Ultrashort TE (UTE) Imaging and T2 Quantification of Short T2 Components in Brain White Matter

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INTRODUCTION

White matter in the brain has long T2 components which are typically imaged using conventional magnetic resonance imaging techniques (1-3). However, a wide range of short T2 values have also been reported, ranging from 8 ms down to 200 µs (1, 2). Here we implemented an ultrashort TE (UTE) sequence to image the short T2 components in brain white matter at 3T. The UTE sequence can achieve a short TE of 8 µs by combining half pulse excitation, radial ramp sampling and fast transmit/receiver switching (4). Long T2 signals were suppressed using a long adiabatic inversion pulse, as well as dual echo subtraction. T2 of the short T2 components was measured at 3T.

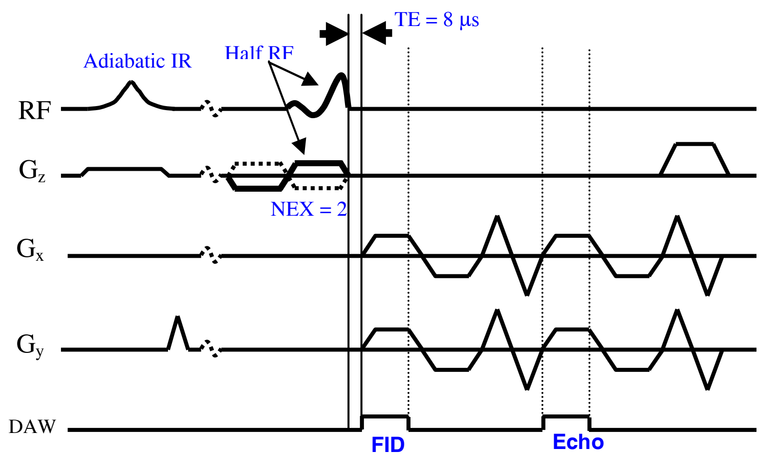

Figure 1. Pulse sequence diagram for dual echo ultrashort TE (UTE) sequence. Half pulses were applied with the slice selection gradient successively positive and negative, and the two acquired data sets were added to form a slice selective excitation. Long T2 white matter signals were suppressed using a long adiabatic inversion pulse. The long T2 gray matter signals were suppressed using echo subtraction.

MATERIALS AND METHODS

The 2D UTE sequence (Figure 1) combines half-pulse excitation and dual echo radial ramp sampling. A long slice selective adiabatic fast passage (Silver-Hoult) inversion pulse of duration 17 ms was played to invert the long T2 magnetization of the white matter. Image acquisition began following a time delay (TI) necessary for the magnetization of inverted long T2 components to reach the null point for white matter. Echo subtraction was performed to suppress the long T2 gray matter, which might be just partially suppressed by the adiabatic IR pulse. Volunteer studies were carried out on a 3T Signa TwinSpeed scanner (GE Healthcare Technologies, Milwaukee, WI) using an 8-channel head coil. The imaging parameters are: FOV = 24 cm, TR = 1.5 s, TE = 8µs and 8 ms, TI = 420 ms, flip angle = 60°, BW = 62.5 kHz, readout = 256 (actual sampling points = 132), projections = 191, slice thickness = 3 mm, scan time = 9.5 min.

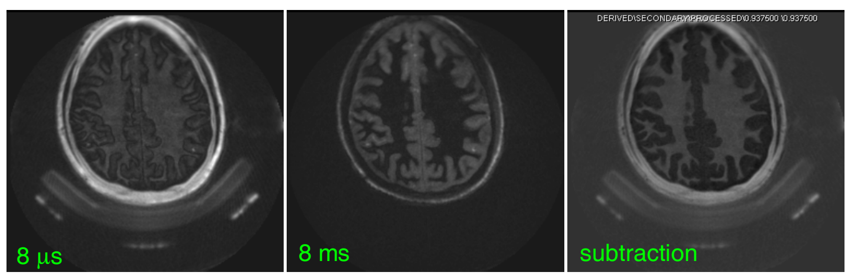

Figure 2. Dual echo UTE images of the brain white matter imaged with FOV of 24 cm, readout of 256, slice thickness of 3.0 mm, producing an acquired pixel size of 0.94×0.94×3.0 mm^3 with a total scan time of 9.5 minutes. The white matter appears bright in the first echo, and dark in the second echo which confirms that a TI of 420 ms correctly nulls the long T2 white matter, leaving only short T2 white matter signal in the first echo. Echo subtraction suppresses long T2 gray matter signals, and selectively depicts the short T2 white matter with high contrast.

RESULTS AND DISCUSSION

Figure 2 shows the dual echo UTE images of the brain white matter. The echo subtraction image showed excellent contrast for the short T2 components due to the combination of long T2 white matter suppression and long T2 gray matter subtraction. Image spatial resolution was significantly higher than reported at 1.5 T (0.94×0.94×3.0 mm^3 vs. 1.3×1.3×5.0 mm^3) (5). The measured T2* value of 370 µs is slightly longer than that reported by Nayak et al. (100~350 µs), where long T2 signals were suppressed using a 4 to 8 ms nonselective hard 90^0 pulse followed by a dephaser (2). The longer adiabatic inversion pulse may results in less attenuation of the short T2 white matter signals, and better suppression of the long T2 white matter signals (6).

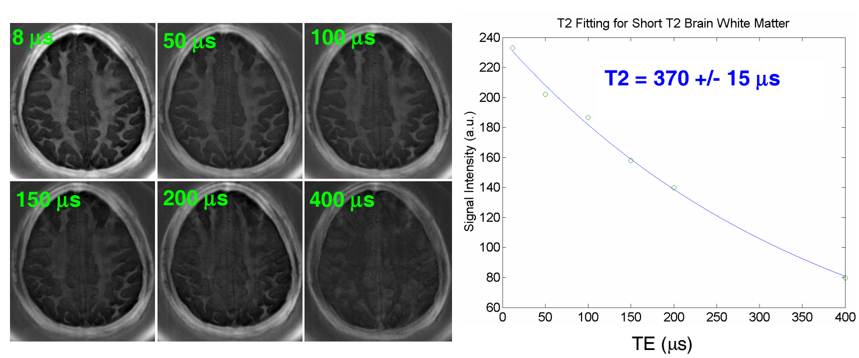

Figure 3. T2 measurement by varying TE and suppressing long T2 using an adiabatic inversion pulse. A short T2 of 370 µs was estimated using single component exponential fitting.

CONCLUSIONS

Short T2 components in brain white matter can be imaged with high contrast using UTE sequences at 3T. This has considerable potential for quantitative imaging of short T2 tissues.

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