A Preliminary Diffusional Kurtosis Imaging Study of Parkinson Disease: Comparison with Conventional Diffusion Tensor Imaging

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Introduction: White matter abnormalities have been extensively investigated in Parkinson disease (PD). Diffusion tensor imaging (DTI) studies have reported diffusion abnormalities in the cerebral white matter in patients with PD,[1-3] but these findings are controversial. Diffusional kurtosis imaging (DKI) is an extension of DTI that enables simultaneous quantification of Gaussian and non-Gaussian diffusion in the brain.[4] DKI is a sensitive marker of tissue microstructure and as such provides information complementary to DTI metrics.[5,6] The aims of this preliminary study were to investigate how the white matter is altered in PD as measured with DKI and to compare this to what is shown with DTI.

Methods: DKI scans were obtained from 12 patients with PD and 10 age- and sex-matched healthy controls. Diffusion-weighted images were obtained on a 3T MR imager (Achieva; Philips Healthcare) using a spin-echo EPI sequence with 3 diffusion weightings (b = 0, 1000, and 2000 s/mm^2) along 20 diffusion-encoding directions. Parametric maps of the standard DTI metrics of MD and FA, as well as the additional DKI metric of mean kurtosis (MK) were obtained. FA maps were spatially normalized to standard space using the FMRIB Software Library (FSL), and the resulting transformation was applied to normalize the other maps. Following spatial normalization, standard and skeleton-based voxelwise analyses were performed using tract-based spatial statistics (TBSS).

Results: FA values in the frontal white matter and in part of the genu of the corpus callosum were significantly lower in patients with PD than in healthy controls (Figure 1). Reductions in MK were seen more extensively throughout the brain: in addition to the frontal white matter, reduced MK was seen in the parietal, occipital, and right temporal white matter. TBSS analyses identified appreciably more significant voxels with MK than with DTI measures.

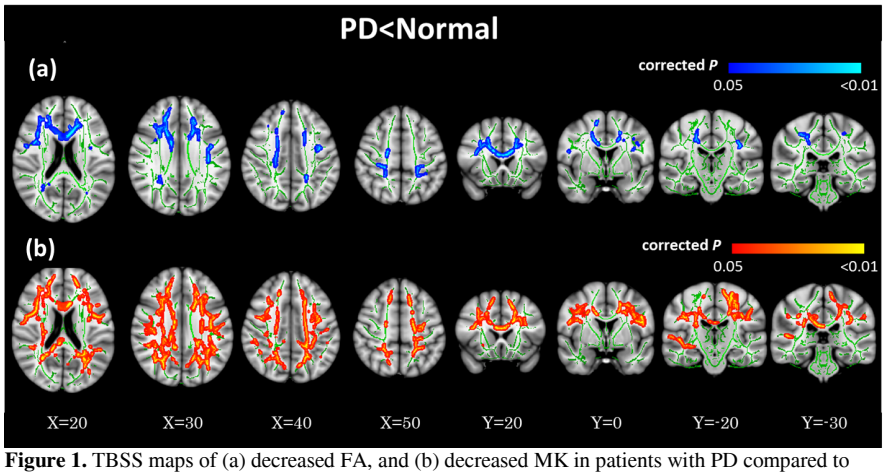

Figure 1. TBSS maps of (a) decreased FA, and (b) decreased MK in patients with PD compared to age-matched healthy subjects shown in neurological convention. In the TBSS maps, the FA skeleton with FA > 0.3 is shown in green, and voxels with one-sided permutation-corrected $P < 0.05$ are marked in blue (FA) and red (MK).

Conclusion: DKI can detect changes in the cerebral white matter of PD patients more sensitively than conventional DTI. By providing a potentially more sensitive marker of brain pathology in PD, DKI may enable improved monitoring of disease progression and more effective treatment planning.

References: 1. Hattori T, Orimo S, Aoki S, et al. Hum Brain Mapp. 2012; 33:727–739. 2. Kamagata K, Motoi Y, Abe O, et al. AJNR 2012; 33:890–895. 3. Lee JE, Park HJ, Park B, et al. J Neurol Neurosurg Psychiatry. 2010;81(3):320–326. 4 Jensen JH, Helpern JA, Ramani A, et al. Magn Reson Med. 2005; 53:1432–1440. 5. Cheung MM, Hui ES, Chan KC, et al. NeuroImage. 2009;45:386–392. 7 Hui ES, Cheung MM, Qi L, et al. NeuroImage 2008; 42:122–134. **Acknowledgments:** This work is supported by a Grant-in-Aid for Scientific Research on Innovative Areas (Comprehensive Brain Science Network) from the Ministry of Education, Science, Sports, and Culture of Japan, and MEXT/JSPS KAKENHI Grant Number 24591787.