

# Parkinson's Disease and Imaging of the Substantia Nigra Structure with 7.0T MRI

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## Introduction

Parkinson's disease (PD) is neurodegenerative disorder which is caused by inexorably progressive death of nigrostriatal neurons in substantia nigra (SN) of the midbrain. Iron stores in SN using magnetic resonance imaging as well as postmortem neurochemical evidence have been discussed [1]. And excessive iron accumulation in SN in PD has suggested an important mechanism for SN neuronal death [2]. T2\* weighted MR image is influenced by iron deposition, so that SN shows up iron-related MRI contrast for all that SN is gray matter [3]. Therefore T2\* MR imaging shows great potential in PD study using ultra high field (UHF) 7.0T MRI because the magnetic susceptibility effects increase linearly with the strength of the static magnetic field. And 3D T2\* Gradient Echo (GE) sequence makes it possible to study a volumetric analysis and a structural morphometry for SN.

## Methods

The 7.0T images were acquired on a Siemens Magnetom scanner with an 8 channel transmit-receive SENSE head coil(NRI) using a 3D T2\* weighted GE sequence with 0.347mm x 0.347mm x 0.35mm resolution, TE/TR=25/50 ms, flip angle=10°, bandwidth=30Hz per pixel. And we used fast imaging techniques, known as GRAPPA(R=2, ref=70), Partial Fourier(Slice-6/8, Phase-6/8) and Asymmetric Echo in order to minimize motion artifacts by tremor or involuntary movement of the PD patient. As a result, the total scan time was significantly decreased to 8 min and 23s from 25 min and 14s. Next, the control group consisted of 10 subjects (mean age, 58.8±5.8) without neurologic deficit. And the group with PD included 10 patients (mean age, 59.9±7.4) scored Hoehn&Yahr Stage 1 to Hoehn&Yahr Stage 3. Then 3D MR images were acquired obliquely at Anterior Commissure (AC)-Posterior Commissure (PC) reference. Precisely, images were acquired at reference that is perpendicular to line splicing a point between mammillary body(MMB) and tegmentum of midbrain to a point between tegmentum of midbrain and pons in midline sagittal MR image (Fig.1(a)). Because of this reference that slices midbrain almost perpendicularly, SN also is sliced perpendicularly and partial volume effect decreases. In addition subthalamic nucleus (STN) that is near to SN greatly is mixed at ventral part of the SN in midbrain MR image of the AC-PC reference, while STN is located at dorsal part of the SN between SN and red nucleus (RN). Thus reference that is oblique to AC-PC reference is better for SN segmentation. Finally, manual tracing of the SN was performed using software packages of 3D Slicer. By the way, the segmentation of the SN was very difficult because many blood vessels exist in cerebral peduncle between RN and crus cerebri (CC) and MR contrast of blood vessels is same as SN in GE images. Moreover boundary of the SN is very ambiguous compared with another tissue. To solve these problems, proper thresholding values are applied. And we used unwrapped phase contrast image of the 3D T2\* MR images for accurate segmentation between SN and STN (Fig.1(c)).

## Results

3D model of the SN by iron-related MRI contrast also was performed using 3D Slicer. First of all, we compared normal subjects with PD patients. One notable difference, contrast of dorsolateral part of the SN in lower midbrain MR images is different fairly (Fig.2(a) yellow arrow). In other words SN of that part of the normal control is bright but PD patient's MR images are dark. Therefore 3D model also shows difference of that part in SN (Fig.2(b) yellow line). Second, ventral view of the model totally shows irregularity of the boundary between CC and SN pars reticulata (SNr) (Fig.2(b)). This fact is caused by a distribution of dopaminergic (DA) neurons looks like the shape of finger [4] and become clear in images tilted to AC-PC reference with corresponding to 3D model.

## Discussion

A robust analysis of the SN for using UHF 7.0T 3D GE T2\* image to model iron-related MRI contrast in PD study has been presented. The method was validated, despite the reduced SNR associated with fast imaging techniques. And 3D model of the SN shows quite well structural changes in PD case. Further works may be deformation-based morphometry and study of correlation between structural change and the pathology.

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**Reference** [1] E. M. Haacke, et al., Magn Reson Imaging 2005; 23:1-25. [2] M. Fasano, et al., J. Neurochem 2006; 96:909-916. [3] J.M. Gorell, et al., Neurology 1995; 45:1138-1143. [4] Bjorklund A et al. Trends Neurosci. 2007;30:194-202.

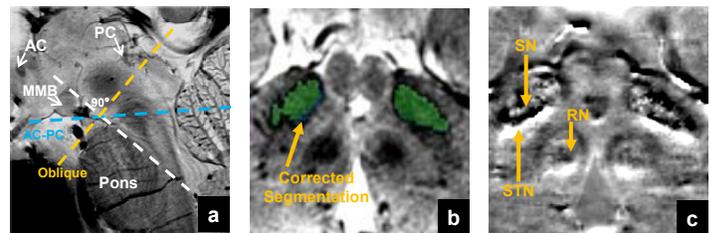


Fig 1. 2D MR images (a) sagittal image (b) oblique 3D T2\* MR image and segmented image (c) phase contrast image

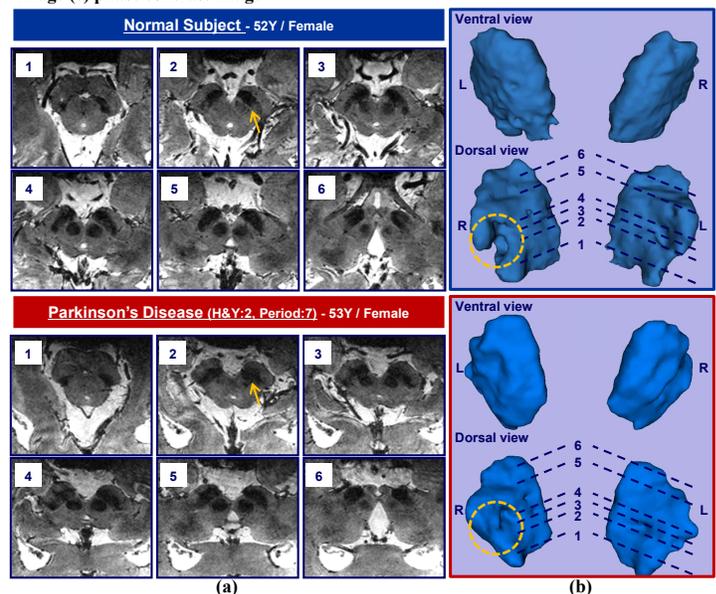


Fig 2. (a) MR image (b) 3D Model of the SN by iron-related MRI contrast