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Accuracy of Magnetic Resonance Parkinsonism Index in Differentiating Progressive Supranuclear Palsy from Parkinson's Disease among South Indian Population: A Retrospective Case Control Study

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Abstract

Context Progressive supranuclear palsy (PSP) is a neurodegenerative disorder which comes under Parkinsonism plus syndrome. As this spectrum of disease has many overlapping clinical as well as imaging findings, some quantitative parameters like magnetic resonance Parkinsonism index and midbrain/pons ratio are useful to differentiate PSP from other PD patients.

Aims The study aimed to detect sensitivity and specificity of magnetic resonance Parkinsonism index in differentiating PSP from PD.

Settings and Design It was a retrospective case–control study conducted in Sri Manankula Vinayagar Medical College, Puducherry, during the period of January 2018 to June 2019.

Materials and Methods The 87 subjects, who were diagnosed and grouped into three categories (PSP, PD, and control) after performing magnetic resonance imaging brain, were reviewed. The parameters like the area of Pons and midbrain, width of MCP and SCP, P/M, M/P, and MRPI were calculated.

Statistical Analysis One-way ANOVA and Chi-square test was used. The sensitivity, specificity, diagnostic accuracy, and cut-off values obtained with receiver operating characteristic curve analysis were determined.

Results The mean age of presentation was approximately 75 years with male predominance. The cut-off value of MRPI obtained in this study was 13.4 with 100% sensitivity and specificity. Even though M/P ratio was found to be statistically significant among PSP patients; cut-off value was not obtained.

Conclusion MRPI was concluded as the better tool in diagnosing PSP compared with the M/P ratio. Hence the combined qualitative as well as quantitative measurement of MRPI will increase the diagnostic accuracy of PSP.

Keywords
- magnetic resonance Parkinsonism index
- midbrain/pons ratio
- progressive supranuclear palsy
- Parkinson's disease

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Introduction

Progressive supranuclear palsy (PSP) is a neurodegenerative disorder, which is diagnosed clinically by postural instability with falls, supranuclear vertical gaze abnormalities with Parkinsonian features, and frontal cognitive disturbances.[1] Although signs such as vertical gaze palsy is specific for PSP, it is difficult to distinguish PSP from other Parkinson's disease (PD) clinically, which makes it essential to make an early distinction between PSP and other PD.[2] This research was mainly conducted to study the diagnostic accuracy of magnetic resonance Parkinsonism index (MRPI) and midbrain and Pons ratio (M/P) in differentiating PSP patients from PD patients and controls.

Materials and Methods

The main aim of this study was to detect sensitivity and specificity of MRPI in differentiating PSP from PD. The study was conducted at Sri Manakula Vinayagar Medical College and hospital, Puducherry, which is a multidisciplinary, 900-bedded hospital with fully equipped radiology department during the period of January 2018 to June 2019. It was a retrospective case–control study of magnetic resonance imaging (MRI) brain done in 87 subjects (58 patients and 29 controls), grouped into three categories—26 PSP patients, 32 PD patients, and 29 controls who were found to be neurologically stable (age >60 years with no gender predilection).

The MRI images like sagittal T1W sequences (TE approximately 15, TR approximately 1,400, 512 × 512 matrix, and 2 mm slice thickness approximately 2 mm) and coronal T2W sequences obtained (TE approximately 125, TR approximately 8000, 512 × 512 matrix, and 2 mm slice thickness) were assessed and parameters like area of pons (P) and midbrain (M), width of middle cerebellar peduncle, and superior cerebellar peduncle (SCP, MCP) were measured.

Mid sagittal T1W images were evaluated for calculating the area of Pons and midbrain (►**Fig. 1a** and **b**). The width of MCP was also calculated from the sagittal T1W echo spin sequence (►**Fig. 1c**). The width of the SCP was measured from the coronal T2W image (►**Fig. 1d**). From these parameters, M/P ratio and MRPI were calculated with the formula (P/M) × (MCP/SCP) for each patient in three categories.[3]

One-way ANOVA was used to assess the association of continuous covariates with the group and Chi-square test was used to test the association of categorical factors with the group. The sensitivity, specificity, and diagnostic accuracy were determined for differentiating PSP from PD and controls by using the optimal cut-off values determined with receiver operating characteristic (ROC) (►**Fig. 2a–c**) curve analysis.

