Section: Radiodiagnosis and Imaging Sciences

Original Research Article

EVALUATING THE ETIOLOGICAL SPECTRUM OF INTRACRANIAL RING ENHANCING LESIONS WITH 1.5 TESLA MRI: OBSERVATIONS FROM A SINGLE TERTIARY CARE CENTER IN NORTH EASTERN INDIA

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Received : 03/05/2025
Received in revised form : 22/06/2025
Accepted : 11/07/2025

Keywords:
Ring-enhancing lesions, MRI, neurocysticercosis, tuberculoma, cerebral abscess, glioma, toxoplasmosis, Northeast India.

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DOI: 10.47009/jamp.2025.7.4.63

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (4); 334-343

ABSTRACT

Background: Cerebral ring-enhancing lesions observed on MRI pose significant diagnostic challenges due to their diverse etiologies, ranging from infectious to neoplastic and vascular causes. In developing countries like India, infectious causes such as neurocysticercosis and tuberculomas predominate, contrasting with patterns in Western nations. This study aims to evaluate the imaging characteristics and etiological distribution of ring-enhancing brain lesions in a tertiary care setting in Northeast India, highlighting regional epidemiological trends and diagnostic approaches. **Materials and Methods:** A retrospective observational study was conducted at Jorhat Medical College and Hospital, Assam, from July to December 2024. Twenty-three patients with ring-enhancing lesions on contrast-enhanced MRI (CEMRI) of the brain were included. Imaging was performed using a 1.5 Tesla GE MRI scanner, with protocols including T1, T2, FLAIR, diffusion-weighted imaging, and post-contrast sequences. A senior radiologist with 18 years of experience analyzed lesion characteristics, including location, size, signal intensity, enhancement pattern, and surrounding edema. Clinical data were retrieved from electronic medical records, and diagnoses were based on radiological features, serology, CSF analysis, and clinical correlation. **Result:** The cohort comprised 14 males and 9 females, aged 14–71 years (mean age 41 years). Infectious etiologies dominated (69.5%, n=16), with neurocysticercosis (30.4%, n=7) being the most common, followed by tuberculomas (n=6), pyogenic abscesses (n=2), and toxoplasmosis (n=1). Neoplastic lesions accounted for 21.7% (n=5), including gliomas (n=2), metastases (n=2), and primary CNS lymphoma (n=1). Subacute infarcts were identified in two cases. Imaging features, such as diffusion restriction in abscesses, eccentric target signs in toxoplasmosis, and specific MRS patterns (e.g., lipid peaks in tuberculomas, elevated choline in neoplasms), aided differentiation. **Conclusion:** This study underscores the predominance of infectious causes, particularly neurocysticercosis, in ring-enhancing brain lesions in Northeast India, reflecting regional epidemiological differences. Advanced MRI techniques, including MRS, play a critical role in non-invasive diagnosis, especially in resource-limited settings where biopsy is often unavailable. These findings enhance understanding of diagnostic patterns and support tailored therapeutic strategies.

INTRODUCTION

Magnetic Resonance imaging (MRI) offers comprehensive anatomical and physiological insights with three -dimensional orientation, superior soft tissue contrast and high spatial resolution.[1] Over the past few decades, MRI has become the investigation of choice for the evaluation of soft tissue pathologies including brain pathologies.[2] Technological advancements in MRI have significantly enhanced its diagnostic precision, contributing to improved tumor characterization, pre-surgical planning and treatment monitoring.

Cerebral ring -enhancing lesions are radiological findings characterized by a central area of hypo intensity on MRI (or hypodensity on CT), surrounded by well-defined rim of contrast enhancement, typically reflecting a necrotic or cystic core with an

ISSN (O): 2687-5365; ISSN (P): 2753-6556

active peripheral inflammatory or neoplastic process.[3] They are common in both sexes and in all age groups.[4]

Magnetic resonance Imaging (MRI) often reveals ring -enhancing lesions in the brain, which present a diagnostic challenge, particularly in the absence of comprehensive clinical history.[5] Differentiating between neoplastic and non-neoplastic causes relies on evaluating imaging characteristics—such as lesion morphology, dimensions, border definition and surrounding edema – alongside clinical context, including patient age, symptomatology and physical findings.[6]

The clinical presentation of ring enhancing brain pathologies varies significantly depending on the location, extent of involvement and underlying etiology. Correlation with the patient's clinical history and any prior investigation is important, as similar radiological appearances can suggest a wide array of various pathologies. Ring enhancing lesions in the brain encompass a broad differential diagnosis, with major etiological categories including infectious, neoplastic, post -treatment related, demyelinating and vascular causes.[7]

In a developing country, like India the spectrum of etiologies associated with cerebral ring enhancing lesions differs significantly from that observed in western nations. Infectious causes remain predominant with tuberculomas and neurocysticercosis being the most common contributors.[8] In the context of HIV/AIDS opportunistic infections such as toxoplasmosis, cryptococcosis and histoplasmosis are increasingly implicated. Beyond infectious origins, ring enhancement on MRI can be seen in a variety of conditions, including primary brain tumors, cerebral abscesses, metastatic lesions, granulomas, subacute infarcts and resolving hematomas. Less frequently ring-enhancing patterns may also occur in demyelinating diseases such multiple sclerosis and in vascular abnormalities like thrombosed aneurysms.

Despite advances in imaging, ring enhancing lesions remain a diagnostic challenge due to their overlapping features. This retrospective evaluation of MRI features in ring enhancing lesions of brain can yield valuable insights into diagnostic pitfalls, patterns of tumors presentation and regional epidemiological trends. In our study we evaluated the imaging features and etiological factors in the pretext of radiological and clinical presentations of patients with ring enhancing lesions on brain MRI in a single tertiary care center in north east India.

MATERIALS AND METHODS

The Retrospective observational study was conducted in the 'Department of Radiodiagnosis and Imaging Sciences, Jorhat Medical College and Hospital, Jorhat Assam' for a period of 6 months from July 2024 to December 2024. Patients diagnosed with ring enhancing lesions based on MRI brain were identified from the hospital information system. A total of 23 cases of either gender were included in the study who underwent CEMRI Brain in 1.5 Tesla General Electric (GE) MRI scanner in supine position.

