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Role of Magnetic Resonance Imaging in Evaluating Ring Enhancing Lesions in Brain

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ABSTRACT

In neuroimaging, Magnetic Resonance Imaging (MRI) is an elementary technique that facilitates clinicians to acumen brain architecture and pathology with unequalled precision. Among intracranial abnormalities, ring-enhancing lesions (RELs) pose a weighty diagnostic perspicacity due to their heterogeneous etiologies and overlapping imaging features. MRI brain with contrast can aid in the diagnostic dilemma of ring enhancing lesions.

Objective: To evaluate the characteristic imaging features of various ring-enhancing lesions on MRI brain study.

Methods: A descriptive cross-sectional study was conducted over a twelve-month period from August 2024 to August 2025 in the Department of Radiodiagnosis, GCS Medical College and Hospital, Ahmedabad. A total of 50 patients with clinical suspicion of some intracranial lesion were included in the study and MRI examinations were performed using a 1.5-Tesla scanner using the standard MRI brain with contrast protocol sequences. Imaging findings were analysed to determine the characteristics of the ring enhancing lesions.

Results: The mean age of patients was 40.8 years ± 16.05 years. Of the 50 patients, 26 (52%) were males and 24 (48%) were females, showing near equal gender distribution. Etiological Distribution showed that most prevalent etiology was Tuberculoma (48%), followed by Metastases (20%), Neurocysticercosis (14%), and GBM/Glioma (12%). Rare etiologies, including Abscesses (4%) and Tumefactive Demyelination (2%), were also identified

Conclusion: MRI is a non-invasive and radiation-free imaging modality that plays a critical role in the accurate diagnosis of ring enhancing lesions in brain, particularly in differentiating them. MRI can significantly enhance diagnostic accuracy and guide the clinician towards accurate diagnosis and treatment of the patient.

Keywords*: Ring-enhancing lesions (RELs), Magnetic Resonance Imaging (MRI) Neuroimaging Tuberculoma Neurocysticercosis.*

INTRODUCTION

In the realm of neuroimaging, Magnetic Resonance Imaging (MRI) stands as a cornerstone technology in order to visualize intricate details of brain with unprecedented clarity and precision. Ring enhancing lesions (RELs) in the brain present a particularly challenging diagnostic scenario.(1)

The ring enhancing lesions in the brain are the lesions that show ring like peripheral enhancement on post contrast study. The differential diagnosis of ring enhancing lesions in brain include (2) –

(1) Infective causes -

- Tuberculoma
- Neurocysticercosis
- Cerebral abscess
- Toxoplasmosis

(2) Malignancy -

- Metastasis
- Glioblastoma multiforme
- Lymphoma/Leukaemia

(3) Inflammatory etiologies -

- Tumefactive demyelination
- Balo' concentric sclerosis

(4) Vascular causes -

Subacute infarct/haemorrhage/contusion

(5) Other -

- Radiation necrosis
- Post operative change

The size, shape, wall thickness of ring-enhancing lesions, the extent of surrounding edema, and the clinical history of the patient ,CSF analysis should be taken into consideration to help distinguish the ring enhancing lesions (3).

Tuberculoma:-

CNS tuberculosis is an AIDS defining illness.

CNS TB manifestations include Tuberculomas, tuberculous abscess. It can occur with or without tuberculous meningitis. When there is tuberculous meningitis along with tuberculomas it can predominantly affects the basal cisterns, the patient may present with cranial nerve palsies because of nerve encasement.(4)

- Tuberculomas are supratentorial in majority, but can be located in infratentorial location and in brain stem. They can be solitary or multiple.
- Surrounding perilesional edema can be seen in the form of T2 ,FLAIR hyperintensity.
- Tuberculomas can be caseating with central necrosis or non-caseating.
- In Caseating granulomas: core is T1 and T2 iso- to hypointense. The rim is T2 iso- to hyperintense with enhancing rim.
- In non-caseating granulomas - The entire lesion is T1 and T2 hypointense with homogenous rim enhancement.(5)
- Tuberculous abscesses in contrast to tuberculomas are large with presence of diffusion restriction.
- Tuberculomas are the commonest ring enhancing lesion encountered in MRI brain with contrast specially in developing countries, due to prevalence of TB.

(2) Neurocysticercosis :-

Neurocysticercosis (NCC) is the most common parasitic disease of the central nervous system, and also one of the most common causes of seizures in endemic areas (Latin America, parts of Oceania, Asia, Eastern Europe, and Africa). 6)

Ingestion of larvae from the adult tapeworm Taenia solium results in by eating raw or poorly cooked pork.

