International Journal of Health Sciences and Research
[Indexed, Peer-Reviewed Journal]
Volume 16; Issue: 3; March 2026
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

Role of Magnetic Resonance Imaging in the Evaluation of Central Nervous System Demyelinating Disorders and Their Mimics: A Retrospective Observational Study at a Tertiary Care Centre in South India

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DOI: https://doi.org/10.52403/ijhsr.20260329

ABSTRACT

Background: Demyelinating disorders of the central nervous system (CNS) comprise a heterogeneous group of inflammatory diseases characterized by damage to the myelin sheath, resulting in neurological dysfunction. These disorders commonly involve the brain, optic nerves, and spinal cord and present with varied clinical manifestations. Early and accurate diagnosis is essential for timely treatment and improved patient outcomes. Magnetic resonance imaging (MRI) is the most sensitive imaging modality for detecting and characterizing demyelinating lesions because of its superior soft-tissue contrast and ability to delineate white matter abnormalities. However, several non-demyelinating conditions may mimic demyelinating disorders on MRI, posing diagnostic challenges in clinical practice.
Methods: This retrospective observational study was conducted in the Department of Radiodiagnosis at Rajarajeswari Medical College, a tertiary care centre in South India. MRI examinations of 30 patients with clinical suspicion of demyelinating disease were reviewed. The study included cases of multiple sclerosis, optic neuritis, acute disseminated encephalomyelitis, transverse myelitis and neuromyelitis optica spectrum disorder. MRI sequences evaluation included T1-weighted, T2-weighted, fluid-attenuated inversion recovery (FLAIR), diffusion-weighted imaging (DWI) and contrast-enhanced sequences where available. Imaging features such as lesion morphology, anatomical distribution, optic nerve involvement, spinal cord lesions, and enhancement characteristics were analyzed.
Results: Among the 30 patients, multiple sclerosis was the most frequently observed demyelinating disorder. MRI findings commonly demonstrated periventricular and juxtacortical white matter plaques oriented perpendicular to the lateral ventricles. Optic neuritis showed optic nerve enlargement with contrast enhancement, while acute disseminated encephalomyelitis presented with multifocal bilateral hyperintense lesions in the cerebral white matter. Transverse myelitis and neuromyelitis optica spectrum disorder demonstrated long-segment intramedullary hyperintensity of the spinal cord on T2-weighted imaging. In addition, several non-demyelinating conditions such as cerebral vasculitis and

leukodystrophies were identified as radiological mimics. MRI proved valuable in distinguishing these mimics from true demyelinating disorders based on lesion distribution and imaging characteristics.

Conclusion: MRI plays a crucial role in the evaluation of CNS demyelinating disorders and their mimics. Recognition of characteristic imaging patterns and awareness of potential mimicking conditions enables accurate diagnosis and facilitates timely clinical management.

Keywords: *Demyelinating disorders, Magnetic resonance imaging, Multiple sclerosis, Neuromyelitis optica spectrum disorder, Acute disseminated encephalomyelitis, Optic neuritis, Transverse myelitis, MRI mimics.*

INTRODUCTION

Demyelinating disorders of the central nervous system (CNS) comprise a heterogeneous group of neurological diseases characterized by damage or loss of the myelin sheath surrounding neuronal axons **[1]**. Myelin is essential for efficient saltatory conduction along nerve fibers, and its disruption leads to impaired neural transmission and consequent neurological dysfunction **[2,3]**. Clinically, patients may present with motor weakness, sensory disturbances, visual impairment, and cognitive deficits. Owing to the heterogeneity of clinical manifestations, diagnosis based solely on clinical findings is often insufficient and requires supportive investigations **[3,4]**.

Among these conditions, multiple sclerosis (MS) is the most common inflammatory demyelinating disease in adults **[3,5]**. Other important entities within the demyelinating spectrum include optic neuritis, acute disseminated encephalomyelitis (ADEM), transverse myelitis, and neuromyelitis optica spectrum disorder (NMOSD) **[6,7]**. Although these disorders may demonstrate overlapping clinical features, they differ significantly in their underlying pathophysiology, disease course, and imaging characteristics. Early and accurate differentiation among these conditions is essential for appropriate therapeutic decision-making and improved clinical outcomes.

Magnetic resonance imaging (MRI) is the imaging modality of choice for evaluating demyelinating disorders due to its excellent soft-tissue contrast and multiplanar capability **[8,9]**. MRI enables detailed assessment of the brain, optic nerves, and spinal cord, facilitating early detection of subtle white matter abnormalities. Conventional MRI sequences, including T1-weighted, T2-weighted, and fluid-attenuated inversion recovery (FLAIR) imaging are fundamental for assessing lesion burden and distribution, while contrast-enhanced sequences provide additional information regarding lesion activity and blood–brain barrier disruption **[10]**.

Characteristic imaging findings such as periventricular lesions, optic nerve involvement, and longitudinally extensive spinal cord lesions serve as important diagnostic markers in differentiating various demyelinating disorders. Beyond diagnosis, MRI plays a crucial role in monitoring disease activity, evaluating treatment response, and predicting long-term prognosis **[11]**.

