e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(9); 1485-1493

Original Research Article

Spectrum of MRI Findings in Clinically Diagnosed Parkinsonism

Patel Nidhiben[1], Patel Avni[2], Mundhra Krati[3], Shah Dharita[4], Hadiya Riddhi[5]

[1]2nd Year Resident, Department of Radio-Diagnosis, SVP Hospital, Smt. NHL Municipal Medical College, Ahmedabad

[2]Assistant Professor, Department of Radio-Diagnosis, SVP Hospital, Smt. NHL Municipal Medical College, Ahmedabad

[3]Associate Professor, Department of Radio-Diagnosis, SVP Hospital, Smt. NHL Municipal Medical College, Ahmedabad

[4]Head of Department and Professor of Department of Radio-Diagnosis, SVP Hospital, Smt. NHL Municipal Medical College, Ahmedabad

[5]1st Year Resident, Department of Radio-Diagnosis, SVP Hospital, Smt. NHL Municipal Medical College, Ahmedabad

Received: 15-08-2023 / Revised: 05-09-2023 / Accepted: 14-09-2023

Corresponding author: Dr. Patel Nidhiben

Conflict of interest: Nil

Abstract:

Background: Differential diagnosis of Parkinsonism in clinical practice is challenging, particularly in early stages. MRI, despite its limitations, significantly improves accuracy in distinguishing between different types of neurodegenerative Parkinsonism.

Aims and Objectives:

1. Differentiate between typical and atypical Parkinson's disease in the early stages using MRI.
2. Investigate structural MRI abnormalities, specifically focusing on the MRPI (Magnetic Resonance Parkinsonism Index), in clinically diagnosed atypical Parkinsonism patients.
3. Rule out alternative diagnoses for Parkinsonism in presenting patients.

Methods: A retrospective study conducted between 2022 and 2023 included 65 patients with Parkinsonism. Among them, 44 had typical Parkinsonism and 21 had atypical Parkinsonism. MRI signs were assessed and MRPI used for diagnostic value. The sensitivity of these MRI findings was calculated to assess their ability to detect and differentiate between typical and atypical parkinsonism.

Results: Among 65 patients, those in parkinsonism group typically had normal brain MRI results after ruling out other causes, while the atypical parkinsonism group predominantly showed MRI findings, particularly suggestive of PSP and MSA, indicating that MRI has higher sensitivity in detecting atypical parkinsonism compared to typical cases.

Conclusions: Brain MRI holds a pivotal role in parkinsonism diagnosis, aiding in the exclusion of other potential causes and facilitating early differentiation between typical and atypical forms. Alongside the MRPI, it can provide valuable support for diagnosing a specific form of atypical parkinsonism.

Keywords: MRI, Parkinson Disease, Atypical Parkinson Disease, PSP (Progressive supranuclear palsy), MSA (multiple system atrophy).

Introduction

Parkinson's disease (PD) is the second most prevalent neurodegenerative movement disorder globally, following Alzheimer's disease. It affects over 1% of the population aged 65 and older, and its prevalence is predicted to double by 2030 [1]. Its distribution is worldwide. Interestingly, it exhibits a slight male predominance. The hallmark pathological feature of neurodegenerative Parkinsonian disorders is the degeneration of the substantianigra (SN).[1] Clinical manifestations of PD encompass bradykinesia, rigidity, and resting tremor. As the disease progresses, patients may also experience postural instability [1] Distinguishing between degenerative parkinsonian disorders based solely on clinical symptoms can pose a significant challenge in the early stages. Atypical parkinsonian disorders (APDs) like multiple system atrophy (MSA), progressive supranuclear palsy (PSP), and occasionally corticobasal degeneration (CBD) are frequent misdiagnoses when attempting to clinically diagnose PD, and vice versa. Other common diagnostic errors in clinical studies involve essential tremor (ET), drug-induced parkinsonism

(DIP), and vascular parkinsonism.[1] .

Neuroimaging plays a pivotal role in both the diagnosis of Parkinsonian disorders and the differentiation between PD and atypical Parkinsonism. Magnetic resonance imaging (MRI) significantly enhances diagnostic accuracy, reduces misdiagnoses, facilitates early detection, and can aid in monitoring disease progression.[3,4,5,6,7,8] Furthermore, advanced MRI techniques, along with functional neuro-imaging approaches such as functional-MRI, and nuclear imaging methods like PET and SPECT, offer a more profound understanding of the intricate neurobiological changes occurring in both PD and APDs. These techniques hold promise for the development of novel neuroimaging biomarkers, although they are beyond the scope of this discussion.[9]

Method

Patient Selection

In a retrospective observational study conducted at Sardar Vallabhbhai Patel Hospital in Ahmedabad, the Department of Radio-Diagnosis reviewed their Picture Archiving and Communication System (PACS) to analyze MRI brain scans conducted between March 2022 and March 2023, specifically using the Parkinson's protocol. They focused on MRI studies that included the MRPI index and ensured that all the MRI scans met high technical quality standards.

