Enhanced detection of cortical lesions in multiple sclerosis using magnetization transfer and double inversion recovery

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Target audience: Scientists and clinicians studying multiple sclerosis.

Purpose: Multiple sclerosis (MS) has long been considered a pure white matter (WM) disease. In recent years, greater attention is paid to cortical pathology in MS. However, detection of cortical lesions is complicated by low contrast on MRI between lesions and surrounding tissue, the relatively low image resolution, and the confounding signal from WM and cerebrospinal fluid (CSF). Double inversion recovery (DIR) simultaneously suppressed the signal from CSF and WM, greatly enhancing the detection of cortical lesions[1,2]. However, the number of lesions detected by DIR is much lower than detected on histology[2]. We propose to use magnetization transfer (MT) in combination with DIR (denoted MT-DIR) for improved detection of cortical lesions in MS.

Methods: Fourteen relapsing-remitting MS patients were enrolled in an IRB-approved study and were scanned on a 3.0 T Philips Achieva system (Philips, Best, The Netherlands). The brain protocol included a fast spin-echo DIR sequence with the following parameters: TR/TE/TI1/TI2 = 5500/247/2400/485 msec. MT-DIR was implemented with the same parameters except TI1 was increased to 2500 msec to optimize CSF suppression with MT. A 25-msec sinc-Gaussian MT pulse (off-resonance = 1600 Hz, pulse angle = 620°) was inserted in the second inversion period. An expert with 20 years in MRI neuroimaging and MS identified cortical lesions on all datasets. The number of lesions was recorded and the Michelson contrast was calculated in a 9x9 window centered on the identified location as: contrast = $(I_{max}-I_{min})/(I_{max}+I_{min})$, where I_{max} and I_{min} denote the maximum and minimum intensities in the 9x9 window, respectively.

Results: Fig. 1 shows a representative case illustrating the enhanced contrast of cortical lesions obtained with MT-DIR compared to DIR. Note the uniform suppression of WM on MT-DIR. Table 1 reports the number of lesions and measured contrast in all 14 cases. In two patients, no lesions were found either on DIR or MT-DIR. In the remaining patients, the number of cortical lesions detected with MT-DIR is almost doubled (123 vs 66) relative to DIR, and the contrast is increased by 31% (0.93 vs 0.71). All lesions detected on DIR were also identifiable on MT-DIR. In one patient (case #11), two lesions were identified on MT-DIR while none were detected on DIR. In that case, the measured contrast at the location identified as a lesion on MT-DIR was found to be ~46% higher than the grey matter location on the corresponding DIR (MT-DIR contrast is 0.92 vs. 0.63 in DIR). Although this study focused mainly on cortical lesions, we noticed an enhancement in the contrast of WM lesions as well.

Conclusion: MT-DIR improves the contrast between cortical lesions and brain tissue, and consistently and uniformly suppresses WM, enabling better depiction of cortical lesions.

References: [1] Bedell BJ and Narayana PA, JMRI 1998; 8: 544–547. [2] Geurts JJ et al. Radiology 2005; 26: 572-7.

Table 1: Number of detected MS lesions and measured contrast for DIR and MT-DIR.

n	Number of lesions		Contrast	
	DIR	MT-DIR	DIR	MT-DIR
1	0	0	—	—
2	5	11	0.58±0.10	0.91±0.09
3	7	10	0.50±0.37	0.94±0.10
4	3	7	0.99±0.02	0.96±0.08
5	2	3	0.70±0.10	0.97±0.03
6	4	11	0.69±0.14	0.94±0.06
7	12	22	0.77±0.09	0.96±0.07
8	14	23	0.71±0.17	0.89±0.12
9	4	10	0.70±0.13	0.96±0.04
10	4	5	0.99±0.02	0.95±0.08
11	0	2	0.63±0.49	0.92±0.01
12	7	13	0.58±0.11	0.92±0.10
13	0	0	—	—
14	4	6	0.93±0.08	0.94±0.04
All	**66**	**123**	**0.71±0.20**	**0.93±0.08**

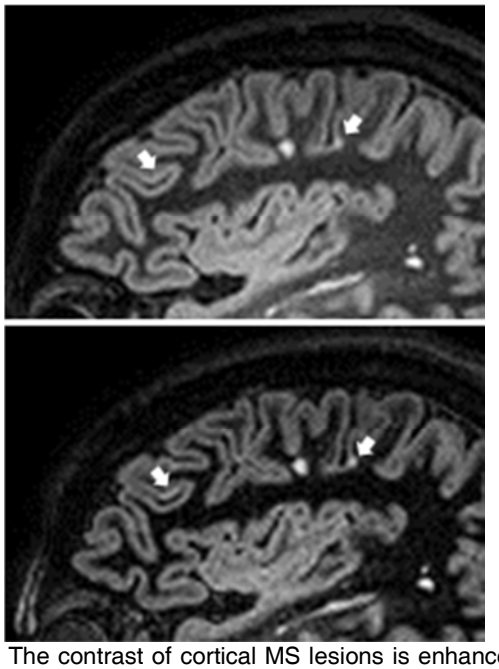

Fig. 1: The contrast of cortical MS lesions is enhanced on MT-DIR (bottom) compared to DIR (top).