Susceptibility-weighted MR imaging of vascular distribution in white-matter MS lesions

J. E. Dixon[1], E. C. Tallantyre[2], P. S. Morgan[3], M. J. Brookes[1], N. Evangelou[2], and P. G. Morris[1]

[1]Sir Peter Mansfield Magnetic Resonance Centre, The University of Nottingham, Nottingham, Nottinghamshire, United Kingdom, [2]Clinical Neurology, The University of Nottingham, Nottingham, Nottinghamshire, United Kingdom, [3]Academic Radiology, The University of Nottingham, Nottingham, Nottinghamshire, United Kingdom

Introduction: Multiple sclerosis (MS) is an inflammatory disease affecting the central nervous system (CNS), which is characterised by areas of demyelination commonly seen throughout the CNS white matter (WM). There is evidence that various distinct processes trigger the formation of WM lesions in MS, which leads to heterogeneity in lesion characteristics. Histological studies[1] have shown a variable relationship between WM lesions and parenchymal blood vessels which has been found to be predictive of treatment response[2], suggesting the importance of the ability to study this relationship *in vivo*. Previous attempts to investigate this using T_2 imaging and MR venography[3] have been limited by the inability to demonstrate both the lesion and vessel simultaneously, resulting in the failure to define and follow the exact spatial relationship. However, use of T_2^* as a contrast mechanism at 7T enables the detection of both WM MS lesions and parenchymal blood vessels in the same image, due to the higher spatial resolution available at 7T and the increased susceptibility effects surrounding deoxygenated blood. In this study we present a technique for assessing *in vivo* the perivascular distribution of WM lesions using T_2^*-weighted imaging.

Methods: Scanning was performed using a Philips Achieva 7T MR scanner with a whole-body gradient coil and a quadrature transmit-receive head coil. T_2^*-weighted scans were acquired using a 3D gradient echo sequence with a 288 x 288 x 100 matrix and 0.67 mm isotropic voxels (TR = 53 ms, TE = 22 ms, flip angle = 14°). A 2D FLAIR image was also acquired in order to confirm that hyperintensities in the T_2^* image were indeed representative of white-matter lesions. This scan used a turbo spin-echo sequence with 120° refocusing pulses, 36 slices with in-plane matrix size 320x320 and 0.6 x 0.6 x 2.0 mm^3 resolution (TR = 10.6 s, TE = 120 ms, TI = 2800 ms). Acquisition times for the scans were 10 and 6 minutes, respectively. Eight subjects with clinically definite MS were recruited from Nottingham University Hospital's MS clinic (2 men, 6 women; 4 relapsing-remitting, 4 secondary progressive; mean disease duration 15.7 years; mean EDSS 6). All subjects gave informed consent and the study received ethical approval from the Nottingham Research Ethics Committee. Lesions were identified by two neurologists (ECT and NE) as discrete hyperintensities on both the T_2^*-weighted and FLAIR images. Hyperintensities smaller than $9mm^2$ were excluded from the analysis in order to avoid the effects of partial volume. Periventricular lesions were defined as those with a border within 4mm of the ventricular surface, all others were defined as peripheral. Vessels appeared hypointense on the T_2^*-weighted images and were counted only if they could be visualised in at least two perpendicular planes.

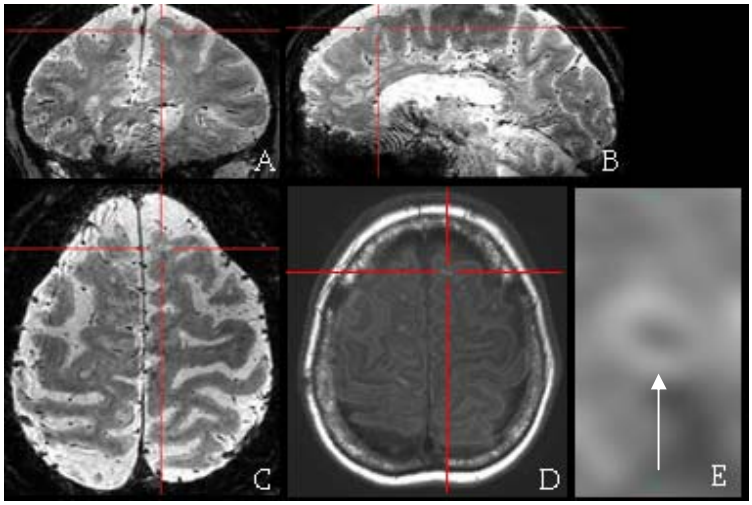

Figure 1 *– T_2^* images of peripheral WM lesion in A) coronal, B) sagittal and C) axial planes. D) shows the corresponding slice in the FLAIR image and E) shows a magnified version of the lesion identified in T_2^* image.*

Results: Across all patients, 89 lesions were identified in the T_2^*-weighted images (49 periventricular, 40 peripheral). Central vessels were seen in 73 lesions (82%) with inter-observer reproducibility of 96%. Periventricular lesions were more likely to be associated with a vessel than peripheral lesions (vessels seen in 96% periventricular lesions and 65% perihperal lesions) and periventricular lesions were often seen to extend along the length of one or more large vessels. An example of a peripheral lesions is shown in figure 1, in coronal (A), sagittal (B) and axial (C) planes. Figure 1(D) shows the same lesion in a FLAIR image, and figure 1(E) shows a close-up view of the lesion in the T_2^* image, with the central vessel appearing as a hypointensity. Figure 2 shows an example of a periventricular lesion on a T_2^* image.

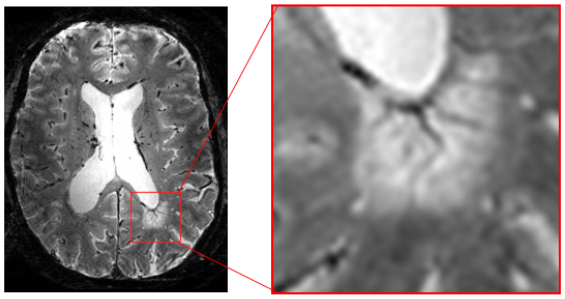

Figure 2 *– T_2^* image of periventricular WM lesion with vessels appearing as hypointensity.*

Conclusions: Susceptibility-weighted imaging enables the identification of both blood vessels and MS lesions on the same image, aiding the study of the perivascular distribution of WM lesions. This represents a distinct advantage over previous studies in which two separate images were required to visualise the lesion and the blood vessels. The finding that 82% of lesions are associated with a vessel ties in with previous histological reports, suggesting that this technique has acceptable sensitivity and that it will prove useful in longitudinal studies of MS lesions.

References: [1] Lucchinetti C et al. Ann Neurol 2000;47:707-717 [2] Zettl UK et al. Neurology 2006;67:1515-1516 [3] Tan IL et al. AJNR Am J Neuroradiol 2000;21:1039-1042.