Improving Slice Resolution of Knee Imaging Using Multiband Slice Accelerated TSE

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Introduction: Typical routine clinical musculoskeletal (MSK) imaging protocols including the knee imaging protocols employ 2D turbo spin echo (TSE) sequences with 3 mm slice thickness. Recently, multiband (a.k.a simultaneous multi-slice) accelerated TSE has been developed [1, 2]. This technique simultaneously excites, acquires, and unaliases multiple slices using parallel imaging method. The benefit of slice acceleration can be materialized in three different directions: (a) saving scan time through shorter TR and/or extending ETL, (b) improving slice resolution with thinner but larger number of imaging slices per TR, and (c) providing better coverage through covering more slices per TR. As multiband imaging bears no signal under-sampling SNR loss and subdued g-factor noise amplification with multi-slice CAIPIRINHA [3], multiband slice acceleration may support higher slice resolution better than conventional in-plane parallel imaging method. It is hypothesized, that multiband slice accelerated turbo spin echo (TSE) can provide higher slice resolution at maintained imaging time for improved image clarity. In this study, we demonstrate the utility of multiband slice accelerated TSE acquisition for improving slice resolution in clinical knee imaging and compare it to routine TSE acquisition at 3T.

Methods: Knee imaging was performed on 2 subjects using a 3T Siemens MRI scanner (MAGNETOM Trio; Siemens Healthcare, Erlangen, Germany) with 15-channel transmit-receive knee coil (QED, Cleveland, OH). Multiband RF pulses were generated for simultaneous multi-slice excitation and echo refocusing. A low resolution multislice 2D GRE scan (TA ≈ 6 seconds) was used as the reference scan to obtain the coil sensitivities [4]. The imaging parameters between multiband and standard TSE were mostly matched except otherwise noticed. Imaging parameters for the TSE scans were as follows: FOV = 140×140-150×150 mm^2, matrix size = 256×205-384×256, 100% phase oversampling, excitation/refocusing flip angle = 90º/150º, readout bandwidth = 170-250 Hz/pixel, echo spacing = 9 -11 ms, in-plane GRAPPA (iPAT) acceleration factor = 2; Sagittal and coronal PD-W: TR/TE = 2500/25 ms, ETL = 7, TA: 1:39 min; Sagittal PD-W with fat saturation: TR/TE = 3500/31 ms, ETL = 7, TA: 2:25 min; **Multiband Slice Accelerated TSE:** slice thickness = 2.5 mm, 40-44 slices, 10% slice spacing; slice acceleration factor = 2, CAIPIRINHA FOV shift factor = 2; Sagittal T2-W: TR/TE = 3090/77 ms, ETL = 11, TA: 1:27 min; Axial T2-W with fat saturation: slice thickness = 3 mm, TR/TE = 4000/52 ms, ETL = 15, TA: 1:15 min; **Standard TSE:** slice thickness = 3 mm, 30 slices, 20% slice spacing; Sagittal T2-W: TR/TE = 2380/77 ms, ETL = 11, restore RF pulse applied, 2 concatenations, TA: 1:59 min; Axial T2-W with fat saturation: slice thickness = 4 mm, TR/TE = 4770/77 ms, ETL = 13, TA: 1:23 min.

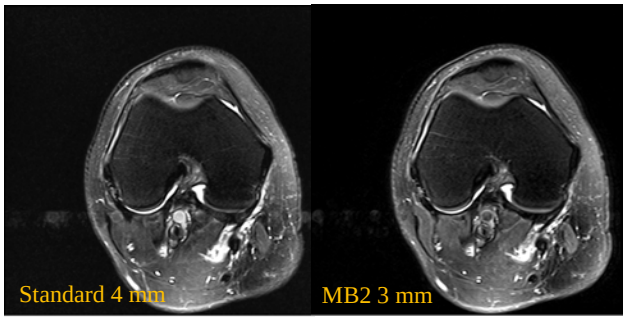

Figure 1. Axial T2-W with Fat Saturation

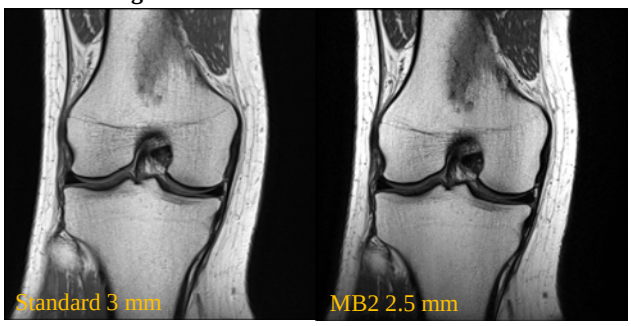

Figure 2. Coronal PD-W

Results/Discussion: Total protocol acquisition times of the five imaging contrasts in three planes were comparable for multiband TSE including reference scan (8:55 min) and standard TSE (9:05 min). With almost equivalent total scan time, the multiband TSE sequence acquired 35% more slices and 20% higher slice resolution than standard TSE, while demonstrating similar high image quality. Representative axial T2-W with fat saturation (Fig. 1), coronal PD-W (Fig. 2), sagittal PD-W (Fig. 3), and sagittal PD-W with fat saturation (Fig. 4) images demonstrate similar contrasts between the corresponding standard TSE and slice accelerated TSE scans. Despite of some minor SNR loss, the higher slice resolution multiband TSE images appear to be sharper and show more details than standard TSE images due to reduced partial volume effect. It is worth noting that the combination of slice acceleration and in-plane parallel imaging works nicely for multiband TSE high resolution knee imaging at 3T.

Conclusion: Our study demonstrates the utility of multiband slice accelerated TSE for improving slice resolution (2.5 mm vs 3 mm) of clinical knee imaging at 3T with no time penalty. Multiband slice acceleration improves the acquisition efficiency of TSE, allowing more number of thinner slices to be covered per TR. Future studies need to evaluate how the higher slice resolution may improve diagnostic accuracy in a standard clinical setting.

References: [1] Wang, ISMRM 2014 [2] Wang, ISMRM 2014 [3] Breuer MRM 2005 [4] Wang, ISMRM 2013

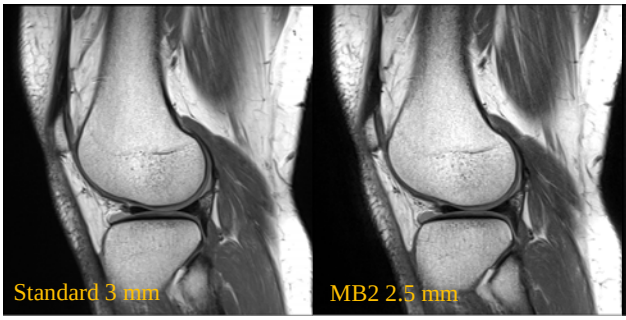

Figure 3. Sagittal PD-W

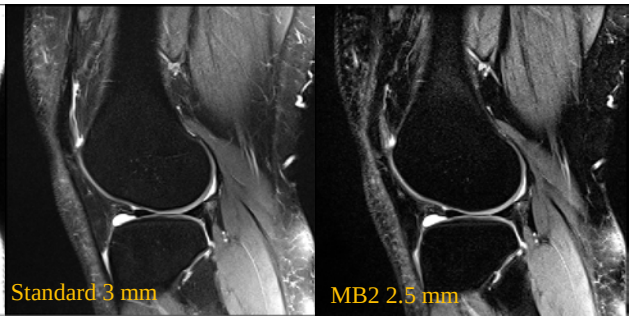

Figure 4. Sagittal PD-W with Fat Saturation

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