Multiband Slice Accelerated TSE: Clinical Applications in Brain imaging

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Purpose: Turbo spin echo (TSE) is the most widely used clinical sequence for generating T2-weighted contrast in head and neck imaging at all clinical field strengths, especially with high in-plane resolution. TSE sequences offer efficient acquisitions through multiple refocusing RF pulses and echoes; however, the minimum TR of TSE sequences can be long even for limited numbers of slices and moderate echo train length (ETL). At typical clinical field strengths ≤ 3T, a TR longer than 3500 ms is considered sufficient for T2-weighted imaging. An even longer TR (necessitated by e.g. more numbers of slices) provides little SNR benefit from increased relaxation, but reduces acquisition efficiency and increases motion sensitivity. Recently developed multiband slice acceleration techniques that simultaneously excite, acquire, and unalias multiple slices [1-3], can reduce volume acquisition time (TR), and may be extended to SE/TSE imaging [4]. Multiband slice acceleration can be used to acquire more slices per TR, or reduce TR for the same slice coverage, or lengthen refocusing echo train for the same TR and slice coverage. Multiband slice acceleration offers two potential advantages over conventional in-plane parallel imaging: no SNR loss associated with signal under-sampling, and reduced g-factor penalty with multi-slice CAIPIRINHA [2] related to the utilization of both phase and slice coil encoding capability. In our study, we demonstrate a new multiband slice accelerated TSE sequence with gradient based CAIPIRINHA [5] and compare it to a traditional TSE sequence for T2-weighted brain imaging at 3T.

Methods: Brain imaging experiments were performed on 3 subjects using a 3.0T Siemens clinical MRI scanner (MAGNETOM Trio; Siemens Healthcare, Erlangen, Germany) with a 32-channel receive-only head coil. Multiband RF pulses were generated for simultaneous multi-slice excitation and echo refocusing. The VERSE technique was applied to the RF pulses to reduce peak power and SAR. A low resolution multislice 2D GRE scan (TA ≈ 6 seconds) was used as the reference scan to obtain the coil sensitivities [4]. Imaging parameters for the TSE scans were as follows: FOV = 230×230 mm^2, matrix size = 384×384, slice thickness = 3 mm, voxel size = 0.6×0.6×3 mm^3, total slices = 36, axial orientation, 25% slice spacing, hyperecho TSE, excitation/refocusing flip angle = 90º/120º, readout bandwidth = 207 Hz/pixel, ETL = 16, echo spacing = 12 ms; Multiband Slice Accelerated TSE: slice acceleration factor = 2, CAIPIRINHA FOV shift factor = 2; TR/TE = 3700/110 ms; Standard TSE: TR/TE = 7310/110 ms. iPAT acceleration factor of 2 and 4 were tested to compare with slice acceleration. Image reconstruction was performed online at the console. Gray matter/white matter (GM/WM) contrast-to-noise ratio (CNR) was compared.

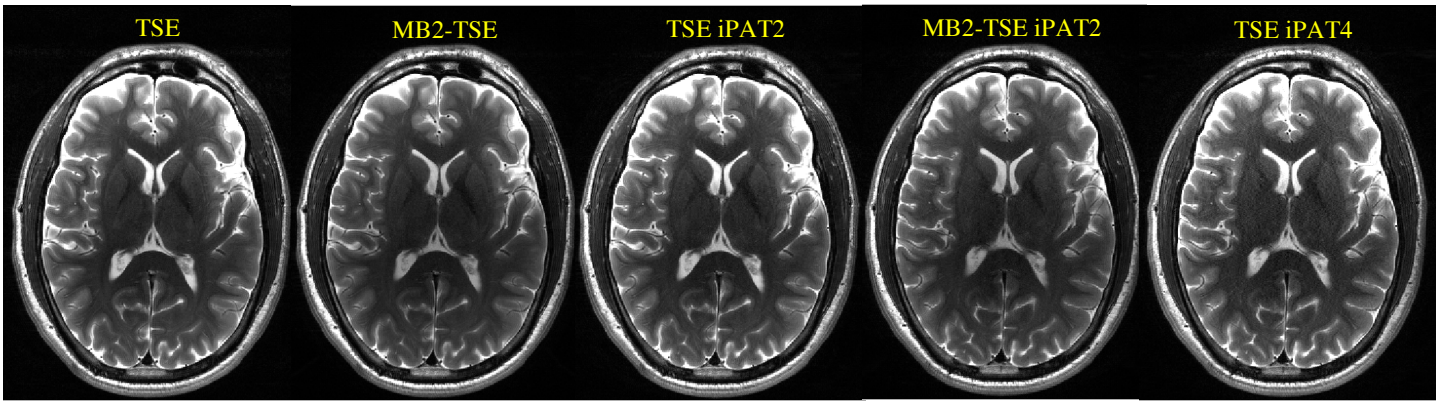

Figure 1. Representative traditional TSE and MB-TSE T2-weighted images of the brain. Even with shorter TR and acquisition time, the MB-TSE images have very similar T2-weighted contrast as the traditional TSE images, except for the cerebrospinal fluid region.

Results: All multiband slice accelerated TSE sequences were executed within SAR safety guideline. Figure 1 shows representative traditional TSE and multiband slice accelerated TSE T2-weighted images of the brain. Slice acceleration can be combined with in-plane parallel imaging to achieve higher total acceleration factor. With at least 50% reduction in imaging time, multiband slice accelerated TSE demonstrated very similar results as standard TSE. There are no visible artifacts or residual aliasing in the reconstructed images. The image contrast is identical between the standard reference and the slice accelerated TSE scans, both with strong T2 weighting (Fig. 1). Table 1 compares the acquisition time and GM/WM CNR between traditional TSE and multiband TSE. Multiband slice acceleration allows high total acceleration factor to achieve short scan time, while maintaining SNR/CNR better than in-plane parallel imaging alone. These results support the utility of multiband slice acceleration as a complementary and/or alternative solution to traditional 1D parallel imaging for time reduction.

Table 1. Comparison of acquisition time and GM/WM CNR between standard TSE and multiband TSE

	TSE	MB2-TSE	TSE iPAT2	MB2-TSE iPAT2	TSE iPAT4
Acquisition Time	**2 min 48 sec**	**1 min 25 sec + 6 sec**	**1 min 28 sec**	**45 sec + 6 sec**	**52 sec**
GM/WM CNR	40.1	35.7	32.8	27.1	23.6

Conclusion: Our study demonstrates the application of multiband slice accelerated TSE for T2-weighted brain imaging at 3T. Multiband slice acceleration improves the acquisition efficiency of TSE. Very similar image quality can be achieved in shorter acquisition time. Future studies need to evaluate the diagnostic accuracy of multiband slice accelerated TSE.

References: [1] Larkman, JMRI 2001 [2] Breuer MRM 2005 [3] Moeller, MRM 2010 [4] Wang, ISMRM 2013 [5] Setsompop MRM 2012

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