A total of 65 cases were selected for this study, and these cases were not consecutive but chosen to represent individuals with either typical or atypical features resembling Parkinson's disease. It's important to note that MRI records that couldn't be accessed digitally or had unclear or illegible information on the request forms were excluded from the study.

In summary, this research aimed to examine a set of MRI brain scans conducted within a specific timeframe at Sardar Vallabhbhai Patel Hospital, with a focus on Parkinson's-related features, to gain insights into this neurological condition

MRI brain Parkinson’s Protocol

All MRI brain examinations included in this study were performed using the 3T SIEMENS MAGNETOM-SKYRA MRI machine.

Table 1: MRI brain Parkinson’s Protocol

Recommended MR sequences	Information	Changes in PD(2)
T1WI	Morphology : Diameter, area , volume.	SN: variable volume changes • Mild hyperintensity of compacta and reticular parts of the substantianigra and red nuclei (due to iron accumulation). • Show loss of normal slight hyperintensity in substantianigra due to loss of neuromelanin Cortex : mild reduction in volume and thickness
T2WI	Morphology: Diameter, area, volume	SN: variable volume changes Cortex : mild reduction in volume and thickness In gliosis- signal increase In iron content - signal decrease
MPRAGE	Morphology: Diameter, area , volume And To calculate certain parameters	To calculate MRI parkinson’s index in atypical parkinsonism Midbrain to pons ratio MRPI index Callosal angle
T2* or SWI	Sensitive to the presence of paramagnetic iron, which is found in the substantianigra. Beside visual inspection of iron-sensitive images	• Absent swallow tail sign • Loss of normal susceptibility signal drop-out of the substantianigra and red nuclei (due to loss of melanin-containing neurons) • Dot-like areas of hyperintensity in the compact part of the substantianigra • May show a confluence of the normal hypointense regions of substantianigra (due to iron accumulation)

Summary on characteristic MRI patterns for the differential diagnosis of neurodegenerative parkinsonism[2]

Table 2: Summary on characteristic MRI patterns for the differential diagnosis of neurodegenerative parkinsonism

	PD	MSA	PSP
Normal	++	-/+	-/+
Putaminal atrophy	-	++	++
Putaminal hyperintense rim	+	++	+
Putaminal hypointensity on T2a	-	++	-
Atrophy of pons and vermiscerebellaris	-	++	+
Signal changes in the pons (hot cross bun sign) or MCPsa	-	++	-
Midbrain atrophy Mickey mouse sign and king-penguin silhouette	-	-	++
MRI planimetry: Decreased ma/pa ratio Increased MRPI	-	+	+++

MRPI index

Calculated by multiplying the pons area to midbrain area ratio by the middle cerebellar peduncle (MCP)width to superior cerebellar peduncle(SCP) width ratio

(Pons/ Midbrain) X (MCP/SCP)

Its primary applications include distinguishing between classic and brainstem variants of Progressive Supranuclear Palsy (PSP) and differentiating PSP from other movement disorders such as Parkinson's disease, clinically unclassifiable parkinsonism, and Huntington's disease. Additionally, MRPI plays a role in monitoring disease progression.

One of its notable strengths is its high accuracy in distinguishing PSP patients from those with Multiple System Atrophy with predominant parkinsonism (MSA-P) or Parkinson's disease. MRPI exhibits a sensitivity, specificity, and positive predictive value of 100%.

A critical threshold to consider is an MRPI value greater than 13.55, which is considered an abnormal result. Such a result strongly suggests that patients with this MRPI level may eventually develop Progressive Supranuclear Palsy (PSP). This index thus aids clinicians in making more accurate diagnoses and prognoses for patients with movement disorders.[10]