Imaging protocol

- Brain localizer
- Axial T2 weighted
- Axial T1 weighted
- Axial T2 FLAIR weighted
- Diffusion weighted Imaging with ADC sequence
- Coronal T1 weighted Fast Spin Echo (FSE)
- Sagittal T2 weighted FSE
- Axial Gradient Echo Sequence (GRE)
- Pre contrast T1 weighted with fat suppression and contrast enhanced images were obtained after intravenous administration of gadolinium-based contrast agent (0.1 mmol/kg body weight)

Image analysis

The scans were reviewed by a senior radiologist with 18 years of experience. The scans were assessed from following imaging features:

- Lesion location
- Lesion size and extent
- Signal characteristics on T1, T2, FLAIR and T1 FS sequences
- Enhancement pattern-complete/partial ring
- Surrounding edema.
- Calcification foci.
- Diffusion Restriction

Relevant clinical information, including patient name, age, gender, symptoms, treatment approach and follow-up data when available was collected from electronic medical records and requisition.

Diagnosis was made based on radiological features, serology, CSF analysis and clinical context.

No histopathological confirmation was available due to conservative management or loss to follow-up.

Inclusive Criteria

1. Patients of any age and gender.
2. Patients with ring enhancing lesions on CEMRI Brain.

Exclusion Criteria

1. Patients with homogenous nodular enhancements, streaky /patchy enhancements without definite rim pattern.
2. Patients who are non-cooperative subjects / attendants were not interested to participate in the study or did not give consent.

RESULTS

Out of the 23 patients included in the final analysis of the study. The cohort consisted of 14 males and 9 females, with an age range of 14 to 71 years (mean age 41 years) with most cases between the ages of 31-50 years. The clinical presentation varied, with the most common symptoms being Seizures, fever, focal neurological signs and deficit, headache, weight loss and vomiting.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

The study encompassed a wide spectrum of spinal tumors, both primary and secondary, with a significant representation of metastatic lesions. The distribution of tumor types is as follows:

Table 1: Table showing the distribution of aetiologies in the study

Aetiology	Specific Diagnoses	Number of Patients
Infective	Neurocysticercosis	7
	Tubercular	6
	Toxoplasmosis	1
	Pyogenic	2
Neoplastic	Glioma	2
	Lymphoma	1
	Metastasis	2
Other	Subacute Infarct	2

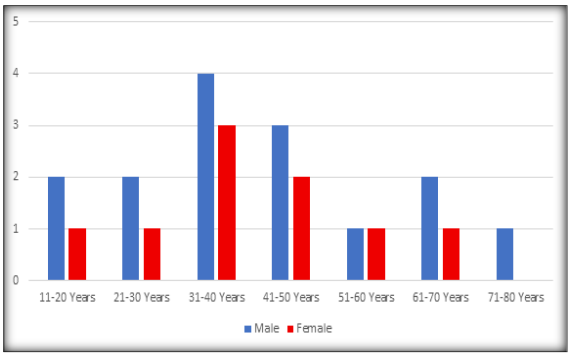

Diagram 1: Bar diagram illustrating the age and sex distribution among the patients

Etiological Distribution

The commonest pathology seen was infective in 16 patients out of which Neurocysticercosis was the most common diagnosis. This was followed by neoplastic causes; 2 cases of glioma, 2 cases of metastasis, 1 case of primary CNS lymphoma and 2 cases of tuberculoma with meningitis. Neoplastic aetiologies were seen in 5 cases; 2 cases of meningioma, 2 cases of glioblastoma multiforme and 1 case of lymphoma. Subacute infarcts showing ring enhancement were seen in 2 patients; as shown in Table 1 and Diagram 2.

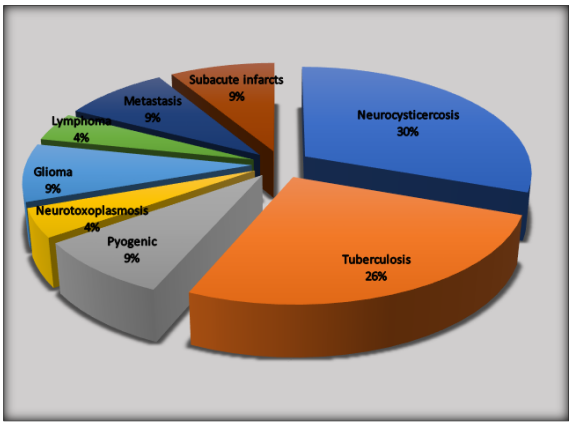

Diagram 2: Pie Chart illustrating the age and sex distribution among the patients

Representative Cases

Case 1: A 29-year-old gentleman presenting with multiple episodes of seizures for 10 days.

