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

Deepak kumar Rajput [1], Palak Rathod [2], Kavita U. Vaishnav [3], Dimpal Sangat [4], Mahima Trivedi [5], Rutu Zala [6], Riya Jain [7], Saloni Patel [8]*

ABSTRACT

Background

Ring-enhancing lesions (RELs) in the brain represent a diagnostic challenge due to their diverse etiologies, ranging from infections to neoplastic conditions. MRI offers superior imaging features to distinguish among these conditions.

Purpose

To evaluate the spectrum of ring-enhancing brain lesions and assess the role of MRI in differentiating these pathologies.

Methods

A retrospective study of 160 patients with RELs on contrast MRI was conducted from May 2022 to July 2025. MRI findings were analyzed with respect to lesion morphology, signal characteristics, and diffusion restriction.

Results

Infective lesions such as tuberculoma (40%) and neurocysticercosis (33%) were most common, followed by abscesses (10%), metastases (13%), and primary tumors (4%). Diffusion restriction was a key differentiator, with all abscesses showing restricted diffusion.

Conclusion

MRI, with its multiparametric capabilities, plays a pivotal role in the non-invasive differentiation of RELs and aids in formulating appropriate management strategies. Advances in MRI techniques—such as diffusion tensor imaging, perfusion imaging, MR spectroscopy, and functional MRI—hold promise for improving diagnostic accuracy and reducing the need for invasive procedures. Incorporating artificial intelligence and radiomics may further enhance lesion characterization and enable more precise, non-invasive differentiation of pathologies in the future.

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4*Corresponding author Dimpal Sangat ,Assistant professor, Phone number: 7990961867, Email id: sangatdimpal93@gmail.com; Deepak kumar Rajput, (Higher grade) HOD , Palak Rathod ,Senior resident, Kavita U. Vaishnav, Associate Professor, Mahima Trivedi ,2nd year post graduate student, Rutu Zala, 2nd year post graduate student , Riya Jain, 1st year post graduate student , Saloni Patel, 1st year post graduate student at department of Radio diagnosis, Narendra Modi Medical college and LG hospital, Ahmedabad.

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INTRODUCTION

Ring-enhancing lesions (RELs) on neuroimaging are diagnostically challenging because of their wide range of underlying causes and frequently non-specific clinical features. Radiologically, an REL refers to an area of altered signal on magnetic resonance imaging (MRI) that displays a well-defined rim of enhancement after intravenous contrast administration[1].Thes e enhancing lesions can vary in size and are commonly accompanied by differing degrees of perilesional vasogenic edema. While they are most often found at the gray–white matter junction, they may also be situated in the subcortical region, deep within the brain parenchyma, or even at superficial locations [2]. RELs encompass a wide range of causes, from infections such as brain abscesses and granulomatous diseases to neoplasms like high-grade gliomas and metastases [3]. Accurate differentiation is vital for appropriate management, yet their non-specific presentation requires a multiparametric diagnostic approach, with advanced neuroimaging being central [4]. MRI is the gold standard for assessing RELs, offering superior soft tissue contrast and multiplanar imaging compared to CT [5,6]. Unlike CT, which mainly depicts tissue density, MRI provides detailed information on tissue composition and function [7], enabling better differentiation between neoplastic and non-neoplastic lesions [8]. This thesis explores the role of MRI in evaluating RELs. Inflammatory and demyelinating disorders such as acute demyelination can mimic tumors, showing incomplete or "open" ring enhancement, usually in periventricular or juxtacortical regions. Sarcoidosis may rarely present as an isolated intracranial granuloma, sometimes with dural or cranial nerve involvement. Radiation necrosis, a post-radiotherapy complication, is characterized by heterogeneous enhancement and low perfusion on advanced imaging [9]. Vascular and traumatic causes include subacute infarcts, which enhance in a gyriform pattern conforming to a vascular territory; subacute hematomas, which display variable signal with a hemosiderin rim on susceptibility sequences; and cerebral contusions, which often involve the frontal or temporal lobes and are associated with hemorrhage. Thrombosed or inflammatory aneurysms may also exhibit ring enhancement, with the degree depending on the extent of thrombosis and inflammation [9]. A key aspect of diagnosis is interpreting MRI findings, which requires understanding different sequences and their sensitivity to tissue characteristics. T1-weighted, T2-weighted, and fluid-attenuated inversion recovery (FLAIR) sequences, along with gadolinium-enhanced T1-weighted imaging, form the core of REL evaluation. Each offers distinct details on lesion morphology, composition, and edema, aiding differentiation between infectious, neoplastic, and inflammatory causes [10].

