Corticospinal Tract Degeneration in Brainstem in Patients with Multiple Sclerosis: Evaluation with Diffusion Tensor Tractography

Y. Ge[1], K. Tuvia[1], M. Law[1], G. Johnson[1], J. Herbert[2], L. Mannon[1], R. I. Grossman[1]

[1]Department of Radiology, NYU Medical Center, New York City, NY, United States, [2]Department of Neurology, NYU Medical Center, New York City, NY, United States

INTRODUCTION: The hallmark of multiple sclerosis (MS) is mutlifocal lesions characterized by inflammatory demyelinating changes that primarily involve the white matter tracts in the brain. There is increasing evidence demonstrating that distal Wallerian degeneration in MS may occur secondary to axonal transaction or damage in MS lesions more proximally [1]. Diffusion tensor imaging provides physiologic information with *in vivo* visualization and quantitative assessment of these white matter pathways. The purpose of this study was to evaluate the effects of supratentorial lesions on corticospinal tract function and integrity at the brain stem level by measuring fractional anisotropy (FA) and fiber tract number (FT).

MATERIALS AND METHODS: Nine patients with clinical relapsing remitting MS disease were studied on a 3.0T MR. After conventional MR imaging, which included T2- and enhanced T1-weighted images, axial DTI data were acquired with a pulsed gradient, double spin echo, echo planar imaging (5300/74; 128x128 matrix; 220x220 mm FOV; forty-five 3 mm contiguous slices; b= 1000 s/mm2) in six directions. Fixed seeds/ROIs (4 voxels with a total of 32 tracts) were placed within each side of corticospinal tract in cerebral peduncle at middle brainstem level without observed lesions. The measurements for FA and FT were then made in both patients and controls. Fiber tracks were constructed using software courtesy developed in Massachusetts General Hospital. This allowed variation of the threshold to follow the primary eigenvector voxel-by-voxel based on both quantitative magnitude and directional information. Both lesion number and lesion volume in both cerebral hemispheres were calculated in patients.

RESULTS: Fiber tractography accurately delineated the corticospinal tract from cerebral peduncle in brainstem through internal capsule to cerebral cortical gyri. The FA was significantly lower (FA= 0.52) in patients with higher lesion load (volume > 1360 mm^3) as compared with those patients (FA = 0.63) with lower lesion load ($p = 0.03$). Correspondingly, there were fewer fibers generated in the corticospinal tracts in patients with higher lesion load (Fig 1). Also patients with lesions in the corticospinal tracts showed lower FA values and lower number of fiber tracts as compared with those who don't have lesions on this pathway. In addition, the total number of fiber tracts was lower in the hemisphere with more lesions (Fig 1b).

CONCLUSION: Wallerian degeneration in white matter tracts has been shown to occur in cerebral infarction with decreased anisotropy values [2]. We have demonstrated that the degree of fiber tract loss in corticospinal tracts at the level of the brainstem in MS patients is likely to relate to the lesion load in the supratentorial brain. This suggests fiber tractography can provide a method for quantifying Wallerian degeneration and axonal transection from remote lesions in MS.

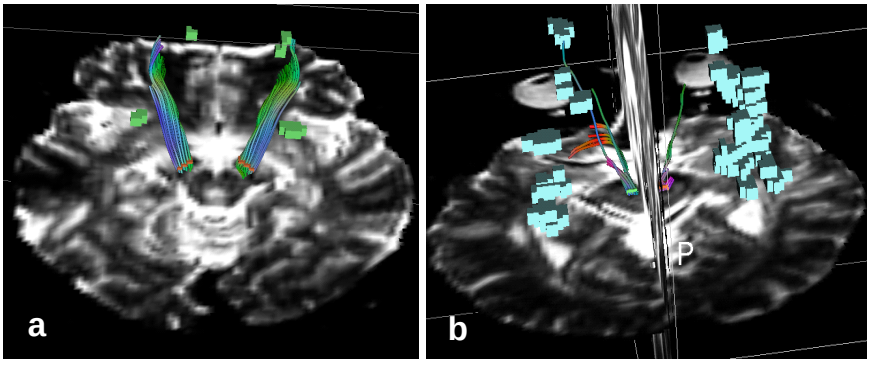

Fig 1. Fiber tracking in corticospincal tract at brainstem level in two MS patients. Fixed size seeds are placed symmetrically in both sides of cerebral peduncle of brainstem in one patient with small (a) and higher (b) lesion number/load. Note the number of fibers of corticospinal tracts is significantly decreased in patient with a higher lesion load, indicating Wallerian degeneration due to remote lesions.

REFERENCES: 1. Trapp BD, N Engl J Med 1998;338:278-285. 2. Zelaya F, Magn Reson Imaging 1999;17:331-348.

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