Neurocysticercosis most commonly manifests in the parenchyma of the brain and typically involves the cerebral hemispheres but can involve the basal ganglia, cerebellum and brainstem. The lesions are commonly found at the Gray–white matter junction, presumably resulting from deposition of the larvae in terminal small vessels of these regions, they can also be located in deep sulci or in perforating branches of perivascular spaces.

There are four main stages (also known as Escobar's pathological stages)(7):

(a) vesicular: viable parasite with intact membrane and therefore no host reaction , MRI features of this stage - Cyst with a dot sign fluid is CSF intensity (MRI) eccentric scolex can sometimes be seen - high signal compared to fluid on T1, DWI, FLAIR and low signal compared to fluid on T2, ADC no enhancement is typical, although very faint enhancement of the wall and enhancement of the scolex may be seen with no surrounding vasogenic edema.

(b)colloidal vesicular: parasite dies within 4-5 years untreated, or earlier with treatment and the cyst fluid becomes turbid; as the membrane becomes leaky edema surrounds the cyst; this is the most symptomatic stage.

MRI features of this stage - cyst fluid is T1, FLAIR hyperintense to CSF. DWI/ADC is variable, ranging from similar to CSF to frank diffusion restriction (high DWI signal, low ADC values. Surrounding edema is noted and the cyst and the wall become thickened and brightly enhances. scolex is seen early in the colloidal phase, similar to vesicular stage, but gradually shrinks down and becomes harder to identify.

(c) granular nodular: edema decreases as the cyst retracts further while the enhancement persists but is less marked. MRI features of this stage - cyst fluid may demonstrate diffusion restriction in early granular nodular stage, disappearing during late phase as calcification occurs.

(d) nodular calcified: end-stage quiescent calcified cyst remnant; no edema.
(3) Cerebral toxoplasmosis :- is a potentially fatal parasitic opportunistic infection caused by the parasite Toxoplasma gondii and is the most common opportunistic infection of the CNS in immunocompromised individuals, such as patients with HIV/AIDS.

Typically cerebral toxoplasmosis manifests as multiple lesions, with a predilection for the basal ganglia, thalami, and Gray-white junction. On contrast enhanced T1 sequences - The eccentric target sign is considered pathognomonic for cerebral toxoplasmosis. The concentric target sign is seen on T2-weighted imaging with alternating layers of hyper and hypointensity.(8)

(4) Abscess :- Abscesses are common in patients with immunodeficiencies - can be tubercular, pyogenic or fungal.
Abscesses can show varied appearance depending upon the stage like early cerebritis, late cerebritis, early or late encapsulating stage.

They typically show diffusion restriction with T1 hypointensity and T2/FLAIR hyperintensity. It has progressive central necrosis, cavity shrinks, decreasing surrounding edema.

(5) Glioblastoma (GBM) and metastases :-
Both GBMs and metastases have thick, irregular wall structures. While GBMs are mostly observed as heterogeneous due to bleeding and necrosis, metastases can be both solid and ring-enhanced.

Diffusion restriction can be observed in the central part of GBMs, it is not as homogeneous as in pyogenic abscesses. Diffusion restriction is not expected in the central part of metastases .However, diffusion restriction may be detected in lung, breast, colon and testicular tumour metastases. While the hyperintensity observed around metastases is entirely due to vasogenic oedema, in GBM, tumour foci spreading throughout the white matter are seen in peritumoral oedemic areas

(6) Tumefactive demyelination: -
They are large demyelinating lesions that present with significant mass effect and surrounding edema. They are most commonly associated with multiple sclerosis (MS).

The characteristic MRI features of tumefactive demyelination include an open ring or incomplete rim of enhancement, a T2-hypointense rim, absent or mild mass effect, and absent or mild perilesional edema.(9)

METHODS

Materials and Methodology

- Study Design: Observational cross-sectional study
- Location: Department of Radiology, GCS Medical College, Hospital & Research Centre
- Duration: August 2024–August 2025(12months)
- Inclusion Criteria: Patients of all ages and genders with suspected ACL injury referred for MRI evaluation
- Exclusion Criteria: Patients with contraindications to MRI scan such as heart pacemakers, Implantable hearing aids, neurostimulators, intracranial metal clips, metallic hip implants

A total of 50 patients were included in the study.
MRI Brain scans were performed using a 1.5 Tesla MRI scanner, equipped with Standard MRI brain with contrast sequences were obtained, including Axial T1,T2,FLAIR

Sagittal T1,DWI,SWI and contrast sequences.
The imaging findings were systematically assessed to determine the ring enhancing lesions in brain and characterise them. All data were documented in a structured format, and imaging findings were correlated with clinical presentation. Data analysis was carried out - Categorical variables were expressed as frequencies and percentages. Continuous variables were summarized using mean and standard deviation.