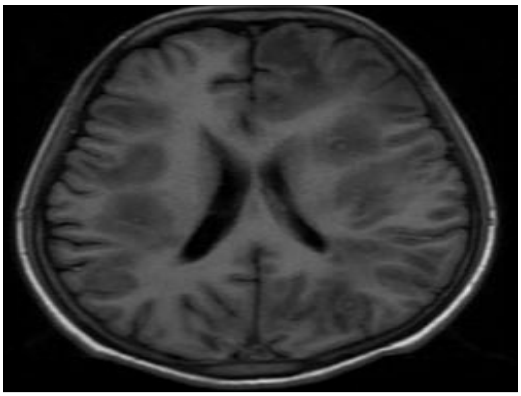

Figure 1 (a): Axial T1

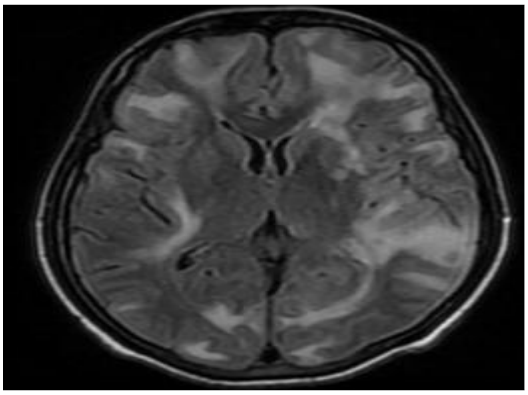

Figure 1 (b): Axial T2 FLAIR

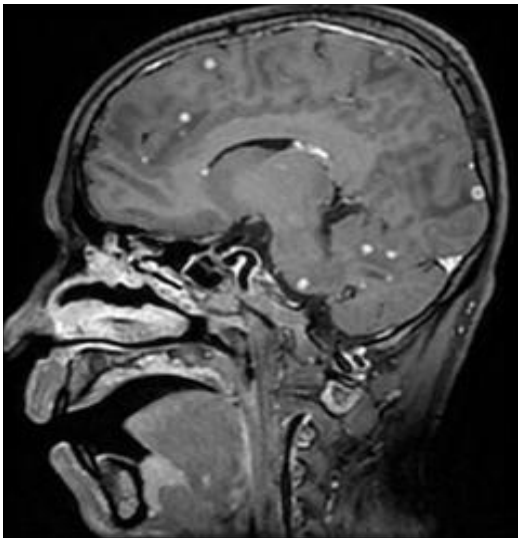

Figure 1 (c): Sagittal T1 FS+C

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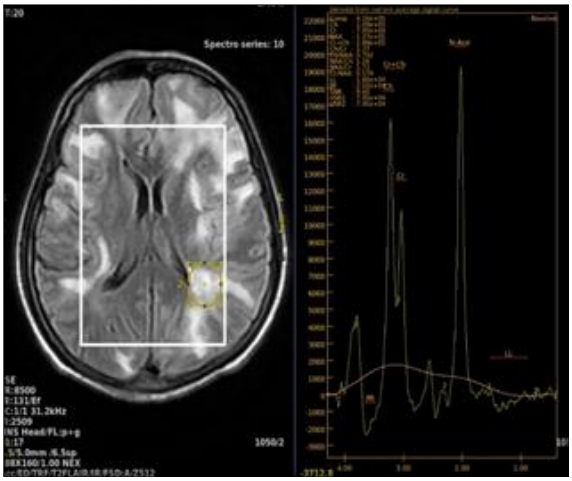

Figure 1 (d): MRS

The images of the patient (Figure 1 a-d: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveals multiple small well defined T1 and T2 hypointense nodular lesions, few showing presence of eccentric T1 iso to hyper intense component within representing scolex in cortical and subcortical regions of bilateral fronto-temporo-parieto-occipital lobes, most of which show peripheral ring enhancement with perilesional edema. On MRS, multiple amino acid peaks are noted. These features are suggestive of varying stages neurocysticercosis.

Case 2: A 20-year-old gentleman presenting with seizures for 10 days and has history incomplete anti tubercular treatment 7 months back for pulmonary TB.

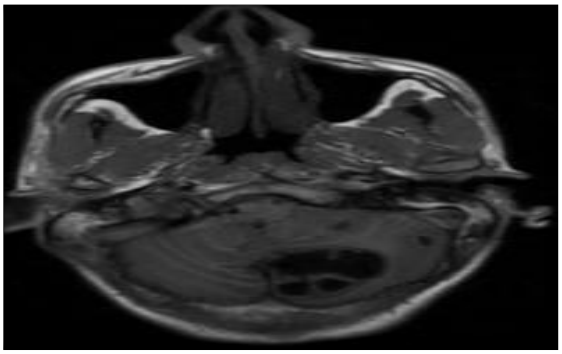

Figure 2 (a): Axial T1

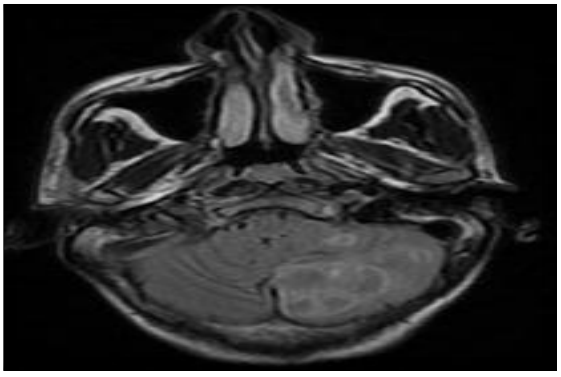

Figure 2 (b): Axial T2FLAIR

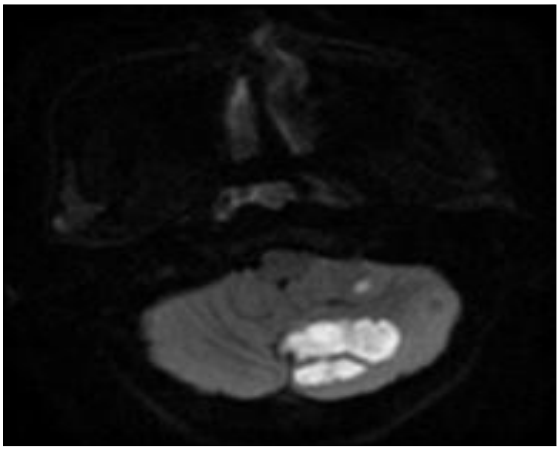

Figure 2 (c): Axial DWI

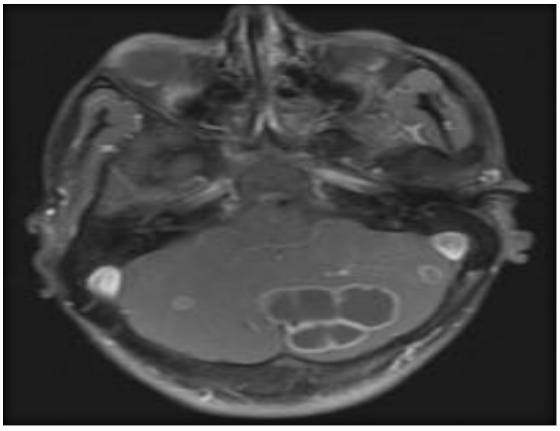

Figure 2 (d): Axial T1 FS+C

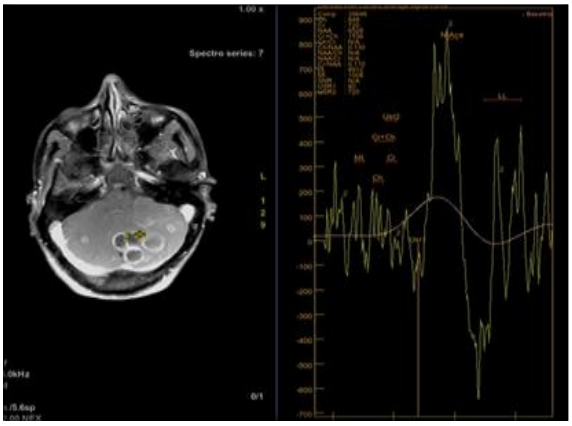

Figure 2 (e): MRS

The images of the patient (Figure 2 a-e: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveals peripherally enhancing well defined conglomerated T1 centrally hypointense, T2 isointense with hyperintense rim in left cerebellar hemisphere showing central diffusion restriction with mild to moderate perilesional edema. On MRS lipid lactate peaks are observed. These features are suggestive of Tubercular abscess.

