Neuronal degeneration in Parkinsonism: A DTI study

Senthil S Kumaran[1], Mohit Saxena[2], Vinay Goyal[2], and Madhuri Behari[2]

[1]Department of N.M.R., All India Institute of Medical Sciences, New Delhi, Delhi, India, [2]Department of Neurology, All India Institute of Medical Sciences, New Delhi, Delhi, India

Introduction: Diffusion tensor imaging (DTI) offers a unique ability to identify microstructural abnormalities, and has been shown to be highly sensitive and specific in differentiating MSA-P from PD[1]. The degeneration of basal ganglia and extra pyramidal regions of the midbrain in Parkinson's disease (PD), multiple system atrophy (MSA) and progressive supranuclear Palsy (PSP) can be characterized using the fractional anisotropy (FA), apparent diffusion coefficient (ADC), axial diffusivity, radial diffusivity and mean diffusivity[2].

Materials and Methods: Forty nine subjects were recruited from the movement disorder clinic of our institute (table 1). DTI data were acquired using 1.5 T MR system (Avanto, M/s Siemens) using single-shot EPI, with the parameters: No. of averages: 2; EPI factor 128; slices: 31, slice thickness: 4.5mm, distance factor: 0, orientation: transverse, FOV: 230mm, TR: 8200ms, TE: 104ms, Flip angle: 90°, bandwidth: 1502 Hz, phase encoding direction: A>>P; b values: 0, 400, 1000, directions: 20, Bandwidth: 1860 Hz, echo spacing: 0.69 ms. Magnetization prepared rapid gradient echo (MPRAGE) images with the following imaging parameters: Slice slab:1, slice per slab: 176, dist factor 50%, Orientation: sagittal; Slice thickness: 1mm, slice resolution: 80; T1:1100ms, TR: 1900ms, TE: 3.37ms, averages: 1; FOV: 256mm, FOV phase: 93.8%, Base resolution: 256, Phase resolution 100, Phase encoding direction: A>>P; Band width: 130 Hz, echo spacing: 8.6ms were obtained for anatomic overlay. The DTI datasets were processed with Nordic Image Control and Evaluation Software (NordicICE Version 2.3.12) from Nordic Imaging lab AS, Norway. The datasets were subjected to smoothing, motion correction and eddy current correction, and processed using the following parameters: exhaustive tracking method and termination criteria as: FA<0.25; tracking angle: 30°; minimum fibre length: 20mm. For fibre tractography, whole brain fibers were estimated and volume of interest was drawn covering the midbrain in the corresponding slice covering the crus cerebri of both side and superior colliculus as shown in (fig.1b). Also, circular ROI (of area ~16mm^2) were drawn. The following results were evaluated: eigen vector colour map (cDTI), FA values[3], Trace weighted (traceW), mean Diffusivity (ADC), Tensor eigen values (λ1, λ2, λ3). The calculations were done for axial diffusivity (λ1), radial diffusivity (λ2+λ3), trace, and mean diffusivity and FA was calculated:

Table 1. Demographic profile of subjects recruited for the DTI study

	No.(Gender)	Age (years)	duration	Stage
Controls	19 (11M 8F)	53.74 ± 7.59	-	-
PD	13 (9M 4F)	53.77 ± 9.46	4.62 ± 2.60	1.92 ± 0.45
MSA	12 (7M 5F)	61.45 ± 6.04	3.00 ± 1.61	3.00 ± 0.89
PSP	5 (3M 2F)	62.60 ± 5.68	4.40 ± 3.29	2.40 ± 0.89

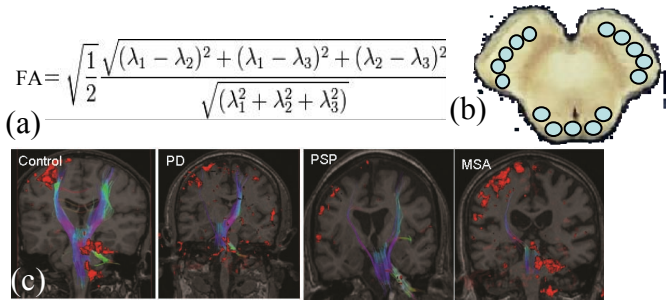
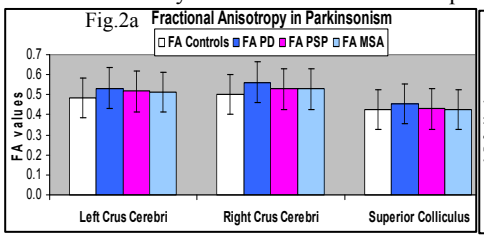
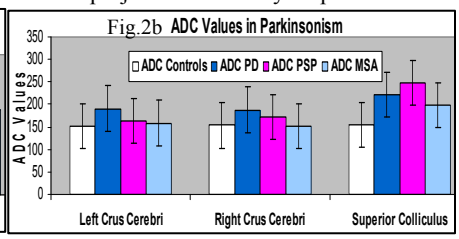


Figure 1. (a) The formula for calculation of FA values in midbrain[3]; (b) midbrain areas where ROI were marked; and (c) the tracts originating from the motor cortex in controls and Parkinsonism.

Results and Discussion: Unpaired 2-tailed Student t-tests were used to determine significant differences between measurements. We observed a reduction in the total number of fibres in the order PD>PSP>MSA, although there was a greater degeneration of midbrain fibre tracts in the order PD>MSA>PSP (Fig. 1(c)). For the right crus cerebri, the axial diffusivity was significantly higher in PD while the radial diffusivity was significantly lower in MSA but higher in PSP. The mean diffusivity was significantly greater in the parkinsonian group as compared to the controls (table2). The FA, and ADC were also calculated using the eigen vector values that revealed a higher FA and ADC values[4] than the controls in the parkinsonian group but was not significant (fig 2). The significantly higher diffusivity in the patients may indicate the degeneration in these areas that may interfere with the cortico-spinal tracts projections and may help in understanding the motor deficit in these patients.





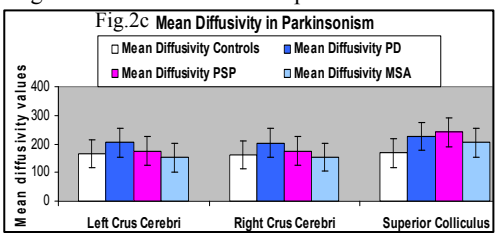


Table 2. The parameters of Diffusion Tensor Imaging data showing differences in values in different regions (block arrow shows significant increase or decrease).

Parameters	Controls	PD	MSA	PSP
Brain Fibres: Total (mid-brain)	7173 (789)	6940 (782)	4302 (669)	4679 (633)
Axial diffusivity (R crus cerebri)	255.81 ± 77.36	339.66 ± 95.28 (p=0.01)▲	250.34 ± 115.12	287.21 ± 93.27
Radial Diffusivity (R crus cerebri)	114.14 ± 41.29	134.17 ± 44.54	104.93 ± 60.43 (0.01)▼	119.39 ± 54.66 (0.01)▲

References:

1. Movement Disorders.2009. 24(6): 863–870
2.Beaulieu C.2002. NMR Biomed; 15:435–455
3. Am J Neuroradiol. 2008. 29:632– 41
4.Chen et.al. 2010. Am J Neuroradiol 31:1879–85