Advanced Myelin Water Imaging Techniques for Rapid Data Acquisition and Long T_2 Component Measurements

Jing Zhang[1], Irene Vavasour[1], Shannon Kolind[2], Baumeister Baumeister[3], Alexander Rauscher[1], and Alex L. MacKay[1,4]

[1]*Department of Radiology, University of British Columbia, Vancouver, BC, Canada,* [2]*Division of Neurology, Department of Medicine, University of British Columbia, Vancouver, BC, Canada,* [3]*Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, BC, Canada,* [4]*Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada*

Target audience: Physicists, neuroscientists, neurologists and radiologists working with MR techniques for measuring myelin content.

Purpose: Myelin water fraction (MWF) is conventionally measured using the T_2 decay curve [1]. We have previously produced whole cerebrum MWF images using a manufacturer-provided multiple combined gradient and spin echo (GRASE) 3D technique [2] with 32 echoes at TE=10ms. Due to both hardware and software limitations, with product GRASE software, the maximum number of echoes was limited to 32. In this work, we modified the pulse sequence to obtain up to 64 echoes with TE as short as 6 ms. We compared MWF for several grey and white matter regions of interest (ROI) for various echo train lengths and TE times.

Methods: All MR imaging experiments were performed on a Philips Achieva 3.0T MR scanner using an 8-channel phased-array head coil for reception and the internal quadrature body coil for transmission. GRASE data were acquired from six healthy volunteers with 4 different combinations of echo train length, TE, TR, and resolution, detailed in Table. For all sequences, the GRASE factor was 3, FOV=230 × 192 × 100cm^3, and images were reconstructed to 1x1x2.5mm^3. In order to be able to identify different regions of interest, T_1-weighted images (TFE) 40 slices, TR/TE = 7.3/2.6ms, IR =728ms, slice thickness = 2.5 mm, 232x190 matrix) were also acquired with the same FOV and resolution.

Table 1. GRASE sequences.

Sequence	Number of Echoes	TE (ms)	TR (ms)	Acquired Resolution (mm)	Scan Time (mins)
a	32	10	1000	1x1x5	14
b	64	6	1427	2x2x5	10
c	48	8	1073	1x2x5	7.5
d	64	8	1427	1x2x5	10

Results: The MWF maps showed slight differences across the four sequences (Figure 1). Figure 2 shows mean ROI MWFs from the six subjects with standard error and t-tests. Sequence c which had a scan time of 7.5 minutes provided similar MWF values to those from the conventional sequence a. Compared to other sequences, sequence b showed slightly lower MWF values for all ROI regions.

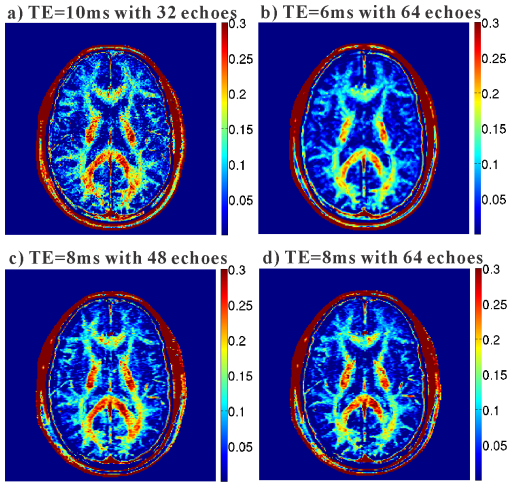

Figure 1. Representative MWF maps.

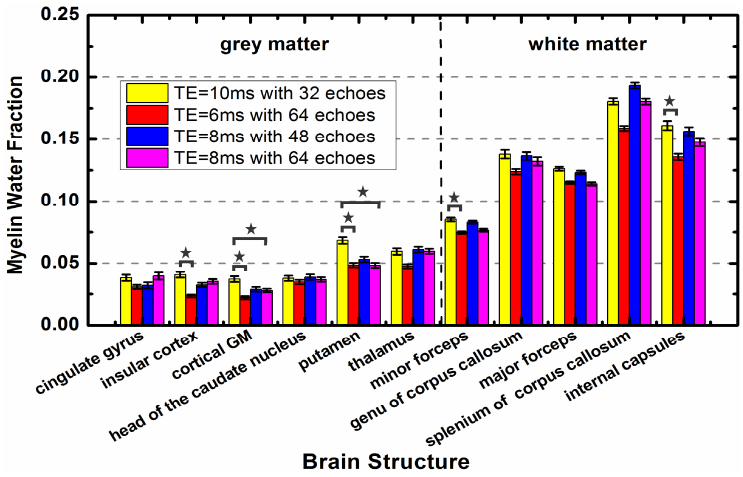

Figure 2. Mean ROI MWF values from six healthy volunteers. * p <0.05.

Discussion: MWF maps created using each of the four sequences are similar, suggesting that the echo train length and echo spacing can be selected to best suit a particular research question without compromising data quality. For instance, for optimised characterisation of the myelin water pool decay, a shorter echo time (as used for sequence b) captures more data that is heavily weighted by the short T_2 component. For exploration of pathological brain expected to have additional long-T_2 components, a longer T_2 decay curve acquisition (as used for sequence d) provides more information regarding water pools with slow relaxation.

Conclusion: In this work, GRASE T_2 decay curves were performed with different TEs and numbers of echoes for six healthy subjects. TE=8ms with 48 echoes allowed us to acquire MWF maps very quickly (within 7.5 minutes), while TE=8ms with 64 echoes enabled us to collect the decay curve out to 512 ms. These sequences permit more applications for myelin water imaging in clinical studies and neuroscience.

References: **[1]** MacKay AL, Whittall K, Adler J, Li D, Paty D, Graeb D. In vivo visualization of myelin water in brain by magnetic resonance. Magn Reson Med. 1994;31(6):673–7. **[2]** Prasloski T, Rauscher A, Mackay AL, Hodgson M, Vavasour IM, Laule C, Mädler C. Rapid whole cerebrum myelin water imaging using a 3D GRASE sequence. Neuroimage. 2012 Jul 6;63(1):533–9.