Imaging cortical lesions at standard and high field-strength (1.5T and 4.7T): post-mortem MRI and histopathology

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Introduction: cortical lesions (histopathologically characterized as type I: mixed gray matter-white matter lesions, and types II-III-IV: purely intracortical lesions) are abundant in multiple sclerosis (MS)[1], and have been related to physical and cognitive decline[2]. However, most of these lesions cannot be visualized with conventional MR imaging (MRI) techniques[3]. As suggested previously[3], using higher MR field-strengths could potentially improve cortical lesion conspicuity.

Aim: to compare the sensitivity of post mortem MRI for cortical lesions (types I-IV) at standard (1.5T) and at high (4.7T) field-strengths.

Method: standard dual-echo T2-weighted spin-echo images of 17 formalin-fixed MS hemispheres (from 13 different patients) and 3 control hemispheres (from 2 different patients) were acquired at 1.5T (TR/TE: 2755/45,90 ms; slice thickness: 3 mm; in-plane resolution: 0.5 x 0.5 mm), as well as mainly proton-density (PD)-weighted images at 4.7T (FSE3D; TR/TE: 4000/9 ms; echo train length 8, 0.2 mm isotropic resolution). 3D-FLAIR (TR/TE/TI: 6500/120/2200 ms; slice thickness: 1.25 mm; in-plane resolution: 0.8 x 0.8 mm) was obtained at 1.5T, and a 3D inversion recovery technique with WM suppression (WSIR) (FSE3D; TR/TE/TI: 4000/9/150 ms; echo train length 8, 0.2 mm isotropic resolution) at 4.7T. Proteolipid protein (PLP)-stained tissue sections (10µm) were matched to the corresponding MR images, and cortical lesions were scored on all four MR sequences (blinded to histology), as well as in tissue sections (blinded to MRI). Subsequently, the sensitivity of the four different sequences for the four cortical lesion types was calculated. Later, an additional retrospective MR scoring was performed (unblinded).

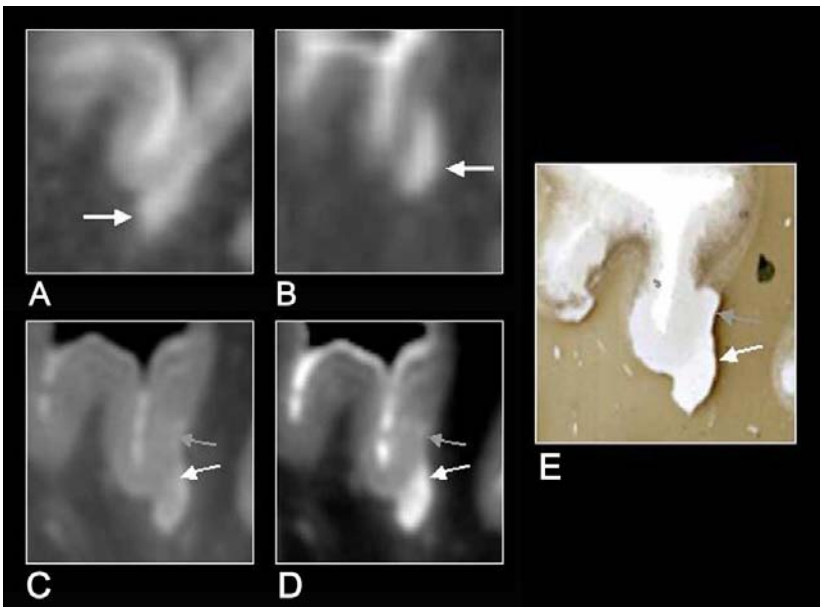

Figure 1

Example of a mixed white matter-gray matter lesion (type I lesion) on standard- and high-field strength MRI and histopathology; (A) 1.5T T2-weighted image; (B) 1.5T 3D-FLAIR; white arrows indicate the lesion (the intracortical part of the lesion is not visible here); (C) 4.7T PD; (D) 4.7T WSIR. Arrows indicate the same lesion, now with a better visible white matter (white arrow) and gray matter part (gray arrow), confirmed by PLP immunohistochemistry (E). Type I lesions are thus relatively easy to pick up with both standard-field and high-field MRI. This is in sharp contrast with the purely intracortical lesions, which remain mostly undetected, even when applying higher field-strengths (not shown).

Results: both 1.5T and 4.7T showed up to 100% of the total amount of histologically detected type I (mixed WM-GM) lesions (N=5). Type II intracortical lesions (N=24) were depicted best with the 4.7T WSIR (25% sensitivity), followed by 4.7T PD (17%). Sensitivity of the two 1.5T sequences for type II lesions was below 15%. Two out of five histologically found type IV lesions were detected with 1.5T PD (40%). Type III lesions were most numerous (N=151), but all four techniques showed sensitivities below 10%, prospectively. Lesion counts generally increased upon retrospective scoring. However, the majority (up to 85%) of intracortical lesions (type II-III-IV) still remained undetected.

Discussion: sensitivity of MRI for cortical lesions remains low even when using higher field-strengths. It is different, however, for specific subtypes of cortical lesions: mixed type I lesions are relatively easily detected by both 1.5T and 4.7T imaging, whereas purely intracortical lesions are not.

References:

1. Bö et al, J Neuropathol Exp Neurol. 2003; 62:723-32.

2. Rovaris M et al, Am J Neuroradiol 2000; 21:402-08.

3. Geurts JJG et al, Am J Neuroradiol 2005; 26:572-77.