This publication aims to reinforce MRI's role as a cornerstone in diagnosing brain RELs. By offering deeper insights into MRI-based evaluation, it seeks to assist clinicians in navigating the complex diagnostic process and improving patient outcomes.

Material & Methodology

Study design, duration, and setting

This was a hospital-based, retrospective, observational, single-center study conducted in the Department of Radiology, L.G. Hospital, from May 2022 to July 2025. Patients were enrolled after obtaining informed consent.

Study population and selection criteria

All patients presenting to the Radiology Department with suspected neurological pathology and MRI findings suggestive of intracranial ring-enhancing lesions were included. Patients with incomplete imaging data, previous neurosurgical intervention for the same lesion, or inadequate clinical records were excluded.

Sample size and sampling

A total of 160 patients fulfilling the inclusion criteria were studied over the 3-year study period.

Study procedures and data collection

All MRI examinations were performed on a Siemens Magnetom Essenza 1.5 Tesla whole-body scanner. The protocol included:

- Axial: T1-weighted (T1WI), T2-weighted (T2WI), and fluid-attenuated inversion recovery (FLAIR)
- Sagittal: T2WI
- Coronal: FLAIR
- Diffusion-weighted imaging (DWI)

For contrast studies, gadopentate dimeglumine (0.1 mmol/kg body weight) was administered intravenously. Post-contrast T1WI with fat saturation was obtained in axial, sagittal, and coronal planes. Lesions were assessed for signal

intensity on T1WI/T2WI/FLAIR, enhancement pattern, rim thickness, perilesional edema, and diffusion restriction.

Relevant clinical data, including history, examination findings, discharge summaries, and laboratory investigations, were reviewed. Histopathological reports, microbiological tests (e.g., sputum AFB), and additional imaging (ultrasound, radiographs, CT) were correlated when available. Sedation was administered in selected patients under anesthetist supervision.

Data analysis

Data were compiled into a master chart and analyzed using Microsoft Excel and IBM SPSS Statistics version 26.0. Categorical variables were expressed as frequencies and percentages, and continuous variables as mean ± standard deviation (SD). Results were presented in tables and charts.

Ethical consideration

Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants. Data were kept confidential and used exclusively for research purposes.

RESULTS AND OBSERVATIONS

The study cohort consisted of a total of 160 patients. As shown in Table 1 and the accompanying pie chart, the most common ring-enhancing pathology was tuberculoma, seen in 64 out of 160 patients (40%), followed closely by neurocysticercosis in 53 patients (33%). Abscesses accounted for 16 patients (10%), metastatic lesions for 20 patients (12.5%), and primary brain tumors for the remaining 7 patients (4.4%).

Table 1: Incidence of various ring enhancing pathologies

Pathology	Patients (160)	Percentage
Tuberculoma	64	40%
Neurocysticercosis	53	33%
Abscess	16	10%
Metastasis	20	12.5%
Primary brain tumor	7	4.4%
Total	160	100%

As illustrated in Table 3 infective pathologies such as brain abscess, tuberculoma, and neurocysticercosis were relatively more frequent among young adults in the 2nd to 4th decades of life. Metastatic lesions predominated in older adults (40 years and above), particularly in the 5th and 6th decades, whereas primary brain tumors were more common from the 4th decade onward.

Table 2: Age distribution in different pathologies

Age group	Abscess	Tuberculoma	NCC	Metastasis	Primary Tumor
0–10 Y	1	4	3	0	0
10–20 Y	4	3	3	0	1
20–30 Y	1	13	8	1	0
30–40 Y	5	14	10	0	1
40–50 Y	3	12	16	4	4
50–60 Y	2	11	9	7	1
> 60 Y	0	7	4	8	0

Infectious lesions, primary tumors, and metastases were more frequent in males. Specifically, males accounted for 9 cases of abscess, 40 cases of tuberculoma, 31 cases of neurocysticercosis, 11 cases of metastasis, and 5 cases of primary brain tumor, whereas females had lower counts in each category (Table 5, Chart 5).