In clinical practice, several non-demyelinating conditions may mimic inflammatory demyelinating disorders on MRI, including vascular, infectious, metabolic, neoplastic, and inherited white matter diseases such as leukodystrophies. These entities may exhibit imaging features similar to demyelinating lesions, thereby posing significant diagnostic challenges. Careful evaluation of lesion morphology, anatomical distribution, symmetry, and enhancement patterns is essential for accurate differentiation **[12]**.

Aim of the Study:

To evaluate the role of magnetic resonance imaging in the assessment of central nervous system demyelinating disorders in patients presenting to a tertiary care centre in South India.

Objectives of the Study:

- To analyze the MRI characteristics and anatomical distribution of lesions in different demyelinating disorders.
- To identify radiological features that help differentiate demyelinating disorders from their mimics.
- To improve diagnostic accuracy and support appropriate clinical management.

MATERIALS & METHODS

Study Design and Setting

This retrospective observational study was conducted in the Department of Radiodiagnosis at Rajarajeswari Medical College and Hospital, a tertiary care centre in South India. The study included patients who underwent magnetic resonance imaging (MRI) for evaluation of suspected demyelinating disorders of the central nervous system during the study period from July 2025 to February 2026.

All cases were retrieved retrospectively from the hospital's Picture Archiving and Communication System (PACS) database. Patient identifiers were anonymized before analysis. Patients were referred from various departments including General Medicine, Neurology and Neurosurgery. Institutional approval was obtained prior to data collection, and patient confidentiality was maintained throughout the study.

Study Population

A total of 30 patients with clinical suspicion of demyelinating disease who underwent MRI examination of the brain and/or spinal cord were included in the study. The diagnosis was established based on clinical evaluation, radiological findings and relevant laboratory investigations where available.

Patients diagnosed with demyelinating disorders such as Multiple Sclerosis, Optic Neuritis, Acute Disseminated Encephalomyelitis, Transverse Myelitis, and Neuromyelitis Optica Spectrum Disorder (NMOSD) were included in the study cohort.

Inclusion Criteria

Patients were included in the study if they met the following criteria:

1. Patients presenting with clinical features suggestive of demyelinating disease.
2. Patients who underwent MRI examination of the brain and/or spinal cord.
3. Patients with imaging findings consistent with demyelinating disorders.

Exclusion Criteria

The following patients were excluded from the study:

1. Patients with incomplete clinical or imaging records.
2. Patients with imaging findings suggestive of other neurological conditions such as neoplasms, infections or vascular lesions.
3. MRI studies with significant motion artifacts or inadequate image quality.

MRI Protocol

All patients underwent MRI examination using standard imaging protocols. The imaging sequences included T1-weighted imaging, T2-weighted imaging, fluid-attenuated inversion recovery (FLAIR), diffusion-weighted imaging (DWI), and post-contrast T1-weighted sequences where clinically indicated. Imaging was performed in multiple planes to evaluate the brain, optic nerves, and spinal cord.

Image Analysis

All MRI studies were reviewed retrospectively by experienced radiologists. Imaging findings were analyzed with

respect to lesion morphology, anatomical distribution, and involvement of specific regions such as periventricular white matter, juxtacortical areas, optic nerves, and spinal cord, as well as contrast enhancement patterns. The imaging characteristics were documented and correlated with the clinical diagnosis.

Statistical Analysis

Descriptive statistical methods were used to summarize patient demographics and imaging findings. The frequency and distribution of different demyelinating disorders and their imaging features were analyzed and presented in the form of tables and percentages.

RESULTS

A total of 30 patients with clinically suspected demyelinating disorders of the central nervous system who underwent MRI examination were included in the study. The demographic characteristics, disease distribution and MRI findings were analyzed.

Age Distribution

The majority of patients in the present study belonged to the young and middle-aged adult population. The highest proportion of cases was observed in the 21–30-year age group, followed by the 31–40-year age group. This age distribution is consistent with the typical epidemiological pattern of inflammatory demyelinating disorders, which commonly affect young adults.

Table 1: Age Distribution of the Study Population (n = 30)

Age Group (years)	Number of Patients	Percentage (%)
18–20	3	10
21–30	10	33.3
31–40	8	26.7
41–50	6	20
>50	3	10
Total	**30**	**100**

Table 1 shows the age distribution of the study population. The highest proportion of patients (33.3%) belonged to the 21–30-year age group, followed by 31–40 years (26.7%).

Gender Distribution

Analysis of gender distribution demonstrated a slight female predominance in the study population. This observation is consistent with previous studies reporting a higher prevalence of several demyelinating disorders among females.

Table 2: Gender Distribution of Patients

Gender	Number of Patients	Percentage (%)
Male	13	43.3
Female	17	56.7
Total	**30**	**100**

Table 2 demonstrates the gender distribution of the study population, showing a slight female predominance with females accounting for 56.7% of cases.

Distribution of Demyelinating Disorders

Among the demyelinating disorders evaluated, Multiple Sclerosis was the most frequently encountered condition in the study cohort. Other conditions identified included Transverse Myelitis, Optic Neuritis, Acute Disseminated Encephalomyelitis, and Neuromyelitis Optica Spectrum Disorder (NMOSD).

