T1-weighted Imaging of Lumbar Spine using Multiband Slice Accelerated Spin Echo

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Introduction: Spin-echo based sequences are frequently used for T1-weighted imaging of the brain and spine at all clinical field strengths. In the spin echo class of sequences, although a spin-echo (SE) sequence provides a pure T1 contrast, a turbo spin echo (TSE) sequence is frequently used because the imaging efficiency of SE techniques is low. TSE sequences offer faster acquisitions, but with some tradeoffs. Since TSE sequences have multiple refocusing pulses for each excitation pulse, the contrast is not purely T1, while also introducing T2 blurring. Due to multiple refocusing pulses and echoes, the minimum TR also is longer for TSE sequences than for SE. A relatively short TR (400 – 800 ms) is generally preferred for good T1 contrast at 3T, with the shorter TR's providing better T1 contrast practically. The restriction on minimum TR in TSE then limits the numbers of slices that can be acquired in one TR. Although more slices can be acquired by adding more TR's, the imaging time increases, thereby reducing the efficiency of TSE. A slice accelerated technique which simultaneously excites, acquires, and unaliases multiple slices has recently been demonstrated [1-3]. Such a multiband slice acceleration technique can be extended to spin-echo based measurements, with the advantages of increasing the efficiency of SE techniques, while maintaining the contrast mechanism. While slice acceleration increases the efficiency of the SE sequence 2-3 times and makes it equivalent to the TSE sequence, it maintains a pure T1 contrast, and allows more slices per TR or permits shorter TR's for improved T1 contrast. The challenge with a multibanded slice accelerated SE sequence is to design an efficient reference scan to unalias the simultaneous acquisition of multiple slices. In this study, we demonstrate a new multiband slice accelerated SE sequence with RF based CAIPIRINHA for control aliasing [2] and compare it to a standard TSE sequence for T1-weighted imaging at 3T.

Methods: Lumbar spine imaging experiments were performed on 2 subjects using a 3T Siemens MRI scanner (Magnetom Verio; Siemens Healthcare, Erlangen, Germany) with spinal array coil. Multiband RF pulses were generated for simultaneous multi-slice excitation and echo refocusing. Inter-slice multiband RF phase shifting was used to reduce peak power. A low resolution multislice 2D GRE scan (TA ≈ 30 seconds) was used as the reference scan to obtain the coil sensitivities for unaliasing the simultaneously acquired slices. Imaging parameters were as follows: Multiband Slice Accelerated SE: TR/TE = 500 ms / 10 ms, FOV = 280 x 280 mm^2, matrix size = 288 x 384, readout bandwidth = 150 Hz/pixel, slices = 28, excitation/refocusing flip angle = 60 º/160 º, slice thickness = 3 mm, slice acceleration factor = 2, CAIPIRINHA FOV shift factor = 2, TA = 4:29 min. TSE: TR/TE = 700 ms (min. achievable) / 9.4 ms, FOV = 280 x 280 mm^2, matrix size =346 x 384, readout bandwidth = 260 Hz/pixel, slices = 13, slice thickness = 4 mm, excitation/refocusing flip angle = 90 º/150 º, echo train length = 3, iPAT acceleration = 2, averages = 2, TA = 4:50 min.

Results: With similar amount of imaging time, multiband slice accelerated SE can acquire much more number of slices than TSE (28 vs 13 slices). Figure 1 shows the comparison between the multiband slice accelerated SE and TSE images from the first subject. Improved T1 contrast can be seen from multiband slice accelerated SE image than the TSE, which is a result of using shorter TR's permissible with the slice acceleration technique. Figure 2 shows the comparison between the multiband slice accelerated SE and TSE images from the second subject. From both subjects, multiband slice accelerated SE images are artifact free and there is no visible residue aliasing from slice acceleration.

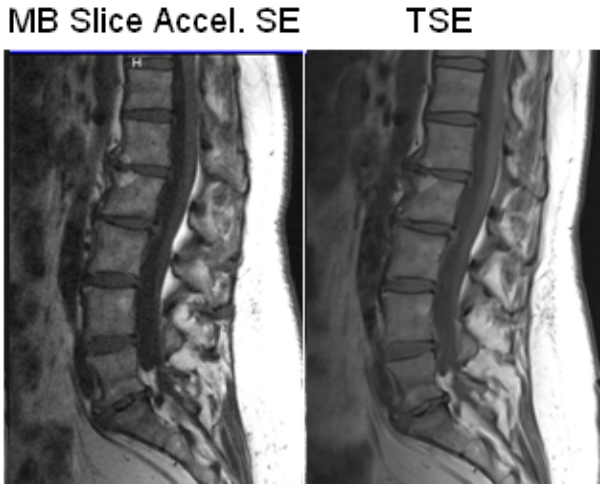

Figure 1. MB-SE and TSE images of the L-spine subject 1. Note the improved T1 contrast as a result of using shorter TR's permissible with the MB SE sequence.

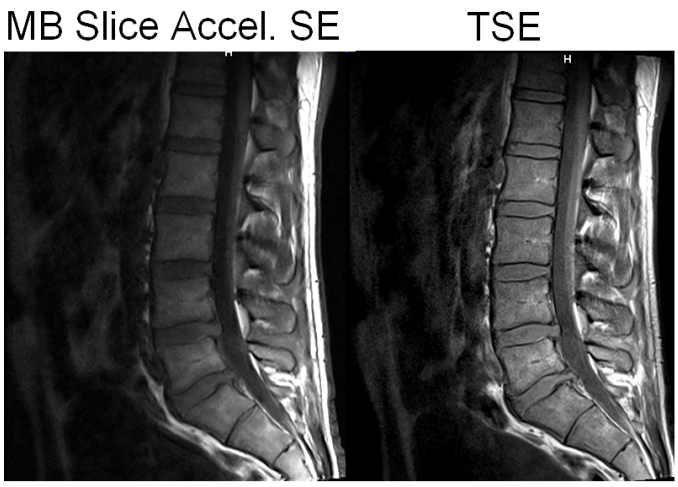

Figure 2. TSE and MB-SE images of the L-spine subject 2. It confirms the result from subject 1.

Conclusion: Our study demonstrates the clinical application of multiband slice accelerated SE for T1-weighted lumbar spine imaging. Better T1 contrast can be achieved with this newly developed sequence than current clinical standard TSE. Future studies need to compare SNR and CNR from multiband slice accelerated SE and TSE with more rigorously matching parameters.

References:

[1] Larkman, JMRI 2001 [2] Breuer MRM 2005 [3] Moeller, MRM 2010.