Changes in diffusion tensor eigenvalues in corpus callosum in secondary progressive multiple sclerosis: a longitudinal DTI study

W. TIAN[1], T. Zhu[1], J. ZHONG[1], X. LIU[1], P. Rao[2], B. M. Segal[2], and X. Liu[3]

[1]a) Department of Imaging Sciences, University of Rochester Medical Center, Rochester, NY, United States, [2]University of Michigan, [3]Department of Imaging Sciences, University of Rochester Medical Center, Rochester, NY, United States

Introduction: Secondary progressive MS (SPMS) is characterized by gradually accumulating neurological disability, the progression speed (rate) varies widely among individuals. DTI is regarded as a more valuable tool to evaluate the thorough brain tissue damage than conventional MRI in MS. In our previous preliminary longitudinal study of diffusion tensor imaging (DTI), SPMS patients with enhancing lesions had a significant decrease in fractional anisotropy (FA) in the body and splenium of corpus callosum (CC), by comparison to a patient group with no enhancing lesions during the study period. The purpose of present study is to evaluate the pattern of temporal changes within CC of the eigenvalues (λ1 , λ2 and λ3) in those patients and investigate the characteristics of anisotropy evolution. **Methods:** The study included 11 untreated patients (55±8 yrs) with clinically definite SPMS, who completed 6 bimonthly MRI scans in one year. MRI was performed on a GE Signa Excite 1.5 T scanner with axial post contrast T1WI, 3D T1WI and DTI (TR/TE=10800/80ms, FOV= 24cm, matrix 128x128, NEX=2; 21 diffusion directions, b=1000, 3mm slice thickness). Based on the presence of T1 enhancing lesions during the one-year study period, patients were divided into enhancing and non-enhancing groups, with 5 and 6 patients in each. The FA value and eigenvalues (λ 1 , λ 2 and λ 3) of genu, body and splenium of CC were measured at every time point using a region of interest (ROI) method with a home-built software. Coregistrations of five longitudinal datasets to the one acquired at baseline were performed based on non-diffusion weighted images. Instead of transforming and reslicing DTI data, ROIs drawn in the baseline image were transformed into the following five longitudinal dataset according to the corresponding transformation matrix of co-registration. Analysis of FA, three eigenvalues and radial diffusivity ((λ2+λ3) /2) change over time were evaluated using repeated measures analysis of variance (ANOVA) with SPSS17. **Results:** The enhancing group (C+), SPMS patients with enhancing lesions showed a significant progressive FA decrease in body and splenium of CC (*p* value of 0.003 and 0.01 respectively), without significant change in the genu part (*p* value 0.53), which is consistent with our previous analyses based on individually hand-drawn ROIs. The statistical results of eigenvalues are listed in table 1. There was no significant change of λ 1 in any of the regions (decrease of 1.34%, 0.41% and 0.45%, respectively). The eigenvalues of λ 2, λ 2 and radio diffusivity in body CC were significant increased ($p < 0.05$) over time (increased by 19.94% for λ2 and by 24.64% for λ 3 comparing the first and last exam). Splenium showed a significant increase over time in λ 3 (increased by 20.88%) and radial diffusivity ($P<0.05$), while λ 2, although increased (9.85%), didn't reach statistical significance ($p>0.05$). There was no significant change of eigenvalues and radial diffusivity in the genu CC. For the non-enhancing group (C-), there was no significant change for eigenvalues, radial diffusivity or FA in any parts of CC. Further more, the fiber tracks across CC showed obvious reduction over a year in the enhancing group (see figure1). **Conclusion:** Our results indicate that the body and splenium part of CC are more vulnerable than the genu CC to damage in patients with SPMS who have enhancing lesions. Significant temporal increase of perpendicular eigenvalues(λ 2 , λ 3) and consequently increase in radial diffusivity rather than changes in axial diffusivity (λ 1) may contribute to FA reduction of CC in active progression status compared to relative stable status. These findings could be of help better understand the pathological process in SPMS progression. Furthermore, they suggest that diffusion parameters other than FA may be used as supplementary markers in evaluating the severity and progression of the disease process allowing for non-invasively monitoring of the disease progression, and in exploring pathological changes in functional pathways in the future.

Table 1: Comparison of changes of eigenvalues over time in the body and splenium of CC in 2 groups. * indicates $P<0.05$. (unit: $x10^{-3}mm^2/ms$)

CC	group	λ2			λ3			λ 1		
		1st scan	6th scan	P value	1st scan	6th scan	P value	1st scan	6th scan	P value
Body	C+	0.662±0.082	0.794±0.068	0.016*	0.487±0.067	0.607±0.092	0.007*	1.645±0.048	1.623±0.052	0.61
	C-	0.592±0.076	0.617±0.08	0.557	0.424±0.034	0.454±0.082	0.544	1.618±0.037	1.598±0.087	0.56
Splenium	C+	0.477±0.043	0.524±0.034	0.15	0.297±0.021	0.359±0.026	0.025*	1.672±0.066	1.665±0.048	0.4
	C-	0.435±0.052	0.458±0.081	0.48	0.285±0.028	0.297±0.031	0.39	1.658±0.075	1.641±0.081	0.58

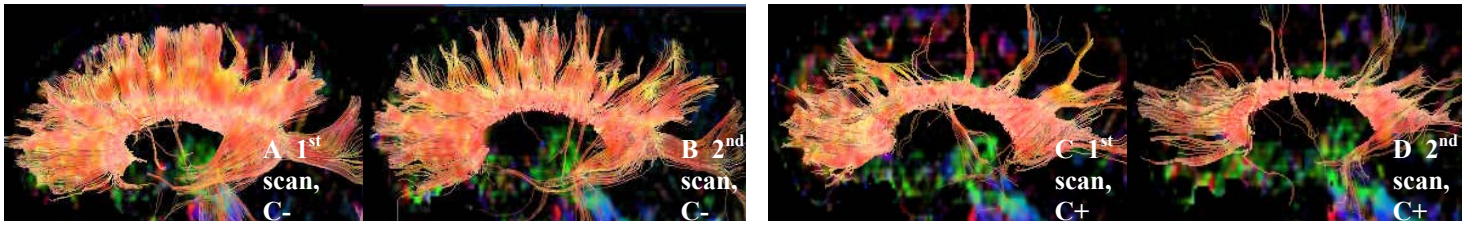

Figure1. Fibers crossing CC at the first (A, C) and last scan of the study (B, D) in 2 patients with and without enhanced lesions over 1-year respectively. Fibers across the body and splenium of CC showed obvious decrease at the end point D (total fiber numbers were 2114) compared to the beginning scan C (total fiber numbers were 3094) in patient with enhancing lesions (C+ patient), while fibers across CC in a patient without enhancing lesions (C- patient) didn't show much change over 1 year from the beginning (A) to the end (B).