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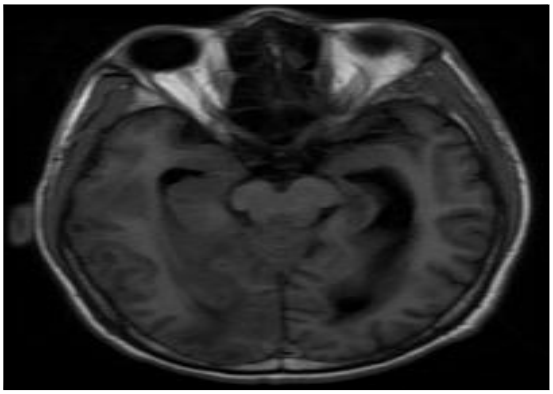

Figure 2 (f): Axial T1

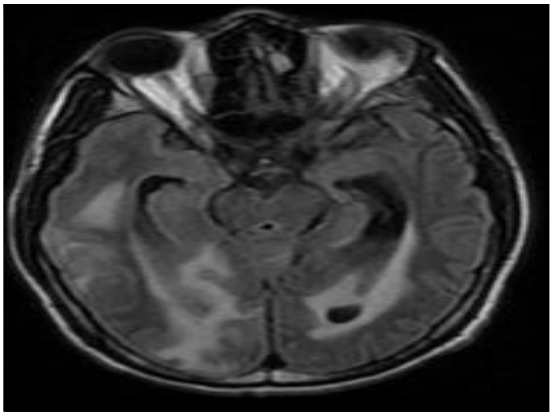

Figure 2 (g): Axial T2 FLAIR

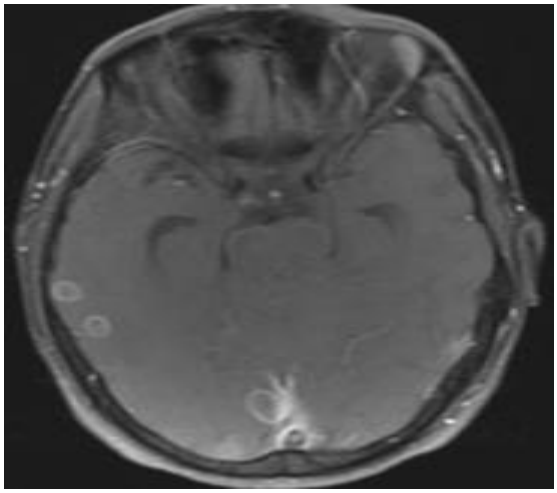

Figure 2 (h): Ax T1FS+C

The images of the same patient (Figure 2 f-h: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveal multiple peripherally enhancing well defined T1 centrally hypointense, T2 iso to hyperintense, noted involving bilateral occipital lobes, right temporal lobe, showing no diffusion restriction with mild to moderate perilesional edema. These features are suggestive of Tuberculomas.

Case 3: A 45-year-old lady with HIV positive status complaining of headache, fever and altered sensorium for 5 days.

