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INJURY TO A SPECIFIC NEURAL PATHWAY DETECTED BY ULTRA-HIGH-FIELD MRI

We present evidence for the potential of ultra-high-field MRI to reveal injury due to multiple sclerosis (MS) not appreciated using lower field imaging. Internuclear ophthalmoplegia (INO) is an eloquent ocular motor syndrome that frequently affects patients with MS. The medial longitudinal fasciculus (MLF) is a periventricular, dorsomedial brainstem tegmentum pathway that yokes the 2 eyes in many types of eye movements.^{1,2} Further, T2 lesions localized in the region containing the MLF strongly associate with INO.³ However, the small diameter of the MLF and lack of contrast between the MLF and the

surrounding neural tissue on conventional MRI hinder direct visualization.⁴ We recently demonstrated that the MLF is clearly visible on T2*-weighted images at 7T among healthy controls.⁴ In this contribution, we demonstrate that hallmarks of the MLF are at most weakly evident among patients with MS with chronic INO. Three patients with MS with bilateral chronic INO (as shown in the figure, D–F: aged 43/52/32 years, male/female/female, primary progressive/relapsing-remitting/relapsing-remitting, Expanded Disability Status Scale score 6.0/5.0/6.0) and 3 healthy controls participated in an institutional review board–approved study. Images were acquired on a 7T Philips Achieva (Philips Healthcare, Cleveland, OH). Because T2-weighted

Figure Ultra-high-field imaging of medial longitudinal fasciculus in multiple sclerosis

T2*-weighted imaging (echo time = 16 ms) reveals medial longitudinal fasciculus (MLF) in controls (A–C, indicated by arrows). MLF is weakly visible in one patient with multiple sclerosis (D) and not visible in the other patients (E, F). Conventional T2-weighted images acquired at 3T indicate bilateral pontine lesions (G–I).

(as opposed to T2*-weighted) contrast on 7T images was not optimal for lesion detection, images were also acquired on a 3T system to assess conventional T2 lesions. Imaging at 7T included a multiecho fast field echo scan with high spatial resolution and T2* weighting ($0.13 \times 0.13 \times 3$ mm voxels, echo time = 12, 16, 20, 24 ms), with scan planes lying perpendicular to the brainstem. Subsequent coregistration with FSL⁵ put all images in a common space. The MLF is clearly visible on all healthy controls at all echo times over a range of as much as 15 mm in the inferior-superior direction (figure, A–C) but is considerably less conspicuous or not visible in the patients with MS with INO (figure, D–F). Conventional T2-weighted imaging at 3T indicates, in each patient, bilateral lesions in the pons overlapping with locations expected for the MLF and extensive and typical T2 cerebral lesions of MS (figure, G–I). Differences in contrast between the MLF and surrounding neural tissue may arise from microscopic changes to myelin structure, readily observed at ultra-high fields, which are inaccessible to technology commonly used in clinical centers. Myelin sheaths result in enhanced contrast in T2*-weighted images.⁶ The lack of contrast in our MS cohort with INO likely arises from the reduction in myelin content and axons secondary to MS inflammatory injury.

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Author contributions: Ken Sakaie: drafting/revision of the manuscript, study concept or design, analysis or interpretation of data, accepts responsibility for conduct of research and final approval. Masaya Takahashi: drafting/revision of the manuscript, study concept or design, analysis or interpretation of data, accepts responsibility for conduct of research and final approval, acquisition of data. Koji Sagiya: study concept or design, analysis or interpretation of data, accepts responsibility for conduct of research and final approval, acquisition of data, study supervision. Ivan Dimitrov: drafting/revision of the manuscript, study concept or design, accepts responsibility for conduct of research and final approval, acquisition of data. Teresa Frohman: drafting/revision of the manuscript, analysis or interpretation of data, accepts responsibility for conduct of research and final approval.

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Study funding: Supported by the National Multiple Sclerosis Society (grant RG 4091 A3/1) and the DADs Foundation.

Disclosure: Ken Sakaie receives funding from Novartis. Masaya Takahashi and Koji Sagiya report no disclosures. Ivan Dimitrov is an employee of Philips Medical Systems. Teresa Frohman receives speaker fees from Biogen and Teva. Gina Remington has been a speaker for NMSS, IOMSN, Biogen, and Teva. Elliot Frohman receives speaker fees from Biogen, Teva, and Acorda and consulting fees from Biogen, Teva, Acorda, Novartis, and Abbott. Robert Fox has received consulting fees from Avanir, Biogen Idec, EMD Serono, and Novartis. Research support and consultant and advisory committee fees from Biogen Idec were paid to the Cleveland Clinic. Go to Neurology.org for full disclosures.

Received May 13, 2013. Accepted in final form September 5, 2013.

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