 2DTSE were 17.5 and 36.8 respectively. Fig.3 shows another image set from the two techniques. The dark shading on the right side of the brain in the 2DTSE image, due probably to B1 transmit field inhomogeneity, did not appear in the 2DPSIF image.

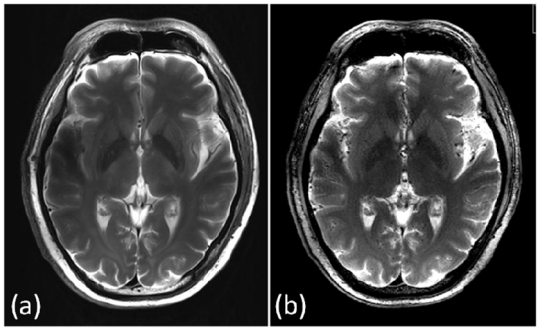

Fig.2: Images from (a) 2DTSE and (b) 2DPSIF. Spatial resolution = 0.68mm x 0.68mm, 4mm thick.

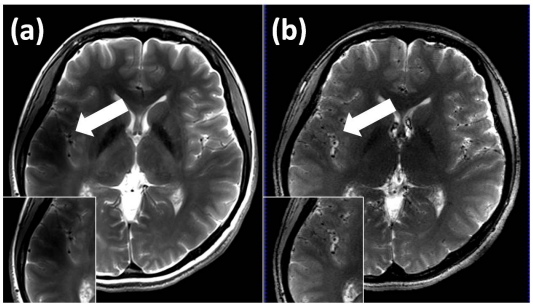

Fig.3: Another image set from (a) 2DTSE and (b) 2DPSIF. Signal inhomogeneity at the white arrow region obscure depiction of anatomical structures. That part was well depicted in (b).

Discussion Both Fig.2 and the SNR/CNR for PSIF at 7T showed that though PSIF has lower SNR compared to TSE, the sequence's WM SNR of around 30 and CNR between GM and WM of about 17 is clinically sufficient for diagnostic purpose even at submillimeter resolution (0.68mm in this case). Different flow properties of PSIF and TSE may account for the different appearance of vessels in the images. Use of PSIF instead of TSE at 7T would mean reduced energy deposition to patients, less stringent requirements on RF systems, shortened scan time and improved sequence robustness. 2DPSIF is also less motion.sensitive. 3DPSIF may offer higher SNR but motion robustness may be compromised.

Conclusion PSIF gives good T2 contrast at a low flip angle, and is therefore insensitive to B1+ imperfections and SAR constraints. The use of short TR also makes it fast. At 7T, the SNR and CNR of PSIF are good enough for diagnostic purpose. Its speed and robustness make it a good choice for T2 weighted imaging of the brain at 7T.

References [1] van der Kolk AG et al., EJR, Sep 19, 2011 (Epub); [2] Collins CM et al., JMRI 21:192, 2005; [3] Gyngell, ML, JMR 81:474, 1989; [4] Chung YC et al., MRM 42: 335, 1999;

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