Results

There is no significant statistical difference found in the age distribution among the three groups.

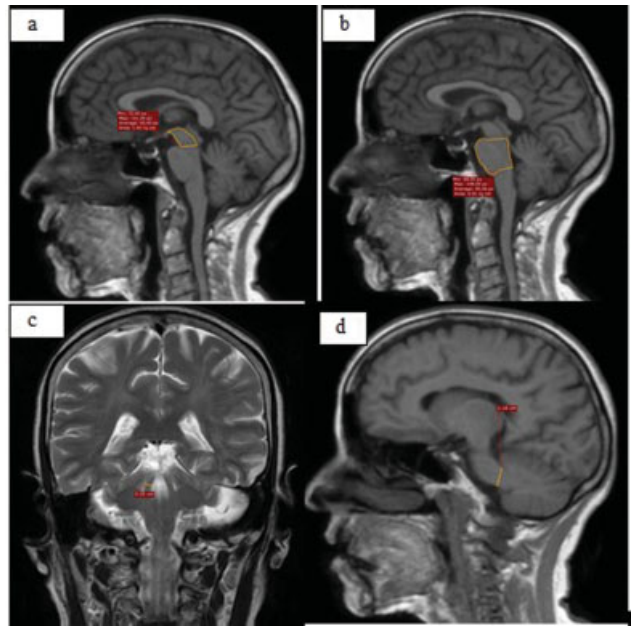

Fig. 1 MRI T1W sagittal image in a control patient showing the midbrain area (1.42 cm^2) (**a**), the area of pons (4.91 cm^2) (**b**), T2W coronal image showing the width of superior cerebellar peduncle (0.33 cm) (**c**), and sagittal image shows the middle cerebellar peduncle width (1.16 cm) (**d**).

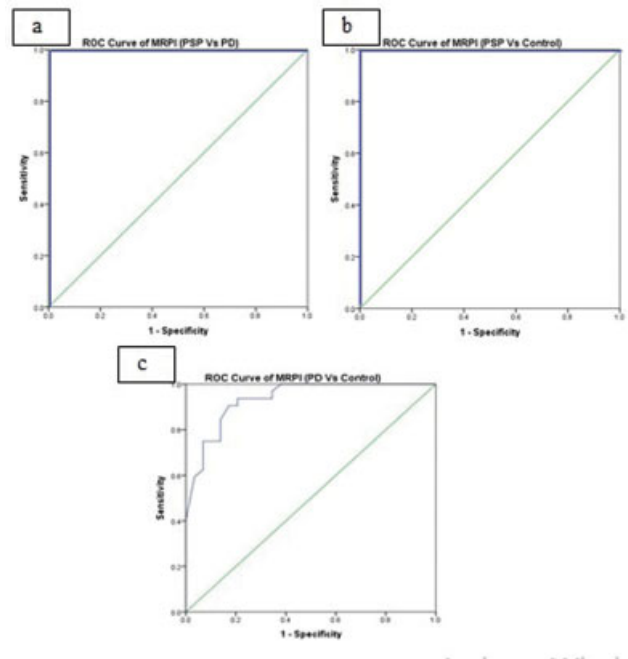

Fig. 2 (**a–c** ROC curve plotted for MRPI to calculate the cut-off value of MRPI index with respect to various study groups (PSP, PD, control groups). MRPI, magnetic resonance Parkinsonism index; ROC, receiver operating characteristics.

The mean age of distribution of PSP was approximately 75 and 72 years for PD in our study and males (approximately 70%) are found to be more commonly affected than females (approximately 30%) in all three groups (►**Table 1**).

Table 1 Mean with standard deviation of demographic data of our study population

Variables	PSP ($n = 26$)	PD ($n = 32$)	Control ($n = 29$)
Age distribution	75 y	72 y	71 y
Sex distribution			
Male	18 (70%)	20 (63%)	16 (55%)
Female	8 (30%)	12 (37%)	13 (45%)

Abbreviations: MRPI, magnetic resonance Parkinsonism index; PD, Parkinson's disease; PSP, progressive supranuclear palsy.