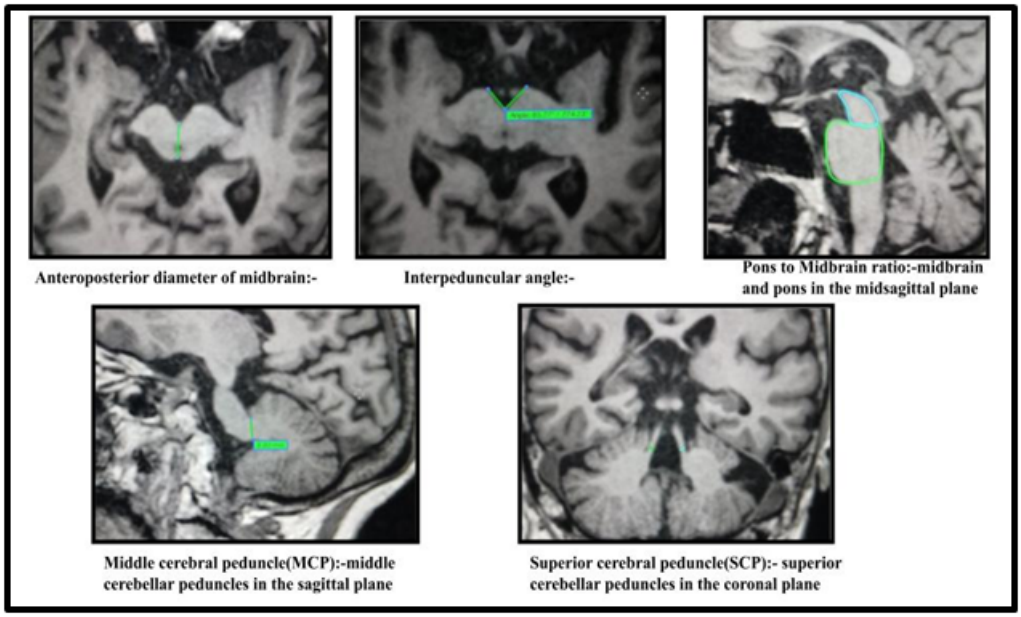


Figure 1:

MRPI 2.0: It is calculated by multiplying the MRPI by the ratio of third ventricular width to frontal horn width.

MRPI 2.0 = MRPI x (V3 / FH)

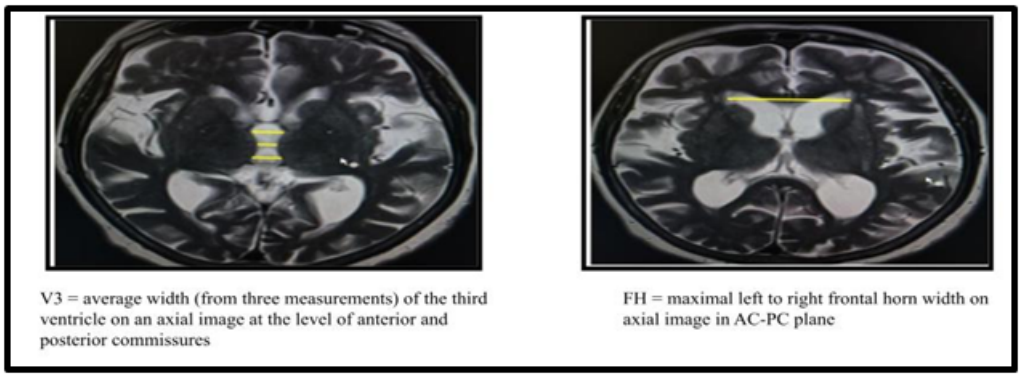


Figure 2:

Cutoff values have been calculated that depend on the clinical context.
PSP-parkinsonian vs Parkinson disease or control: ≥2.18.
PSP-Richardson's syndrome vs Parkinson disease or control: ≥2.50[10]
Pragmatic approach to reading a MRI in patient present with early parkinsonism[2]