Table 3: Distribution of Demyelinating Disorders in the Study Population

Demyelinating Disorder	Number of Patients	Percentage (%)
Multiple Sclerosis	12	40
Transverse Myelitis	7	23.3
Optic Neuritis	5	16.7
Acute Disseminated Encephalomyelitis	4	13.3
Neuromyelitis Optica Spectrum Disorder	2	6.7
Total	**30**	**100**

Table 3 illustrates the distribution of demyelinating disorders among the study population. Multiple sclerosis was the most common condition (40%), followed by transverse myelitis (23.3%) and optic neuritis (16.7%).

MRI Lesion Distribution

MRI evaluation revealed involvement of multiple anatomical regions depending on the type of demyelinating disorder. Periventricular white matter lesions were the most common imaging finding, particularly among patients with multiple sclerosis. Optic nerve involvement was predominantly observed in cases of optic neuritis, while spinal cord lesions were commonly associated with transverse myelitis and neuromyelitis optica spectrum disorder. Patients with acute disseminated encephalomyelitis frequently demonstrated multifocal cerebral white matter lesions.

Table 4: Distribution of MRI Lesions

Lesion Location	MS (n=12)	Transverse Myelitis (n=7)	Optic Neuritis (n=5)	ADEM (n=4)	NMOSD (n=2)
Periventricular	**10**	**1**	**0**	**3**	**0**
Juxtacortical	**8**	**0**	**0**	**2**	**0**
Infratentorial	**4**	**1**	**0**	**1**	**0**
Spinal Cord	**2**	**7**	**0**	**1**	**2**
Optic Nerve	**3**	**0**	**5**	**0**	**1**

Table 4 shows the anatomical distribution of MRI lesions in different demyelinating disorders. Periventricular and juxtacortical regions were most commonly involved in multiple sclerosis, while spinal cord lesions predominated in transverse myelitis and NMOSD. Optic nerve involvement was mainly observed in optic neuritis.

Contrast Enhancement Pattern

Post-contrast MRI sequences demonstrated variable patterns of lesion enhancement. Active demyelinating lesions frequently showed ring or patchy enhancement, while several lesions did not exhibit significant contrast enhancement.

Table 5: Contrast Enhancement Pattern

Enhancement Pattern	MS (n=12)	Transverse Myelitis (n=7)	Optic Neuritis (n=5)	ADEM (n=4)	NMOSD (n=2)
Ring Enhancement	**5**	**2**	**0**	**2**	**0**
Patchy Enhancement	**3**	**2**	**1**	**1**	**1**
No Enhancement	**4**	**3**	**4**	**1**	**1**

Table 5 demonstrates the pattern of contrast enhancement observed on MRI. Ring enhancement was most frequently seen in multiple sclerosis and ADEM, while several lesions across different disorders showed no significant enhancement.

DISCUSSION

The present study evaluated the role of magnetic resonance imaging in the assessment of central nervous system demyelinating disorders in a tertiary care setting. MRI demonstrated characteristic

patterns of lesion distribution and enhancement that aided in identifying different demyelinating disorders. Among the various disorders evaluated, multiple sclerosis was the most frequently encountered condition, followed by transverse myelitis, optic neuritis, acute disseminated encephalomyelitis and neuromyelitis optica spectrum disorder. These findings highlight the importance of MRI in accurately identifying lesion location, extent of involvement and disease-specific imaging characteristics **[7,11]**.

In the present study, the majority of patients were young adults, with the highest proportion occurring between 21 and 40 years of age. Previous epidemiological studies have also reported that inflammatory demyelinating disorders commonly affect individuals in the second and third decades of life **[3,13]**. Early diagnosis in this age group is particularly important because timely therapeutic intervention can significantly influence disease progression and long-term neurological outcomes **[13]**.

A slight female predominance was observed in the present study. Similar gender distribution patterns have been documented in several epidemiological studies of demyelinating disorders, particularly in patients with multiple sclerosis **[3,13]**. Hormonal influences, genetic susceptibility and immunological differences between sexes have been proposed as possible explanations for the observed female predominance in autoimmune demyelinating diseases **[13]**.

Among the various demyelinating disorders evaluated in the present study, multiple sclerosis was the most frequently encountered entity. MRI findings commonly demonstrated periventricular and juxtacortical white matter lesions oriented perpendicular to the lateral ventricles. This pattern, commonly referred to as Dawson's fingers, represents one of the classical imaging features of multiple sclerosis and forms an important component of the diagnostic criteria for the disease **[5,8,9]** (Figure 1A). Similar MRI findings have been reported in previous studies describing periventricular and juxtacortical plaques as characteristic imaging features of multiple sclerosis **[7,9]**. MRI also plays a key role in demonstrating dissemination of lesions in both space and time, which is essential for establishing the diagnosis according to established clinical criteria **[8]**.

Cases of optic neuritis in the present study demonstrated enlargement and contrast enhancement of the affected optic nerve. Optic neuritis is frequently associated with demyelinating disorders and may represent the initial clinical manifestation of multiple sclerosis in a significant proportion of patients. MRI evaluation of the optic nerves demonstrated signal hyperintensity and enlargement of the affected optic nerve consistent with inflammatory demyelination (Figure 2A). MRI evaluation of the optic nerves therefore plays an important role in identifying inflammatory involvement and detecting additional intracranial demyelinating lesions that may support the diagnosis of an underlying demyelinating disorder **[14]**.

