Differential diffusivity in Parkinsonism

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Introduction: Diffusion tensor imaging (DTI) characterizes the orientation of the diffusion properties of water molecules i.e. fractional anisotropy (FA), representing the amount of directionality, and orientation of movement of water molecules[1]. We estimated the FA values in the motor predominant areas i.e. primary motor cortex (PMC), supplementary motor area (SMA), lentiform Nucleus (LN), globus pallidus (GP), substantia nigra (SN) and thalamus (Thm) in the subjects of Parkinson's disease (PD), and compared them to healthy age and gender matched controls.

Materials and Methods: Six male PD patients of age 61.83 ± 12.64 years from the movement disorder clinic of our institute and six healthy controls of age 58.17 ± 10.25 years were recruited for the study. DTI data was acquired using 1.5T MR Scanner (Avanto, M/s. Siemen) using single-shot EPI, with parameters: no. of averages: 2; slice group: 1, multi-sliced-interleaved, EPI factor 128; slices: 31, slice thickness: 4.5mm, distance factor: 0, orientation: transverse, FOV: 230mm, FOV phase: 100%, TR: 8200ms, TE: 100ms, Flip angle: 90, bandwidth: 1502 Hz/pixel, base resolution: 128, phase resolution: 100, phase encoding direction: A>>P; B values: 0, 400, 1000, directions: 20, bandwidth: 1860, echo spacing: 0.69. Coregistered magnetization-prepared rapid gradient- echo (MPRAGE) images with the following imaging parameters were obtained for anatomic overlay Slice slab:1, slice per slab: 176, dist factor 50%, orientation: sagittal; slice thickness: 1mm, slice resolution: 80; T1:1100ms, TR: 1900, TE: 3.37, averages: 1; FOV: 256mm, FOV phase: 93.8%, base resolution: 256, phase resolution 100 phase encoding direction: A>>P; bandwidth: 130, echo spacing: 8.6. The DT imaging datasets were processed with Nordic Image Control and Evaluation Software (NordicICE Version 2.3.12) from Nordic Imaging lab AS, Mollenveien, Bergen, Norway. The dataset was processed for smooth, motion correction and eddy current; and processed using the following parameters: exhaustive tracking method and termination criteria as: FA<0.250; tracking angle: 30º; minimum fibre length: 20mm. For fibre tractography, whole brain fibres were estimated and volume of interest covering the midbrain in the 13th slice was drawn to cover the *crus cerebri* of either side and superior colliculus. The FA values, and tensor eigen values (λ1, λ2, λ3) were estimated for the PMC, SMA, LN, GP, SN and thalamus in patients and controls. The FA was calculated using the following expression:

$$FA = \sqrt{\frac{3}{2}} \frac{\sqrt{(\lambda_1 - \lambda_2)^2 + (\lambda_1 - \lambda_3)^2 + (\lambda_2 - \lambda_3)^2}}{\sqrt{(\lambda_1^2 + \lambda_2^2 + \lambda_3^2)}}$$

Statistical unpaired 2-tailed Student t-tests were performed to determine significant differences ($p \leq 0.05$) between measurements.

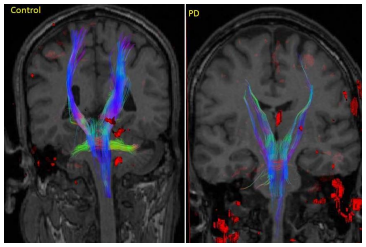

Figure 1.The overlay of the BOLD activation pattern and the DTI fiber tractography results overlaid onto the T1-weighted MPRAGE

Results: We observed a significant loss (Table 1) in the whole brain fibers (6940±782) in PD subjects as compared to (7173 ±789) in controls (Figure 1). We observed lowered FA values in the bilateral PMC and SMA, $GP_{internal}$, and right thalamus that were significant for SMA (p=0.03) and thalamus (p=0.03).

Discussion: The lower FA values in the PMC indicate a lower functional connectivity[2] (white matter loss) though FA measurement depends on factors like myelin thickness/axonal packing density and therefore may not necessarily imply reduced network functionality. The increased FA values in the pallidum and right thalamus represent atrophy in the cortico-striato-thalamo-cortical loop[3]. The FA values in the SN and left thalamus were observed to be higher as compared to controls[4]. The FA measurements of the substantia nigra could serve as a marker for disease progression and therapeutic response.

Table 1. FA values in motor predominant areas in PD and controls

	P.M.C		S.M.A		LN		Gpe		Gpi		SN		THLM	
Hemisphere	L	R	L	R	L	R	L	R	L	R	L	R	L	R
PD	**0.5 ±0.2**	**0.6±0.2**	**0.4±0.2**	**0.5±0.2**	0.7±0.3	0.6±0.1	0.7±0.1	0.7±0.2	**0.5±0.1**	**0.6±0.2**	0.8±0.1	0.8±0.1	0.4±0.1	**0.3±0.2**
Controls	0.7±0.2	0.7±0.2	07±0.1	0.6±0.1	0.3±0.1	0.5±0.3	0.6±0.1	0.6±0.4	0.6±0.2	0.8±0.4	0.7±0.2	0.7±0.1	0.4±0.1	0.5±0.1

Conclusion: The decreased FA white matter connecting affected gray matter regions in PD may imply that loss of coherence, reduction of axonal packing, and demyelination in these areas that may result in the reduced functional connectivity.

References:
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