Imaging Ultra-short T2 Species in the Brain

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Introduction:

Previous studies have shown that a wide variety of T2 species exist in white matter [1-4]. The most commonly imaged are the long T2 component around 108 ms, and the short T2 component around 15 ms (often called myelin water). Ex vivo studies have demonstrated the presence of other components with T2 on the order of 1 ms.

We have attempted to image these short T2 species in a full body scanner with high performance gradients using a half-pulse projection reconstruction (HPPR) sequence. We are able to achieve echo times as short as 228 µs.

Methods:

The pulse sequence is shown in Figure 1. A half-pulse variable rate excitation is followed by short PR readouts and a spoiler in the slice select direction. The main lobe of the excitation occupies under 500 µs and the total readout occupies 1024 µs. There is a minimum deadtime of 228 µs between excitation and readout due to hardware timing restrictions and RF recovery. Therefore the minimum echo time is also 228 µs. Suppression of long T2 species is essential for getting good dynamic range from short T2 species. Long-T2 suppression is implemented with a 4 to 8 ms nonselective hard 90° excitation followed by a dephaser [5]. This is done before each imaging excitation. Note that this suppression pulse has a limited bandwidth and does not suppress long-T2 lipid signal.

This sequence was implemented on a GE Signa 1.5 T scanner with gradients supporting 40 mT/m strength and 150 T/m/s slew rate and a fast receiver capable of sampling at 250 kHz.

Results:

Five normal volunteers were scanned using this sequence. Sample images shown in Figure 2 illustrate the observed rapid signal decay due to ultra-short T2.

Ts. A slice in another volunteer was scanned using a 700 ms TR and TEs of 228 µs, 600 µs, and 1 ms. Ts estimates were computed using signal ratio comparison and least squares. The T2 histogram from white matter is shown in Figure 3b. A majority of the signal is from T2s in the range 100-350 µs.

Discussion:

We have demonstrated the feasibility of in-vivo imaging of sub-millisecond T2 species. One application for this sequence could be the imaging of demyelinating conditions. Figure 4 contains images of an ex-vivo sample from a patient with multiple sclerosis (MS), with arrows indicating periventricular white matter disease.

References