QUANTITATIVE SUSCEPTIBILITY MAPPING AS A POTENTIAL BIOMARKER IN PARKINSON'S DISEASE: A CLINICAL APPLICATION STUDY

Sung-han Lin[1], Chin-Song Lu[2], Yi-Hsin Weng[2], Yao-Liang Chen[3], Yi-Ming Wu[3], and Jiun-Jie Wang[1]

[1]*Medical Imaging and Radiological Science, Chang Gung University, Taoyuan County, Taiwan, Taiwan, [2]Department of Neurology, Chang Gung Memorial Hospital and College of Medicine, Chang Gung University, Taoyuan, Taiwan, [3]Department of Radiology and Intervention, Chang Gung Memorial Hospital, Taoyuan, Taiwan*

PURPOSE

The Parkinson's disease (PD) has been associated with iron deposition in the striatum and basal ganglia[1]. The susceptibility weighted imaging allows for the measurement of the mineralization in the brain and following qualitative analysis. In the current study the susceptibility abnormality of the gray matter in deep brain for PD patients has been investigated. For this purpose, the Quantitative Susceptibility Mapping (QSM) was applied, which provided precise measurement of the susceptibility differences between PD patients and normal controls.

METHODS

Two age-matched subject groups were recruited including 30 normal control subjects (aged 60.7±7.1 years) and 33 PD patients (aged 62.4±7.9 years). The study was approved by the institution review board. Susceptibility-weighted imaging was performed on a 3T MR scanner (TIM-Trio, Siemens, Germany). Axial images were acquired using multi-echo gradient echo sequence with matrix size = 240×320×80, spatial resolution = 0.72×0.72×1.5 mm, TR= 45ms, TEs =12.06/20.5/28.94/37.36ms, FA = 15°. The QSM was estimated by the morphology enabled dipole inversion approach[2]. Differences in susceptibility were compared in manually selected regions of interest (ROI) in striatum and basal ganglia including the caudate nucleus (CN), the putamen (PU), the globus pallidus (GP), the substantia nigra (SN) and the red nucleus (RN) (colored regions in Fig. 1). In the following, indices "r" and "l" indicate right and left side of the ROI in the brain, respectively. For the statistical comparison, nonparametric Wilcoxon rank-sum i.e. Mann–Whitney U test was performed with significant level $p<0.001$.

RESULTS

Figure 1 shows the QSM of the representative normal subject (top) and PD patient (bottom) in deep brain for slices with the striatum (left column) and basal ganglia (right column). The median magnetic susceptibility values of deep brain obtained from PD patients were compared with the ones from normal controls using nonparametric statistics. Except for the bilateral CN and the right SN, significant susceptibility differences between PD patients and normal controls have been detected (Fig. 2). Increased susceptibility was found for the most part of ROIs.
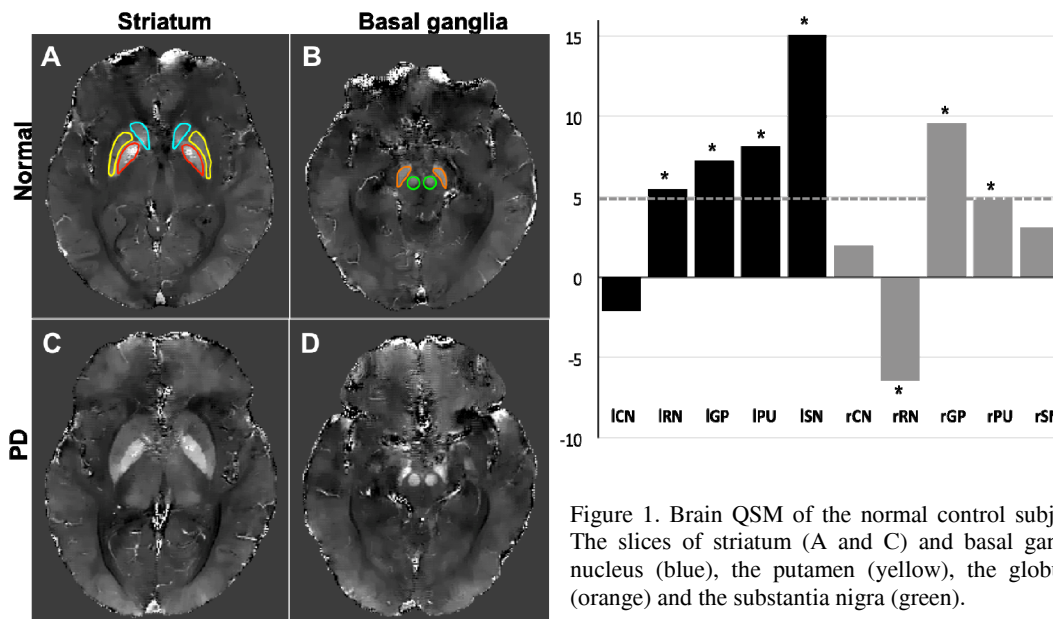

Figure 2. Susceptibility differences of median values (in %) between PD patients and normal controls in the selected ROIs: the caudate nucleus (CN), the red nucleus (RN), the globus pallidus (GP), the putamen (PU), and the substantia nigra (SN). The "l" and "r" indicate left and right side. ROIs in the left side were plotted with black bars and the right side ones were plotted in gray bars. Stars indicate the significant difference with p<0.001. The dash line shows the 5% changes threshold.

Figure 1. Brain QSM of the normal control subject (top) and PD patient (bottom). The slices of striatum (A and C) and basal ganglia (B and D) show the caudate nucleus (blue), the putamen (yellow), the globus pallidus (red), the red nucleus (orange) and the substantia nigra (green).

DISCUSSION&CONCLUSIONS

In the current study, the regions with significantly increased susceptibility were found to be consistent with the PD pathological regions including the SN, PU and GP[1]. The disrupted balance of neurotransmitters would contribute to the PD progression. The major pathologic aspect of PD consists in the death of dopaminergic neurons in the SN which projects into the PU. The decreased trend of the susceptibility changes in left SN, PU and GP could potentially reflect the disrupted gamma-aminobutyric acid (GABA) pathway, which may contribute to the secondary symptoms of PD[3]. In addition, different trend between left and right side was observed and might be explained by the neuronal laterality of PD[3]. In RN, the opposite difference between right and left sides could be the bias of statistics, which was caused by the small size of the corresponding ROI. The obtained results represent the feasibility of QSM as a sensitive method for the measurement of the severity of the pathological changes underlying PD.

REFERENCES

1. Gupta D, Saini J, Kesavadas C et al. Utility of susceptibility-weighted MRI in differentiating Parkinson's disease and atypical parkinsonism. Neuroradiology. 2010;52(12):1087-94. **2.** Liu J, Liu T, de Rochefort L et al. Morphology enabled dipole inversion for quantitative susceptibility mapping using structural consistency between the magnitude image and the susceptibility map. NeuroImage. 2012;59(3):2560-8. **3.** Choe BY, Park JW et al. Neuronal laterality in Parkinson's disease with unilateral symptom by in vivo 1H magnetic resonance spectroscopy. Investigative radiology. 1998;33(8):450-5.