Table 2 Mean with standard deviation of various MR planimetric measurements in our study population

Variables	PSP ($n = 26$)	PD ($n = 32$)	Control ($n = 29$)
Pons area (cm^2)	4.8950 ± 0.55999	4.7384 ± 0.82279	4.4648 ± 0.64571
Midbrain area (cm^2)	0.9412 ± 0.15843	1.3116 ± 0.28216	1.5817 ± 0.31195
Width of MCP (cm)	1.3354 ± 0.24609	0.9272 ± 0.23317	1.1700 ± 0.19860
Width of SCP (cm)	0.3735 ± 0.10480	0.3119 ± 0.05954	0.4524 ± 0.08279
P/M	5.3073 ± 0.94920	3.7294 ± 0.83307	2.8793 ± 0.49974
MCP/SCP	3.7015 ± 0.87366	2.9534 ± 0.49913	2.6245 ± 0.43940

Abbreviations: MCP, middle cerebellar peduncle; SCP, superior cerebellar peduncle SCP.

Patients with PSP exhibited less value of midbrain area (►**Table 2** and ►**Fig. 3a–c**) when compared with the other two groups with the mean value of 0.9 and also found to be very significant with p-value <0.001, which points to the main pathology of midbrain atrophy in PSP.[1]

Meanwhile, there is no statistical significance noted in the Pons area among the three groups (p-value 0.07) (►**Table 2**).

Patients with other PD show highly significant difference in the mean value of width of middle cerebellar peduncle (0.9 ± 0.3; p value < 0.001) as middle cerebellar peduncle atrophy can occur in multisystem atrophy disease (►**Table 2** and ►**Fig. 4a–c**).[4]

Several studies prove the atrophy of SCP in PSP patients, but in our study no significant results related to it were noted (►**Table 2**).[5]

Patients with PSP were also found to have cardinal findings (p-value of <0.001) with the parameter M/P ratio (lower in PSP patient with mean value of 0.18 ± 0.036) and P/M ratio (higher in PSP patients with mean value of 5.3 ± 0.94), which

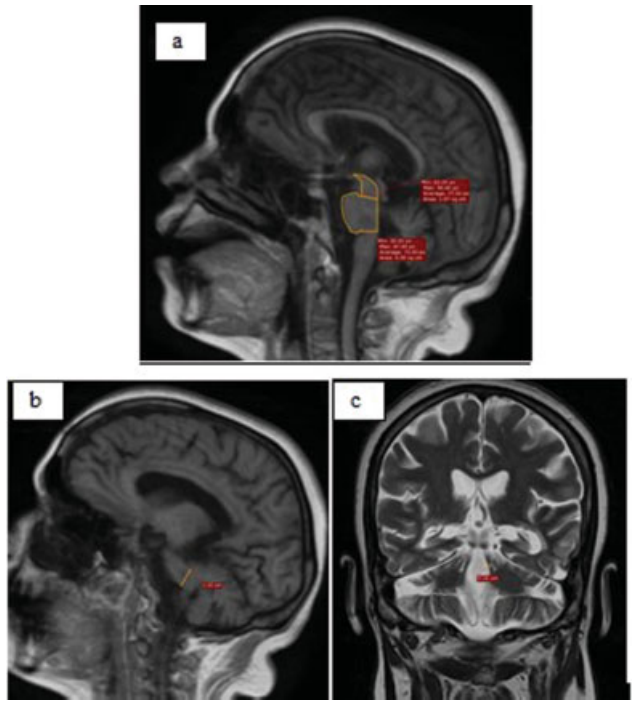

Fig. 3 T1W sagittal image of progressive supranuclear palsy patient (**a**), calculating the area of midbrain and pons which was 1.07 and 4.35, respectively. P/M ratio = 4.1; M/P ratio = 0.24. T1W sagittal (**b**) and T2W coronal (**c**) of progressive supranuclear palsy patient showing the width of MCP (1.22) and SCP (0.16).