Patients diagnosed with acute disseminated encephalomyelitis (ADEM) demonstrated multifocal hyperintense lesions involving the periventricular, juxtacortical, and deep white matter regions on MRI (Figure 1B). ADEM is typically characterized by widespread inflammatory demyelination occurring after viral infection or immunological stimulation. The imaging findings observed in this study are consistent with previously reported descriptions of ADEM, which commonly demonstrate large poorly defined lesions involving the subcortical white matter and deep grey matter structures **[15]**.

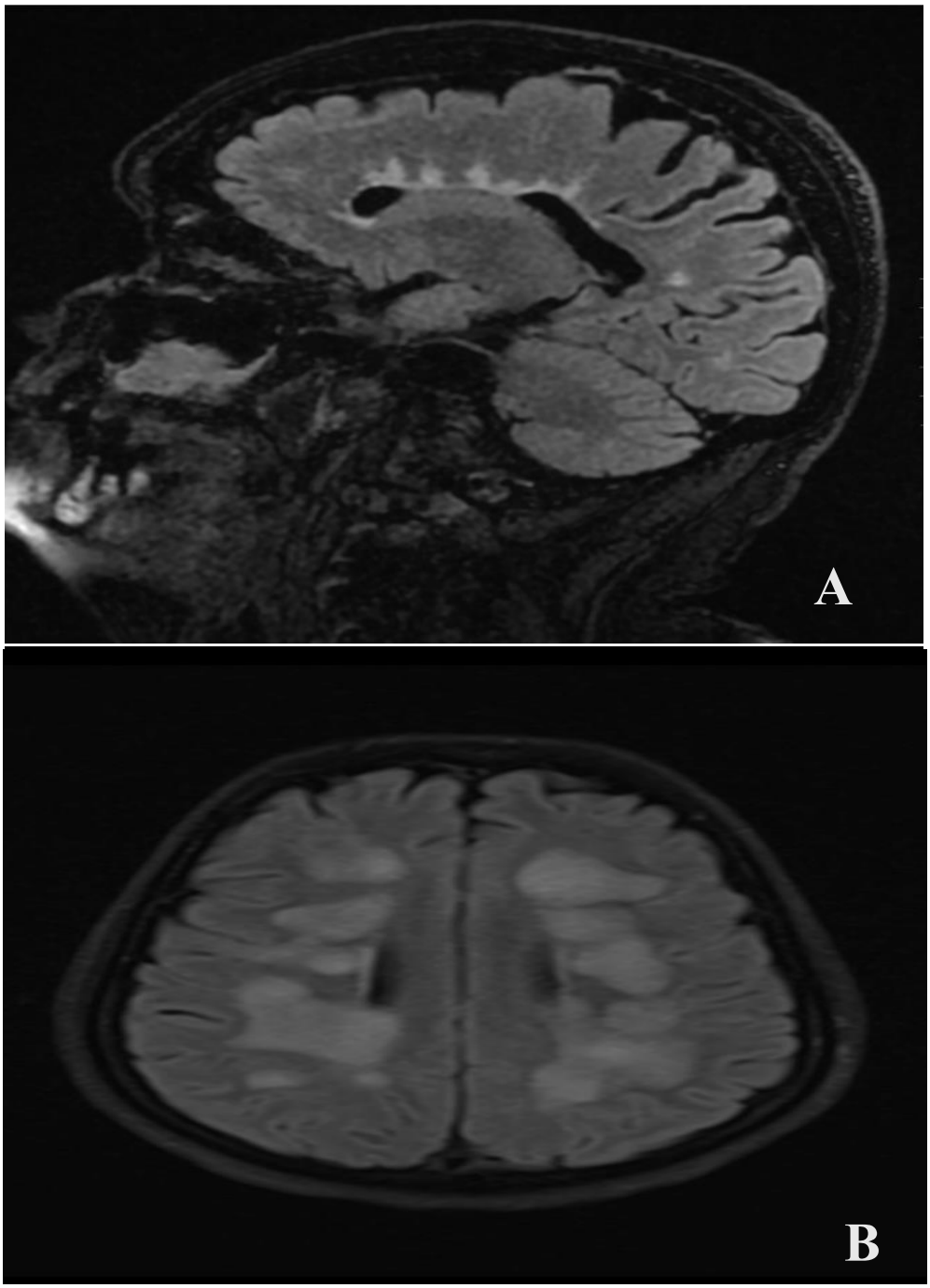

Figure 1:
A. Sagittal T2 FLAIR MRI sequence demonstrating multiple periventricular hyperintense lesions oriented perpendicular to the lateral ventricles (Dawson's fingers) in multiple sclerosis (MS).
B. Axial T2 FLAIR MRI sequence showing multiple hyperintensities in bilateral juxtacortical, periventricular and deep white matter of cerebral hemispheres consistent with acute disseminated encephalomyelitis (ADEM)

In cases of transverse myelitis, MRI demonstrated intramedullary spinal cord hyperintensity involving long segments on T2-weighted imaging (Figure 2B). MRI evaluation of the spinal cord is essential in these cases because it helps differentiate inflammatory demyelination from compressive, vascular, or neoplastic spinal cord pathologies **[16]**. Identification of lesion length, location, and enhancement pattern can significantly aid in narrowing the differential diagnosis of inflammatory

myelopathies. Previous studies have also reported that long-segment spinal cord involvement represents an important imaging feature of inflammatory myelopathies including transverse myelitis **[16]**.

