Water-Specific Quantitative MRI Relaxometry of the Brain using Spatial-Spectral Water Excitation: Preliminary Experience

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Purpose: The presence of lipid can affect relaxometric quantitative MRI (qMRI) measurements and act as a confounder in deriving parametric data. The purpose of this work was to test a pulse sequence for spatial- and spectral-selective qMRI relaxometry *in vivo* for deriving qMRI parameters in brain imaging.

Methods: The mixed turbo spin echo pulse (mixed-TSE) sequence was implemented with second order binomial water-selective spatial-spectral excitation pulses (1), hereafter SSE-mixed-TSE (Figure 1). Mixed-TSE is a four time point pulse sequence that incorporates the principles of differential T1- and T2-weighting in a single acquisition. By substituting the standard spatially-selective excitation pulses with binomial chemically-selective spatial-spectral excitation pulses (Figure 1), a chemically specific qMRI pulse sequence results. As noted, a second-order binomial (1-2-1) pulse was employed for SSE-mixed-TSE consisting 22.5°-45°-22.5° spatially selective pulses interspaced by 2.3ms. Key imaging parameters: 40 slices/ 0.937x0.937x4.4mm^3/ 8,120msTE1, 2/ 700,4065msTI1, 2 and 8130msTR.

The brain of a single volunteer was imaged using both non-chemically selective mixed-TSE sequence as well as the SSE-mixed-TSE pulse sequence using a 1.5T clinical MRI scanner. The directly acquired images were used as input for qMRI algorithms to yield parametric maps of PD, T1, T2 (including secular-T2), and ADC (using correlation time diffusion techniques, CT-D) (2, 3), of the brain (Figure 2). These qMRI parameters derived using SSE-mixed-TSE were compared to those derived from the mixed-TSE pulse sequence without the use of water-selective spatial-spectral excitation pulses for both gray and white matter of the brain as well as CSF.

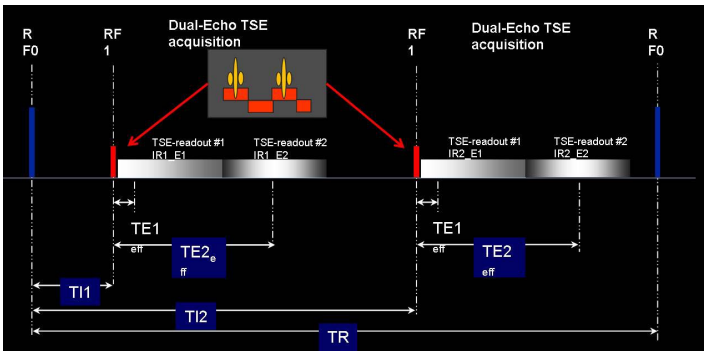

Figure 1. Mixed-turbo spin echo pulse sequence implemented with second order binomial water selective excitation pulses.

Results: Excellent fat suppression, comparable SNR, and lack of artifacts were obtained with the SSE-mixed-TSE pulse sequence (Figure 2). Compared to the non-selective mixed-TSE derived parameters, the qMRI derived parameters of selected regions of interest (Table 1) show excellent agreement between the two pulse sequences with the exception of T2, which are consistently longer for the SSE-mixed-TSE pulse sequence. qMRI derived parameters using the two pulse sequences demonstrated similar degrees of uncertainty.

Table 1. Comparison of qMRI parameters in brain using mixed-TSE compared to SSE-mixed-TSE pulse sequence

Sequence/Anatomy	**qMRI Parameter**				
Mixed-TSE	**Relative PD**	**T1 (ms)**	**T2 (ms)**	**Secular-T2 (ms)**	**CT-D (10^{-3} mm^2/s)**
White Matter	0.50 +/- 0.02	553.1 +/- 20.6	70.5 +/- 3.8	75.3 +/- 4.4	0.80 +/- 0.02
Gray Matter	0.66 +/- 0.01	1104.7 +/- 46.1	103.8 +/- 5.9	108.9 +/- 6.3	0.83 +/- 0.01
Ventricular CSF	1.00 +/- 0.03	4340.3 +/- 198.1	2273.2 +/- 788.8	3155.8 +/- 1310.3	3.92 +/- 1.0
SSE-mixed-TSE					
White Matter	0.53 +/- 0.01	552.3 +/- 19.0	74.9 +/- 4.0	80.4 +/- 4.5	0.77 +/- 0.02
Gray Matter	0.69 +/- 0.02	1078.2 +/- 59	111.3 +/- 6.2	117.4 +/- 7.0	0.83 +/- 0.01
Ventricular CSF	1.00 +/- 0.03	4177.2 +/- 338.0	2146.2 +/- 576.6 ms	2954.5 +/- 959.7	3.74 +/- 1.2

Conclusion: Water specific qMRI parameters (PD, T1, CT-D) of the brain obtained with the SSE-mixed-TSE pulse sequence were in good agreement with those obtained with the non-selective mixed-TSE, as well as observations by others with a different technique (4). A consistent T2 lengthening was also observed for the SSE-mixed-TSE data. Spectrally selective qMRI may offer insight into both normal structures as well as pathology without the confounding effects of lipids.

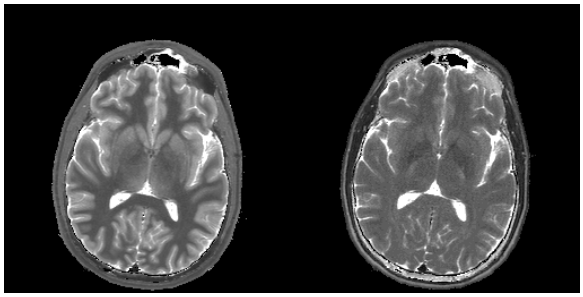

Figure 2. Representative parametric map image quality. T1 and T2 maps constructed using SSE-mixed-TSE as input.

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