Multi-Echo SE- vs. Multi GRE-Derived Myelin Water Fraction Imaging at 3 T

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TARGET AUDIENCE: Clinicians and basic scientists interested in MR-based myelin imaging of the brain.

INTRODUCTION: Myelin specific imaging is of considerable interest for the detection and monitoring of diseases such as multiple sclerosis. Due to the challenges of directly imaging myelin-associated hydrogen nuclei with T_2 times under 1 ms, alternative myelin imaging techniques that exploit the relaxation behavior of myelin-associated water have been sought. Using a multi-echo-spin-echo (MESE) sequence, myelin water fraction (MWF) images have been obtained through multicomponent analysis of T_2 decay using non-negative least squares (NNLS)[1]. However, compared to MESE sequences, multi-gradient recalled echo (MGRE) sequences have the advantage of providing short first echo times, short echo spacing, fast whole-brain or multi-slice acquisitions, and a low specific absorption rate (SAR). MWF imaging based on multicomponent analysis of T_2^* decay has therefore been proposed and demonstrated recently using both NNLS[2,3] and 3-component exponential fitting[4,5]. Here we report on a comparison of MWF maps derived from MESE vs. MGRE data using NNLS analysis.

METHODS: Measurements were performed on a Siemens 3 T scanner with a 32-channel head coil. One healthy subject (29y) was scanned following approval by the local ethics committee and after giving informed consent. The protocol consisted of: second order manual shimming for the correction of magnetic field inhomogeneities (MFIs), a single-slice MESE sequence (FOV = 220 x 220 mm^2, 0.9 x 0.9 mm^2 resolution, 5 mm slice thickness, TR = 2000 ms, BW = 260 Hz/px, 32 echoes, ΔTE = 10 ms, scan time = 14.4 min), a clinical routine 3D MPRAGE sequence, and two MGRE acquisitions with identical parameters (FOV = 300 x 234.3 x 67.6 mm^3, 1.2 x 1.2 x 2.6 mm^3 resolution, TR = 100 ms, BW = 980 Hz/px, 32 echoes, 2 averages, scan time = 16.3 min, ΔTE = 3 ms) except for TE1 = 2 ms (first acquisition) and TE1 = 4 ms (second acquisition). The images from the two MGRE acquisitions were interleaved resulting in 64 echoes (TE = 2, 4, 5, 7, 8, 10, …). White matter (WM) masks were generated using the technique described in[6] and voxel-wise multicomponent analysis of MESE and MGRE data based on regularized NNLS was performed using Matlab (The Mathworks Inc).

RESULTS AND DISCUSSION: The signal to noise ratio (SNR) measured at TE_1 for MESE (Fig. 1a) and MGRE (Fig. 2a) was 259 and 186, respectively (well above the minimum recommended SNR for multicomponent analysis[7]). The MWF map obtained from MESE data is shown in Fig. 1b and the MWF obtained from MGRE data at a corresponding slice is shown in Fig. 2b. The mean(std) WM MWF in the slices shown (Fig.1b and Fig. 2b) was 19(11)% for MESE and 8(7)% for MGRE. T_2 and T_2^* distributions (Fig. 1c and Fig. 2c) revealed two distinct components for both sequences: ~10 ms (corresponding to myelin water) and ~65 ms (intra/extra-cellular water) for MESE, and ~3 ms and ~45 ms for MGRE in a region of interest (ROI) located in the splenium of the copus callosum.

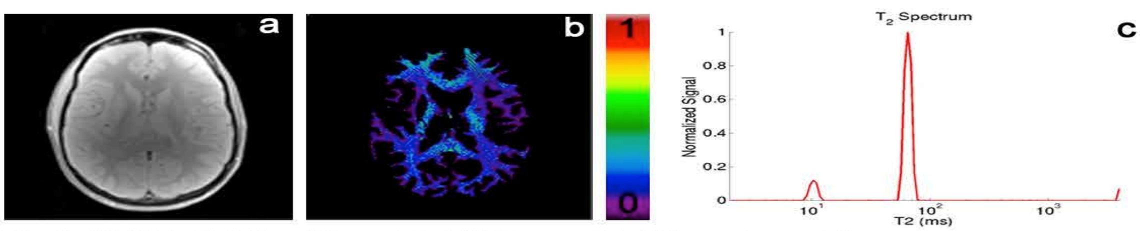

Fig.1: MESE at TE1 = 10 ms (a), MWF map (b), T2 spectrum (c)

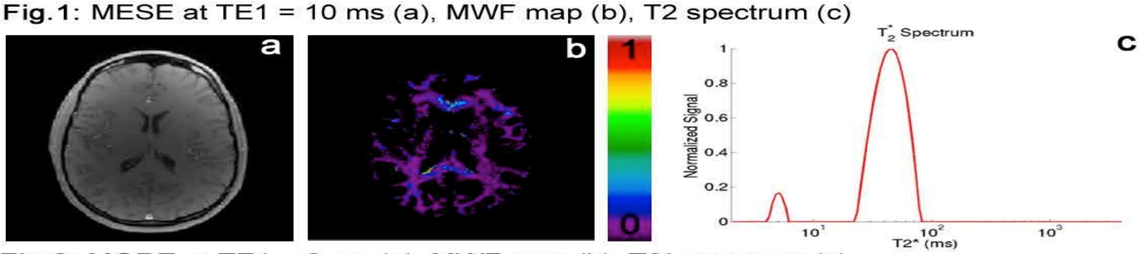

Fig.2: MGRE at TE1 = 2 ms (a), MWF map (b), T2* spectrum (c)

The mean WM MWF for the MESE technique is comparable with literature values[8]. A similar mean WM MWF value has been obtained with MGRE using NNLS at a lower field strength[2]. In[3], MWF maps were reported using NNLS and a 2D acquisition at 3 T. Since MFIs are thought to play a role in the MESE-MGRE MWF discrepancy[2,3], and 3D acquisitions generally have less signal loss due to MFIs (compared to 2D acquisitions)[9,10], an evaluation of the MWF at 3 T using a 3D acquisition was sought. To further reduce the effect of MFIs, voxel sizes were kept at a minimum and two MGRE-images were acquired to compensate for the loss in SNR. In this way, the signal decay could be sampled up to 64 times with short echo spacing (when combining the images from both MGRE acquisitions), but with a lower bandwidth and therefore higher SNR. The findings indicate that under the aforementioned conditions, MGRE-derived MWFs remain significantly lower than MESE-derived MWFs. These results suggest that additional work is required to determine the origins of the reduced MWF measured with MGRE sequences versus the conventional MESE technique.

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