

Suppression of Artifacts in Simultaneous 3D T1 and T2*-weighted Dual-Echo Imaging

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Introduction

T₁ and T₂*-weighted images are routinely used in clinical study. Since acquisition of both images in 3D requires a long scan time, it would be beneficial if they can be acquired simultaneously. Although dual-echo can allow us to acquire two images simultaneously, optimal T₁ and T₂* contrast cannot be easily achieved because of the conflicting scan parameters between the two images. This issue could be resolved by an echo-specific k-space reordering scheme [1,2]. However, the echo-specific k-space reordering scheme requires abrupt jumps in scan conditions (e.g., flip angle) between k-space regions, which can potentially cause ringing artifacts. In this study, we propose a strategy to suppress the ringing artifacts in dual echo sequence with an echo specific k-space reordering scheme, by implementing smooth transition regions between the k-space regions with abrupt jumps.

Material and Methods

The experiment was performed on a 3T Siemens Trio Scanner with standard body coil. Two normal male volunteers were scanned for this study approved by IRB. Imaging scan parameters were: TR = 30 ms, TE = 3.73 / 20 ms, acquisition bandwidth = 211 / 50 Hz/pixel, matrix size = 320 × 260 × 20, corresponding field of view (FOV) = 220 × 178 × 100 mm³, slice oversampling = 20 %, and partial Fourier along slice encoding = 6/8, scan time = 2 min 22 sec. The k-space acquisition was reordered as described in [1]. The k-space center regions of the first and second echoes were acquired with flip angles of 25° and 5° respectively. To minimize the potential ringing artifacts, smooth transition regions with flip angle changes of 1° per PE line were added at the beginning of scan and between the two regions with abrupt changes in flip angle as shown in Fig. 1b. Images acquired with proposed technique were compared with images acquired with single echo and images acquired with the dual echo method without the smooth transition.

Results and Discussion

First echo and second echo images acquired with dual-echo sequence without the smooth transition regions showed well conserved T₁ and T₂* contrast but with ringing artifacts along PE1 direction (left column in Fig. 2). The artifacts were effectively suppressed by implementing the proposed smooth transition regions (middle column in Fig. 2), which made the images close to the conventional single echo sequence. Figure 3 shows artifact-free multi-slice T₁ and T₂*-weighted images simultaneously acquired by echo-specific k-space reordered dual-echo imaging with the proposed smooth transition regions. Also, we confirmed that abrupt changes of RF pulse flip angle can generate visible artifacts in the anatomical T₁ and T₂*-weighted images.

The linear shape in the transition regions worked well in this study. When the allowed transition period is short like dynamic scans, however, we may need a better transition scheme (e.g. sinusoidal shape) than the current linear shape, which is beyond the scope of the current study.

Conclusion : Abrupt flip angle changes in echo-specific k-space reordered dual-echo imaging could cause ringing artifacts. The artifacts could be remarkably reduced by implementing smooth transition in the regions of abrupt flip angle changes.

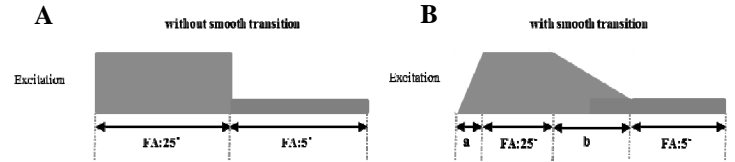


Fig. 1. RF pulse flip angle distributions without (A) and with (B) the proposed smooth transition. The vertical and horizontal axes represent the flip angle and phase-encoding lines, respectively. Note the abrupt jumps in flip angle shown in (A) are reduced by the proposed smooth transition shown in (B).