RESULTS & DISCUSSION

A total of 50 patients were included in the study over a 12-month period, presenting with clinical signs and symptoms suspicious of ring enhancing lesions like headache, seizures, fever, focal neurological deficits like weakness, altered mental status, vomiting, nausea, papilledema, diplopia, etc.

Age wise distribution of the patients -

- Mean Age: 40.8 years
- Standard Deviation (SD): ± 16.05 years

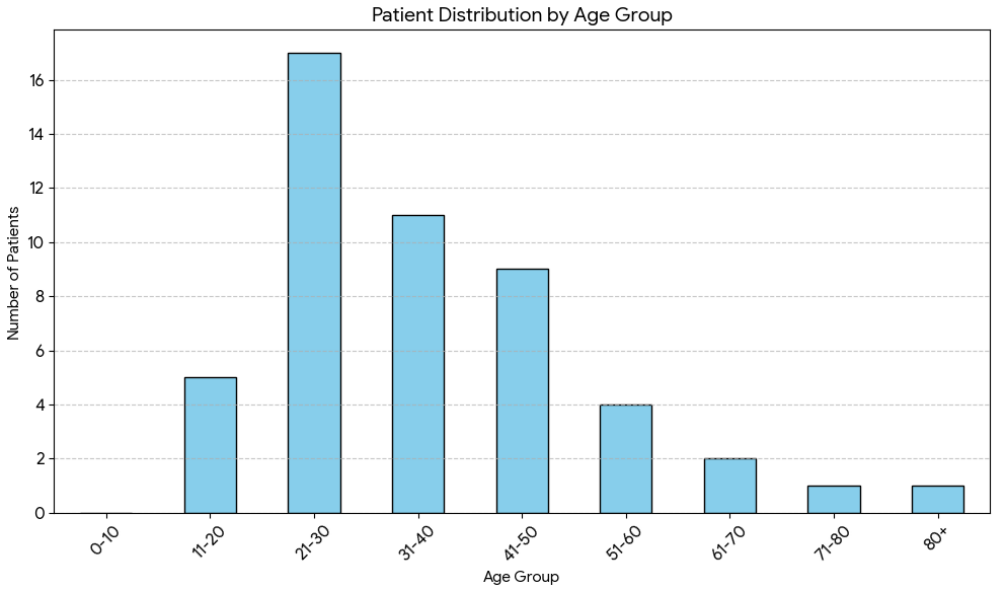

Figure 1 - showing Age group wise distribution of patients with ring enhancing lesions

Gender Distribution

Table1: Gender distribution of patients

Diagnosis	Male	Female
Tuberculoma	13	11
NCC	4	3
GBM / Glioma	4	2
Metastases	4	6
Abscess	1	1
Tumefactive demyelination	0	1
Total	26	24