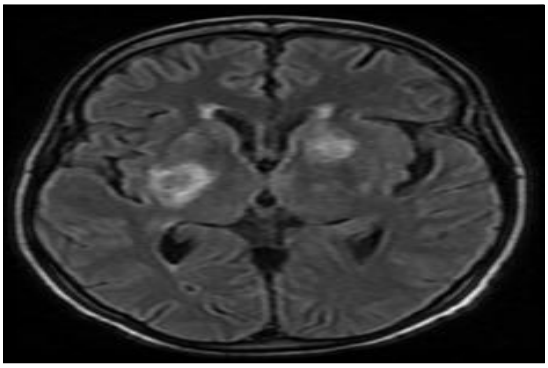

Figure 3 (a): T2 FLAIR Axial

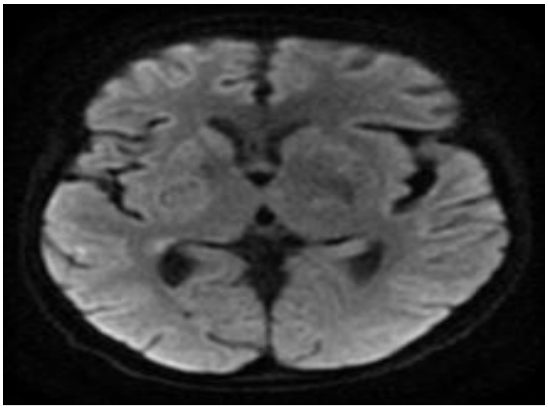

Figure 3 (b): Axial DWI

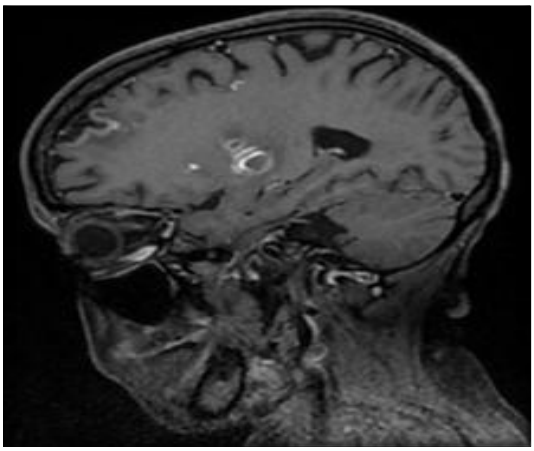

Figure 3 (c): Sagittal T1 FS +C

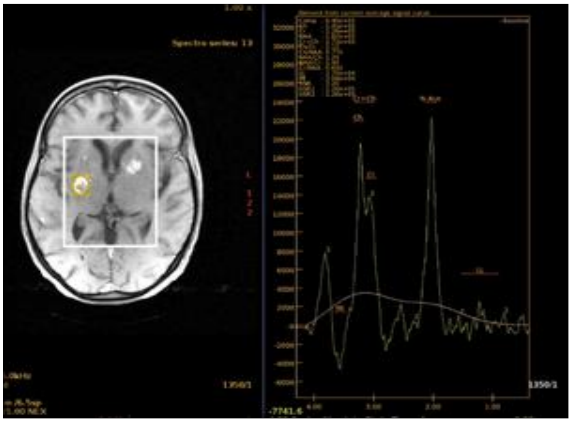

Figure 3 (d): MRS

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The images of the patient (Figure 3 a-d: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveal multiple well defined discrete lesions of varying sizes which on T2-weighted images show a concentric hyper- and hypointense zones with few showing small eccentric nodule in the wall are noted scattered in bilateral capsulo-ganglionic regions. There is perilesional edema predominantly in bilateral capsulo-ganglionic regions. There is restriction of diffusion in most of the lesions. On post contrast study, there is rim enhancement. On MRS, the lesions show increased choline peak, decreased NAA peak. These features are suggestive of Cerebral Toxoplasmosis.

Case 4: A 65-year-old lady complaining of seizures and altered sensorium for 5 days.

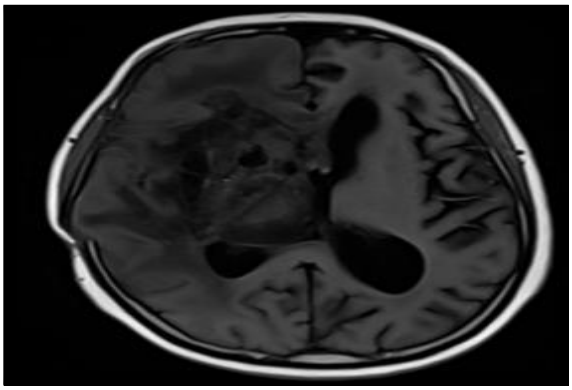

Figure 4 (a): Axial T1

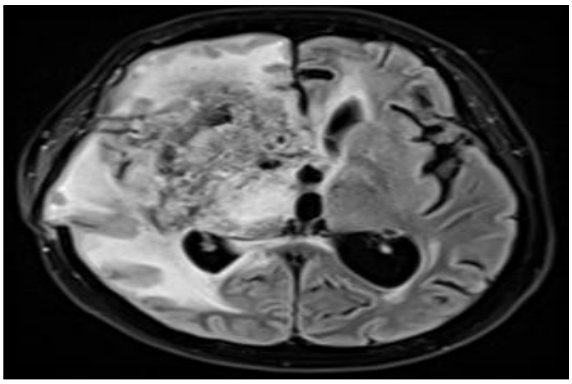

Figure 4 (b): Axial T2 FLAIR

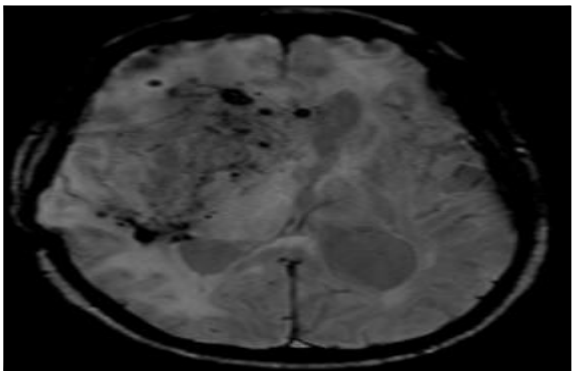

Figure 4 (c): Axial SWI

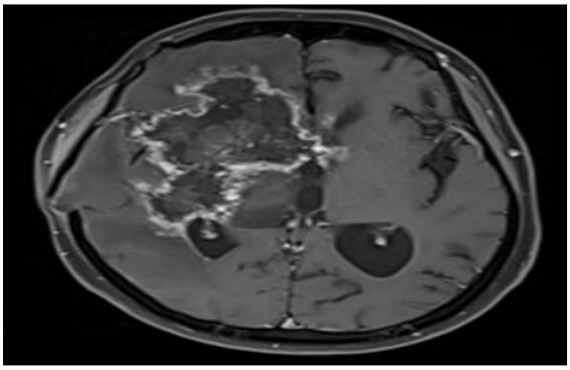

Figure 4 (c): Axial T1 FS +C

The images of the patient (Figure 4 a-d: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveal ill-defined area of increased signal intensity on T2/FLAIR images affecting right temporal and frontal lobes, with surrounding and significant mass effect. After contrast administration irregular peripheral enhancement was visualized. Susceptibility foci noted on SWI suggestive of intralesional haemorrhage. The lesion demonstrates pathological brain metabolites spectrum with increased choline-to-creatine ratio and significantly decreased NAA (Image not included). These features are suggestive of High-grade glioma.

Case 5: A 63-year-old gentleman with HIV positive status presenting with neurological deficits and seizures for 1 week.