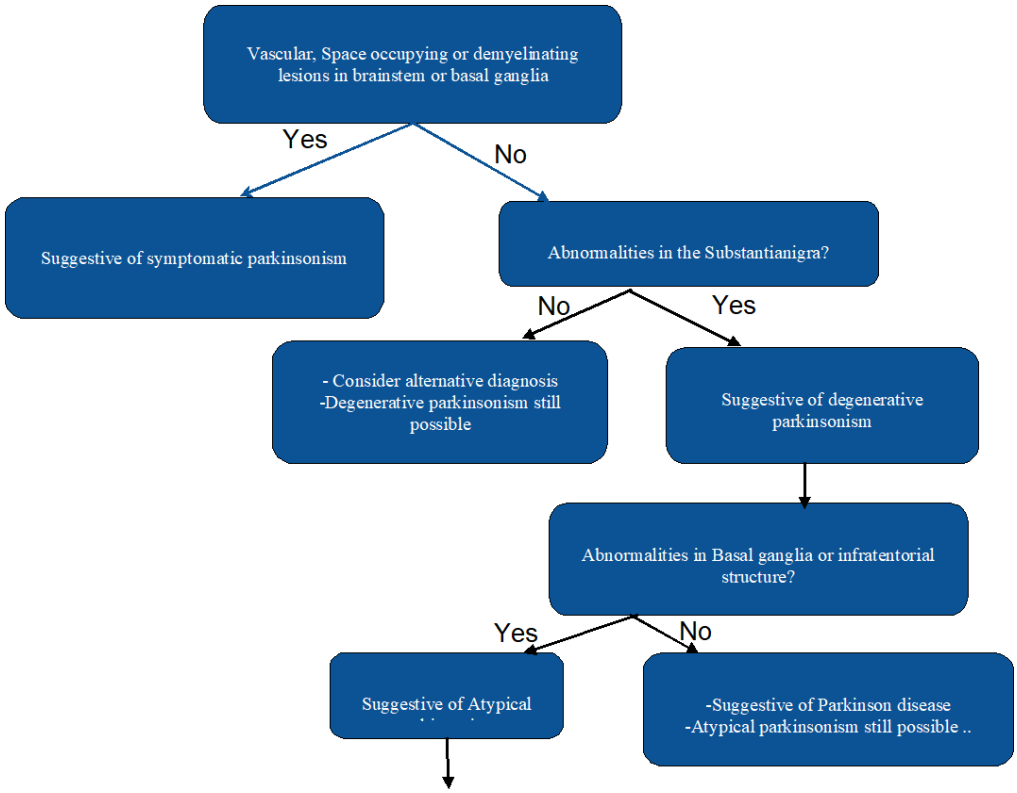


Figure 3:

Abnormalities in	Suggestive for
Putamen	MSA>PSP
Thalamus	PSP
Midbrain	PSP
Pons	MSA
Cerebellum	MSA
Superior cerebellar peduncle	PSP
Middle cerebellar peducle	MSA

Figure 4:

PSP patients had greater midbrain and superior cerebellar atrophy whereas MSA-P patients had greater pontine and middle cerebellar atrophy.

Image Processing: All cases were randomized using the Microsoft Excel randomisation function and identifiers were removed from each MRI examination.

Statistical Analysis: Data depicted in form of tables & charts.

Ethical Considerations: 'The Institutional Review Board at a Gujarat University approved the research. (2023/August/17/No.7). Patient consent for individual cases was waived as all studies were retrospectively collected from the institutional Picture Archiving and Communication System (PACS) and studies were anonymised prior to review by individual readers.

Observations

Table 1: Age & Gender Wise Distribution

Age	Male	Female	Total	Percentage
< 50 year	2	2	4	6
50 - 60 year	8	2	10	15
60-70 years	19	8	27	42
70-80 years	12	9	21	32
> 80 years	1	2	3	5
	42	23	65	100

Maximum number of patients were in the age group of 60-70 years (42%).

Sex ratio: M:F – 2 : 1

Male predominance is noted.

Results

Out of 65 patients enrolled,

1) 44 patients were assigned to the parkinsonism group, Out of them majority of (N=28 , 63%) patients had normal MRI brain parkinson's protocol. Only 15 patients had abnormal findings in the MRI brain. In which 5 (11% patients) had shown the typical feature of parkinsonism with absence of swallow tail sign, , 5 (11% patients) has shown the MRI feature of atypical parkinsonism and 5 (11% patients)had diagnosed with secondary causes of parkinsonism like vascular parkinsonism & normal pressure hydrocephalus. Sensitivity of MRI findings is 12% in patients with typical parkinsonism.
2) And 21 patients were assigned to atypical parkinsonism, out of them 11 (52 % patients) had MRI feature suggestive of atypical parkinsonism- PSP and 3 (14 % patients) showed MRI findings of MSA, 7 (33% patients)had normal MRI findings. Sensitivity of MRI findings is 66% in patients with atypical parkinsonism.