Distribution of the patients according to the MRI diagnosis -

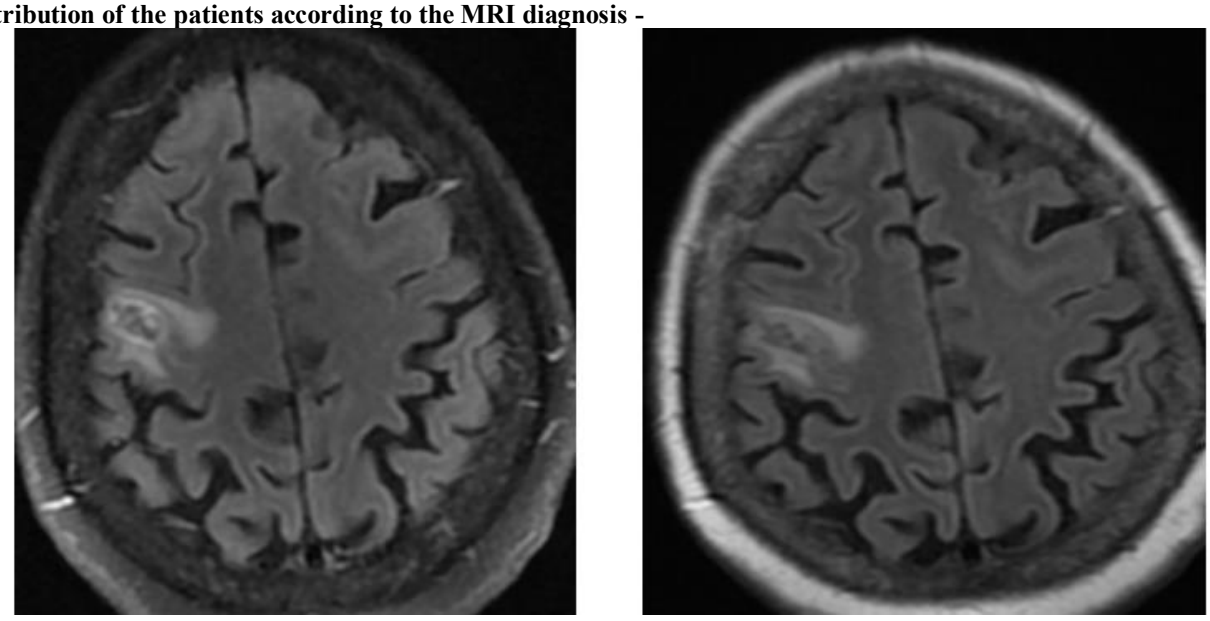

Figure2 - showing Right frontal sulcal space tuberculoma

Etiological Distribution: The most prevalent etiology was Tuberculoma (48%), followed by Metastases (20%), Neurocysticercosis (14%), and GBM/Glioma (12%). Rare etiologies, including Abscesses (4%) and Tumefactive Demyelination (2%), were also identified.

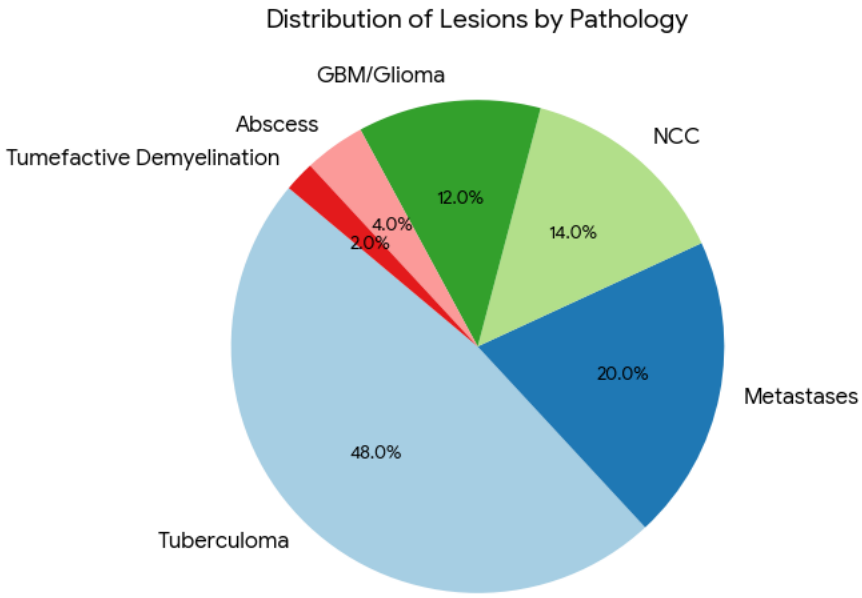

Figure3 - showing Distribution of patients with ring enhancing leisons by pathology

Table2: Distribution of patients according to the etiology and no of lesions

Pathology	Most Common Location
GBM/Glioma	Temporal / Parietal region
Metastases	Cerebellum / Parietal region
Demyelination	Frontal region
Abscess	Temporal / Gangliocapsular region
Tuberculoma	Generalized
NCC	Frontal / Temporal region

Table3 : showing lesion distribution with most common location

Pathology	Most Common Location
GBM/Glioma	Temporal / Parietal region
Metastases	Cerebellum / Parietal region
Demyelination	Frontal region
Abscess	Temporal / Gangliocapsular region
Tuberculoma	Generalized
NCC	Frontal / Temporal region

Table4 : showing lesion distribution in terms of diffusion restriction

Diffusion Pattern	Number of Cases (n)	Percentage (%)
Showing Restriction (Complete/Partial)	27	54%
Showing No Restriction (Facilitated)	23	46%