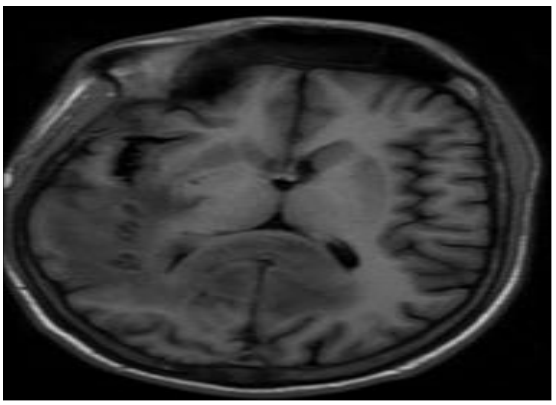

Figure 5 (a): Axial T1

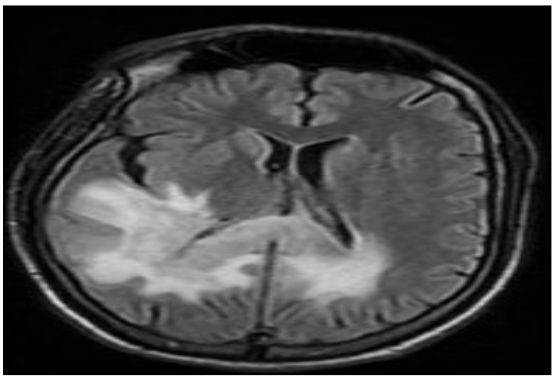

Figure 5 (b): Ax T2 FLAIR

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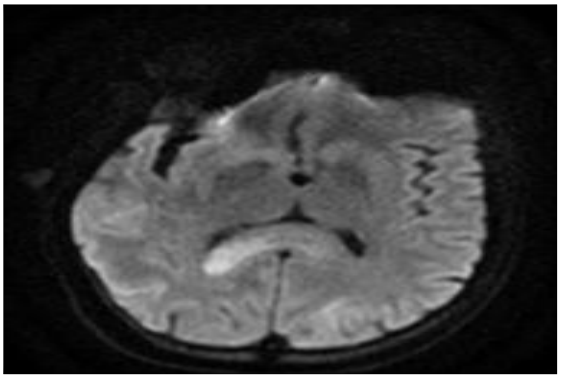


Figure 5 (c): Axial DWI

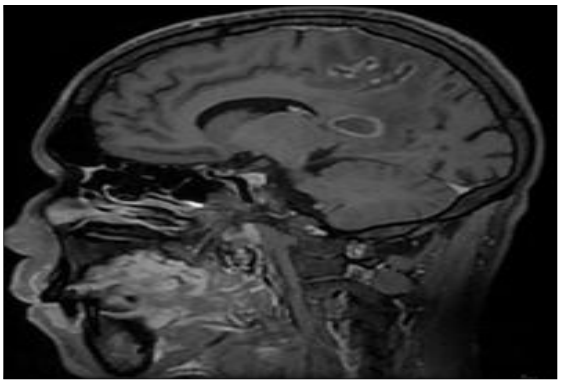


Figure 5(d): Sagittal T1 FS+C

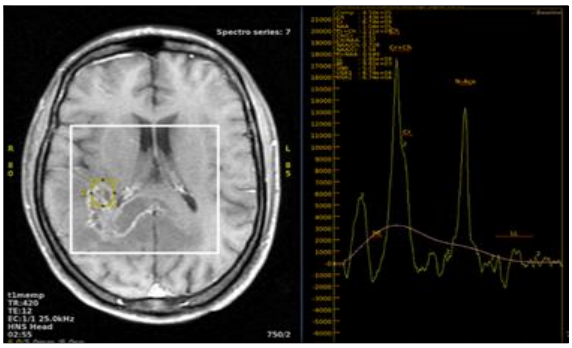


Figure 5 (e): MRS

The images of the patient (Figure 5 a-d: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveals an ill-defined multifocal T2/FLAIR hyperintense and T1 hypointense lesion noted involving posterior body and splenium of corpus callosum, bilateral parietal and right frontal and temporal lobes with extensive perilesional edema extending to involve capsulo-ganglio-thalamic region on right side and bilateral occipital lobes.

On DWI there is patchy diffusion restriction noted. On postcontrast study there is peripheral enhancement with central non-enhancing areas within s/o necrosis. On MRS there is increased choline peak followed by lipid peak and decrease in NAA. These features are suggestive of AIDS related Lymphoma.

Case 6: A 51-year-old gentleman with history of lung cancer under treatment, now presenting with headache and seizures for 3 days.

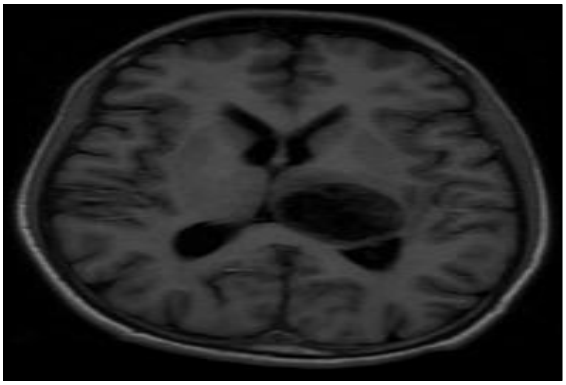


Figure 6 (a): Axial T1

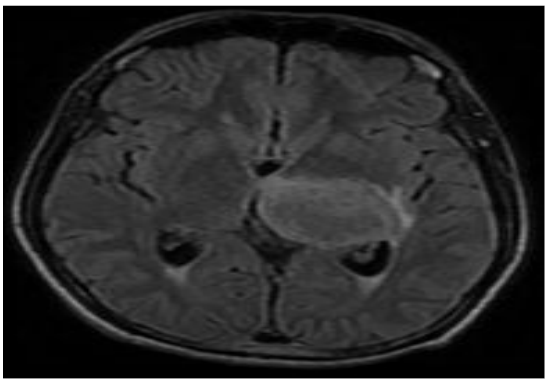


Figure 6 (b): Axial T2 FLAIR

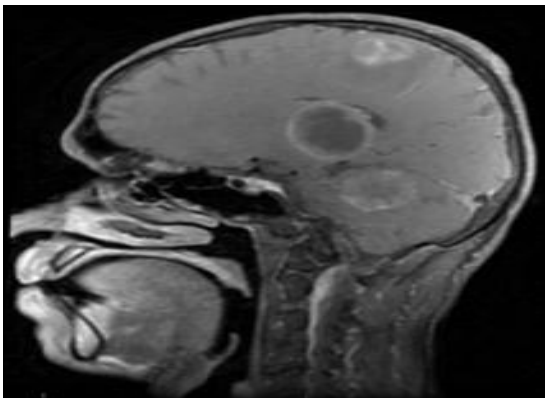
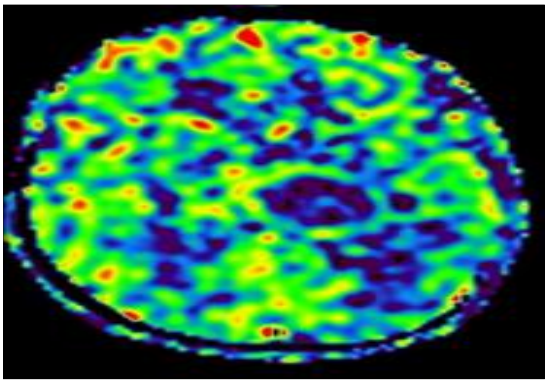


