Simultaneous T1 and T2* weighted 3D Anatomical Imaging using a Dual-Echo Sequence

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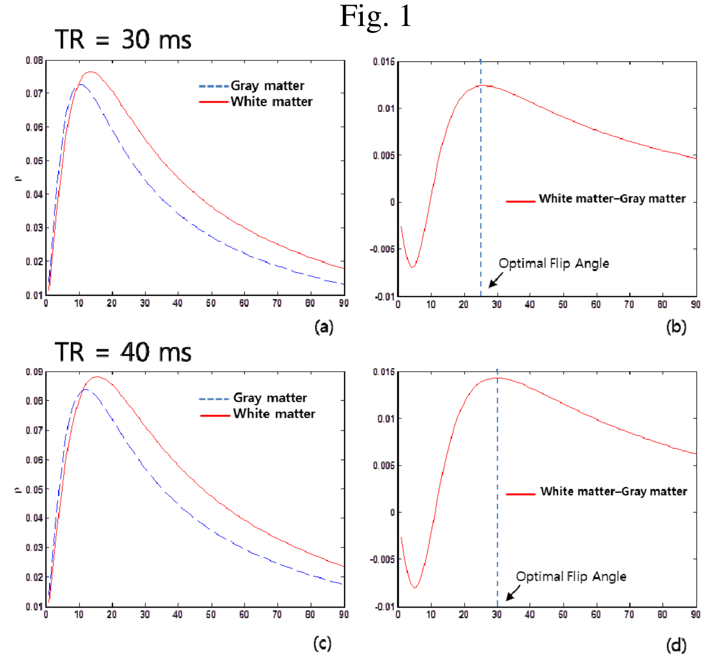
Introduction

T1 and T2*-weighted imaging protocols are commonly used in routine clinical study. Since acquisition of T1 and T2*-weighted images in 3-dimensional high spatial resolution requires scan time of several minutes, and thus it would be beneficial if we can acquire anatomical T1 and T2*-weighted images simultaneously. In this study, we developed a new dual echo sequence that enables us to acquire both 3D T1 and T2* images simultaneously. We implemented an echo-specific K-space reordering scheme (1), to satisfy requirements for both T1 and T2* contrast, and optimized flip angles for T1 and T2*-weighted dual echoes by computer simulations.

Material and Methods

Computer simulations were performed to determine the optimal flip angle that maximizes the T1 signal difference between white and gray matter regions for a given TR. The simulation was performed using MATLAB 2010a. The signal intensities of gray matter and white matter were derived using the equation for the standard gradient echo sequence, over a flip angle range of 0° to 90° for TR = 30ms and 40ms using the following parameters: voxel spin density of gray matter = 0.8, voxel spin density of white matter = 0.65, T1 of gray matter at 3T = 1820 ms, T1 of white matter at 3T = 1084 ms (2). The flip angle that leads to maximum signal intensity difference between white and gray matter regions is found for each TR. Using the optimal flip angle values determined from the simulation study, experiments were performed to acquire dual echo images of T1 and T2*. To satisfy optimal flip angle for both echoes, K-space center regions of the two echoes were acquired at different RF excitations, as shown in the sequence diagram in Fig. 2. The experiments were performed on a 3T Siemens system with 12 channel head RF coil. One normal male volunteer was scanned for the study approved by the Institutional Review Board. Imaging parameters were: TR = 40 ms, time to dual echo (TE) = 3/20 ms, slice thickness = 3 mm, bandwidth = 150/50 Hz/pixel, flip angle = 30°/18°, matrix size = 256 × 192 × 32, FOV = 165 × 220 × 96 mm^2. To avoid wraparound artifact, a slice oversampling (25%) was employed. The total scan time for data set was 3 min.

Fig. 1



The spin density of white and gray matter region is plotted over flip angle for (a) TR = 30ms and (c) TR = 40 ms. The corresponding white and gray matter difference plots are shown in (b) and (d)

Results and Discussion

The optimal angles for T1 contrast between gray matter and white matter were 30° and 25°, when TR = 40 ms and 30 ms, respectively. The contrast was minimized but the signal intensities were relatively high at lower flip angles around 10-20°. Based on the simulation results, we used flip angles of 30° and 18° for the first (T1) and the second (T2*) echoes, respectively, based on the echo-specific K-space reordering method (Fig.2). Figure 3 shows representative 3D anatomical T1 and T2*-weighted images acquired by the proposed method. The proposed method enables us to acquire both 3D T1 and T2* weighted images with scan time of ~3 min and a reasonable spatial coverage and resolution, and thus may be helpful for accelerating routine clinical studies. Further studies are necessary to systematically compare the proposed method with the conventional methods.

References

1. Park et al, MRM 61:767-774. 2. Stanisz et al, MRM 2005;54:507-512.

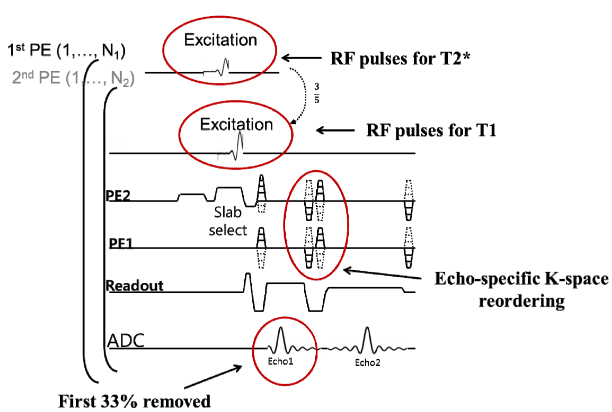


Fig. 2

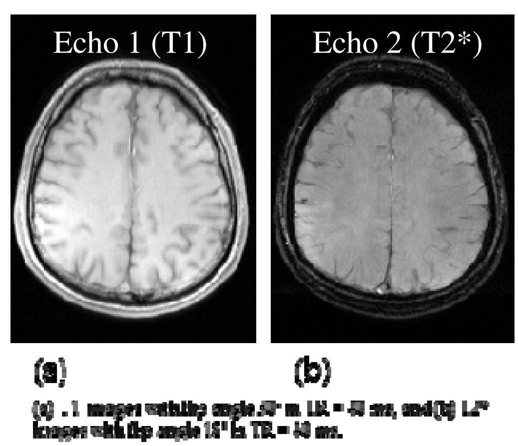


Fig. 3