TOTAL	50	100%

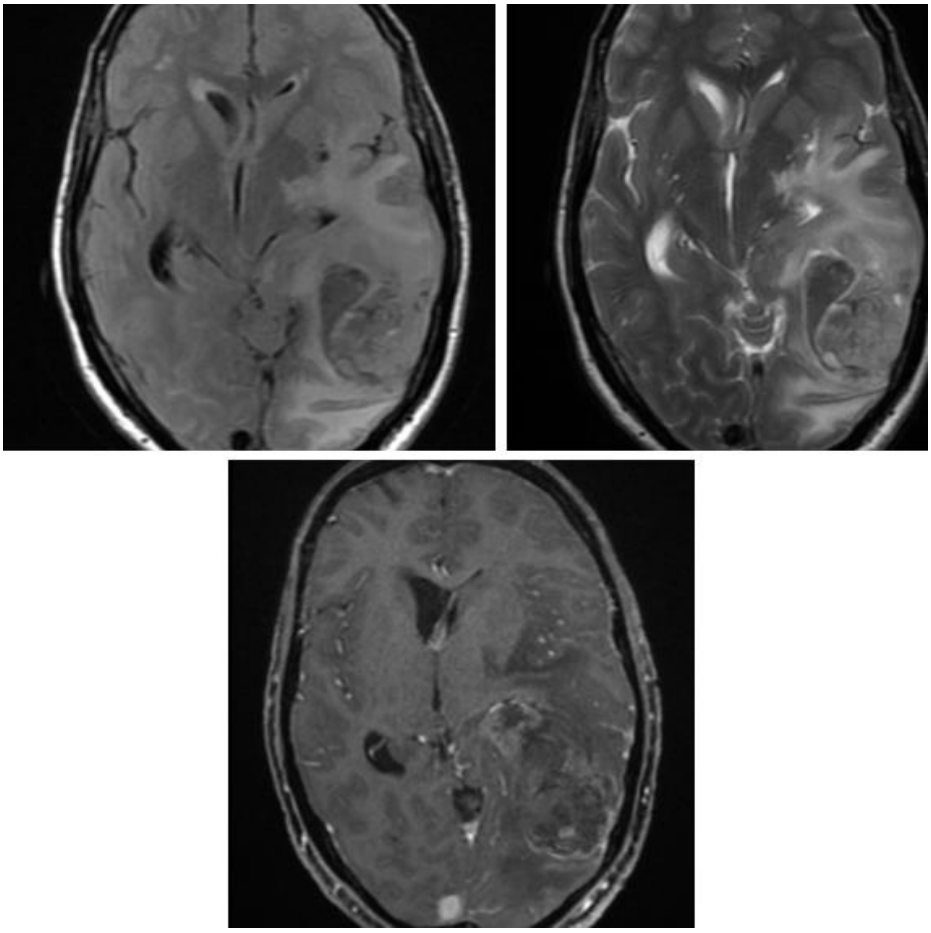

Figure 4 - Glioblastoma in left parieto - occipital lobe with compression on left lateral ventricle and surrounding edema