Figure 6 (c): Axial T1 FS+C



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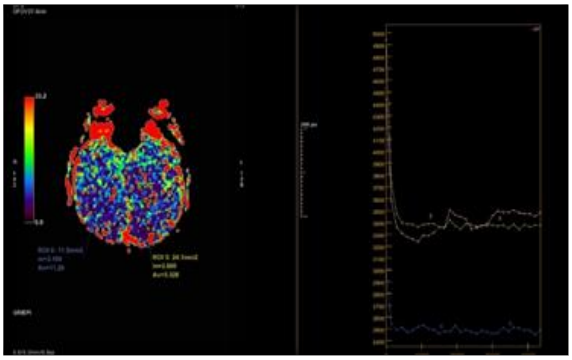

Figure 6 (d and e): MR Perfusion study

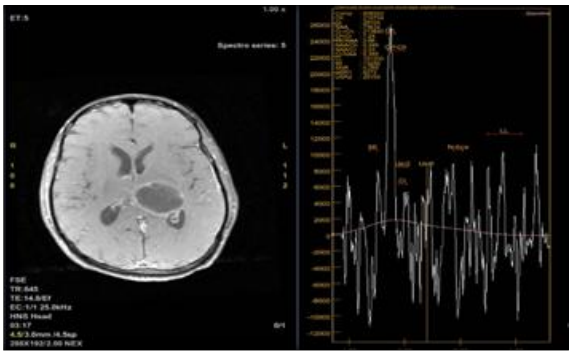

Figure 6 (f): Axial T1

The images of the patient (Figure 6 a-f: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveal multiple intra-axial heterogeneous T2/FLAIR hyperintense and T1 hypointense lesions involving bilateral occipito-temporal lobes, left thalamus and posterior limb of left internal capsule. The lesion in left thalamus is showing mass effect in form of effacement and compression of body of left lateral ventricle. On DWI, peripheral diffusion restriction noted. No susceptibility artefacts noted on SWI sequences within the lesion. On postcontrast study there is peripheral ring enhancement of the lesions with non-enhancing internal necrotic area. On MRS, a choline peak is noted in the wall of the lesions. On ASL, there is reduced CBF noted in the involved regions. These features are suggestive of Cerebral metastases.

Case 7: An -year-old lady presenting with nonsensical speech for 10 days.

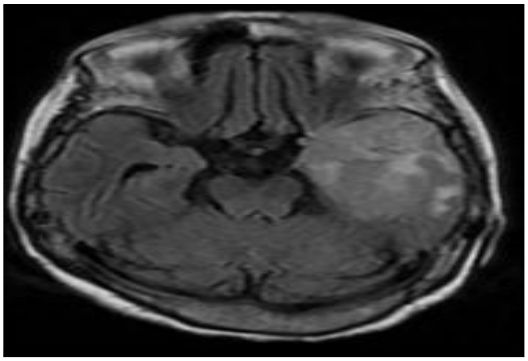

Figure 7 (a): T2 FLAIR Axial

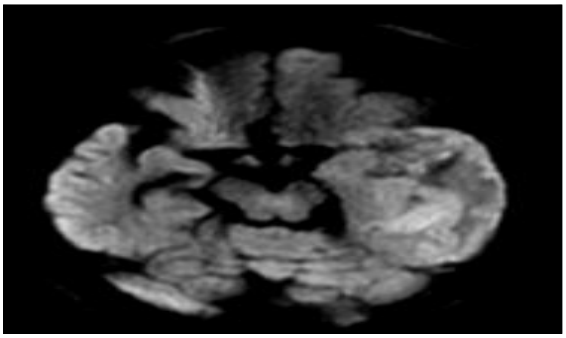

Figure 7 (b): DWI

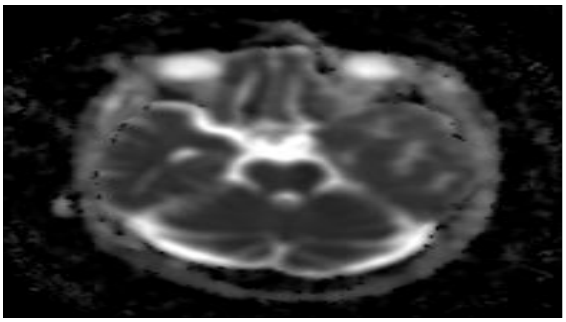

Figure 7 (c): ADC

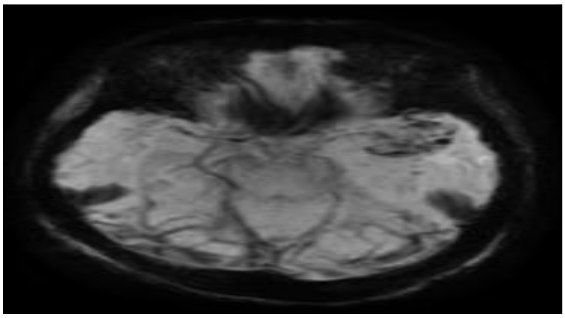

Figure 7 (d): SWI

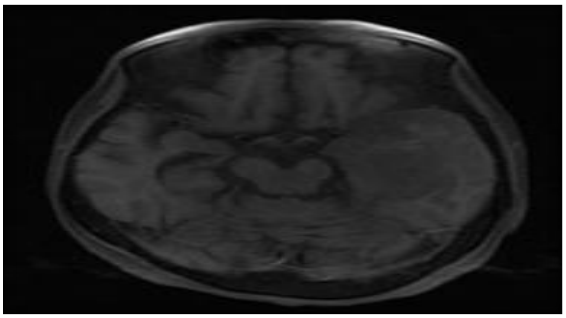

Figure 7 (e): T1 FS Axial

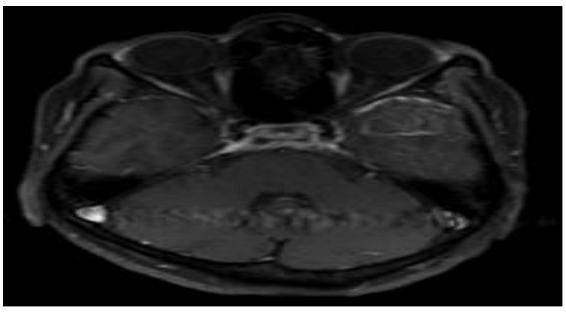

Figure 7 (f): T1 FS + C Axial

ISSN (O): 2687-5365; ISSN (P): 2753-6556

The images of the patient (Figure 7 a-f: Origin, Department of Radiology, Jorhat Medical College and Hospital, Jorhat, Assam, India.) reveal ill-defined T1 hypo, T2/FLAIR hyperintense area in the left temporal lobe with intralesional patchy T1 hyperintensity showing susceptibility artefacts on SWI sequences, on DWI there is patchy diffusion restriction and subtle postcontrast peripheral enhancement. There is effacement of left lateral ventricle, adjacent cerebral sulci and sylvian fissure. These features are suggestive of Subacute infarct.