Table 3: Gender distribution in different pathologies

Gender	Abscess	Tuberculoma	NCC	Metastasis	Primary Tumor
Male	9	40	31	11	5
Female	7	24	22	9	2

As shown in Table 4 and Chart 4, tuberculoma and abscesses were predominantly solitary (75% of cases). In neurocysticercosis most often presented with multiple lesions (87.5% and 90% of cases, respectively), while metastatic lesions, one-third of cases were solitary, while all primary brain tumors presented as solitary lesions.

Table 4: Solitary vs Multiple

Pathology	Solitary	Multiple
Abscess	12	4
Tuberculoma	8	56
NCC	5	48
Metastasis	7	13
Primary	7	0

Most tuberculomas (70.8%) and abscesses (83.3%) were hyperintense. Metastases were predominantly T1 hypointense. Neurocysticercosis demonstrated more hypointense (73.3%), and no primary brain tumors were variability, with 55% hypointense, 30% mixed, and 15% hyperintense.

Table 5: T1 characteristics (by pathology)

Pathology	Hypointense	Mixed	Hyperintense
Tuberculoma	45	11	8
NCC	29	16	8
Abscess	13	3	0
Metastasis	14	3	3
Primary Tumor	5	2	0

All abscesses, all primary brain tumors, and most cases of neurocysticercosis (80%) were T2 hyperintense. Tuberculomas showed more varied signals, with 58.3% hyperintense, 27% mixed, and 27% hypointense. Almost all metastases (93.3%) were hyperintense (Table 10, Chart 10).

Table 6: T2 characteristics (by pathology)

Pathology	Hyperintense	Mixed	Hypointense
Tuberculoma	37	14	13
NCC	42	8	3
Abscess	16	0	0
Metastasis	19	1	0
Primary Tumor	7	0	0

All abscesses showed diffusion restriction. Metastases showed restriction in 75% of cases, while tuberculomas, 77% had restriction, while only 32.5% of primary brain tumors were less likely to restrict diffusion. neurocysticercosis cases demonstrated this feature.

Table 7: Diffusion characteristics (by pathology)

Pathology	Present	Absent
Tuberculoma	37	27
NCC	13	40
Abscess	16	0
Metastasis	15	5
Primary Tumor	3	4

CASE 1: Tuberculoma with basal meningitis :