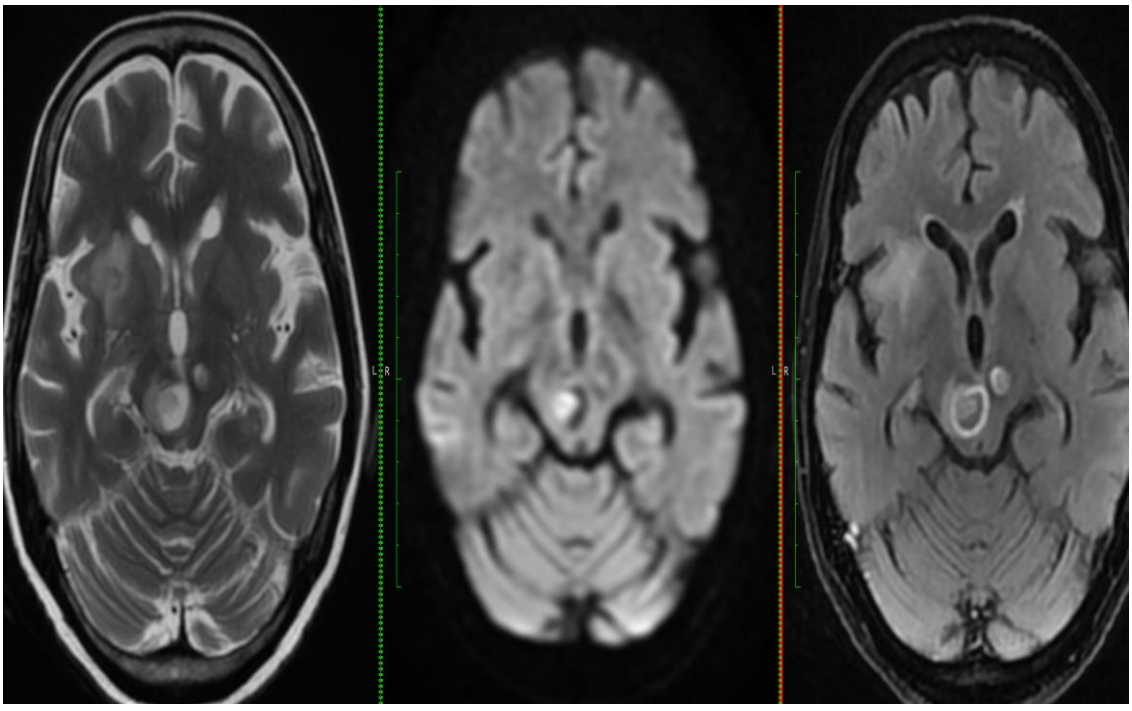

Figure 5 - Neurocysticercosis - vesicular stage

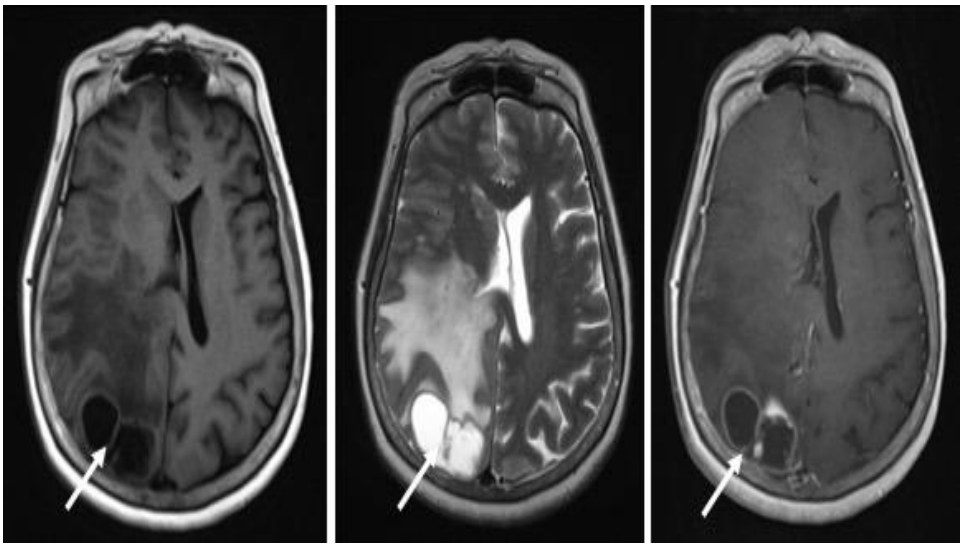

Figure 6 - Cerebellar metastases

