

A population-averaged whole brain myelin concentration map using ViSta myelin water imaging

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INTRODUCTION Myelin is an electrical insulator and is a key substrate for salutatory conduction in the nerve system. It has been well-studied that myelin thickness is a primary determinant for nerve conduction velocity¹. Abnormality in myelin affects information processing and cognition². Thus, imaging myelin has important applications both in neuroscience and clinical research. Myelin water imaging (MWI) measures signals from water molecules in the gap of neighboring myelin layers³ and has been suggested as a good biomarker for myelin. Recently, a new high quality MWI method, direct visualization of short transverse relaxation time component (ViSta)⁴ has been developed. The signal characteristics of ViSta have shown that 1) the signal (> 95%) is primarily generated from short T_2^* in the range of myelin water (< 25 ms)⁴, 2) the phase⁵ and MT effects⁶ of the signal agree with the results from myelin water, and 3) a 3D ViSta apparent myelin water fraction (aMWF⁴ due to T_1 weighting) map is highly correlated with a conventional 3D MWF map ($r = 0.81$)⁸. Compared to conventional MWI, ViSta has provided substantially improved image quality⁹ and demonstrated better reproducibility⁹. Hence, the method is an alternative approach to obtain a quantitative measure of myelin content. In this study, a population-averaged aMWF map of ViSta ($n = 33$) was generated and the result was used to explore the spatial distribution of myelin content in the whole brain. The areas of large myelin content were investigated by comparing the result with DTI fiber tracks.

METHODS Data were collected from 33 subjects (35.3 ± 9.9 yo; IRB-approved) with no history of neurological disorder using a 3T MRI scanner (Siemens). Whole brain 3D MWI data were acquired using a 3D ViSta sequence⁴. The scan parameters were as follows: 32 slices, resolution = $1.5 \times 1.5 \times 4$ mm³, TR/TE = 1160/6.5 ms, $TI_1/TI_2/TD = 560/220/380$ ms, partial k-space in phase = 6/8, PE lines per segment = 11, number of segments = 11 and scan time = 6.53 min. A reference scan which had the same readout as 3D ViSta was acquired (TR = 75 ms) to generate aMWF (see ref. 3 for details). After generating individual aMWF maps, a population-averaged aMWF map was produced by registering individual aMWF maps to a T_{1w} anatomy template (MNI152). After registration, the aMWF maps from all subjects were averaged. For comparison, DTI was acquired in the same resolution (30 directions, $b = 1000$ s/mm², 2 averages).

RESULTS Figure 1 shows the result of a population-averaged ViSta aMWF map. High aMWF values are observed in the genu and splenium of corpus callosum (CC), internal capsule posterior limb (or cortico spinal tract; CST), optic radiation (OR), superior longitudinal fasciculus (SLF), inferior longitudinal fasciculus (ILF) and white matter around motor/sensory cortex areas. Figure 2 illustrates three different views of high aMWF areas and the corresponding fibers in DTI. Generally, long distance fibers which connects to distal areas of the brain (e.g. CC, SLF, ILF) and connects body to the brain (CST, and OR) present high myelin contents.

DISCUSSION and CONCLUSION In this study, we generated a whole brain population-averaged ViSta aMWF map. This map may serve as a template to compare myelin concentration differences among different groups. The results can be expanded to generate aMWF maps of different age groups when larger population data are collected.