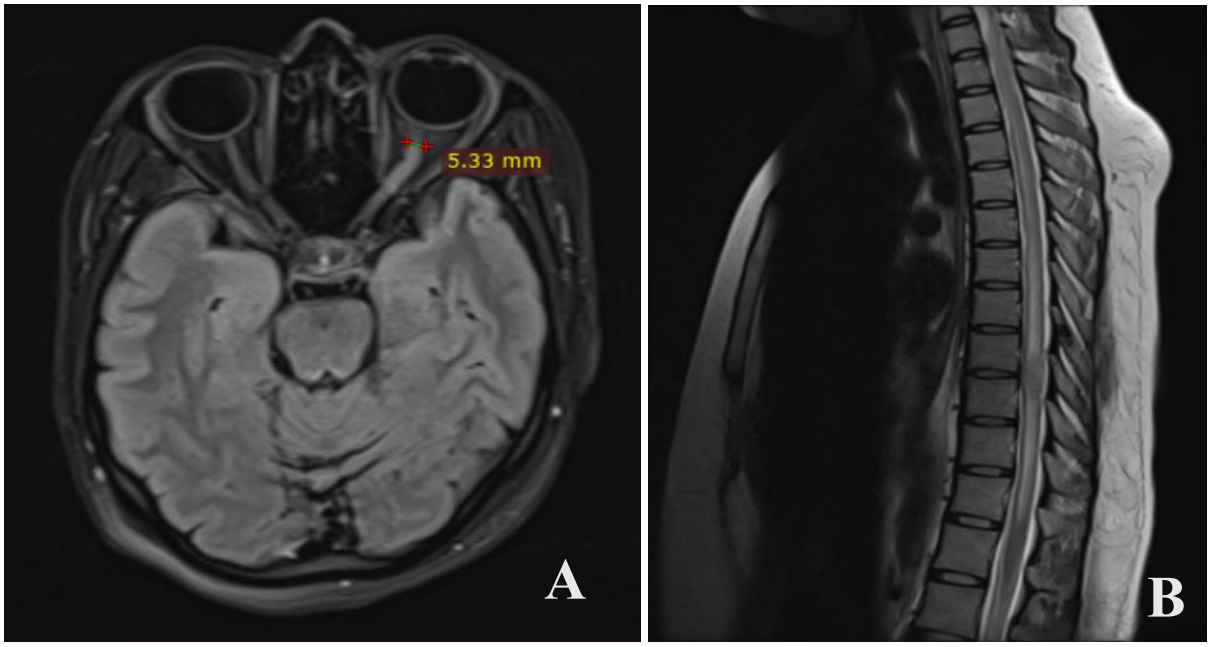

Figure 2:
A. Axial T2 FLAIR MRI sequence the brain and orbits demonstrating hyperintensity and mild enlargement of the left optic nerve consistent with inflammatory demyelination seen in optic neuritis. B. Sagittal T2-weighted MRI sequence of the spine demonstrating hyperintense signal involving the spinal cord from C7-T11 vertebral levels consistent with transverse myelitis and an intramedullary hypointense lesion at T8-T9 intervertebral disc space suggestive of Tuberculoma.

Neuromyelitis optica spectrum disorder (NMOSD) represents another important inflammatory demyelinating disorder affecting the optic nerves and spinal cord. MRI findings in NMOSD typically demonstrate longitudinally extensive spinal cord lesions extending over three or more vertebral segments, often involving the central cord (Figure 3A). Optic nerve involvement may also be observed in NMOSD, reflecting inflammatory demyelination of the optic pathways (Figure 3B). Recognition of these imaging features is important because NMOSD differs from multiple sclerosis in its pathophysiology, treatment strategies, and clinical prognosis **[6]**.