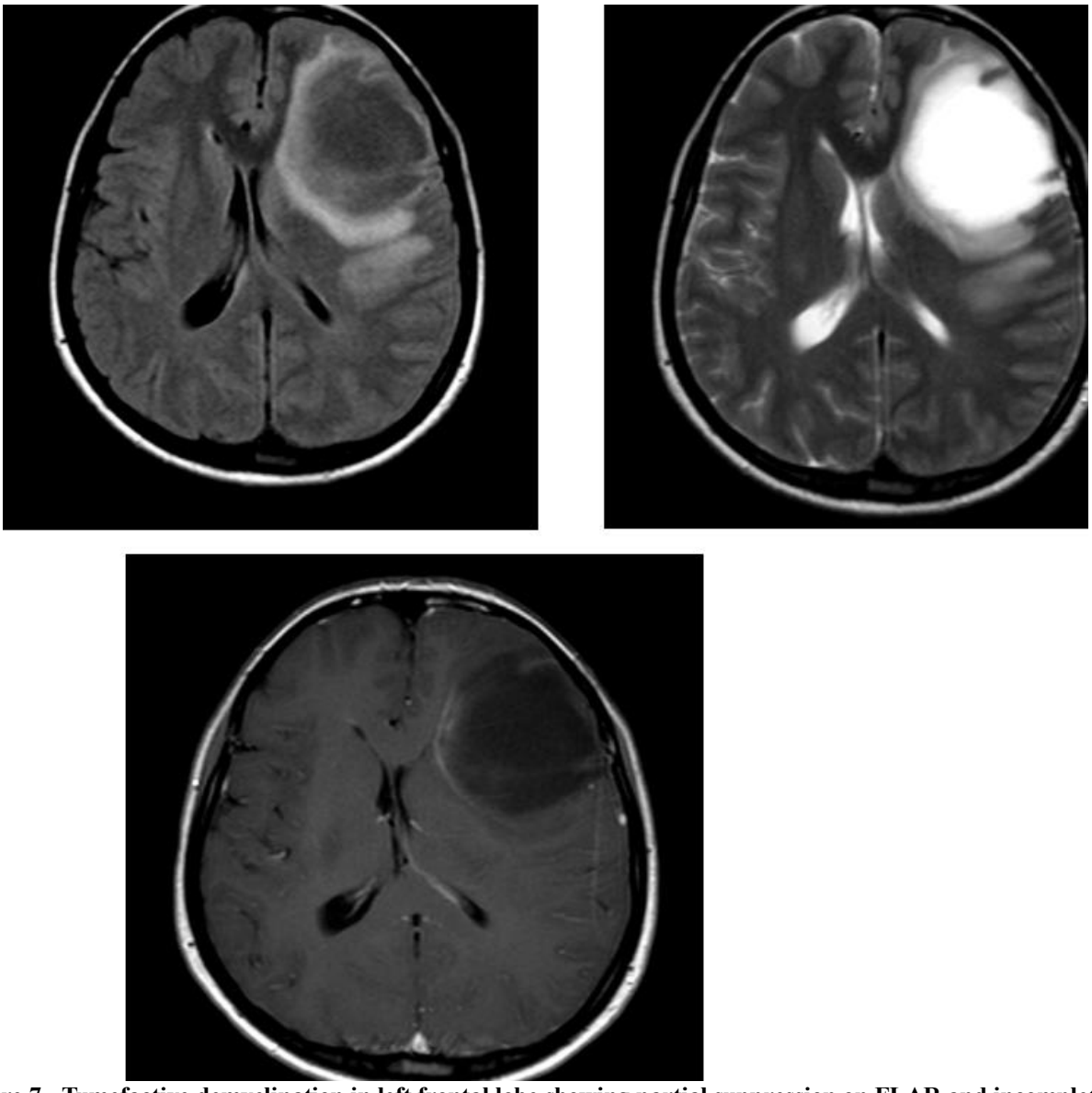

Figure 7 - Tumefactive demyelination in left frontal lobe showing partial suppression on FLAR and incomplete or ring enhancement