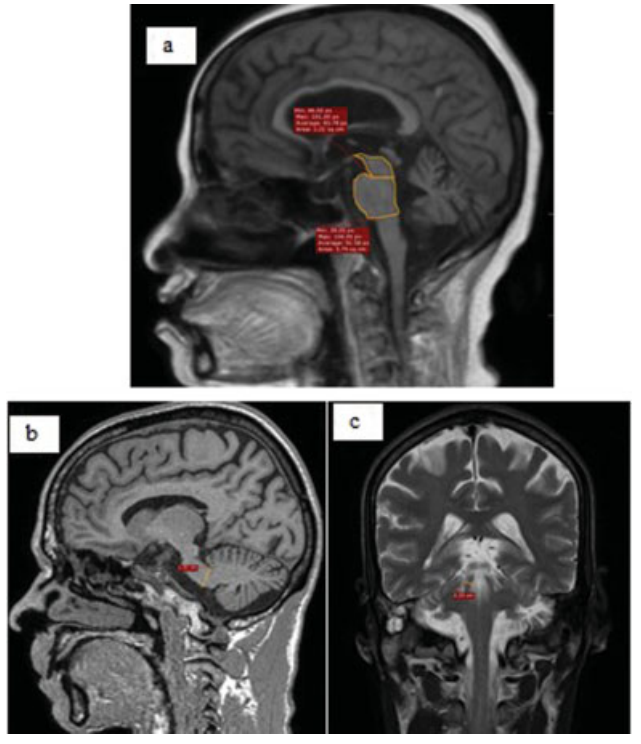

Fig. 4 T1W sagittal image of Parkinson's disease patient, calculating the area of midbrain and Pons (**a**) which was 1.21 and 3.79, respectively. P/M ratio = 3.15; M/P ratio = 0.32. T1W sagittal (**b**) and T2W coronal (**c**) of Parkinson's disease patient showing the width of MCP (1.3) and SCP (0.33).

Table 3 Mean with standard deviation of M/P ratio and MRPI index in PSP, PD, and control groups

Variable	PSP ($n = 26$)	PD ($n = 32$)	Control ($n = 29$)
M/P	0.1838 ± 0.03678	0.2766 ± 0.05469	0.3531 ± 0.05419
MRPI	19.5077 ± 5.7862	10.4503 ± 1.22262	7.5000 ± 1.50751

Abbreviations: MRPI, magnetic resonance Parkinsonism index; PD, Parkinson's disease; PSP, progressive supranuclear palsy.

Table 4 Cut-off value of MRPI index in PSP, PD vs. control groups with their corresponding sensitivity and specificity

MRPI	Cut-off value	Sensitivity	Specificity
PSP vs. PD	13.4	100%	100%
PSP vs. control	12.35	100%	100%
PD vs. control	9.025	91%	83%

Abbreviations: MRPI, magnetic resonance Parkinsonism index; PD, Parkinson's disease; PSP, progressive supranuclear palsy.

also indicates that there is atrophy of midbrain in PSP patients.

The mean MRPI value was higher in almost all patients of PSP patients compared with PD and controls as described in (►**Table 3**). MRPI value for PD and control patient was found to be less than 12 (PD: 10.4 and control: 7.5) with no overlapping value with PSP patients, which was found to be 19.5.

The cut-off value of MRPI was fixed as 13.4 (►**Table 4**) using ROC curve analysis (►**Fig. 2a–c**) with 100% sensitivity and 100% specificity in case of PSP versus PD group and 12.3 in PSP versus control group.

Although the M/P ratio was found to be statistically significant in PSP patients (p-value <0.0001) and the mean value (approximately 0.2) is less compared with the other two groups (►**Table 3**), the cut-off value could not be made out as the values are very low, and thus MRPI index is deduced as a good predictor for the quantitative assessment of PSP.

Discussion

Parkinsonism plus syndromes are a group of neurodegenerative disorder under which are categorized the PSP, multisystem atrophy, and corticobasal degeneration. As a group, they present with symptoms of Parkinsonism (rigidity and bradykinesia), but typically have some slightly different clinical picture.[5]

PSP is a form of atypical Parkinsonism which is characterized by slow ocular saccades, eyelid apraxia, and restricted eye movements with particular impairment of downward gaze. In later stages, speech and swallowing difficulty and dementia become evident.[1]

Multisystem atrophy manifest as a combination of parkinsonian, cerebellar, and autonomic features and can be divided into a predominant parkinsonian form.