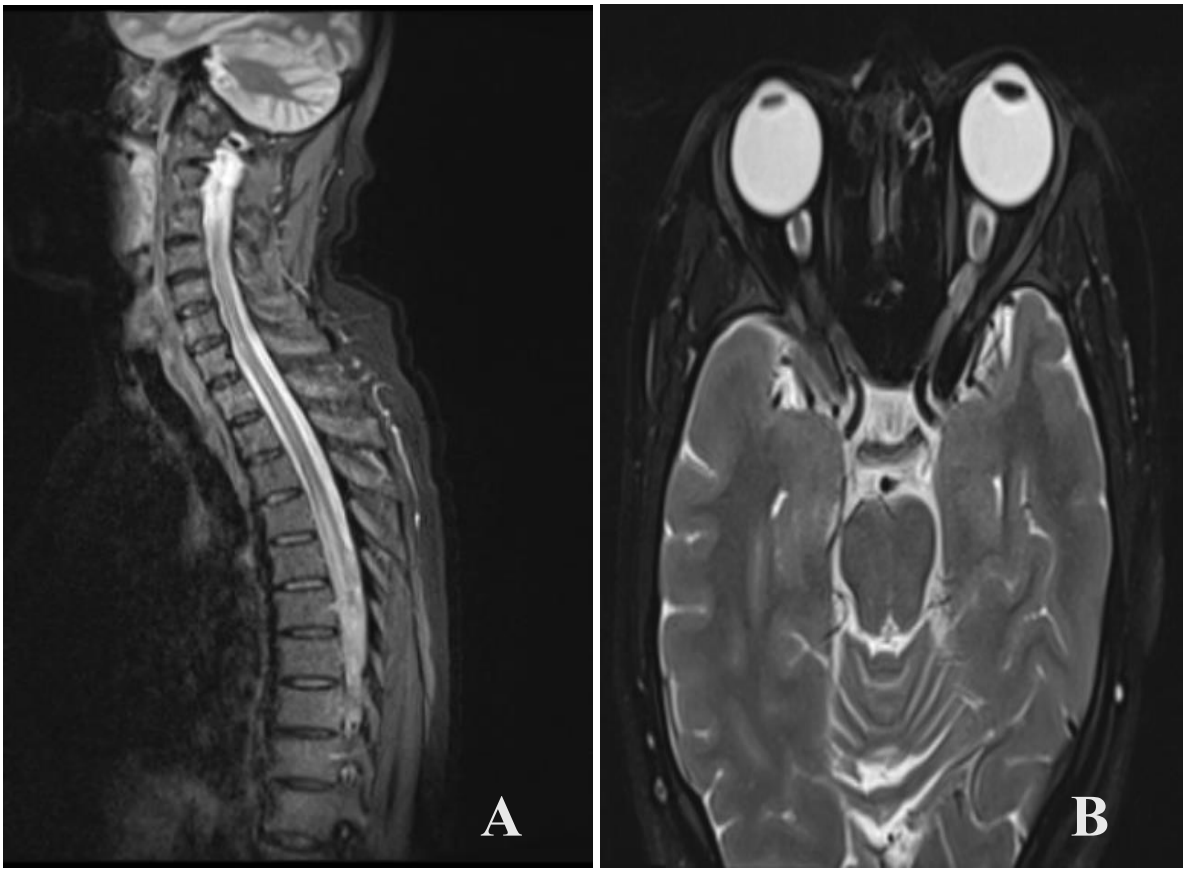

Figure 3:
A. Sagittal T2-TIRM MRI sequence of the cervicothoracic spine demonstrating longitudinally extensive intramedullary hyperintense lesion involving multiple vertebral segments, consistent with neuromyelitis optic a spectrum disorder (NMOSD).
B. Axial T2-weighted FS (Fat Saturation) MRI sequence of the brain and orbits demonstrating hyperintensities in the bilateral optic nerves with inflammatory changes, representing optic nerve involvement associated with NMOSD.

Analysis of lesion distribution in the present study revealed that periventricular white matter involvement was the most common imaging finding. Previous studies have also demonstrated that demyelinating plaques frequently occur in the periventricular regions due to the presence of small perivenular inflammatory processes affecting the white matter tracts **[5,9]**. Such characteristic lesion distribution patterns provide valuable clues that aid in the radiological diagnosis of demyelinating disorders.

Contrast enhancement patterns observed in the present study also provided useful information regarding disease activity. Active inflammatory lesions demonstrated ring or patchy enhancement on post-contrast imaging, reflecting disruption of the blood–brain barrier. The presence of contrast enhancement therefore indicates active inflammatory demyelination and may help determine the stage of lesion evolution and guide therapeutic decisions **[9,10]**.

MRI Mimics of Demyelinating Disorders

Several non-demyelinating conditions may closely resemble inflammatory demyelinating disorders on magnetic resonance imaging and therefore represent important radiological mimics. These include small vessel ischemic changes, central nervous system vasculitis, hereditary leukodystrophies such as megalencephalic leukoencephalopathy with subcortical cysts (Van der Knaap disease), progressive multifocal leukoencephalopathy, tumefactive lesions mimicking primary

brain tumours such as glioma or lymphoma, and mitochondrial disorders including MELAS **[11,17,18]**.

Certain hereditary leukodystrophies such as megalencephalic leukoencephalopathy with subcortical cysts (Van der Knaap disease) may demonstrate diffuse white matter abnormalities with characteristic subcortical cysts on MRI (Figure 4A,4B). The presence of symmetrical white matter involvement and anterior temporal cysts helps differentiate this condition from acquired demyelinating diseases **[18]**.

