An improved SWI method for nigrosome 1 imaging

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INTRODUCTION In Parkinson's disease, dopaminergic neurons in substantia nigra (SN) is gradually lost over the progression of the disease. Recently, it has been suggested that this change may be related to the reduction of the susceptibility contrasts in a substructure of SN known as nigrosome 1 (Fig. 1) [1-5]. Hence, visualizing nigrosome 1 may provide an important clinical tool in detecting and assessing Parkinson's disease. Previously, the structure was successfully delineated at 7T using a high-resolution SWI image [1,2,4,5] demonstrating the relationship between the structure and the disease. At clinical field strength (3T), however, the structure was visible with a limited contrast to noise ratio (CNR) hampering diagnostic confidence. In this work, we proposed an approach to enhance the CNR of the nigrosome 1 structure. Additionally, a navigator echo was acquired to compensate for physiological noises (respiration) in the data. The new approach substantially improved CNR and successfully visualized nigrosome 1 at 3T.

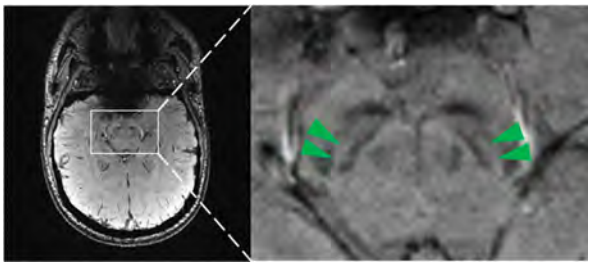

Figure 1. Nigrosome 1 (arrows) in Substantial Nigra (The brain is upside down)

METHODS A total of six subjects, two PD patients and four control subjects were scanned at a Siemens 3T scanner (IRB-approved). To improve CNR, we modified a conventional SWI sequence to acquire multi-echo data with a readout navigator at the last echo. The sequence with the navigator was not available for patient. The sequence parameters were as follows: TR = 78 ms, resolution = 0.5 x 0.5 x 1 mm^3, BW = 120 Hz, # echoes = 6 (including a navigator echo TE = 11.0:10.8:65.0 ms), # slices = 30, and total scan time = 6 min. For the localization of SN, MPRAGE was acquired as a reference and an oblique coronal slab (3 cm) that covers SN was imaged. After data collection, respiration-induced B_0 fluctuation was corrected using the navigator echo. The corrected k-space data were processed to generate magnitude and phase images in each echo. SWI reconstruction was performed at each echo image, and then the generated SWI images of all echoes were combined to enhance the visibility of the nigrosome 1 structure. Two combination methods, sum of squares (SOS) and mean, were compared. Additionally, the same data were reconstructed for conventional SWI reconstruction in the 3rd echo (TE = 32.6 ms) without the navigation echo correction. For evaluation, two ROIs (nigrosome 1 and the last of SN) were manually drawn and CNRs (signal difference between the two regions divided by noise std of the magnitude image) were calculated.

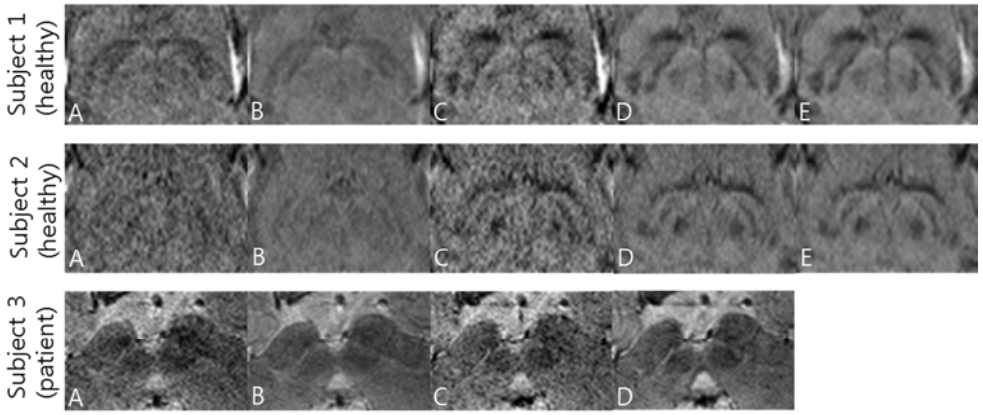

Figure 2. Two healthy volunteers (first and second rows) and a PD patient (third row). (A) single-echo GRE magnitude (TE=32.6ms), (B) multi-echo GRE magnitude (SOS recon), (C) conventional SWI, (D) multi-echo SWI (mean recon), (E) multi-echo SWI with navigator echo (mean recon)

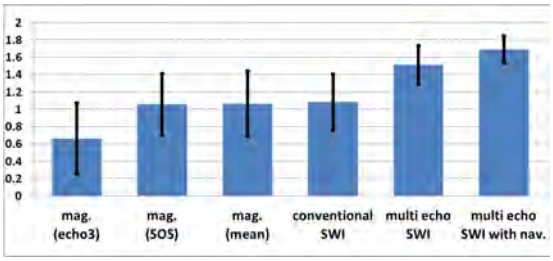

Figure 3 Comparison of CNR

RESULTS Compared to T_2*-weighted magnitude images (Fig. 2a), multi-echo magnitude SOS images (Fig. 2b), and conventional SWI images (Fig. 2c), the visibility of nigrosome 1 are substantially improved in the combined SWI images from multi-echo data (Fig. 2d,e) in the healthy subjects. The navigator echo corrected further improved the visibility images (Fig. 2e). In the patient images (last row in Fig. 2), however, nigrosome 1 are not clearly distinguishable. Figure 3 shows quantitative CNR comparison results demonstrating the highest CNR in the multi-echo combined SWI images with navigator echo correction.

DISCUSSION In this study, we visualized the nigrosome 1 structure in high CNR by combining multi-echo SWI and navigator echo correction. This method may improve clinical diagnosis of the Parkinson's at 3 T. **REFERENCES** [1] Kwon, Annlas of Neuro, 2012 [2] Balzejewska, Neurology, 2013 [3] Schwarz, PLOS one, 2014 [4] Schwarz, Lancet, 2014 [5] Cosottini, AJNR, 2014