ADC measurement in the middle cerebellar peduncle allows the differentiation of MSA from PD and PSP

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Introduction

Clinical differentiation of Parkinson's disease (PD) from parkinsonian syndromes such as multiple system atrophy (MSA) and progressive supranuclear palsy (PSP) is difficult in the early stage of the disease (1) with a high rate of misdiagnosis (2). In the present study, we used DWI to extensively assess the ADC values in the middle cerebellar peduncles, basal ganglia, brainstem and cerebral white matter regions, to identify objective diagnostic markers for differential diagnosis in patients with PD, MSA, and PSP.

Methods

Eleven consecutive patients with PD (age 61y±8, mean±SD), fourteen consecutive patients with MSA (65y±6), nine patients with PSP (73y±9), and thirteen healthy controls (68y±8) were recruited. Clinical diagnosis of PD, MSA and PSP was made by a movement disorder specialist (G.N.) according to established consensus criteria. All patients were evaluated clinically, tested for levodopa response, and examined with MRI. At the onset of the disease eleven MSA patients presented features of parkinsonism (MSA-P), and three exhibited cerebellar signs such as ataxia (MSA-C), but at the time of the study all MSA patients presented a combination of various signs. Informed consent was obtained from all participants.

Subjects were studied in a 1.5T General Electrics Medical Systems (Milwaukee, Wisconsin) Signa Horizon LX whole-body scanner. Axial DW images were obtained (thickness = 5 mm, inter-slice gap = 1 mm) using a single-shot EPI sequence (matrix size = 192 x 192 mm), as previously reported (3). Orthogonal x, y, and z diffusion encoding gradients were applied with gradient strengths corresponding to b-values of 300, 600 and 900 mm^2/s. In addition, images without diffusion weighting were acquired corresponding to b = 0 mm^2/s and exhibiting a T2-contrast. Assuming a signal attenuation depending mono-exponentially on the b-value, the apparent diffusion coefficient (ADC) of each direction was determined pixel-wise using a least-squares fit. By calculating the mean of the three directions, the ADC trace map was generated. Regions of interest (ROIs) were determined in different brain regions including basal ganglia, thalamus, white matter, pons, and middle cerebellar peduncles (MCP). Statistical significance, determined by the nonparametric Mann-Whitney U test or the Fisher's PLSD test (ANOVA), was taken as $p<0.05$.

Table. *Diffusion-weighted imaging in MSA, PSP, PD patients and controls. ADC values (x 10^{-3} mm^2/s) are reported as mean value (SD).*

Group (n)	Putamen	Caudate	Globus pallidus	Thalamus	Middle cerebellar peduncle	Prefrontal white matter	Precentral white matter	Pons
MSA (14)	0.98 (0.03)	0.91 (0.05)	0.93 (0.05	0.92 (0.03)	0.99 (0.09)	0.90 (0.04)	0.90 (0.06)	1.04 (0.013)
PSP (9)	0.94 (0.05)	0.91 (0.05)	0.93 (0.02	0.94 (0.03)	0.82 (0.03)	0.97 (0.05)	0.94 (0.06)	0.91 (0.07)
PD (11)	0.88 (0.03)	0.84 (0.02)	0.86 (0.03	0.90 (0.04)	0.79 (0.04)	0.91 (0.04)	0.86 (0.03)	0.86 (0.06)
CONTROLS (13)	0.88 (0.04)	0.84 (0.03)	0.86 (0.02	0.88 (0.03)	0.78 (0.06)	0.85 (0.03)	0.81 (0.03)	0.85 (0.04)
Statistics*								
MSA vs PSP	n.s.	n.s.	n.s.	n.s.	<0.001	0.048	n.s.	n.s.
MSA vs PD	<0.001	0.024	0.011	n.s.	<0.001	n.s.	n.s.	0.005
MSA vs CONTROLS	<0.001	0.008	0.009	0.007	<0.001	0.009	0.004	0.003
PSP vs PD	0.047	0.002	0.002	n.s.	n.s.	n.s.	0.041	n.s.
PSP vs CONTROLS	n.s.	0.008	0.001	0.006	n.s.	<0.001	0.001	n.s.
PD vs CONTROLS	n.s.	n.s.	n.s.	n.s.	n.s.	0.005	0.013	n.s.

** Pairwise comparisons among groups. P-values refer to Mann-Whitney U test and corrected according to Bonferroni:*

Results

Water ADC values were similar in corresponding right and left hemisphere regions of interest (ROIs) in both normal subjects and patients and hence are reported as mean values. The ADC of the middle cerebellar peduncles was able to completely differentiate MSA patients from PSP, PD patients and healthy volunteers (Table) with 100% sensitivity and 100% specificity. ADC in other regions considered showed an overlapping among groups.

Discussion

DWI discriminates MSA from PSP and PD and healthy volunteers on the basis of MCP ADC values. These *in vivo* results confirm the pathological findings that the majority of MSA patients have moderate or severe degenerative changes not only in the nigrostriatal but also in the olivopontocerebellar systems (4). Previous DWI studies showed that ADC of the putamen could discriminate well between MSA-P or PSP patients and PD patients but basal ganglia ADC values overlap when MSA-P and PSP patients were compared (5). Our findings indicate that, in order to substantially contribute to the *in vivo* differential diagnosis between MSA, PSP and PD, ADC measurements should not be limited to the basal ganglia but should also include the MCP.

References

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