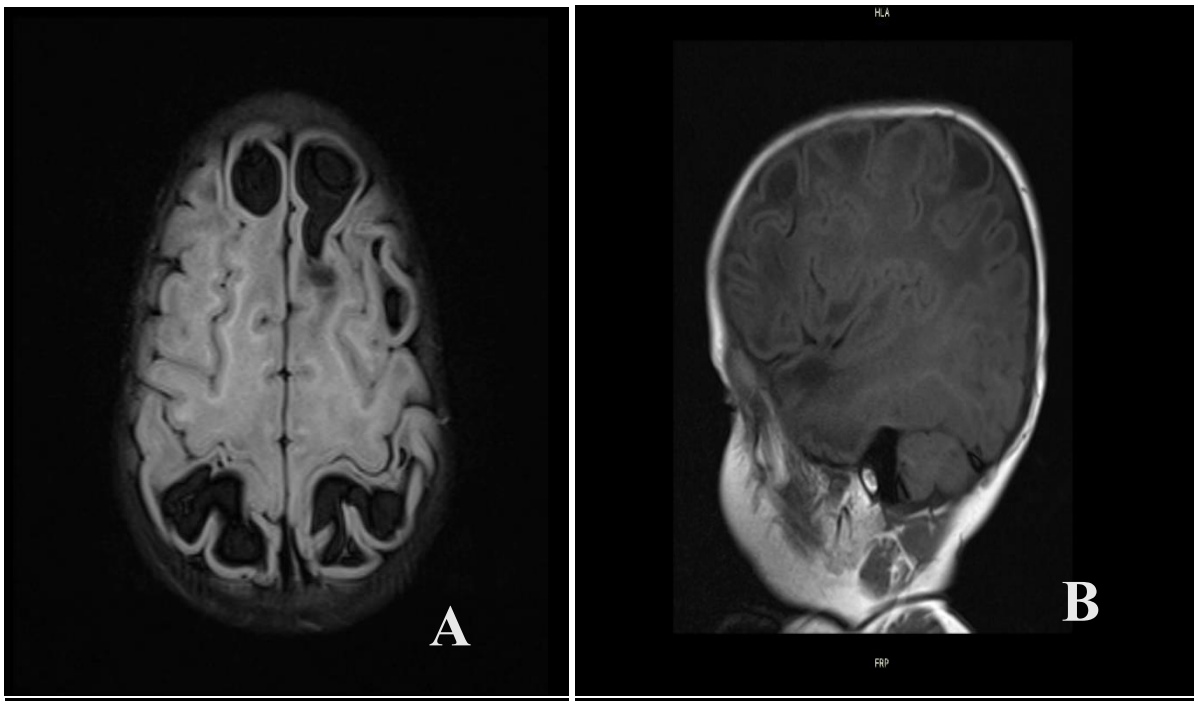

Figure 4:

A. Axial T2-FS MRI sequence demonstrating diffuse symmetrical hyperintense signal within the cerebral white matter with subcortical cystic changes in the bilateral anterior temporal, frontal and high posterior parietal lobes, characteristic of megalencephalic leukoencephalopathy with subcortical cysts (Van der Knaap disease).

B. Sagittal T1-weighted MRI showing diffuse white matter signal abnormalities with associated cystic changes, supporting the diagnosis of Van der Knaap disease, a known radiological mimic of demyelinating disorders.

Central nervous system vasculitis may also present with multifocal white matter lesions on MRI. These lesions may show vascular territory distribution and can be associated with cortical infarcts or hemorrhagic changes. MRI may demonstrate multifocal hyperintense lesions with diffusion restriction reflecting ischemic changes (Figure 5A–C) **[19].**

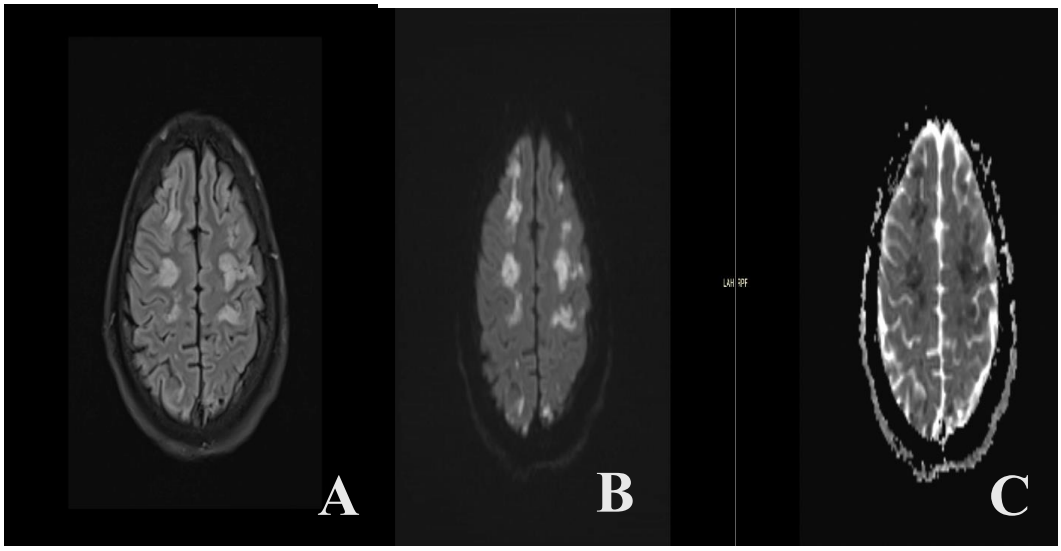

Figure 5:
A. Axial FLAIR MRI demonstrating multiple patchy hyperintense lesions within the bilateral cerebral hemispheres.
B. Diffusion-weighted imaging (DWI) showing areas of diffusion restriction corresponding to the lesions, suggesting acute ischemic changes.
C. Apparent diffusion coefficient (ADC) map demonstrating corresponding low signal intensity confirming restricted diffusion, consistent with central nervous system vasculitis, a known radiological mimic of demyelinating disorders.

