

ORAL PRESENTATIONS

Seeing is believing: Ultra-high field magnetic resonance imaging in vascular and neurodegeneration research

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Ultra-high field (UHF) magnetic resonance (MR) refers to a main operating field strength of 7 teslas (T) or higher. UHF MR offers unique opportunities for revealing new insights into the microstructures and functions of the brain that are not available on conventional field strength MR. Recently, the U.S. Food and Drug Administration (FDA) has cleared the 7 T magnetic resonance imaging (MRI) device for clinical use, which has doubled the 7 T systems installed in the US. Central to this powerful evolution is the concomitant increase of signal-to-noise ratio (SNR) and susceptibility contrast at UHF MRI. Compared to 3 T, 7 T offers a 2 to 3-fold increase in image SNR, which will allow us to image high resolution with voxel volume of less than 0.1 mm³, while the largely increased susceptibility or T2* contrast at ultra-high field MRI will be the key benefit for brain imaging. Sequences sensitive to magnetic susceptibility include susceptibility-weighted imaging (SWI) and quantitative susceptibility mapping (QSM). Thanks to the susceptibility-induced blooming

effect, small veins at a micro level (*e.g.* <50 μm) can be seen on 220 x 220 μm matrix size SWI.¹ With the strengths being provided on UHF MR, several key clinical benefits are discussed. The perivenous lesion development or central vein sign in multiple sclerosis (MS) has been revealed *in vivo* for the first time,² which has proved useful for a differential diagnosis of MS.³ Seven teslas MRI showed improved detection of cortical MS lesions that are consistent with histopathological patterns of cortical demyelinating lesions regarding their cortical layer involvement that are not seen on 3 T MRI.⁴ The visibility of small venous architecture, including small cortical and medullary veins, has an important implication for tissue oxygen utilization and neuronal degeneration.⁵ By introducing an ultrasmall-superparamagnetic-iron-oxide (USPIO) contrast agent (*e.g.*, ferumoxytol), the small arterioles can also be seen on 7 T SWI, which allows the detection of small arterial tortuosity in the elderly, likely the major cause of small vessel disease. Seven teslas markedly increased the sensitivity in detecting iron deposition and microbleeds associated with brain structures and lesions, and this provides critical insights on brain pathology, in particular in age-related neurodegenerative diseases. Seven teslas MRI improves the characterization of age-related choroid plexus degeneration, including both volume and signal changes, which may have an impact on waste clearance and cerebrospinal fluid (CSF) production. Figure 1 demonstrates a few representative examples of the potential of 7 T. In summary, seeing the unseen on 7 T provides opportunities not only for an early diagnosis, but also for clinical research of disease mechanisms and treatment strategy development.

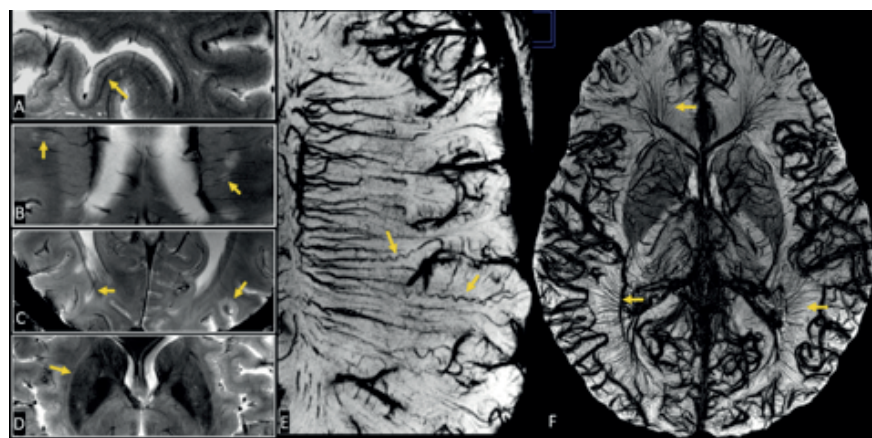


Figure 1. Seeing is believing: 7 T potentials show (A) cortical layers, (B) central vein sign of multiple sclerosis (MS), (C) MS lesion developing along veins, not fiber tracts and cortical lesions, (D) varied age-related iron deposition, (E) small arterial tortuosity with corkscrew appearance, (F) whole brain microvascular mapping on ultrasmall-superparamagnetic-iron-oxide (USPIO)-enhanced magnetic resonance imaging.

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