Evaluation of fractional anisotropy and apparent diffusion coefficient of Broca's area in Parkinson's disease using diffusion tensor imaging

J-H. Lee[1,2], S-Y. Kim[1], K-B. Lee[1,2], D-W. Lee[1], Y-B. Choi[2], and B-Y. Choe[1]

[1]Department of Biomedical Engineering, The Catholic University of Korea, Seoul, Korea, Republic of, [2]Department of Radiology, Kyunghee University Medical Center, Seoul, Korea, Republic of

INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disease caused by progressive loss of the dopaminergic neurons in the substantia nigra. Eighty nine percent of patients with PD have problems with speech and voice production, which is caused by damage to the central nervous system. However, the neurological mechanism associated with the language problems of patients with PD has not been determined. The areas of the brain responsible for language in humans are Broca's and Wernicke's areas. Broca's area is connected to Wernicke's area by the arcuate fasciculus (AF), which is a pathway made of neurons. The purpose of this study was to reconstruct the connection of nerve fibers in Broca's and Wernicke's areas by diffusion tensor imaging (DTI) in patients with PD and determine the presence of neurodegenerative changes based on the fractional anisotropy (FA) and apparent diffusion coefficient (ADC) values.

MATERIALS AND METHODS

Subjects Twenty-two patients 60 years of age or older participated in this study. Eleven patients with Parkinson's disease (6 women and 5 men; mean age, 70.36 ± 4.65 years) and 11 gender -and age-matched control subjects (6 women and 5 men; mean age, 67.00 ± 3.80 years) were enrolled.

MR Imaging Acquisition Protocol MR imaging was performed with a 3.0T scanner (Intera Achiva; Philips Medical Systems, Netherlands) equipped with a 16-channel neurovascular phased array coil. All patients were examined by single-shot spin echo EPI sequences for DTI using a 3D T1 turbo field echo sequence for anatomical information.

Data analysis All images were post-processed on a console using a DTI program provided for the Philips 3.0T MRI system. A virtual dissection of the arcuate fasciculus, of the left hemisphere, was performed using two regions of interest (ROIs).

RESULTS

The fiber bundles were confirmed to be connected to Broca's and Wernicke's areas by fiber-tractography (Fig.1-2). Fig.1 shows the pathway of nerve fibers connected by the AF in Broca's and Wernicke's areas in four subjects. In Fig.2, fiber-tractography image and 3D T1-weighted image are fused to identify the anatomical location of AF. The mean and the p-value for the FA and ADC of Broca's and Wernicke's areas of patients with PD and controls are shown in Table.1. The nonparametric Mann-Whitney U-test showed that the FA value in Broca's area was statistically significant for the patients with PD compared to the controls ($p<0.001$). In addition, the FA value for Wernicke's area was statistically significant for the patients with PD compared to the controls ($p=0.045$). However, ADC value for Broca's and Wernicke's areas was not statistically significant. The distribution of the FA and ADC values measured in controls and patients with PD is illustrated in a scatter plot (Fig.3).

DISCUSSION AND CONCLUSION

In this study, there were two important findings. First, we found that the FA values in Broca's and Wernicke's areas of patients with PD were significantly decreased compared to controls. Second, fiber-tractography helped to visualize the connection of nerve fibers in language area of left hemisphere. In conclusion, the results of this study showed the visualization of the pathway of nerve bundles between Broca's and Wernicke's areas using fiber-tractography. The findings showed that the FA values were significantly decreased in patients with PD compared to the controls. These results suggest that neurodegenerative changes occur in the language areas of patients with PD.

ACKNOWLEDGEMENT

This study was supported by a grant of the Seoul R&BD Program (10550), grants (2010-0008096) from the Basic Science Research Programs through the National Research Foundation (NRF) and the program of Basic Atomic Energy Research Institute (BAERI) which is a part of the Nuclear R&D Programs funded by the Ministry of Education, Science & Technology (MEST) (2009-0078390)"of Korea

REFERENCES

[1] Broca P. Bull Soc Anthropol. 2, 235 (1861). [2] Catani M, Jones DK, ffytche DH, Ann Neurol. 57, 8 (2005). [3] Powell HW et al., Neuroimage. 32, 388 (2006). [4] Vaillancourt DE et al., Neurology. 72, 1378 (2009).

Table 1. Mean FA and ADC values for Broca's and Wernicke's areas in controls and patients with PD.
(All data are expressed as mean ± standard deviation. FA, fractional anisotropy; ADC, apparent diffusion coefficient)

		Control	Parkinson	P-value
Broca	FA	0.337 ± 0.037	0.257 ± 0.029	0.001
	ADC	0.774 ± 0.120	0.863 ± 0.119	0.115
Wernicke	FA	0.426 ± 0.106	0.350 ± 0.111	0.045
	ADC	0.741 ± 0.074	0.794 ± 0.122	0.224

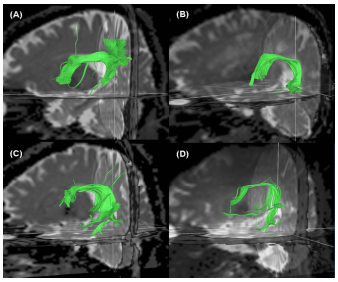

Fig.1. Reconstructed fiber-tractography of the direct pathways in four individual subjects superimposed on b=0 images (A, B, C, D). The direct pathways of the arcuate fasciculus were observed in all subjects; however, there were individual variations.

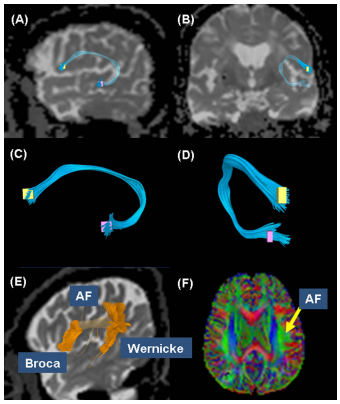

Fig.2. FA and ADC values were determined by the small yellow and pink ROIs in Broca's and Wernicke's areas on the reconstructed image. (AF; arcuate fasciculus, Broca; Broca's territory, Wernicke; Wernicke's territory)

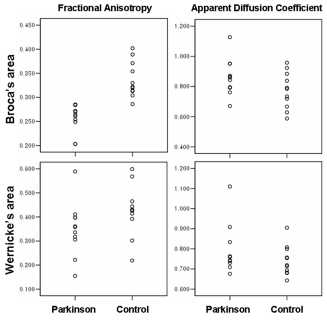

Fig.3. FA and ADC values of patients with PD and the controls are shown in a scatter plot. The FA values of the patients with PD were lower than the control group in both Broca's and Wernicke's areas.