Similarly, small vessel ischemic changes may produce periventricular and deep white matter hyperintensities on T2-weighted and FLAIR imaging without diffusion restriction (Figure 6 A-C). These lesions are more commonly observed in older individuals with vascular risk factors and lack the typical morphology and orientation of demyelinating plaques seen in multiple sclerosis **[17,19]**

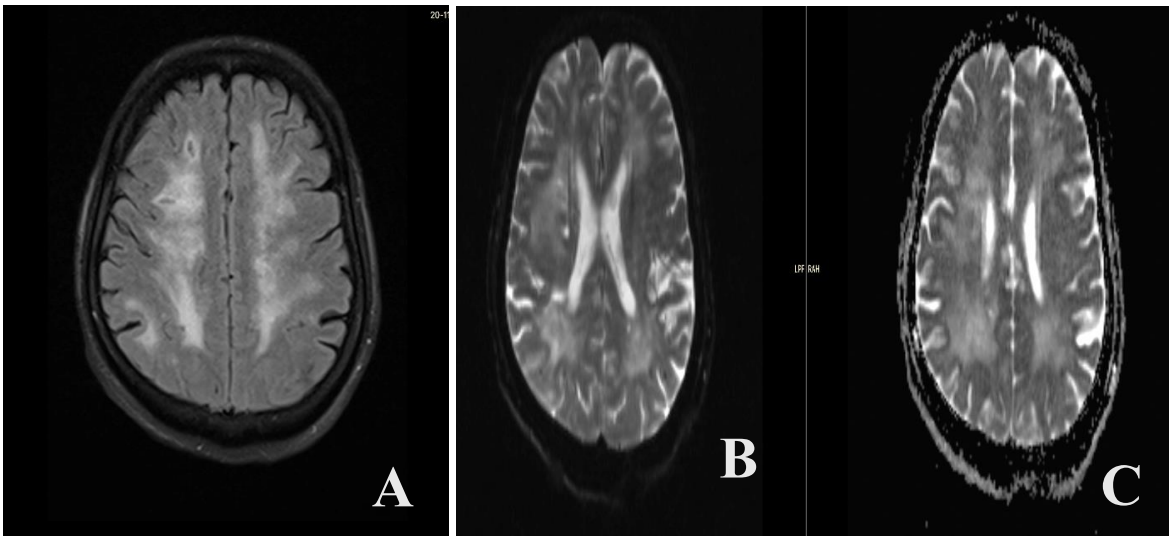

Figure 6:
A. Axial FLAIR MRI sequence demonstrating confluent hyperintensities in bilateral centrum semiovale, corona radiata, periventricular and fronto-parietal deep white matter consistent with severe small vessel ischemic changes (Fazekas grade III).
B. Diffusion-weighted imaging (DWI) showing no significant diffusion restriction within the white matter lesions.
C. Apparent diffusion coefficient (ADC) map demonstrating corresponding increased signal intensity without restricted diffusion, supporting chronic ischemic white matter changes, a known radiological mimic of demyelinating disorders.

Recognition of these imaging patterns together with clinical correlation is essential for accurate differentiation between inflammatory demyelinating disorders and their radiological mimics.

Overall, the findings of the present study emphasize the important role of magnetic resonance imaging in the evaluation of central nervous system demyelinating disorders. MRI enables early detection of demyelinating lesions, characterization of lesion morphology and distribution, and differentiation among various demyelinating conditions. Integration of MRI findings with clinical and laboratory data significantly improves diagnostic accuracy and facilitates early initiation of appropriate treatment strategies, ultimately contributing to improved patient outcomes **[7,10]**.

Limitations of the Study

The present study has certain limitations. First, the study included a relatively small sample size of 30 patients, which may limit the generalizability of the findings. Second, the retrospective nature of the study may introduce selection bias because only patients who underwent MRI examination were included. Additionally, advanced immunological investigations such as antibody markers associated with neuromyelitis optica spectrum disorder were not available for all patients. Histopathological confirmation was also not available in all cases, and diagnosis was primarily based on clinical and radiological correlation. Despite these limitations, the study provides valuable insights into the MRI characteristics and lesion distribution of central nervous system demyelinating disorders and highlights important radiological mimics encountered in clinical practice.

CONCLUSION

Magnetic resonance imaging plays a crucial role in the evaluation of central nervous system demyelinating disorders. MRI enables accurate assessment of lesion morphology, anatomical distribution, and disease extent within the brain, optic nerves, and spinal cord. Characteristic imaging patterns such as periventricular plaques, optic nerve involvement, and longitudinal spinal cord lesions provide important diagnostic clues for differentiating various demyelinating conditions including multiple sclerosis, transverse myelitis, optic neuritis, acute disseminated encephalomyelitis, and neuromyelitis optica spectrum disorder. Awareness of radiological mimics such as leukodystrophies, vasculitis, and small vessel ischemic changes is also essential for accurate interpretation of MRI findings. Early recognition of these imaging features facilitates timely diagnosis, appropriate clinical management, and improved patient outcomes. Therefore, MRI remains an indispensable imaging modality in the diagnosis and evaluation of demyelinating diseases of the central nervous system

Declaration by Authors

Ethical Approval: Approved
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Sayali Kothawade, Seetha Pramila V.V, Parthasarathi. Role of magnetic resonance imaging in the evaluation of central nervous system demyelinating disorders and their mimics: a retrospective observational study at a tertiary care centre in South India. *Int J Health Sci Res.* 2026; 16(3):233-245. DOI: *https://doi.org/10.52403/ijhsr.20260329*

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