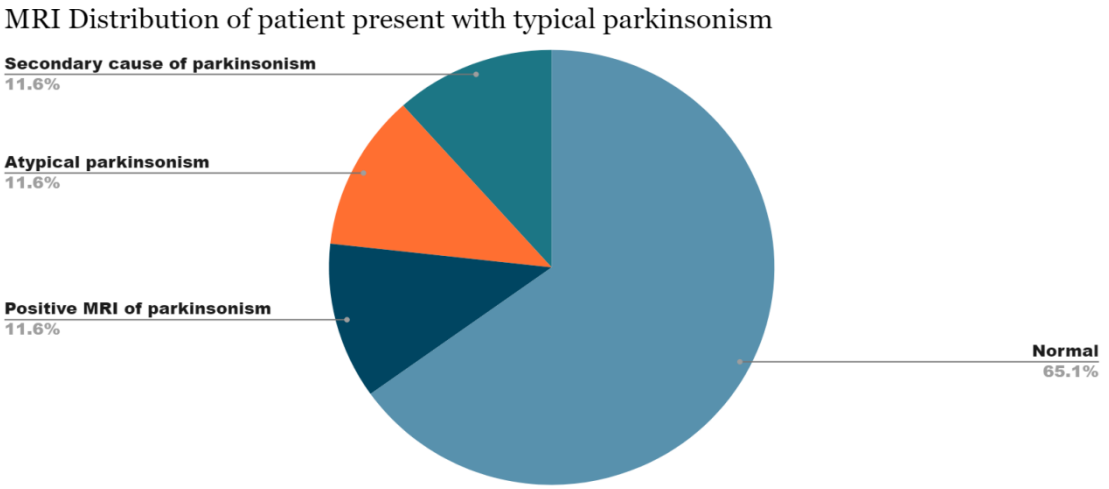


Figure 5:

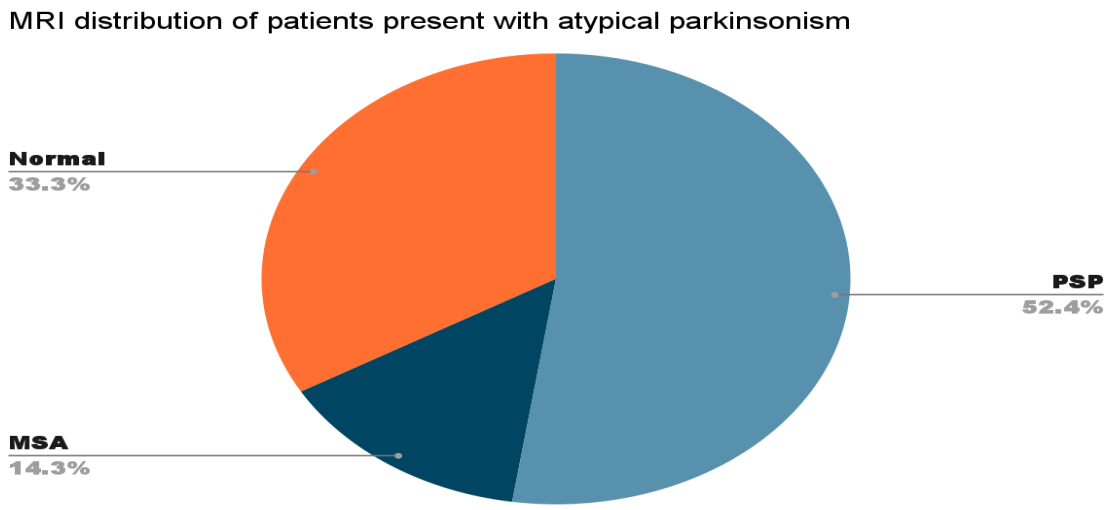


Figure 6:

Discussion

Parkinson's Disease (PD) stands as the most prevalent neurodegenerative form of parkinsonism, followed by progressive supranuclear palsy and multiple system atrophy (MSA). Although consensus diagnostic criteria exist for PD and atypical parkinsonian disorders (APD) like progressive supranuclear palsy, MSA Parkinson variant, and corticobasal degeneration, distinguishing between these clinical entities, particularly in the early stages, can be challenging[11]

Magnetic resonance imaging (MRI) is a valuable tool for excluding secondary causes of parkinsonism. In this context, the absence of the swallow tail sign emerges as the most reliable indicator in PD patients [12,13,14]. SWI/T2* imaging demonstrates its utility in revealing putaminal hypointensity, even in the early stages of MSA-p. This suggests that iron deposition linked to putaminal degeneration can manifest early in the disease process [15]. MSA-C is marked by pons and cerebellum atrophy, along with the characteristic "hot cross bun" sign on imaging[16]. PSP is characterized by midbrain atrophy[17].while asymmetric frontoparietal-perirolandic atrophy is a distinguishing feature of CBD[18]. Patients presenting with parkinsonism-like symptoms undergo MRI brain assessments and are categorized into the parkinsonism group and atypical parkinsonism group. It's important to note that the diagnosis of PD and specific forms of APD remains a clinical diagnosis in accordance with current diagnostic criteria and standards.

