Faster Sodium MRI through TPI-SENSE: Results at 7T

Y. Qian[1], G. Wiggins[2], L. L. Wald[2], and F. E. Boada[1]

[1]Department of Radiology, University of Pittsburgh, Pittsburgh, PA, United States, [2]Department of Radiology, Massachusetts General Hospital, Massachusetts, MA, United States

INTRODUCTION

Sensitivity encoding (SENSE) parallel imaging with the twisted projection imaging (TPI) trajectory has potential for significantly accelerating data acquisition due to the true three-dimensional nature of the trajectory design. Previous work has shown that the TPI approach offers higher acceleration performance than conventional Cartesian implementations of SENSE (1-3). In sodium (^{23}Na) MRI, TPI-SENSE allows acquisitions of higher pitch data sets without much increase in readout time, leading to less loss of signal-to-noise ratio (SNR) and less blurring of image from the fast transverse relaxation of the sodium nucleus. This abstract presents, for the first time, the TPI-SENSE technique for accelerating sodium imaging of human brain on a whole-body 7T MRI scanner with a 15-channel array coil. Our results demonstrate that a six-fold acceleration is achievable without significant loss of image quality.

METHODS AND MATERIALS

Healthy volunteers were scanned on a whole-body 7T scanner (Magnetom Tim 7T, Siemens Medical Solutions, Erlangen, Germany) with a home-built 15-channel ^{23}Na array coil (Fig. 1a) using the TPI-SENSE data acquisition scheme (Fig. 1b-c). The k-space was sampled in a spherical volume (Fig. 1b) using a group of concentric cones on which the TPI trajectories were rotated so that constant sample density is achieved. Accelerations in data acquisition were obtained by skipping some of the cones and rotations (Fig. 1c). The TPI-SENSE image reconstruction was implemented offline using the self-calibration method (4) in which the conjugate gradient (CG) iterative algorithm for non-Cartesian trajectories was used (5).

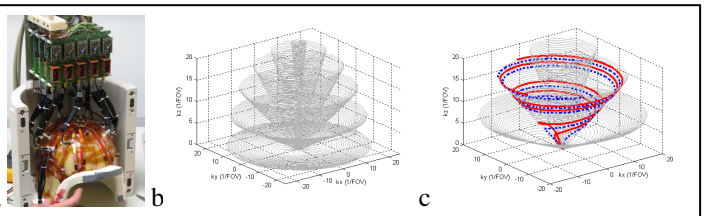

Fig. 1. a) 15-channel Tx/Rx sodium array coil at 7T. b-c) Conceptual diagram of the TPI-SENSE sampling in the k-space: b) the upper-half k-space sphere fully sampled with cones and TPI rotations on the cones and c) a 2x reduction in cones and 2x reduction in rotations by skipping every other rotation (red or blue TPI projection).

RESULTS AND DISCUSSION

Figure 2 shows TPI-SENSE brain images of a healthy volunteer at slice #30 out of 64 slices All image reconstructions converged within 19 CG iterations at δ<0.0001. Specifically, the r11 image (i.e., the image with no acceleration) was converged at the 6th iteration, the r13 image at the 11th iteration, the r23 image at the 8th iteration, the r15 image at the 19th iteration, but the r25 image at the 10th iteration. In Figure 2 (bottom) the difference images between the accelerated (r12-r25) and reference (r11) images show that the undersampling artifacts are visible at r14, r15, r24, and r25, suggesting that these accelerations may not be acceptable due to their large residual artifacts. For the image error measurements, a region of interest (ROI) covering the whole brain (red circle) was selected. The mean image error at r14 (Fig. 3) is almost the same as that at r23. The SNR performance of TPI-SENSE sodium MRI could not be assessed due to lack of the background noise. A region of support was used in the CG reconstructions, which excluded the background in order to accelerate the iterative process. Consequently, the measured image error contains bias and noise components that cannot be independently ascertained in the current study. The separation can, however, be performed using Monte Carlo simulations as we did in Ref. 1. *In conclusion*, TPI-SENSE sodium MRI with a 15-channel array coil has been shown to have the potential for yielding an acceleration of up to 2×3 without a significant degradation in image quality (image error of 6.6%).

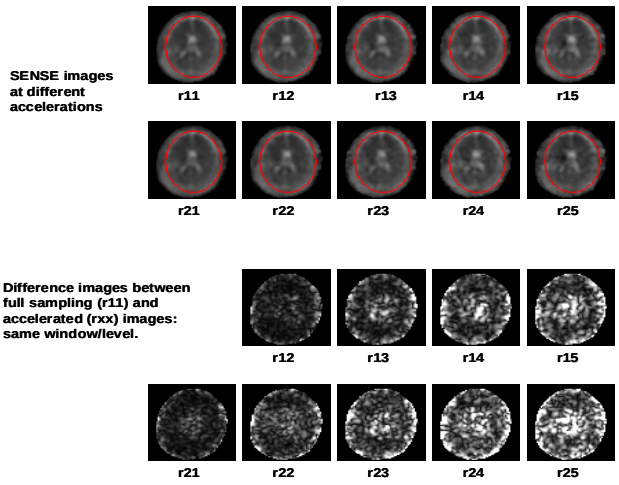

Fig. 2. **Top**: TPI-SENSE sodium brain images of a healthy volunteer at different accelerations r11-r25 in ring x rotation. **Bottom:** the difference images between the accelerated images and the fully-sampled image (r11). The red circles indicate the regions of interest (ROIs). Acquisition parameters: hard RF= 0.8ms, flip angle=90º (nominal), TR/TE=100/0.52ms, averages=4, FOV=220mm, matrix size=64×64×64, rings=22, p=0.4, total TPI projections=980 for full sampling.

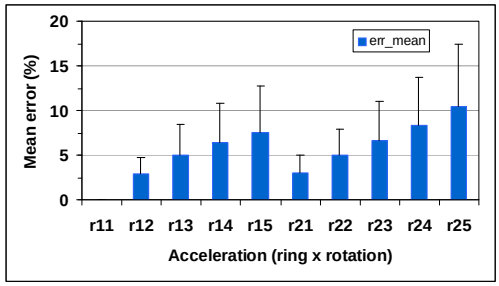

Fig. 3. Image error of the accelerated images in Fig. 2. The mean error in the ROI (defined in Fig. 2) at r23 (6.6%) is almost the same as that at r14 (6.4%), indicating a large acceleration number of 2x3 is achievable.

REFERENCES [1] Qian Y, etc. ISMRM 2006; p11. [2] Qian Y, etc. ISMRM 2006; p3381. [3] Qian Y, etc. ISMRM Non-Cartesian Workshop 2007; poster#20. [4] Qian Y, etc. MRM 2004; 52:688-692. [5] Pruessmann KP, etc. MRM 2001; 46:638-651.