References: [1] Waxman, 1980, Muscle & Nerve, [2] Fields, 2008, Trends Neurosci, 31, 361 [3] Mackay A, MRM, 1994, 673 [4] Oh, Neuroimage, 2013, 83, 485 [5] Kim, MRM, 2014 (available online) [6] Lee, ISMRM, 2014, #338 [7] Oh, ISMRM, 2014, #4280 [8] Prasloski, Neuroimage, [9] Oh, ISMRM, 2014, #3143

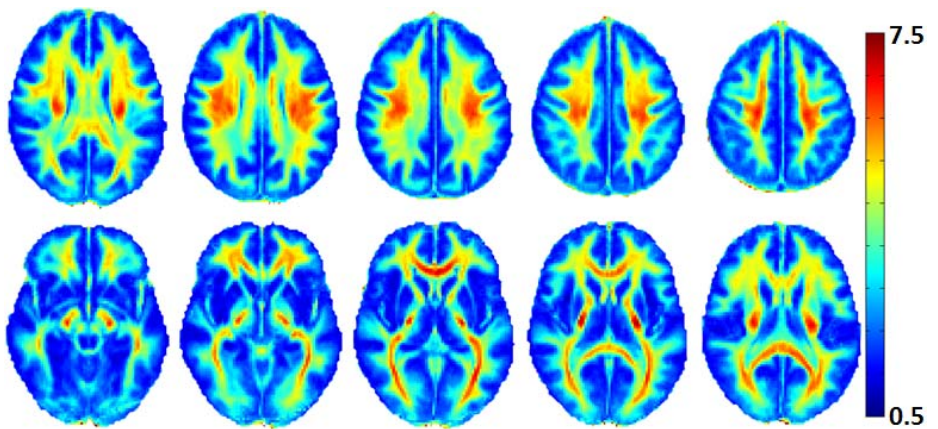


Figure 1. population-averaged apparent myelin water fraction (aMWF) using ViSta

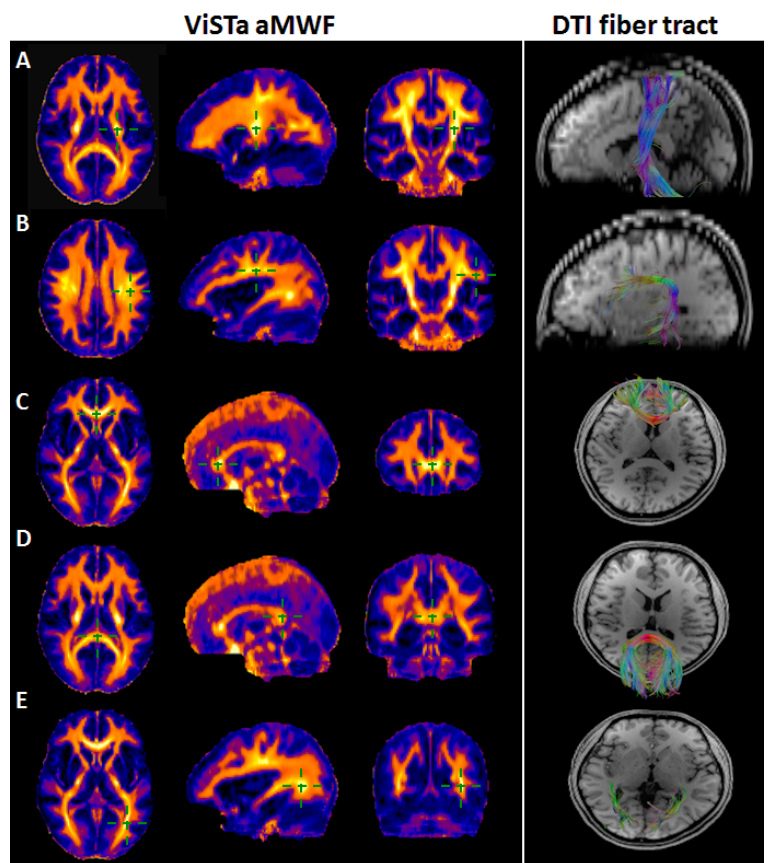


Figure 2. Three axis views of high aMWF areas and corresponding DTI fiber tracts: (A) Cortico-spinal tract (internal capsule posterior limb), (B) Superior longitudinal fasciculus, (C) Genu of corpus callosum, (D) Splenium of corpus callosum and (E) Optic radiation.