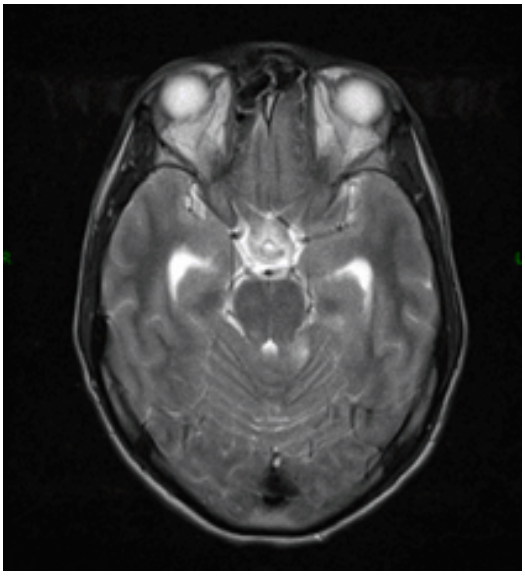


Fig.1 : T2WI

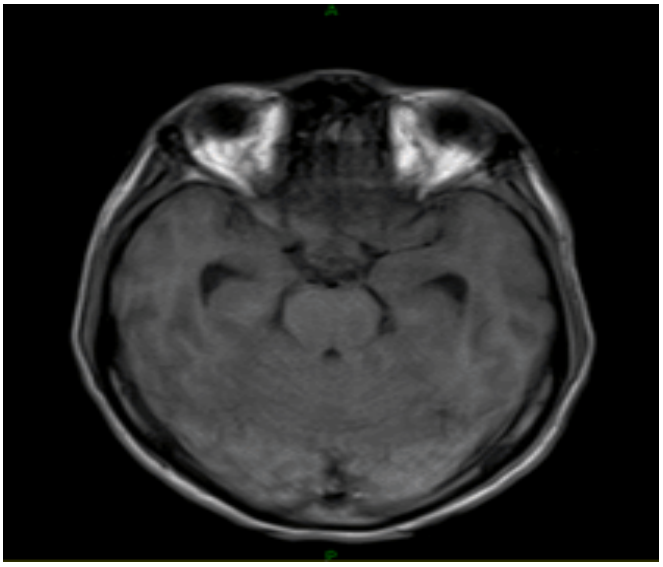


Fig 2 : T1WI

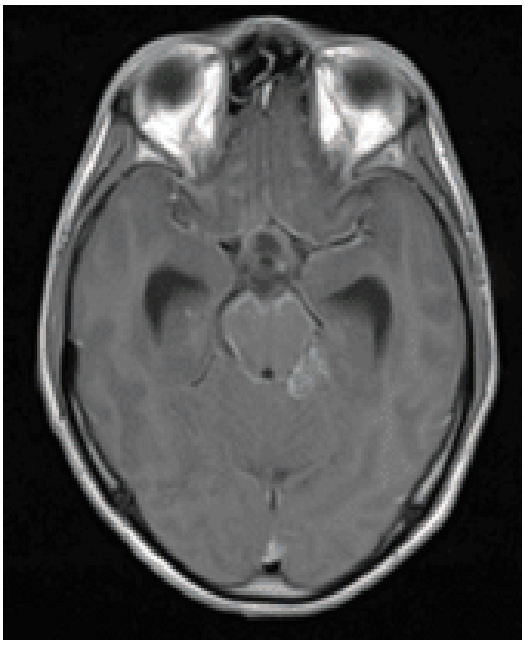


Fig 3 : T1 post contrast

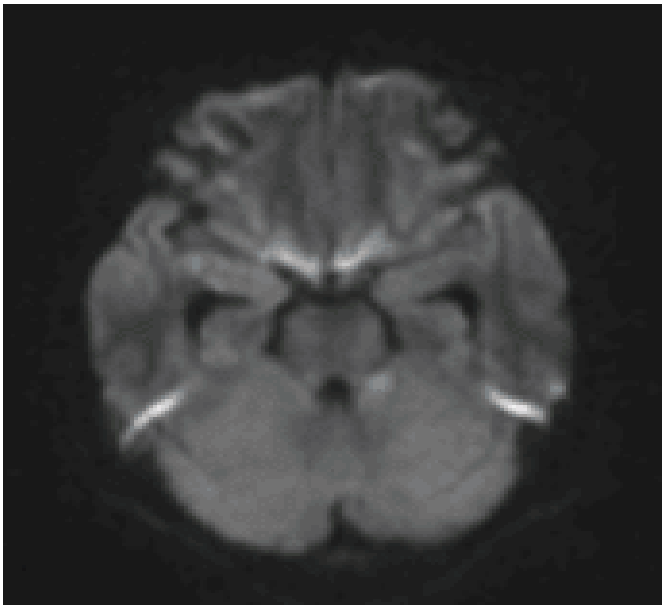


Fig 4 : DWI

Multiple ring-like enhancing lesions are seen in left superior cerebellar region close to basal cistern on left side. Abnormal lepto-meningeal enhancement in basal cisterns and fissures with mild hydrocephalus. The lesions appear hypointense on T1WI and hyperintense on T2WI and show mild diffusion restriction.

● CASE 2 : Brain Abscess :