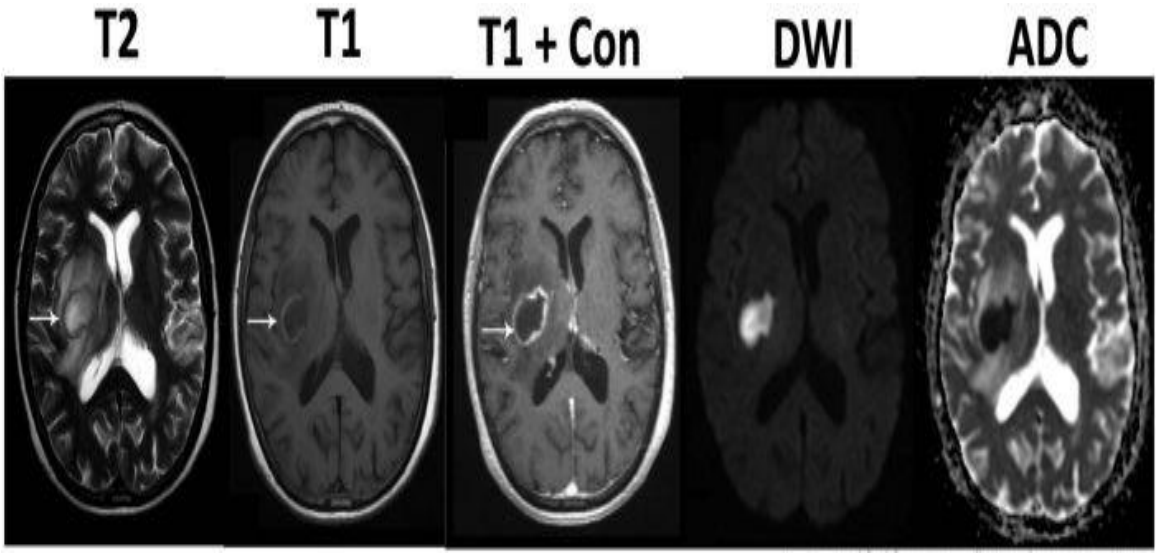

Figure 8 - Cerebral abscess with diffusion restriction

DISCUSSION

Age distribution of the patients -

- The Young Cohort (10 – 40 years)
- This group represents the majority of the dataset (52%).
- Almost exclusively infectious. Tuberculoma is the leading diagnosis, followed by Neurocysticercosis (NCC).In this age range, a ring-enhancing lesion is statistically much more likely to be an infection than a malignancy.
- The Middle-Age Transition (40 – 50 years)
- This is the most "diagnostic-heavy" decade. While Tuberculomas are still present, we see the first significant appearance of Glioblastoma Multiforme (GBM) and Metastases.
- The Senior Cohort (50 – 80 years)
- The trend flips toward malignancy. Metastases (primarily from breast and lung primaries) and GBM account for the vast majority of new cases in this age group.

This age wise distribution of the lesions is consistent with Patil, Y. P., Patel, C. R., Kuber, R. S., & Sekhon, R. K. (2021) : "Characteristics of Ring Enhancing Lesions in Brain in Correlation with MRI and MR Spectroscopy. which studied 50 patients and found NCC (38%) and Tuberculomas (32%) as the top causes, with seizures as the primary symptom. It mirrors the finding that the 20-30 age group is the most affected.(10)

Gender Distribution

Diagnosis	Key Insights
Tuberculoma	Roughly equal, with a very slight male lean.
NCC	Predominantly affects young adults of both genders.
GBM / Glioma	Higher incidence in males (2:1 ratio)
Metastases	Slightly higher in females, primarily due to Breast Cancer
Abscess	No significant gender bias in this small sample.
Tumefactive demyelination	No significant gender bias in this small sample.

Tumefactive demyelination **No significant gender bias in this small sample.**

Distribution of the patients according to the MRI diagnosis -

Etiological Distribution: The most prevalent etiology was Tuberculoma (48%), followed by Metastases (20%), Neurocysticercosis (14%), and GBM/Glioma (12%). Rare etiologies, including Abscesses (4%) and Tumefactive Demyelination (2%), were also identified.

The findings are consistent with Chatterjee, R., et al. (2025): "Clinic etiological Profile of Ring Enhancing Lesion of Brain: A Record-based Observational Study from Eastern India in the Journal: Bengal Physician Journal, 12(3), 112–118 stating

that - Tuberculoma (43.3%) was the most common etiology in their 60-patient cohort, reinforcing our finding that infection remains the top cause of ring enhancing lesions in India.(11)

- Small Lesions (<15 mm)
- NCC: Consistently small, typically 5 mm to 10 mm.
- Tuberculoma: Frequently tiny, ranging from 4 mm to 12 mm, especially when appearing in clusters.
- This is in congruence with the article Patwari, S. (2017). Diagnostic dilemma in differentiating Neurocysticercosis (NCC) and Tuberculomas (TB) on Imaging.(12)
- Medium Lesions (15 - 30 mm)
- Tuberculoma: Larger solitary versions reach 15 mm to 17 mm.
- Abscess: Measured between 18 mm and 20 mm.
- Tumefactive Demyelination: This specific case measured 35 mm in frontal region which is the common age group and location found in this pathology.
- Metastases: Smaller metastatic deposits fall in this range.
- Large Lesions (>30 mm)
- Metastases: Larger cystic variants reach up to 42 mm.
- GBM / Glioma: These are the largest masses in the dataset, often exceeding 50 mm

CONCLUSION

In our cohort of 50 patients, we observed a distinct bimodal distribution: infectious etiologies, primarily Tuberculoma and Neurocysticercosis, dominated the younger age groups (20–40 years), while neoplastic processes, including Glioblastoma and Metastases, were the predominant findings in patients over 50. Furthermore, rare but critical mimics like Tumefactive Demyelination were correctly identified by correlating "mass-like" frontal lobe involvement with the patient's fourth-decade age profile.

Clinical diagnosis of ring enhancing lesions in the brain relies on focused clinical examination of the signs and symptoms of the patient which often raises strong suspicion of these pathologies alongside the CSF examination.

Magnetic resonance imaging remains the gold standard diagnostic modality due to its high sensitivity and accuracy in detecting ring enhancing lesions in the brain to characterize and differentiate these lesions for appropriate management.

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