Whole brain myelin water imaging using T2* decay analysis at 3T

Yoonho Nam[1], Bonsuk Koo[1], Dosik Hwang[1], and Dong-Hyun Kim[1]
[1]*Electrical and Electronic Engineering, Yonsei University, Seoul, Korea, Republic of*

Introduction Quantitative myelin water imaging can be a useful tool for studying white matter diseases such as multiple sclerosis. Normally multi-echo (CPMG) spin-echo based T_2 imaging is performed for quantitative myelin water imaging by separating short T_2 component which is regarded as myelin water [1]. Myelin water imaging via multi-echo gradient echo based T_2^* imaging has recently been introduced as an alternative to multi-echo spin echo based T_2 imaging [2]. T_2^* based myelin water imaging has benefits such as lower SAR, larger volume coverage. An added benefit can be its combined usage with other brain imaging mechanisms such as quantitative susceptibility imaging, which has also shown its correlation with myelin imaging [3]. Recent study conducted at 7T shows the potential for T_2^* decay analysis for quantitative myelin water imaging using 50 averaged single-slice [4]. In this work, the potential for whole brain quantitative myelin water imaging using T_2^* decay analysis was investigated at 3T.

Methods Ten healthy subjects were scanned on a 3T Siemens Tim Trio with the following parameters: TR = 4s, flip angle = 90°, first TE = 1.8 ms, echo spacing = 1.93 ms, 48 echoes (1.8 ~ 92.5 ms), bandwidth per pixel 1502 Hz/px, voxel size 2x2x2 mm^3, matrix size 128x128x40, interleaved 2D multi slices without gap, total scan time = 8.5 min. For anatomical reference, T_1-weighted images were also acquired using MPRAGE sequence. Mono-exponential fitting excluding the first six echoes (~11.5 ms) was performed to each voxel to estimate the short T_2^* components. The difference between the obtained data and the fitted data at first echo (1.8 ms) was taken as the relative amount of short T_2^* components under the assumption that signal decay after seventh echo (13.4 ms) is governed by long T_2^* components [4]. Four ROIs (minor forcep, genu, splenium and major forcep) were manually determined to observe the regional difference in the residual pattern. Post-processing method based on sinc correction was applied to signal in genu to investigate the effect of macroscopic field inhomogeneity [5].

Results Figure 1 shows the signal decay curve and the fitted signal in splenium region. From the relative devation, significant difference is observed at first echo. The pattern of the difference curve in splenium region is similar to previous study at 7T [4]. Figure 2 shows the volumetric display of the signal difference at first echo. Most white matter regions have relatively large positive differences but some frontal white matter regions which are highly affected by B_0 field inhomogeneity have negative differences. Figure 3 shows the averaged difference curves from 10 subjects for each ROIs. In minor forcep and genu, the fitting results are not reliable because the standard deviations over the subjects are very large. This unreliable fitting result can be explained by the effect of macroscopic B_0 field inhomogeneity. Figure 4 shows the fitting results after field inhomogeneity correction in genu using sinc correction. Although only the effect of linear field gradient in slice-selection direction was compensated, the signal difference at first echo increased significantly similar to the level of splenium.

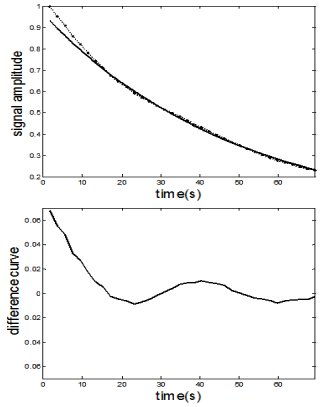

Fig. 1: The fitted signal (solid) and its difference curve between the fitted data (solid) and the obtained data (dashed) in splenium region.

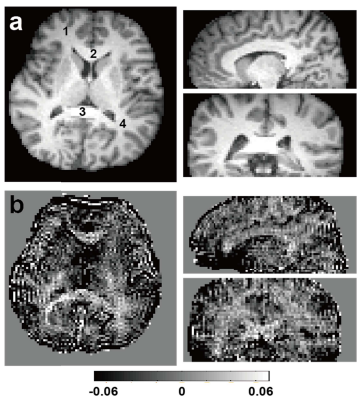

Fig. 2: a. T_1-weighted images (MPRAGE) with four ROIs (1: minor forcep, 2: genu, 3: splenium, 4: major forcep) **b.** corresponding first echo (1.8ms) differences between the fitted data and the obtained data.

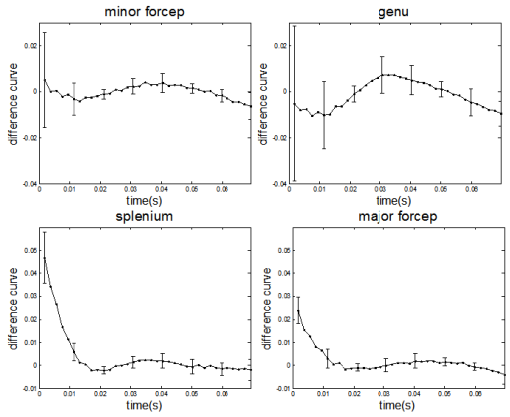

Fig. 3: Subject-averaged difference curves for ROIs. The error bars indicate the standard deviation over the subjects.

Discussion & Conclusion The deviations from exponential fitting and their regional differences in white matter were observed at 3T. The observed results are similar to previous study. The physiologic basis of the difference curve is under debate. In fact, myelin water fraction is not a unique source of first echo difference but seems to highly correlate with first echo difference [4]. Nevertheless, T_2^* decay analysis can be an efficient tool for whole brain quantitative myelin water imaging if more exact correlation between myelin water fraction and deviations from mono-exponential fitting is demonstrated. In addition, using a sinc correction routine, the effects of macroscopic B_0 field inhomogeneity can be partially corrected.

Acknoledgements This work is financially supported by the Ministry of Knowledge Economy (MKE) and Korea Institute for Advancement in Technology (KIAT) through the Workforce Development Program in Strategic Technology, by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MEST) (No. 2011-0003312), and by Siemens Medical Systems.

References [1] Mackay et al. MRM 1994;31:673-677, [2] Hwang et al. Neuroimage 2010;52:198-204, [3] Liu et al. Neuroimage 2011;56:930-938, [4] Gelderen et al. Proc. ISMRM 2011 p4455, [5] Fernandez et al.MRM 2000;44:358-366.

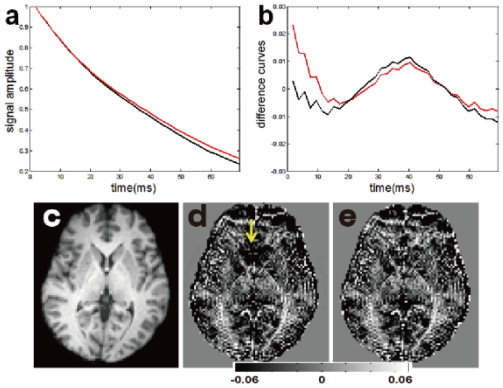

Fig. 4: a. The obtained signal decay (black) and the corrected signal decay (red) in genu. **b.** the difference curves between the fitted data and the signal decay. **c,d,e.** T_1-weighted image and its corresponding first echo differences before(d) and after(e) correction