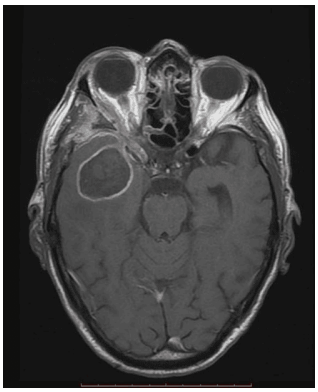


Fig 5 :Axial T1 post contrast

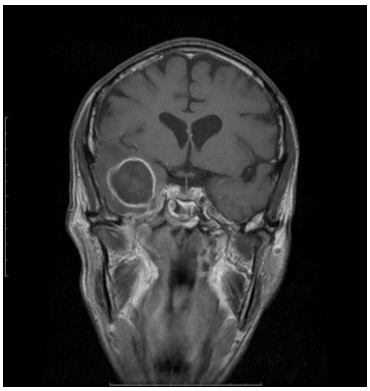


Fig 6 :Coronal T1 post contrast

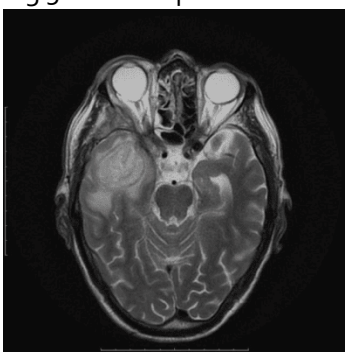


Fig. 7 : T2WI

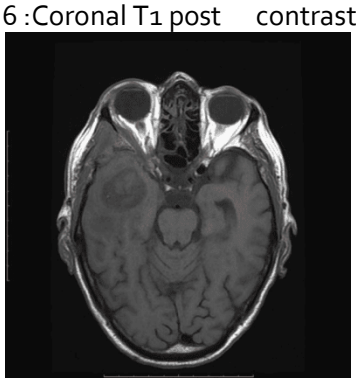


Fig. 8 : T1WI

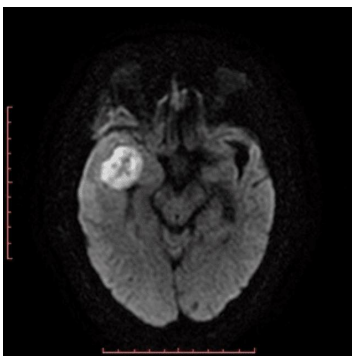


Fig. 9 : DWI

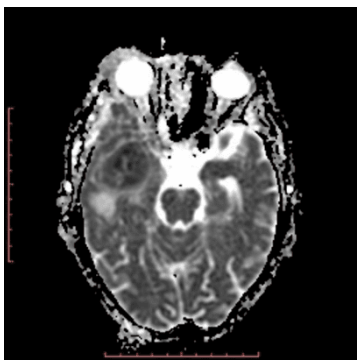


Fig. 10: ADC

Large cystic space occupying lesion in right anterior temporal lobe which appears hypointense on T1WI and hyperintense on T2WI. The lesion shows diffusion restriction and peripheral rim enhancement on post contrast images.

● CASE 3 : Neurocysticercosis :

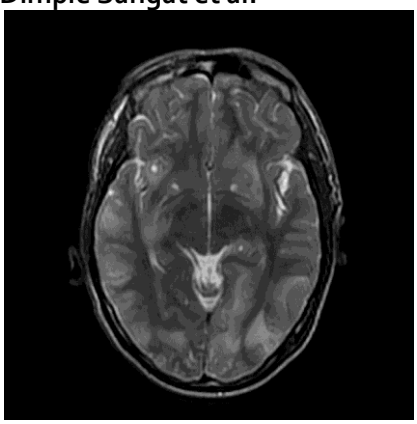
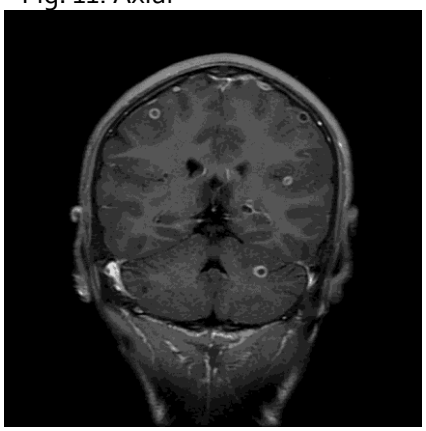


Fig. 11: Axial



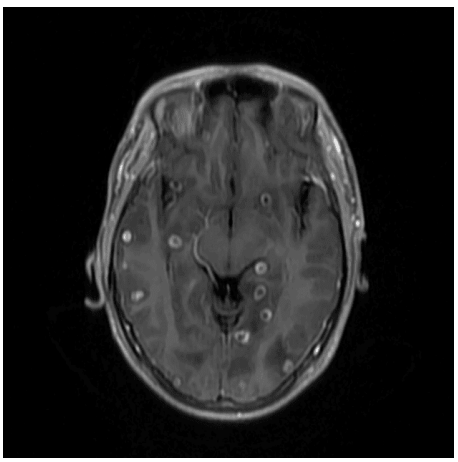
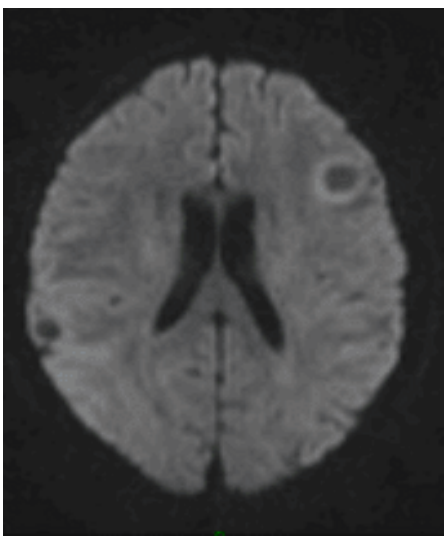


Fig. 12: Axial T1

Fig. 13: Coronal T1 postcontrast

Multiple sub-centimeter ring-enhancing cystic lesions scattered throughout the bilateral cerebral, cerebellar hemisphere, and deep nuclei. They appear hypointense on T1W and hyperintense T2W. Perilesional edema seen around some of these lesions causing mass effect on the adjacent parenchyma.