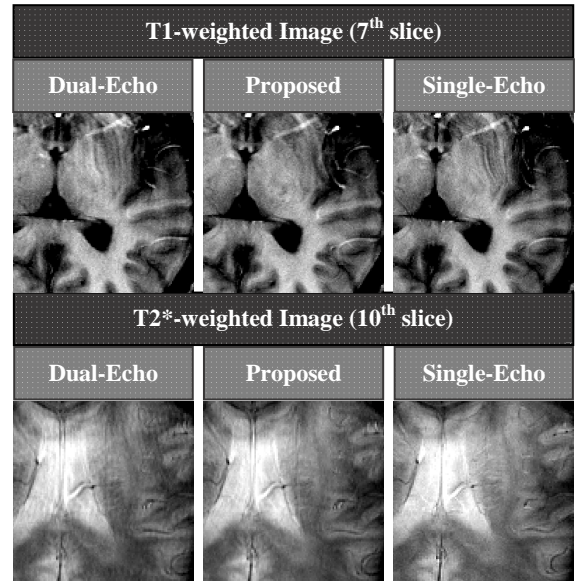


Fig. 2. Magnified T₁ (top) and T₂*-weighted (bottom) images. “Dual-Echo” and “Proposed” respectively represent echo-specific k-space reordered dual-echo imaging without and with the proposed smooth transition regions. “Single-Echo” represents conventional single-echo imaging for separate acquisition of T₁ and T₂*-weighted images

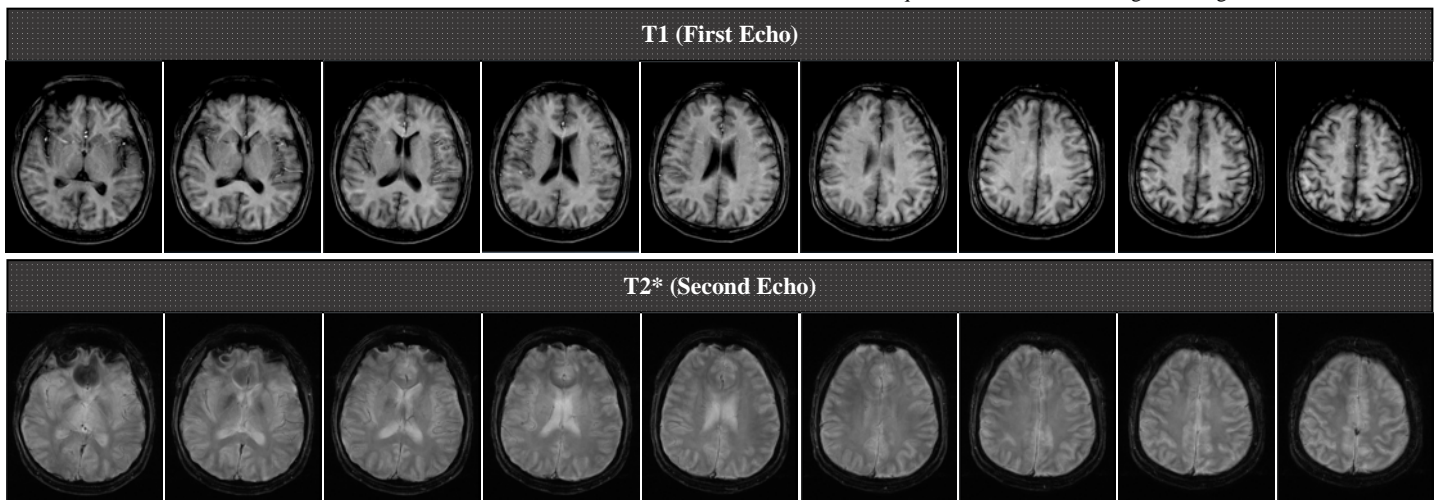


Fig. 3. 3D T₁ and T₂*-weighted images simultaneously acquired with the proposed dual echo sequence with smooth transition (7th ~ 15th slices). ST = 2 min 22 sec.

References

1. Park et al, MRM 61:767-774 (2009).
2. Do WJ et al, ISMRM p1491 (2014).