A 7-Tesla Longitudinal Study on Proportion of Veins in Plaques of Patients with Multiple Sclerosis

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Target audience: Radiologists who specialize in neuro-MR imaging and imaging of multiple sclerosis (MS) at 3 Tesla and 7 Tesla.

Purpose: Intralesional veins are known to be a histopathological hallmark of MS[1,2]. Susceptibility-weighted-imaging (SWI), combined with fluid-attenuated inversion recovery (FLAIR) sequences at 3 Tesla, and FLAIR–like contrast on 7 Tesla MRI systems,[3] allows detailed imaging of veins[4] as small in diameter as approximately 0.2 mm. The purpose of this pilot study was to monitor the dynamics of intralesional veins over a period of two years in plaques and corresponding normal-appearing white matter (NAWM) in patients with relapsing-remitting (RRMS) and secondary progressive MS (SPMS), compared to an age-matched control group.

Methods: Ten patients with MS and ten age-matched healthy controls were enrolled in a two-year prospective, longitudinal study. All patients underwent an annual neurological examination, as well as a brain MRI, over the two-year period. At all three time-points, high-resolution depiction of veins was obtained with 7T-SWI. Veins were manually segmented into plaques of different maturation stages, in their corresponding NAWM of the same layer, as well as in the white matter of the appropriate age-matched control areas. The dynamics of vein-volume to tissue-volume ratio during the two years was assessed with regard to subtypes of MS and maturation of plaques.

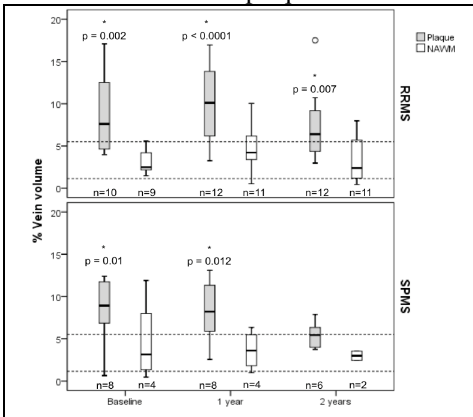
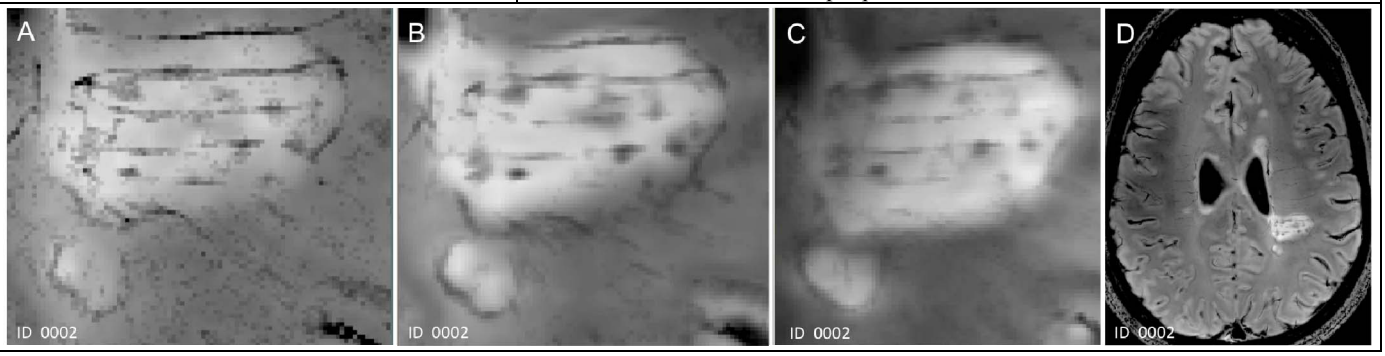


Figure 1 (left): Median venous proportion of mature plaque (grey bars) and corresponding NAWM (white bars) during the two years**.** The box plot demonstrates the proportion of veins in % (vein-to-tissue ratio) in mature plaques, corresponding NAWM plaques, and age-matched control areas within two years. There was a significantly higher proportion of veins in mature RRMS and SPMS plaques (at baseline and at one-year follow up) compared to their age-matched control group over the two years. There was no significant dynamic found in proportion of veins between plaques within a group nor between groups within time. Corresponding normal-appearing white matter was not available for every plaque, and the venous proportion of NAWM was found to be equivalent to the venous proportion of the control group, at all time points and in both subgroups.

Figure 2 (bottom): Proportion of veins in plaques did not change over the two years. **A**: Baseline: 3T-Flair-7T-SWI; **B**: one-year follow-up; **C**: two-year follow-up: 7T-Flair-7T-SWI; **D**: overview of plaque location: 7T-Flair-7T-SWI.



Results: The inflammatory tissue of RRMS and SPMS plaques shows a significantly higher proportion of deoxygenated veins compared to corresponding non-inflammatory control tissue and corresponding NAWM tissue. The proportion of visible veins within plaques did not change significantly over two years–neither within the subgroups nor between subgroups. We found a trend toward an increasing proportion of visible veins in the pre-plaque areas and a significant increase in venous proportion in newly developed plaques compared to the control group. The proportion of veins in the NAWM was in accordance with control values.

Discussion: Since SWI is also a measure of oxygen desaturation, the significantly higher proportion of deoxygenated veins in plaques may indirectly reflect the higher oxygen demand in inflammatory tissue compared to healthy controls.

Conclusion: The ultrahigh spatial resolution provided by the high SNR and the higher phase shift at 7T enables the analysis of vein density in MS plaques compared to NAWM, which may provide an insight into the pathophysioloy of MS *in vivo*.

References: 1. Sinnecker T, Bozin I, Dorr J, et al. Periventricular venous density in multiple sclerosis is inversely associated with T2 lesion count: a 7 Tesla MRI study. *Multiple sclerosis (Houndmills, Basingstoke, England).* Jun 26 2012. **2.** Tallantyre EC, Morgan PS, Dixon JE, et al. A Comparison of 3T and 7T in the Detection of Small Parenchymal Veins Within MS Lesions. *Investigative Radiology.* Sep 2009;44(9):491-494. **3.** Tallantyre EC, Brookes MJ, Dixon JE, Morgan PS, Evangelou N, Morris PG. Demonstrating the perivascular distribution of MS lesions in vivo with 7-tesla MRI. *Neurology.* May 27 2008;70(22):2076-2078. **4.** Ge Y, Zohrabian VM, Grossman RI. Seven-tesla magnetic resonance imaging - New vision of microvascular abnormalities in multiple sclerosis. *Archives of Neurology.* Jun 2008;65(6):812-816.