● CASE 4 : Metastasis (Lung carcinoma) :



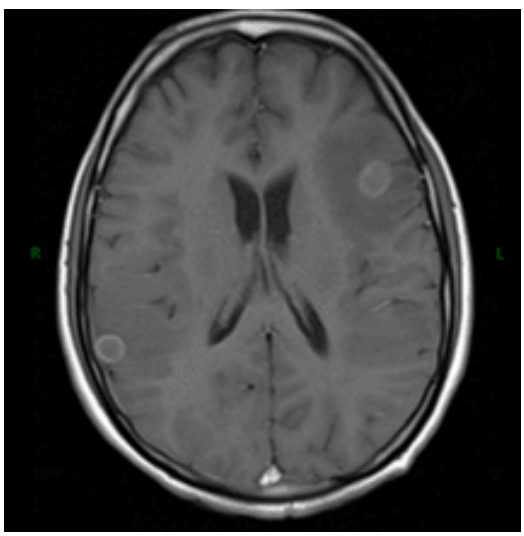


Fig.14 :DWI Fig.15: Axial T1 postcontrast

MR images show multiple cerebral and cerebellar ring enhancing lesions with associated oedema. The lesions appear hypointense on both T1WI and T2WI and show no diffusion restriction.

● CASE 5 : Primary brain tumour (High Grade Glioma) :

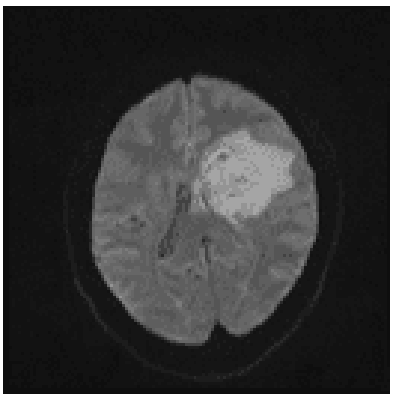


Fig. 16: DWI

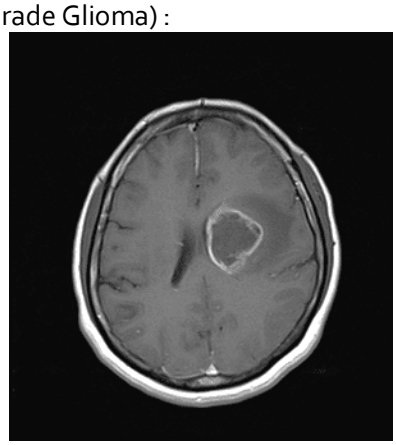


Fig.17 : Axial T1 postcontrast

There is evidence of an irregular heterogeneous signal intensity mass lesion involving left posterior frontal region on T2W images which appears iso to hypointense on T1W images. The lesion shows thick irregular peripheral rim of enhancement with internal non enhancing area. The lesion does not show true diffusion restriction.

● CASE 6 : Glioblastoma :

