High-resolution SENSE DTI and Fiber-Tracking Study at 3 Tesla in Multiple Sclerosis

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Introduction

Multiple sclerosis (MS) lesions show heterogeneous pathological hallmarks: inflammation, demyelination, gliosis, axonal loss, and remyelination. The predominance of one or another process can contribute to phenotypic differences between MS patient groups. Diffusion tensor (DT) is very sensitive in depicting pathology and may help in differentiating phenotypes of the disease (1). Several authors have used tractography to study the three-dimensional architecture of white matter tracts (2,3,4). The maps generated correspond well with known anatomy (2,3). Until now, the anatomical assignment of lesions to particular white matter (WM) tracts in MS imaging studies was unspecified.

In this study we evaluate the ability of DT Fiber-Tracking to show changes of WM tracts in different types of MS lesions and in the correspondent normal appearing white matter (NAWM) and to anatomically assign the MS lesions to particular WM tracts by using the colour-coded fractional anisotropy (FA) maps.

Patients and Methods

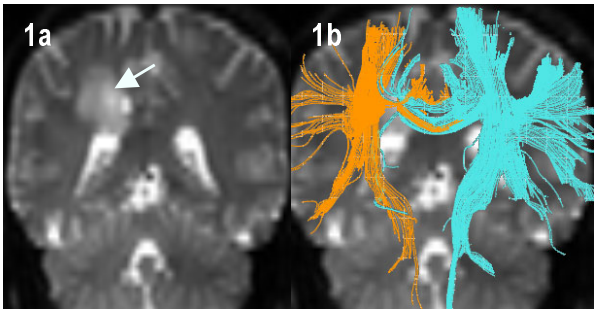
Fourteen patients (8 women, 6 men) with clinically definite MS and 8 healthy volunteers (5 women, 3 men) entered the study. Conventional T2WI, T1WI, FLAIR and DTI data were acquired using a 3-Tesla whole body system equipped with 80 mT/m, 100 mT/m/ms gradient coils and a 6-channel receive head coil array. For the DTI data, a SENSE (5) reduction factor of 2.1 was used in a single-shot SE-EPI scheme (matrix = 96x96, FOV = 200x200x105mm, 44 slices, slice thickness = 3 mm, TE = 71ms, TR = 7751ms). Diffusion weighting with a b-factor of 1000 s/mm2 was performed along six directions, complemented by one scan with b = 0. Processing of the DTI data involved calculating the diffusion tensor elements, eigenvectors, diffusivity and anisotropy at each voxel. Anisotropy maps were obtained using the orientation-independent FA values. For patients, a region of interest (ROI) was defined in lesion areas on the T2-weighted scans and in the contralateral correspondent NAWM. FA values were measured in these selected ROIs. Lesions with diameter >5mm were used as seed areas for fiber-tracking. ROI values and tracts generated were compared with areas of identical topography and size seeded in the contralateral correspondent NAWM. For controls ROIs were bilaterally defined in frontal cingulum, forceps minor, major and corona radiata. Fiber-tracking, distortion correction and analysis have been performed using software developed by collaborators at our institution. Colour-coded map were generated showing the main direction of any anisotropic tissue in accordance with a standard colour coding scheme. For fiber-tracking, a line propagation algorithm was used (4).

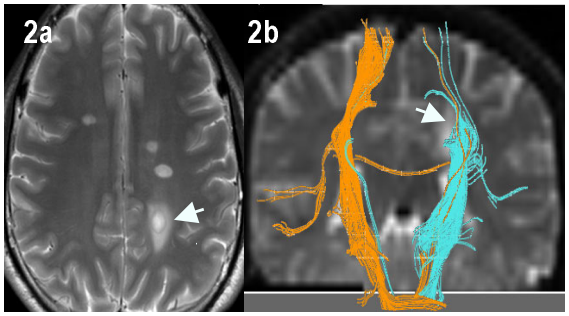
Results

Ten clinically definite relapsing-remitting (RR), 2 secondary progressive (SP), and 2 primary progressive (PP) MS patients were studied. Their mean age was 34 (range 22-64). The mean age of the volunteers was 30 (range 22-40). Fifty-seven MS-lesions were assessed. Fifty were supratentorially, 7 infratentorially located. Nineteen lesions were enhancing. Thirty-seven lesions were hypointense on T1WI. Three lesions showed perifocal edema, 2 lesions had diameter > 2.5 cm. The most frequent supratentorial locations in the WM fibers were: corona radiata, corpus callosum, forceps major, cingulum. The most frequent infratentorial locations in the WM fibers were: ponto-cerebellar, cortico-spinal, cortico-nuclear tracts. The tractography showed no differences in the depiction rate of fibers in enhancing and in nonenhancing lesions. The depiction rate was reduced in 30 hypointense lesions, while there was no significant change of the depiction rate assessed in the isointense T1WI lesions. For lesions with diameter > 1.5 cm, a focal reduction of the depiction rate was observed (Fig 1a-b). Displacement and rarefaction of fibers was observed in lesions surrounded by edema (Fig 2 a-b). In SP patients there was focal and diffuse reduction in the depiction of fibers. The cingulum was tracked in 3 normal subjects and in 5 patients. A consistent rarefaction of fibers was observed in patients both with and without isolated cingulum lesions.

Discussion

These data suggest DTI fiber-tracking is able to show changes of WM tracts in different types of MS lesions and in the correspondent NAWM. The tracking results likely reflect variations in FA values, and seem to provide supplementary information to the known observed changes in signal intensity on T1WI. The anatomical assignment of the MS lesions performed by using the color FA maps could be applied in a wider patient population for additional characterization of the different clinical MS subgroups. Tractograms of WM tracts (Association, Commissural, Projection fibers) allow a more comprehensive anatomical study of this disease.





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