Utilizing magnetic resonance (MR) planimetry, both the midbrain-to-pontine area ratio (m/p-ratio) and the MR parkinsonism index (MRPI) have proven valuable in differentiating progressive supranuclear palsy (PSP) from Parkinson's disease (PD) and the Parkinson variant of multiple system atrophy (MSA-P). Both the m/p-ratio and the MRPI can aid in the clinical differentiation of neurodegenerative parkinsonism. Certainly, the implications and significance of the findings presented in the study.

Early Diagnosis of Atypical Parkinsonism

The study highlights the crucial role of MRI in early diagnosis, particularly for atypical parkinsonian disorders like Progressive Supranuclear Palsy (PSP) and Multiple System Atrophy (MSA). Early diagnosis can be a game-changer in patient care, as it allows for more appropriate and timely management strategies to be employed.

Clinical Challenges in Differential Diagnosis

Parkinsonism presents a clinical challenge, especially in its early stages when the symptoms may not be distinct. The study's emphasis on the need for additional tools like MRI to aid in differential diagnosis underscores the complexity of these neurodegenerative disorders. Early and accurate differentiation is essential for tailoring treatment and support to the specific needs of each patient.

Importance of MRI Findings

The significance of specific MRI findings cannot be overstated. For instance, the absence of the swallow tail sign in PD patients is a noteworthy observation. Such imaging biomarkers can serve as valuable diagnostic tools, potentially reducing the time and uncertainty associated with clinical diagnosis alone.

Clinical Guidelines and Decision-Making

The study reaffirms that, despite the advances in medical imaging, clinical diagnosis remains the

gold standard for Parkinson's disease and atypical parkinsonism. However, MRI can play a complementary role in refining diagnoses and improving decision-making, especially when clinical presentations are ambiguous.

Patient-Centered Care

Timely and accurate diagnosis is essential for providing patient-centered care. It allows healthcare professionals to initiate appropriate treatments, offer psychological support, and engage patients in discussions about their prognosis and care preferences. This holistic approach can significantly improve the quality of life for individuals living with these challenging conditions. The study suggests that MRI is more beneficial for diagnosing clinically suspected atypical parkinsonism compared to typical parkinsonism. MRI aids in the early detection of atypical parkinsonism and the characterization of its specific features using the MRPI index and the Midbrain/Pons ratio. In cases of typical parkinsonism, MRI findings often appear normal, making MRI primarily useful for excluding other potential causes of parkinsonism, such as vascular causes or normal pressure hydrocephalus.

In summary , this study underscores the evolving role of MRI in the diagnosis and differentiation of parkinsonian disorders. While clinical judgment remains paramount, the integration of advanced imaging techniques like MRI is enhancing our ability to provide early, precise, and patient-tailored care for individuals affected by these complex neurodegenerative conditions. The study's findings have the potential to influence clinical practice, research, and the overall management of Parkinson's disease and atypical parkinsonism.

Conclusion

Indeed, MRI assumes a pivotal role in the comprehensive assessment and care of individuals with Parkinson's disease. Its primary objective in this context is to meticulously rule out alternative, and occasionally treatable causes of parkinsonism, including vascular causes and normal pressure hydrocephalus. Beyond this critical function, brain MRI also serves the purpose of distinguishing between the typical presentation of Parkinson's disease and atypical parkinsonism. Moreover, it contributes significantly to the diagnostic process and aids in assessing the prognosis associated with specific forms of atypical parkinsonism. In essence, MRI emerges as an indispensable tool in the holistic approach to Parkinson's disease, offering vital insights for both diagnosis and tailored management.

Normal substantianigra at 3T T2* weighted gradient images.

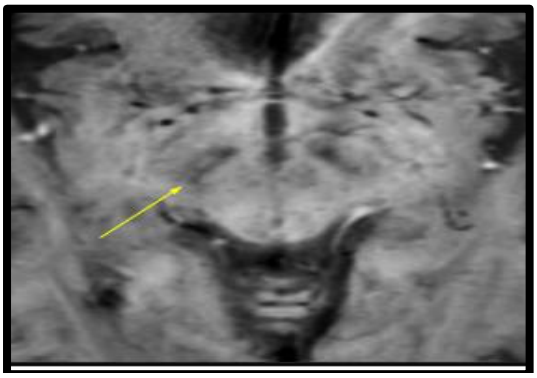


Figure 7:

At the level of red nucleus it shows linear hyperintensity between two layers of substantianigra hypointensity. Called as swallow tail sign,nigralhyperintensity or dorsal hyperintensity.