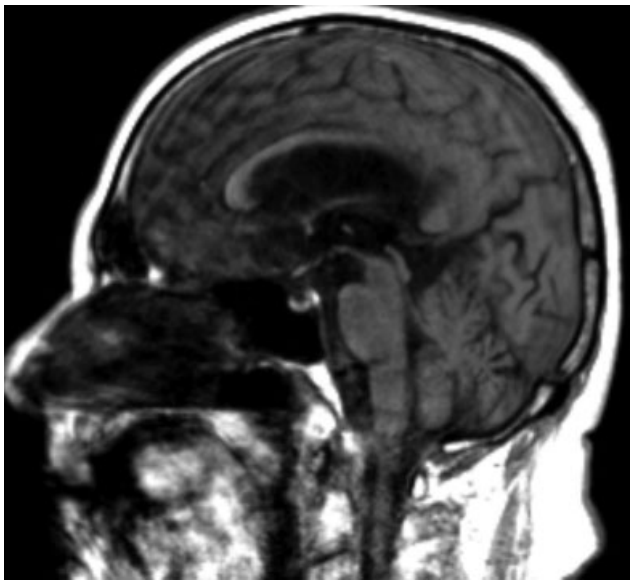

Fig. 5 MRI T1W sagittal image shows Hummingbird sign in a case of progressive supranuclear palsy (PSP).

Corticobasal degeneration is rare and usually manifest by asymmetric dystonic contractions and clumsiness of one hand coupled with cortical sensory disturbances manifest as apraxia, agnosia, focal myoclonus, or alien limb phenomenon.[6]

Atypical Parkinsonism spectrums are associated with degeneration of dopamine neurons. Neuroimaging of the dopamine system is usually not helpful in the diagnostic purpose.[7]

MRI forms the mainstay of imaging modality for these conditions. Even though some qualitative markers like Humming bird sign (►**Fig. 5**) (seen in mid sagittal images due to atrophy of midbrain with preservation of Pons), morning glory sign (due to widening of interpeduncular cistern with lateral concavity of midbrain) and Mickey Mouse sign are specific for PSP to differentiate from other PD, these are mostly observed in the late stages of the disease.[5] So, for early distinction of PSP, some quantitative markers like MRPI and midbrain/pons ratio (M/P) are useful.[8,9]

In our study results, the mean value of midbrain area was statistically significant in PSP patients compared with the other two groups (PD and control), which was similar in comparison to the study done by Zanigni et al,[10] where the area of midbrain was found to be the most accurate significant diagnostic marker with 96% sensitivity and 98%specificity than MRPI, where they obtained a cut-off value as ≥ 10.67 with 87% sensitivity and 93% specificity.

Another significant remark of PSP is the atrophy of midbrain, which is pointed by our quantitative results of higher P/M and lower M/P ratio in PSP patients.

On plotting the ROC curve, the cut-off value of MRPI was obtained as 13.4 with 100% sensitivity and specificity from our study (►**Fig. 2a–c** and ►**Table 4**). Although M/P ratio was found to be statistically significant, cut-off values were very low.

In a study conducted by Constantinides et al,[4] the cut-off value of MRPI was achieved as 12.6 with 91% sensitivity and 95% specificity and the cut-off value for M/P ratio was obtained as <0.22 with 88% sensitivity and 84% specificity.

Among the three parameters which they included in their study (MRPI, M/P ratio, and M/CC), MRPI was established as the best parameter for the diagnosis of PSP.

Nigro et al[11] study compared the manual and automatic method of calculation of MRPI and concluded with a cut-off value of MRPI for PSP patients as >13.42 with almost 93% sensitivity and 100% specificity.

Quattrone et al[2] concluded that MRPI index along with combined assessment of routine MR imaging can help differentiate patients with PSP from those with PD, with a cut-off value of ≥13.5 (100% sensitivity and specificity).

Limitations

- The study was conducted with less number of samples.
- Three-dimensional T1W sequences were not obtained as routine investigation.
- Interobserver correlation was not obtained, as they were not blinded.

Conclusion

From this study, MRPI index has ascertained to be additional quantitative marker in diagnosing PSP patients with a cut-off value of MRPI as 13.4 in comparison to M/P ratio. Some parameters like midbrain area, Pons/midbrain ratio, and M/P are also useful for the diagnosis of PSP. In conclusion, combined qualitative as well as quantitative measurement of MRPI will further improve diagnosing PSP.

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None.

Conflict of Interest
None declared.

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