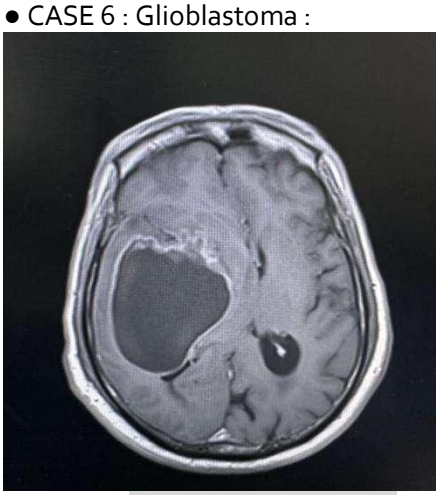


Fig 18 : Axial T1 post contrast

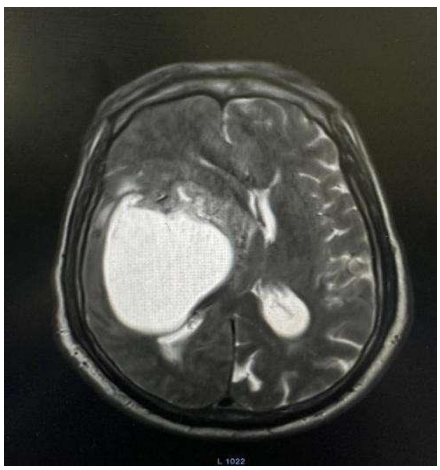
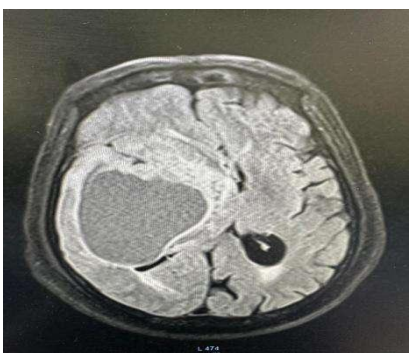


Fig 19: T2WI

Fig 20 : T1WI



There is evidence of altered signal intensity mass lesion with mainly cystic and peripheral solid component in right fronto temporal lobe, the lesion causes peripheral heterogeneous contrast enhancement of solid component and ring enhancement of cystic component.

● CASE 7 : Tuberculoma :

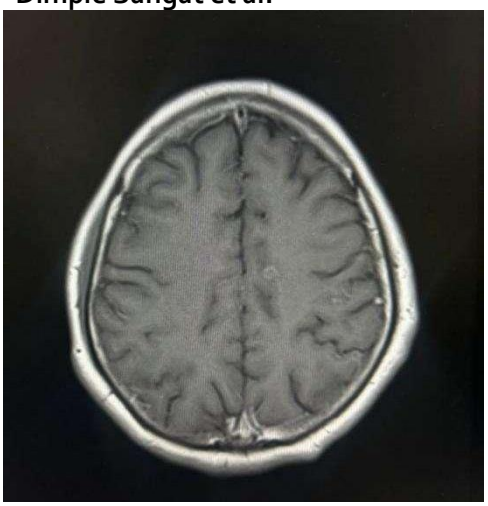


Fig 21 : T1WI

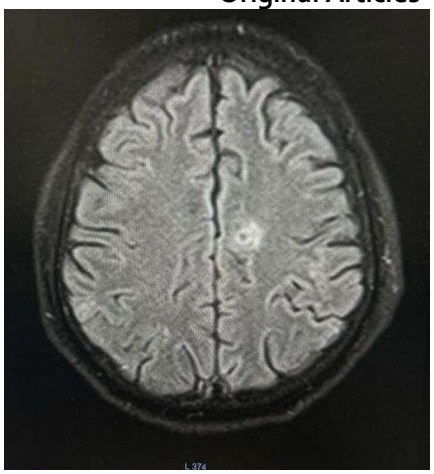


Fig.22 : FLAIR

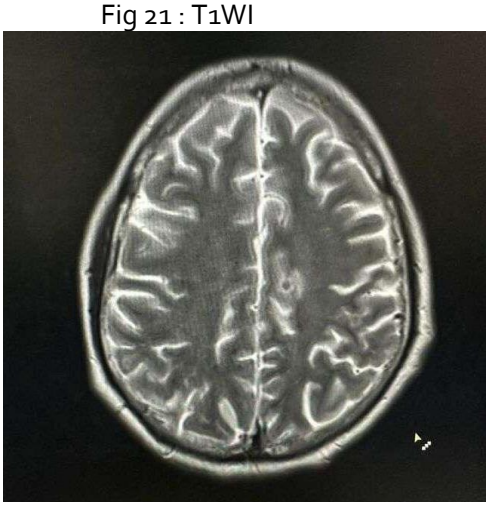


Fig 23 : T2WI

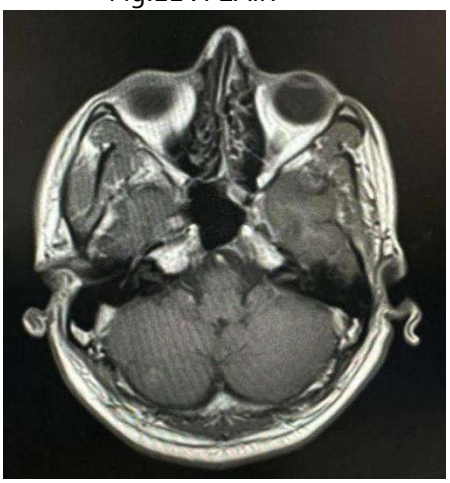


Fig 24 : T2WI

Few well defined ring enhancing lesions appaering hypointense on T2/FLAIR images with surrounding edema on post contrast study in left frontal and right cerebellar hemisphere.

