

## 7T MRI: A Powerful Vision of Microvascular Abnormalities in Multiple Sclerosis

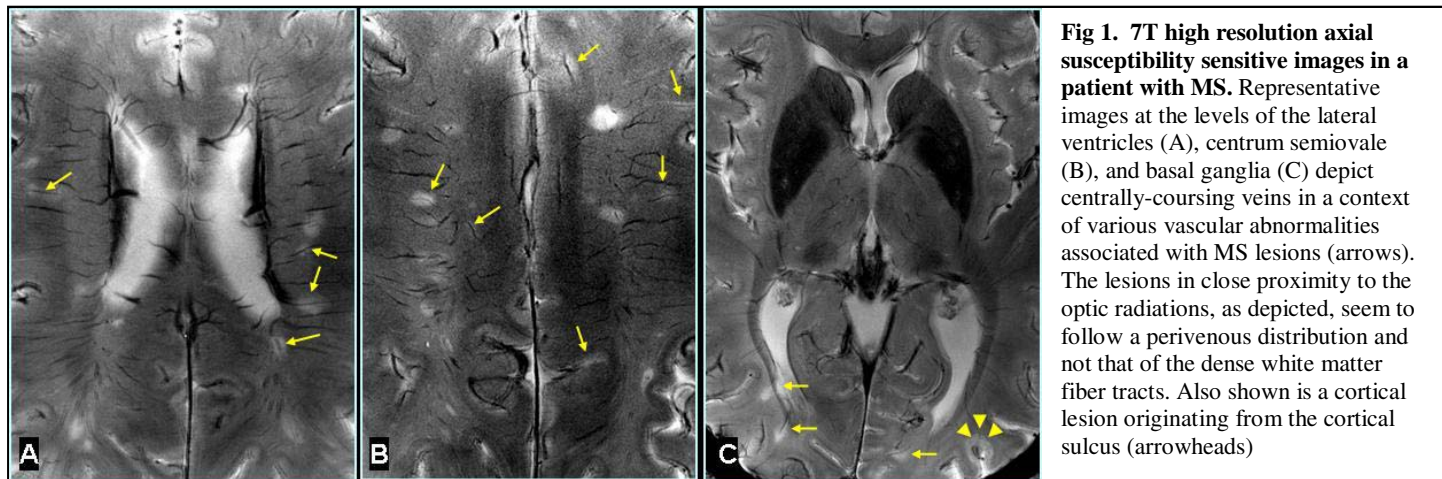
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**Introduction:** Multiple sclerosis (MS) lesions have been linked to venous abnormality, although the derivation of these lesions from the vasculature has been difficult to assess in vivo (1,2). Ultra-high-field (e.g. 7T) MR has provided increased visibility of venous vasculature by taking advantage of markedly increased intrinsic intensity and susceptibility contrast (3). We report findings acquired at 7T MR in two MS patients, and demonstrate enhanced detection of unique microvascular abnormalities in MS.

**Materials and Methods:** Two female patients with clinically definite relapsing-remitting (RR) MS, Patient 1 aged 54 years and Patient 2 aged 39 years, who had received initial diagnoses 6 and 7 years earlier, respectively, and with expanded disability status scale (EDSS) scores of 2.0 and 2.1 respectively. Neither of whom had used steroids within 3 months prior of the present MR. The 7T whole-body human MR system (Siemens, Erlangen, Germany) with maximum gradient strength of 72 mT/m effective and a newly developed 24-element head coil array (Nova Medical Inc., Massachusetts) were used. 2D high resolution susceptibility sensitive imaging was acquired in the axial plane with the following imaging parameters: TR/TE/flip angle = 500ms/25ms/35°, slice thickness = 2mm, acquisition matrix = 1024x1024mm<sup>2</sup>, with pixel of 0.23x0.23mm<sup>2</sup>. This sequence was optimized to best visualize both venous structures and lesions.

**Results:** 7T high resolution (pixel size: 0.23x0.23mm<sup>2</sup>) susceptibility sensitive T2\*-weighted imaging clearly delineates the intimate relation between lesions and veins in MS. In our two RRMS patients, we were able to demonstrate a total of 80 MS lesions, 58 and 22 lesions independently, and all lesions showed a strict perivascular distribution, following the form, orientation, and course of the vessels, this feature being best noted in small lesions. The diameter of veins associated with lesions ranged from 0.3mm – 0.7mm. As shown in Figure 1, a variety of vascular abnormalities associated with lesions are observed. Among these, more than half of lesions (about 59%) are small lesions that show subtle abnormal signal intensities strictly at the perivascular spaces, with well-defined central veins (see Figure 1), providing a direct evidence of vascular involvement and lesion pathogenesis in MS. Small lesions with relatively obscured veins, and large lesions with well-defined and ill-defined vessels are also shown in Figure 1. White matter tracts, such as those of the optic radiations, being well depicted on 7T, allowed us to accurately visualize MS lesions along a venous distribution but not aligned with the course of the fiber tracts (Figure 1C). In addition, we found a lesion embedded within the cortical sulcus (Figure 1C).



**Fig 1. 7T high resolution axial susceptibility sensitive images in a patient with MS.** Representative images at the levels of the lateral ventricles (A), centrum semiovale (B), and basal ganglia (C) depict centrally-coursing veins in a context of various vascular abnormalities associated with MS lesions (arrows). The lesions in close proximity to the optic radiations, as depicted, seem to follow a perivenous distribution and not that of the dense white matter fiber tracts. Also shown is a cortical lesion originating from the cortical sulcus (arrowheads)

**Discussion and Conclusion:** 7T MR provides sophisticated imaging capabilities by virtue of increased signal intensity and susceptibility effects, the fundamental quantities underlying image resolution and contrast, respectively. Our findings established that approximately half of total MS lesions in our two patients are small with well-defined central veins, and that these diffuse, subtle signal abnormalities may correspond to early vascular changes. This represents the first time that such subtle vascular inflammatory abnormalities have been demonstrated in vivo. Improved detection of these lesions in the early stage of development on 7T MRI will have substantial ramifications on future diagnosis, monitoring, and therapeutic response in MS. Therefore, utilizing ultra-high-field MRI for precise characterization of microvascular abnormalities in early MS lesion development may allow for immediate pharmacologic intervention directed at these initial changes.

**References:** 1. Adams CW, J Neurol Sci 1985; 69: 269-83; 2. Ge Y. AJNR 2005; 26: 2316-9. 3. Abduljalil AM, JCAT 1999; 23(6):832-41.

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