Reproducible Protocol for Human White Matter Fiber Tracking and Quantitative Analysis of Their Status

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INTRODUCTION; Diffusion tensor imaging (DTI) has been used for in vivo white matter tract reconstruction (1,2). In order to use this technique for quantitative analyses for tract-specific MR parameter measurements, reproducible and well-characterized protocol for ROI drawing is imperative. In this study, we established and refined protocols for 8 white matter tracts by repeating procedures for protocol setup and reproducibility measurements. The protocols were then applied to normal DTI database to measure FA, ADC, and T2 of individual tracts.

PURPOSE; To establish fiber tracking protocols to measure FA, ADC, and T2 of individual white matter tracts.

METHOD; Subjects ; Five adults (19-29yo,mean 23.8yo, M1,F4) participated our study. Informed consent was obtained.

Data aqusition; Imaging protocols are (a)DWI (ss EPI,TE80ms, TR>6s, matrix 96x96, recon.256x256, FOV240mm, thickness 2.5mm, no gap, SENSE (r2.5), averaging 3, 30 independent axes, b-value 700), (b) T2 weighted images (TE 100/40) using 1.5 T Philips Gyroscan . The six elements of diffusion tensor were calculated at each pixel of the data using multivariate linear fitting. After diagonalization, FA and the color maps were obtained.

ROI criteria for fiber tracking;

We defined the ROI drawing protocols for; Cingulum upper part (CgU), Cingulum lower part (CgL), Cortico Spinal Tract (CST), Anterior Thalamic Radiation (ATR), Inferior Longitudinal Fasciculus (ILF), Inferior Fronto-Occipital Fasciculus (IFO), Superior Longitudinal Fasciculus-body (SLF-B) and -temporal projection (SLF-T). Fiber tracking were performed by FACT (threshold: tract turning angle 40 deg. inner product 0.77, FA 0.2) based on these ROI drawing protocols.

Statistical analysis; We measured (a) intra-rator (same operator, 3 times) and (b) inter-rator (2 operators) reproducibility for each major tracts. For spatial matching of the multiple trials, kappa (k) value was calculated; k value of 0.80-1.0 is considered as almost perfect agreement.

Tract based analysis; Tract coordinates were superimposed on FA, ADC, and T2 maps to measure the parameters of each tract.

RESULTS;

Statistical analysis for tracking reproducibility; Intra-and inter-rater reproducibility showed excellent reproducibility for spatial matching of these selected white matter tracts (Table 1). Reproducibility of FA, ADC, and T2 were all within 5%.

Tract based analysis; Fig.1 showed the correlation between average FA and T2 of the major tracts. CST indicates relatively high FA and T2 values. ADC of each tract was CgU 0.631, CgL 0.684, CST 0.754, ATR 0.598, ILF 0.636, IFO 0.639, SLF-B 0.653, and SLF-T 0.674 x 10^{-5} mm^2/s, indicating relatively high ADC of the CST.

CONCLUSIONS

This study shows that fiber tracking algorithm can be used as a region growing tool to segment specific areas of white matter and to perform quantitative studies once robust protocols are established. Our first application to normal population clearly indicates that each white matter tract system has characteristic signatures in FA, ADC, and T2. This approach should improve sensitivity and specificity of quantitative MR studies of the white matter injuries.

Table 1; The K values of Intra- and Inter-rator variability for major tracts in the human white matter fiber tracts

	CgU	CgL	CST	ATR	ILF	IFO	SLF-B	SLF-T
Intra-rator	**0.986**	**0.955**	**0.952**	**0.919**	**0.939**	**0.942**	**0.938**	**0.914**
Inter-rator	**0.927**	**-**	**0.784**	**0.76**	**0.87**	**0.90**	**0.87**	**0.88**

0.81-1.0; almost perfect agreement, 0.61-0.80 ;substantial, 0.41-0.60; moderate

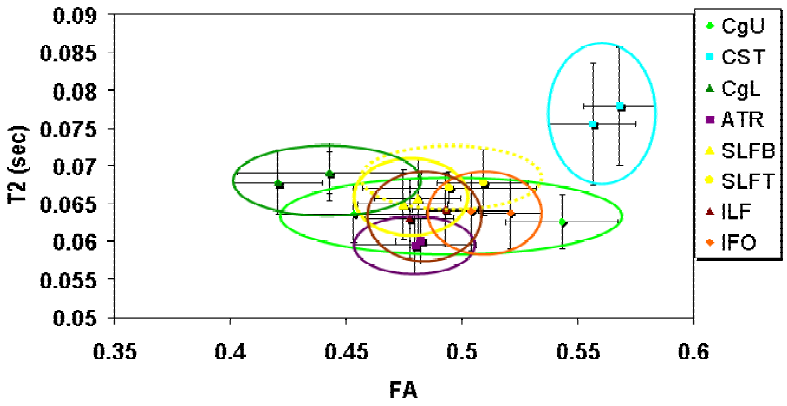

Fig.1: Correlation between average FA and T2 value of each tract.

References;1) Mori S et al, Ann Neurol,2000;47,412-414

2) Conturo TE et.al, Proc Natl Acd Sci USA 1999,96;10422-10427

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