

Parkinson's Disease - Direct Visualization by 7.0T Brain Imaging

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Introduction

Parkinson's disease (PD) is a representative neurodegenerative disorder which is caused by progressive loss of dopaminergic (DA) neurons in the substantia nigra (SN). Therefore, the SN has been one of the most suspected regions that potentially lead us to look at for diagnosis of PD¹⁾. In SN, much iron ions are deposited. T2*, or susceptibility weighting, is heavily influenced by iron deposition, so that nuclei like the SN show up nicely as dark structures on a light background. The magnetic susceptibility effects increase linearly with the strength of the static magnetic field. At low static field the T2*-weighted images are not very sensitive to the iron deposited areas. Increasing the static field to 7.0T provides a significant increase in SNR and contrast, thus enabling the acquisition of higher-resolution and higher-contrast images with increased sensitivity to the susceptibility differences. At 7.0T it is possible to make clear shape and boundary pictures of the SN.

Methods

The magnet used was the 7.0T research prototype MRI scanner (Magnetom 7T, Siemens) with gradient strength of 40 mT/m. All the images were acquired using 2D T2* weighted Gradient Echo sequence. The specific MR imaging parameters used were; Repetition Time = 750 msec; Echo Time = 17.8 msec; Flip Angle = 45. In plane resolution was 0.25 mm and the slice thickness was 2 mm. For the purpose, we have developed a specifically designed 7.0T optimized 8-channel SENSE coils. The control group consisted of 8 subjects (3 men and 5 women) 40 to 65 years old (mean age, 52.5±8.1) without neurologic deficit or abnormal findings on conventional 1.5T MR images. The group with Parkinson's disease included 5 early patients (3 men and 2 women, Hoehn&Yahr Stage 1) 45 to 65 years old (mean age 58.2±8.3, mean duration 3.25±0.5) and 5 advanced patients (1 man and 4 women, Hoehn&Yahr Stage 3) 54 to 65 years old (mean age 57.2±4.5, mean duration 8.6±2.5).

Results & Conclusions

In the case of normal control (Fig.1(A)), the boundaries between the SN and CP appear smooth and clean "ARC" shapes stretching from posterior to anterior (Fig.1(B) yellow line), especially toward ventrally. This clean and smooth "ARC" shape boundaries between the SN and CP toward the anterior aspects are the hallmarks of the normal controls. This clean and smooth arc between the SN and CC toward lateral and anterior aspect is totally lost in PD as shown in Fig. C. Since the arc boundary between SN and CP is deformed to a serrated shape in PD

(Fig.1(D) yellow line), it appears possible to use these visible and distinctive changes as a diagnostic marker of PD. We suggesting that there is a degradation of the SN as a result of the Parkinson's disease. This deformed "ARC" shape boundaries are the hallmarks of the PD patients. In the SN, DA neurons which projecting to striatal, located in the ventral tier of the SNc, and extends throughout large parts of the SNr. In Parkinson's disease patients, over 60% of the nigro-striatal DA system is lost, and it arise the motor dysfunction. So the lost of DA neuron in SN (both SNc and SNr) alter the shape of SN. Especially, in SNr a distribution of DA neurons looks like the shape of finger (Fig.1(B) green circles)²⁾. So as DA neurons are lost, the boundary between SNr and CP deformed to a serrated shape in PD patients. Like the 7.0T T2*-weighted axial images in cadaver, the boundary between the SNr and CP of the normal control appears smooth and clean 'ARC' shape (Fig.1(E)-(F) yellow lines, Courtesy from William. I. Rosenblum) but the PD patient has serrated 'ARC' shape (Fig1.(G)-(H) yellow lines, Courtesy from William. I. Rosenblum). These results are matched with our 7.0T MR images.

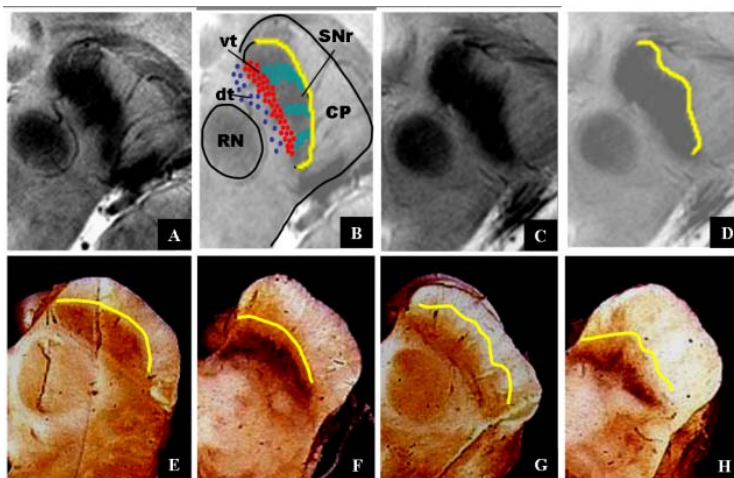


Fig.1 - Typical selected axial view images of age matched normal control (A) and PD patient (C) obtained from 7.0T T2* weighted imaging. A boundaries between the SN and CP are displayed with yellow line (B, D). A distribution of DA neurons in SN(B). Cadaver images (Courtesy from William. I. Rosenblum) of normal healthy people(E-F) and PD patient(G-H).

Discussion

We have observed clear and distinctive differences in shape of SN or boundary between SN and its surrounds with 7.0T T2*-weighted or susceptibility weighted MR imaging. This technique suggests that there is a way to non-invasive diagnosis of PD with an accuracy and certainty that has never been possible in-vivo human by any other techniques hitherto available.

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References

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