Preliminary Diffusional Kurtosis Imaging of the substantia nigra in de novo Parkinson disease: Diagnostic Utility of Histogram Analysis

Koji Kamagata[1], Masaaki Hori[1], Kohei Kamiya[1], Michimasa Suzuki[1], Akira Nishikori[2], Mariko Yoshida[1], Fumitaka Kumagai[2], Taku Hatano[3], Hiroyuki Tomiyama[3], Nobutaka Hattori[3], and Shigeki Aoki[1]

[1]*Department of Radiology, Juntendo University School of Medicine, Tokyo, Bunkyo-ku, Japan,* [2]*Department of Radiological Sciences, Tokyo Metropolitan University, Tokyo, Japan,* [3]*Department of Neurology, Juntendo University School of Medicine, Tokyo, Bunkyo-ku, Japan*

Target audience: Neurologist**,** Neuro-radiologists, Basic and clinical researchers working on neuroimaging of neurodegenerative disease.

Introduction: The potential for histogram analysis of diffusion metrics to reveal brain-tissue damage in neurodegenerative diseases such as Parkinson disease (PD) and multiple system atrophy has been pointed out in several studies [1, 2]. Patients with PD show a selective loss of dopaminergic neurons in the substantia nigra pars compacta (SNpc), a structure in the midbrain. Recent developments in diffusion tensor imaging techniques offer new promise for identifying surrogate markers of degeneration within the SNpc in vivo [3, 4]. Here we explore the usefulness of analyzing histograms of mean diffusivity (MD), fractional anisotropy (FA), and mean kurtosis (MK) derived from diffusion tensor/kurtosis imaging of SN to diagnose PD.

Methods: DKI scans were obtained from 15 patients with PD and 12 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* values) along 32 diffusion-encoding directions. The imaging parameters were as follows: repetition time/echo time, 4000/80 (ms/ms); number of signals acquired, one; section thickness, 5 mm; number of sections, 20; field of view, 110 × 110 mm^2; matrix, 112 × 112; imaging time, approximately 9 min; *b* values, 0, 1000, and 2000 s/mm^2. The gradient length (δ) and time between the two leading edges of the diffusion gradient (Δ) were 21.4 and 39.6 ms. MD and FA were calculated on the basis of a conventional monoexponential model by using data for $b = 0$ and 1000 s/mm^2. MK was calculated from data for all values of *b*. Regions of interest were drawn in the SNpc with reference to the b0 image. Histograms of MD, FA, and MK were generated for all pixels in the SNpc (Figure 1). The Mann–Whitney *U* test was used to assess between-group differences in MD, FA, and MK. All resulting *P* values were corrected with the Bonferroni method. Receiver operating characteristic (ROC) analysis was also performed to compare the diagnostic abilities of the mean and median values of MD, FA, and MK.

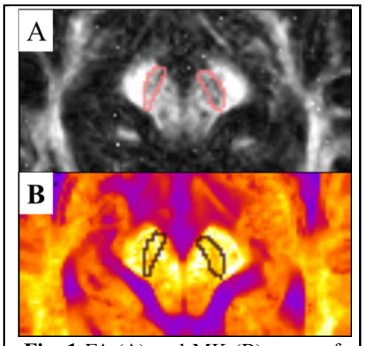

Fig. 1 FA (A) and MK (B) maps of the regions of interest in the substantia nigra pars compacta (SNpc).

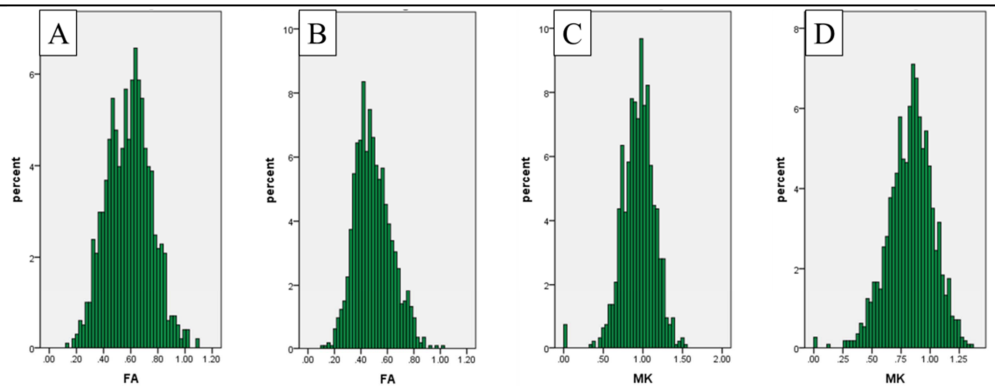

Fig. 2 Histograms of FA in the SNpc for a group of healthy controls (A) and a group of patients with PD (B). Histograms of MK in the SN for the healthy controls (C) and patients with PD (D).

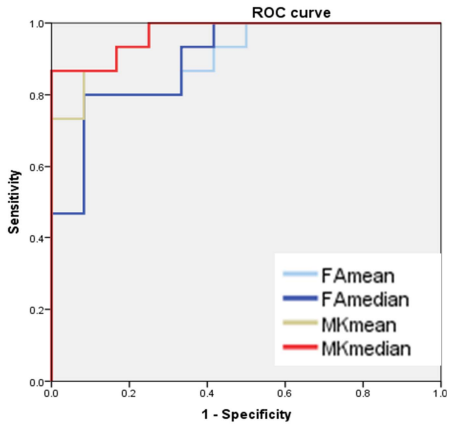

Fig. 3 ROC plots from the mean and median values of FA and MK in SN**pc**.

Results: Mean and median values of FA and MK in the SNpc were significantly lower in PD patients than in healthy controls, in line with the consistent neurodegenerative damage known to occur in this structure in PD. The area under the ROC curve was 0.972 for the median MK and 0.961 for the mean MK in the SNpc. The median MK showed the best diagnostic performance (mean cutoff, 0.910; sensitivity, 0.93; specificity, 0.83).

Discussion: The finding that mean and median values of FA and MK in the SNpc were significantly lower in PD patients is consistent with pathologic patterns of nigral degeneration. **Conclusion:** Histogram analysis of diffusion metrics in the SNpc may be expected to improve the ability to diagnose PD in vivo because they provide complementary and different information.

References: 1. Nicoletti G, et al. Radiology 2013;267:843–50. 2. Testa C, et al. JMRI 2004;19:274–82. 3. Vaillancourt DE, et al. Neurology 2009;72:1378–84. 4. Wang JJ, et al. Radiology 2011;261:210–7.