DISCUSSION

A study by Smirniotopoulos et al,[9] described intraaxial patterns of enhancement and categorized them into 4 types namely gyral enhancement, nodular cortical and subcortical enhancement, deep and periventricular enhancement and deep ring enhancement. Our study retrospectively evaluated 23 patients with MRI evidence of ring enhancing lesions in brain. Our sample included 16 Infective lesions (69.5%), 5 neoplastic tumors including metastases (21.7%), and two cases of subacute infarcts.

Infective lesions were the most frequent encountered etiology (n=16 of 23 cases) in our study. They were categorized into neurocysticercosis, CNS tuberculosis, pyogenic abscesses and neurotoxoplasmosis. This is concordant with the study by Muhammad Shahbaz Alam et al,[10] with infective etiology constituting approximately 51.4% of total cases. They reported pyogenic abscesses as the most frequent among infective etiology. However, neurocysticercosis (n=7 of 23 cases, 30.4 % of total cases), being the most frequently encountered pathology in our study.

As described in previous literature,[3] Neurocysticercosis demonstrates characteristic findings on magnetic resonance imaging (MRI), often presenting as thin-walled ring-enhancing lesions. These lesions are commonly located in the brain parenchyma—particularly at the grey-white matter junction—as well as in the subarachnoid space and ventricular system. Similar features are also observed in our study.

Diagnosing an intracranial abscess can be challenging because its clinical presentation is often nonspecific,[11,12] and its imaging morphology may mimic other cystic brain lesions—most notably cystic gliomas and metastatic deposits.[13] Restricted diffusion within the rim of a ring-enhancing cystic lesion relative to normal-appearing white matter (NAWM)is highly suggestive of a cerebral abscess.[14] The abscesses in our study showed similar characteristics.

As explained in literature, magnetic Resonance Spectroscopy (MRS) in brain tuberculomas typically reveals prominent lipid peaks, reflecting the high lipid content of Mycobacterium tuberculosis. Elevated choline levels, along with reduced N-acetyl aspartate (NAA) and creatine concentrations, are commonly observed. Notably, all tuberculomas demonstrated a choline-to-creatine ratio exceeding 1, a finding not seen in cases of neurocysticercosis. Our study corroborated these findings with a study by Shetty G et al.[15]

Central nervous system toxoplasmosis is associated with distinctive imaging findings: the eccentric target sign on contrast-enhanced T1-weighted MRI and the target sign on T2-weighted sequences. The eccentric target sign refers to a ring-enhancing lesion containing a small, eccentrically located enhancing nodule. Similar findings are reported by C.E. Offiah et al,[16] and Lipika Gupta et al.[17]

In individuals with HIV, primary central nervous system lymphoma (PCNSL) typically presents as solitary rather than multiple lesions. These lesions frequently involve deep brain structures, such as the basal ganglia, periventricular regions, and the corpus callosum. On contrast-enhanced imaging, the lesions often show irregular, peripheral, ring-like enhancement, closely resembling the enhancement pattern observed in CNS toxoplasmosis. Our study corroborated these finding as stated by Lipika Gupta et al.[17]

In our study 5 cases, out of total 23 were of neoplastic etiology, similar to the study by R Archana et al,[18] we found two cases with multiple thick rings enhancing metastatic lesions from the breast and lung primaries. The lesions demonstrated hypointensity on T1-weighted sequences and hyperintensity on T2-weighted images. Magnetic Resonance Spectroscopy findings consistently showed an elevated choline peak accompanied by a reduction in N-acetylaspartate (NAA) levels. Also, we corroborated the features of two ring enhancing high grade gliomas.

Two cases were included in the study showing subtle ring enhancement with MR features of subacute infarcts. We reviewed the literature for ring enhancing subacute infarct came to the conclusion of we can include these cases as chameleons of ring enhancing lesions.

CONCLUSION

This retrospective observational study presents a detailed analysis of ring-enhancing lesions of brain identified on MRI, categorized according to their underlying etiology and characteristic imaging features. Diagnoses were established through a combination of clinical follow-up, serological testing, detailed radiological evaluation, and clinico-radiological correlation—an approach reflective of real-world diagnostic challenges in settings where histopathological confirmation is either not feasible or indicated. The study encompassed a wide range of pathologies, including infectious etiologies such as neurocysticercosis, tuberculosis, toxoplasmosis, and pyogenic abscesses; neoplastic conditions including high-grade gliomas, metastatic deposits, and primary

ISSN (O): 2687-5365; ISSN (P): 2753-6556

CNS lymphoma; and non-infectious causes like subacute infarcts, thereby illustrating the broad differential for ring-enhancing lesions.

Distinct imaging signatures—such as T2 hyperintense cystic lesions with central diffusion restriction in pyogenic abscesses, the eccentric target sign in toxoplasmosis, and the presence of cysts with a scolex (central dot sign) in neurocysticercosis—were critical in directing the radiological diagnosis. Magnetic Resonance Spectroscopy (MRS) further aided in differentiation: tuberculomas typically demonstrated prominent lipid peaks, while neoplastic lesions were characterized by elevated choline levels and a reduced N-acetylaspartate (NAA) concentration. These imaging patterns aligned well with previously reported literature, reinforcing the reliability of MRI as a non-invasive diagnostic modality.

Overall, this study reaffirms the pivotal role of brain MRI in the evaluation and management of ring-enhancing lesions, particularly in resource-limited settings where invasive procedures like biopsy are deferred. MRI not only facilitates accurate diagnosis but also informs therapeutic planning and future follow-up.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556