Diagnosis of Early-stage Idiopathic Parkinson's Disease: Feasibility of Nigrosome 1 Imaging at 3T

Eung Yeop Kim[1], Young Noh[2], Young-Hee Sung[2], and Jongho Lee[3]

[1]Radiology, Gachon University Gil Medical Center, Incheon, ., Korea, [2]Neurology, Gachon University Gil Medical Center, Incheon, ., Korea, [3]Electrical and Computer Engineering, Seoul National University, Seoul, ., Korea

Introduction: Recently, Schwartz et al. suggested that visualizing nigrosome 1 using MRI may assist the diagnosis of idiopathic Parkinson's disease (IPD) [1]. The study, however, enrolled subjects with various severity of the disease and lacked independent confirmation of IPD using a gold standard (dopamine transporter (DAT) imaging using ^{18}F-FP-CIT PET or SPECT). Generally, diagnosing an early stage Parkinsonism is more difficult than an advanced stage. In the early stage of IPD, patients often present asymmetric motor symptoms, which have been suggested to correspond to the nigrostriatal degeneration in the contralateral hemisphere.[2] Here, we hypothesized that dopaminergic cell loss in the substantia nigra pars compacta reflects the contralateral symptoms in early-stage IPD and that this loss is observable by the structural change in the region of the nigrosome 1 at 3T MRI. To validate these hypotheses, we acquired DAT PET data and 3T MRI data from early-stage IPD patients and correlated the laterality of the imaging results with the patient symptoms.

Methods: A total 24 patients (age, 63.6±11.0; 14 male) with IPD and 13 healthy controls (age, 61.6±12.3; 4 male) were enrolled. For MRI, 3T MRI with a 32-channel head coil was used. An oblique axial slab was acquired using a 3D multiecho GRE sequence (MEDIC, a variant of multi-echo GRE that combines multi-echoes). The imaging orientation was vertical to the longitudinal axis of the midbrain that was visualized on a sagittal MPRAGE image (Fig. 1). The sequence parameter for MEDIC was as follows: TR = 88 ms; # echoes = 6; mean TE of the echoes = 39 ms (or up to 45 ms in a few subjects); FA = 10°; Matrix size = 384×384×20; FOV = 192×192×30 mm^3; GRAPPA = 2. Additionally, an oblique coronal slab was obtained by the same sequence. The orientation was parallel to the the longitudinal axis of the midbrain which was depicted on a sagittal MPRAGE image (Fig. 1). Two independent raters classified the bilateral nigrosome 1s (arrows on Fig. 1) as 'normal', 'possibly normal' or 'abnormal' separately.

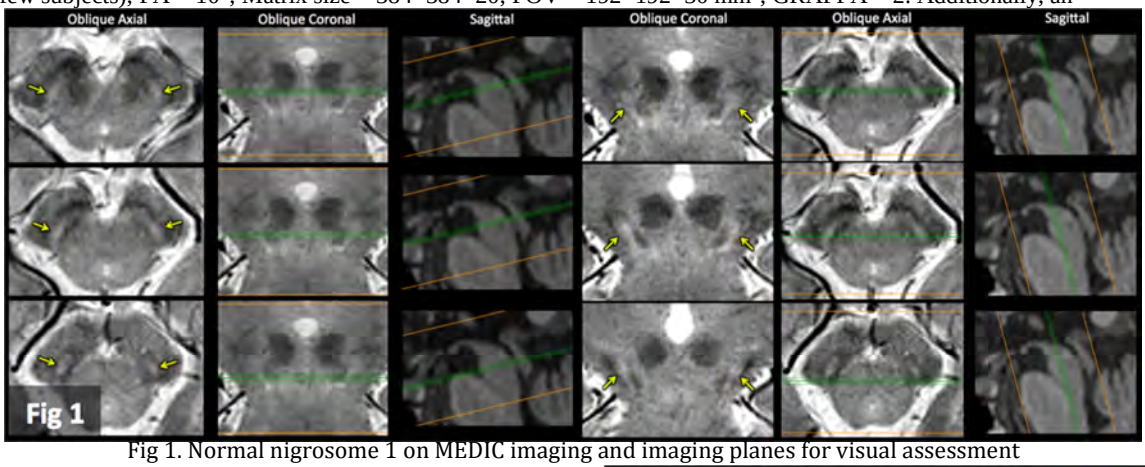

Fig 1. Normal nigrosome 1 on MEDIC imaging and imaging planes for visual assessment