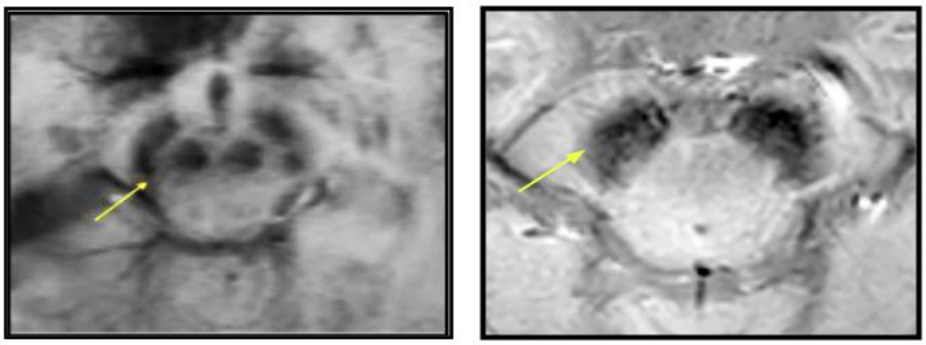


Figure 8:

A 3-T susceptibility-weighted image of Parkinson's disease shows loss of nigral hyperintensity in the substantianigra- Loss of swallow tail sign. There are prominent iron deposits in the substantiating.

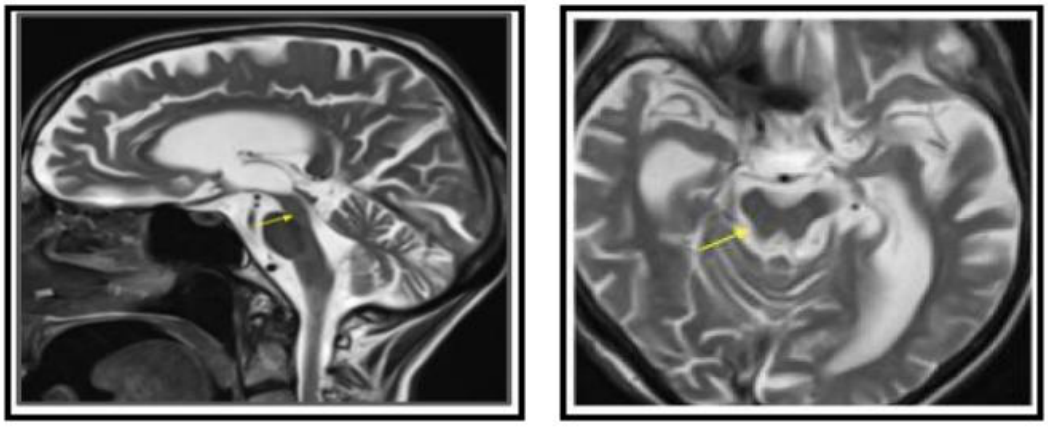
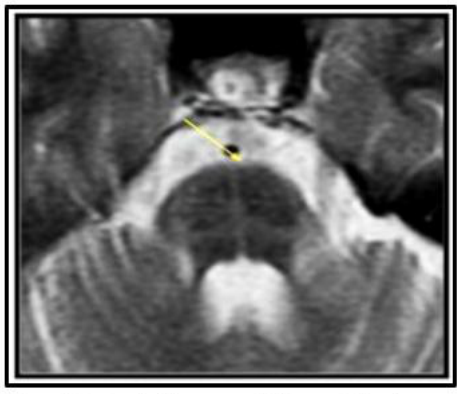
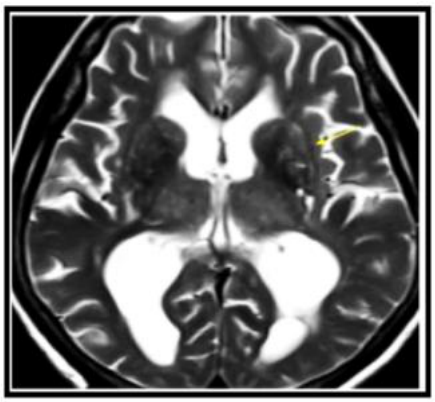


Figure 9:

In 3T MRI findings in progressive supranuclear palsy. In a sagittal T2-weighted sequence, the Hummingbird sign is seen , due to the volumetric reduction of the midbrain in relation to the pons.
In axial plane , themickey mouse sign seen due to widening of the interpeduncular cistern and retraction of the dorsolateral region of the midbrain.



