Susceptibility Mapping of the Substantia Nigra in Parkinson patients at 7 T after one year of diagnosis and treatment

A. Schäfer[1], D. V. Ott[2], A. Focke[2], J. Schwarz[2], D. Weise[2], R. Turner[1], and S. A. Kotz[1]
[1]Max-Planck-Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]University Hospital, Leipzig, Germany

Introduction: Parkinson's disease (PD) is characterized by the degeneration of dopaminergic neurons in the substantia nigra (SN). Here, oxygen radicals are produced excessively. The presence of these radicals leads to neuronal cell death. MR images of the SN show different transverse relaxation times in PD patients. This supports the pathological finding of increased iron content in the SN of these individuals [1]. A recent study used phase information to image iron concentration in the brain [2]. This is a promising approach because of the direct relationship between susceptibility and measured field-shift. However, the use of phase images may lead to further issues due to the non-local effects of the measured field-shift [3]. It has been shown that susceptibility mapping may indicate a higher iron concentration of the SN in clinically diagnosed but not medicated PD patients compared to young healthy volunteers [4]. Here we present results of a continuing study [4] by calculating the susceptibility of the SN of an age-matched control group, and also comparing the susceptibility values of the patients after one year of diagnosis and treatment (L-DOPA).

Methods: 8 patients (clinically diagnosed PD, not medicated; 55-77 years of age, 1 female), 7 healthy controls (22-30 years, 4 female) and 12 age-matched healthy controls (55-74 years, 6 female), who gave informed consent, were examined on a whole body 7T scanner (MAGNETOM, Siemens Medical Solutions, Erlangen, Germany) using a 24 channel phased array coil (Nova Medical). The study was approved by the local ethics committee. For imaging a 3D spoiled gradient multi-echo sequence (TR=40 ms; TE=9.76/19.19/28.62 ms; bw=150 Hz/pixel; voxel=0.6x0.6x0.8mm³) was used.
The phase data, which show the effects of a field perturbation $B_{dz}(\mathbf{r})$, were unwrapped using PhUN [7]. Only the region around the red nuclei and SN was analyzed, the rest of the brain being masked out with an ellipsoidal mask. A 2nd order polynomial fit to the unwrapped data was subtracted from the unwrapped data to obtain high-pass filtered phase data. The filtered phase data were divided by $\gamma B_0 TE$ to convert the field-shift to units of ppm. The data were re-sampled to 0.6 mm isotropic resolution. The susceptibility was then calculated by $\chi(\mathbf{r})=FT^{-1}(-3\cdot B_{dz}(\mathbf{k})/B_0\cdot C^{-1}(\mathbf{k}))$, where $B_{dz}(\mathbf{k})$is the field perturbation in *k*-space, B_0 the main magnetic field and $C(\mathbf{k})=3k_z^2/|\mathbf{k}|^2-1$ the convolution kernel [5,6]. Voxels with $C(\mathbf{k})< |0.25|$ were set to zero before the inverse Fourier transform to reduce noise amplification [6].

Results and Discussion: The average value of the susceptibility of the SN is calculated to be 0.15±0.05 ppm and 0.1±0.01 ppm for patients and healthy controls, respectively. Figure 1a shows the susceptibility of the SN for *de novo* Parkinson patients (red) and healthy controls (green). For healthy volunteers, the susceptibility of the SN does not appear to increase with age. This agrees very well with a previous study using the R_2* values, where a plateau for the SN is reached at an age of 15 years [8]. However, 5 out of 8 patients show an increased susceptibility within the SN compared to healthy controls. So far 4 patients have been re-examined with the same scan protocol and post-processing steps after diagnosis and one year of treatment. As shown in Figure 1b the susceptibility values are very similar to the first measurement. It seems there is thus no strong evidence of a short-term effect of treatment on the iron concentration in the SN, given the reasonable assumption that the susceptibility maps reflect iron concentration in the basal ganglia [5,6].

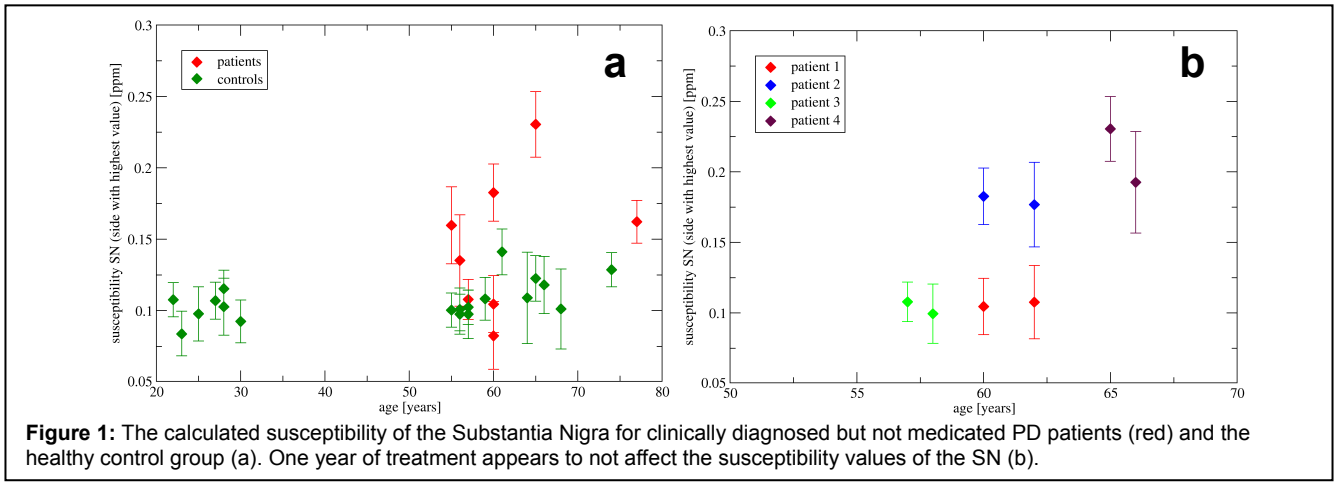

Figure 1: The calculated susceptibility of the Substantia Nigra for clinically diagnosed but not medicated PD patients (red) and the healthy control group (a). One year of treatment appears to not affect the susceptibility values of the SN (b).

References: **[1]** Gorell *et al.* Neurology 45:1138-1143 (1995); **[2]** Yao *et al.* NeuroImage 44:1259-1266 (2009); **[3]** Schäfer *et al.* NeuroImage 48:126-137 (2009); **[4]** Schäfer *et al.* Proc ISMRM 18:1966 (2010) ; **[5]** Shmueli *et al.* MRM 62:1510-1522 (2009); **[6]** Wharton *et al.* MRM 63:1292-1304 (2010); **[7]** Witoszynskyj *et al.* Med Image Anal. 13:257-68 (2009); **[8]** Aquino *et al.* Radiology 252:165-172 (2009)