Asymmetry was determined once the rate was different between the right and left nigrosome 1s. Clinical laterality was evaluated by scores of UPDRS part III tested bilaterally. DAT PET using ^{18}F-FP-CI was also acquired from the patients and the data were evaluated for asymmetry.

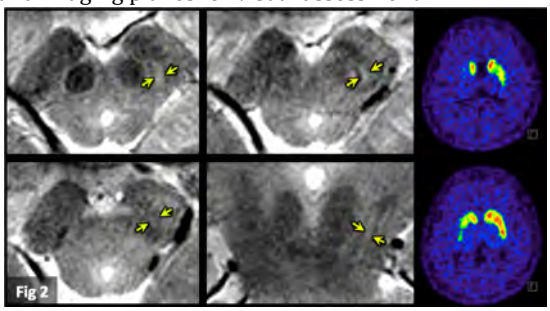

Fig 2. The right nigrosome 1 is affected on MRI, correlating with UPDRS of 7 on the left. PET shows abnormality on the right.

Results: In MRI images, inter-rater agreement for the abnormality of nigrosome 1 was excellent (k = 0.863). Two out of 13 normal controls were misclassified as the abnormal group. Diagnostic sensitivity, specificity, and accuracy were 100%, 85.7%, and 94.6% respectively. Inter-rater agreement on the laterality of nigrosome 1 was also excellent (k = 0.835). In the IPD patients, the correlation of the asymmetry on nigrosome 1 determined by MRI and clinical laterality evaluated by UPDRS part III was high (Spearman's rho = 0.629, P = 0.001) (Fig. 2). On the other hand, the correlation of the asymmetry on DAT PET data and clinical laterality was lower than that of MRI and clinical laterality (Spearman's rho = 0. 371, P = 0.074) (Fig. 3).

Conclusion and Discussion: Here we investigated the feasibility of imaging the nigrosome 1 on 3T MRI for the diagnosis of early-stage IPD patients. Our results suggest that the abnormality of nigrosome 1 in IPD can be detected by 3T MRI with a high accuracy (94.6%). The clinical laterality was in higher concordance with the laterality in MRI nigrosome 1 imaging than that in DAT PET. This finding may have clinical implications which may negate the need of DAT PET particularly when definite asymmetric abnormality is observed in nigrosome 1 and correlates with clinical laterality. Despite the high sensitivity of the nigrosome 1 imaging as a diagnostic marker for IPD (100%), its specificity was relatively low (85.7%) limiting the utility of the nigrosome 1 imaging in a clinical use. The specificity may be enhanced by an imaging sequence with the higher SNR and resolution. Prior to this study, we tested a few different MRI sequences (e.g., SWI) in elderly healthy subjects in order to examine the feasibility to visualize pathology in nigrosome 1. We found that both high SNR and high spatial resolution are required for the visualization. MEDIC gave a good compromise between the resolution and SNR. Since there may be partial-volume effects from the relatively thick slice, the coronal images provided additional information that may be hidden in the axial data.

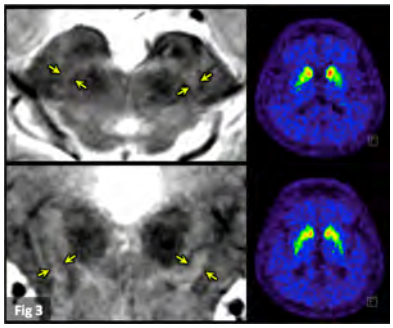

Fig 3. UPDRS of 6 and 3 (right and left). The right nigrosome more affected on MRI. PET shows symmetric abnormality.

References: 1. Schwarz et al., PloS One 2014;9:e93814. 2. van der Hoorn, et al., Parkinsonism Relat Disord 2011;17:58-60