A Comparison of 3T and 7T in the Detection of Small Parenchymal Veins Within MS Lesions

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Objective: Histologic examination of multiple sclerosis (MS) brain lesions reveals heterogeneity including the presence or absence of a central blood vessel. Recent work has shown that $T_2^*$ weighted magnetic resonance imaging at 7T allows the identification of small parenchymal veins within MS lesions. The aims of this study were (1) to compare whether a comparable sequence at 3T was also capable of demonstrating parenchymal veins within MS brain lesions, and (2) to investigate the potential of 7T $T_2^*$ weighted imaging to differentiate between MS white matter lesions and age-related vascular lesions seen in controls.

Materials and Methods: Seven patients with demyelinating brain disease and 7 healthy volunteers were scanned at 3T and 7T. Fluid attenuated inversion recovery (FLAIR) images acquired at 3T were used to identify each brain lesion in each patient. A comparison of images from both field strengths was then made to determine whether white matter lesions seen in 3T FLAIR images could be identified in $T_2^*$-weighted images, and whether a central vein could be detected.

Results: A total of 358 brain lesions were identified in the brains of the 7 patients using 3T FLAIR images. The 3T $T_2^*$ sequence detected 89% of FLAIR lesions compared with 94% using the 7T $T_2^*$ sequence ($P = 0.0002$). A central vessel could be identified in 45% of visible lesions using 3T $T_2^*$ and 87% of visible lesions using 7T $T_2^*$ ($P < 0.0001$). Using 7T $T_2^*$ imaging, a central vein was evident in only 8% of the discrete white matter lesions found in the brains of healthy volunteers.

Discussion: This study suggests that ultra high field imaging is advantageous in demonstrating detailed structural anatomy of MS lesions. $T_2^*$ imaging can be used in the future to investigate the pathogenesis of MS lesions. The potential for ultra high field imaging to discriminate between MS white matter lesions and microangiopathic lesions warrants further investigation as this would represent a clinically useful application.

Key Words: multiple sclerosis, MRI, ultra high field, white matter lesions, blood vessels

Invest Radiol 2009;44: 491–494

Magnetic resonance imaging (MRI) is a valuable tool for diagnosing and monitoring patients with multiple sclerosis (MS). However, variation in the appearance of MS lesions in histology is not always reflected by equal variation in lesion appearance using MRI. Furthermore, it remains difficult, using conventional MRI, to distinguish between the white matter (WM) lesions seen in MS and those associated with age or vascular risk factors which are suspected to arise secondary to microangiopathy. The WM demyelinating plaques seen post mortem in MS have long been recognized to be closely associated with small parenchymal veins. This perivascular distribution is in line with the widely held hypothesis that the formation of an MS lesion depends on the entry of inflammatory cells from the systemic circulation into the brain parenchyma. The notion that every MS plaque shares this common mechanism has been challenged, however, by the finding of heterogeneity in the pathologic appearances of early MS lesions including the presence or absence of a central vein.1

Imaging of MS lesions and parenchymal veins has been attempted previously at conventional field strengths (1.5T/3.0T). Coregistration of MR angiography images with corresponding $T_2^*$ weighted images is one method which has been used to explore this relationship.2 The feasibility of using 2 separate images to accurately describe the spatial relationships between lesions and vessels, however, will necessarily rely on the ability to coregister images within a fraction of a millimeter. The use of $T_2^*$-weighted imaging to simultaneously demonstrate MS lesions and small veins was first reported at 1.5T. Following the administration of gadolinium contrast agent, vessels could be seen as hypointense structures within most MS lesions using a sequence with high in-plane resolution and thick slices.3 Increased signal-to-noise ratio (SNR) and enhanced susceptibility contrast mechanisms experienced at higher field strengths can be exploited to generate detailed imaging of the relationship between veins and WM lesions in MS without the use of contrast agent. Recently, ultra high field (7T) MRI has been used to study the frequency of central veins in MS lesions using a single $T_2^*$-weighted image with whole brain coverage.4 In view of the low availability of ultra high field scanners, here we investigate whether the more accessible 3T scanners can demonstrate the same effect. In addition, we assess whether 7T $T_2^*$ imaging can differentiate between the white matter lesions seen in MS patients and those seen incidentally in controls.

MATERIALS AND METHODS

Seven subjects with clinically definite relapsing-remitting MS were recruited from Nottingham University Hospital’s MS outpatient clinic. Patient characteristics were: 3 men and 4 women; mean age 37 years, range 24 to 48; mean disease duration 10.7 years, range 1.2 to 25 years; median Expanded Disability Status Scale 2, range 0 to 6. All patients were clinically stable at the time of imaging (not experiencing a relapse of MS). Seven healthy volunteers (4 men and 3 women; mean age 43 years, range: 26–60) were recruited by local advertisement. All subjects gave informed consent and the study had ethical approval from the Nottingham research ethics committee.

Data Acquisition

7T images were acquired using an Achieva scanner (Philips Medical Systems, Best, The Netherlands), equipped with whole-body gradients, a 16-channel SENSE rf receive coil and head only volume transmit coil (Nova Medical, Inc. 150 West Street, Suite 201, Wilmington MA). 3T images were acquired using an Achieva scanner (Philips Medical Systems, Best, The Netherlands) equipped...