MRI T2-weighted axial images of 75 year old male, strating pontine atrophy with the **'Hot cross bun' sign** rophy of cerebellum.**Diagnostic of cerebellar form of MSA-C.**



Axial T2WI show large ventricles/sulci and thinned atrophic putamina with an irregular lateral rim of hy and hyperintensity.**suggest changes of MSA-P.**

Figure 10:

References

1. Aarsland, D., Batzu, L., Halliday, G.M. et al. Parkinson disease-associated cognitive impairment. Nat Rev Dis Primers. 2021; 7: 47.
2. Heim, B., Krismer, F., De Marzi, R., &Seppi, K. Magnetic resonance imaging for the diagnosis of Parkinson's disease. Journal of neural transmission (Vienna, Austria: 1996). 2017; 124(8): 915–964.
3. Rajput AH, Rozdilsky B, Rajput A. Accuracy of clinical diagnosis in parkinsonism–a prospective study. Can J Neurol Sci (Le journal canadien des sciences neurologiques) 1991;18(3):275–278.
4. Meara J, Bhowmick BK, Hobson P. Accuracy of diagnosis in patients with presumed Parkinson's disease. Age Ageing. 1999; 28(2):99–102.
5. Jankovic J, Rajput AH, McDermott MP, Perl DP. The evolution of diagnosis in early Parkinson disease. Parkinson Study Group. Arch Neurol. 2000;57(3):369–372.
6. Hughes AJ, Daniel SE, Ben-Shlomo Y, Lees AJ. The accuracy of diagnosis of parkinsonian syndromes in a specialist movement disorder service. Brain J Neurol. 2002;125(Pt 4):861–870.
7. Schrag A, Ben-Shlomo Y, Quinn N. How valid is the clinical diagnosis of Parkinson's disease in the community? J Neurol Neurosurg Psychiatry. 2002;73(5):529–534.
8. Tolosa E, Wenning G, Poewe W. The diagnosis of Parkinson's disease. Lancet Neurol. 2006;5(1):75–86.
9. Weingarten CP, Sundman MH, Hickey P, & Chen NK. Neuroimaging of Parkinson's

disease: Expanding views. Neurosci Biobehav Rev. 2015; 59: 16–52.
10. Czarniecki M, Botz B, Smith D, et al. Magnetic resonance parkinsonism index. Reference article, Radiopaedia.org (Accessed on 19 Jul 2023)
11. Seppi K. MRI for the differential diagnosis of neurodegenerative parkinsonism in clinical practice. Parkinsonism & related disorders, 2007;13 Suppl 3: S400–S405.
12. Schwarz ST, Afzal M, Morgan PS et-al. The 'swallow tail' appearance of the healthy nigrosome - a new accurate test of Parkinson's disease: a case-control and retrospective cross-sectional MRI study at 3T. PLoS ONE. 2014;9 (4): e93814.
13. Shams S, Fällmar D, Schwarz S, Wahlund L-O, van Westen D, Hansson O, Larsson E-M, Haller S. MRI of the Swallow Tail Sign: A Useful Marker in the Diagnosis of Lewy Body Dementia? American Journal of Neuroradiology. 38(9): 1737.
14. Cheng Z, Zhang J, He N, Li Y, Wen Y, Xu H, Tang R, Jin Z, Haacke EM, Yan F, Qian D. Radiomic Features of the Nigrosome-1 Region of the Substantia Nigra: Using Quantitative Susceptibility Mapping to Assist the Diagnosis of Idiopathic Parkinson's Disease. Frontiers in aging neuroscience. 2019;11: 167.
15. Lee, J. H., & Baik, S. K. Putaminal hypointensity in the parkinsonian variant of multiple system atrophy: simple visual assessment using susceptibility-weighted imaging. Journal of movement disorders, 2011; 4(2): 60–63.
16. Naidoo, A. K., Wells, C. D., Rugbeer, Y., & Naidoo, N. The "Hot Cross Bun Sign" in Spinocerebellar Ataxia Types 2 and 7-Case Reports and Review of Literature. Movement disorders clinical practice, 2022; 9(8): 1105–1113.
17. Choi, S. M., Kim, B. C., Nam, T. S., Kim, J. T., Lee, S. H., Park, M. S., Kim, M. K., de Leon, M. J., & Cho, K. H. (2011). Midbrain atrophy in vascular Parkinsonism. European neurology, 2011;65(5): 296–301.
18. Gaillard F, Botz B, Sharma R, et al. Corticobasal degeneration. Reference article, Radiopaedia.org (Accessed on 08 Sep 2023).