DISCUSSION

Magnetic Resonance Imaging in the Characterization of Intracranial Ring-Enhancing Lesions: A Retrospective Study of 160 Patients

Intracranial ring-enhancing lesions constitute a diverse and diagnostically challenging group, encompassing both infective and neoplastic etiologies. Accurate differentiation between these entities is essential for guiding patient management, as treatment strategies vary considerably depending on the underlying cause. In this prospective study of 160 patients, magnetic resonance imaging (MRI) was systematically utilized to characterize such lesions, with the aim of defining imaging patterns, identifying common etiologies, and correlating radiological findings with clinical and laboratory data.

Incidence and Demographic Profile

In our cohort, the most prevalent etiology was tuberculoma, observed in 64 patients (40%), followed closely by neurocysticercosis (NCC) in 53 patients (33%). Metastatic lesions were present in 20 patients (12.5%), abscesses in 16 patients (10%), and primary brain tumors in 7 patients (4.4%). This distribution is consistent with the epidemiological profile of developing countries, where infective pathologies such as tuberculoma and NCC dominate.

The 40–50-year age group accounted for the highest proportion of cases (23.3%), followed by the 30–40-year group (20%) and 50–60-year group (18.3%). Infective lesions were more common in younger age groups, whereas neoplastic lesions—metastases and primary brain tumors—were predominantly

observed in patients over 40 years.

Gender analysis revealed a male predominance (60% male vs. 40% female), with higher male representation in all pathological categories. This pattern may reflect sociocultural and occupational factors contributing to differential exposure risks.

Multiplicity of Lesions

Multiplicity of lesions emerged as an important differentiating factor. Multiple lesions were significantly more common in tuberculoma (87.5%) and NCC (90%) cases, supporting their infectious etiology. Conversely, abscesses were solitary in 75% of cases, and all primary brain tumors were solitary. Metastases displayed variable multiplicity, with two-thirds of cases presenting multiple lesions.

Multiplicity assessment on MRI is clinically relevant, as it provides an early clue towards likely etiology and can help prioritize differentials even before advanced imaging sequences or laboratory data are available.

MRI Signal Characteristics

T1-Weighted Imaging

Across all lesions, T1 hypointensity was the most common finding (67.5%), followed by mixed intensity (20.6%) and hyperintensity (11.9%). Tuberculomas and abscesses were predominantly hypointense, reflecting their solid granulomatous or purulent core. NCC displayed a more varied T1 signal, with a substantial proportion (30%) showing mixed intensity. Metastases were also mostly hypointense (73.3%), while primary brain tumors rarely displayed hyperintensity.

T2-Weighted Imaging

On T2-weighted sequences, 75.6% of lesions were hyperintense, 14.4% mixed, and 10% hypointense. NCC and abscesses were almost universally hyperintense, whereas tuberculomas exhibited a broader range of signal intensities, consistent with differences between caseating and non-caseating forms. Nearly all metastases (93.3%) and all primary brain tumors were hyperintense.

Diffusion-Weighted Imaging (DWI)

DWI proved valuable in distinguishing abscesses from other lesions. All abscesses demonstrated marked diffusion restriction due to viscous pus and high cellularity. Tuberculomas exhibited restriction in 77% of cases, reflecting their solid caseating content. NCC rarely restricted diffusion (32.5%), consistent with its cystic nature. Metastases restricted in 75% of cases, while primary tumors showed less frequent restriction.

These findings reaffirm DWI as a crucial adjunct to conventional MRI in differentiating pyogenic abscesses from necrotic tumors and certain granulomatous lesions.

Pathology-Specific Imaging Profiles

Tuberculoma: T1 hypointense in the majority, variable T2 signal, frequent multiplicity, and high prevalence of diffusion restriction. Ancillary findings such as basal meningeal enhancement or evidence of systemic tuberculosis on chest imaging strengthened diagnostic confidence.

Neurocysticercosis: Typically T1 hypointense and T2 hyperintense with minimal edema; the scolex, when visible, was pathognomonic. Multiplicity was common, and diffusion restriction was rare.

Our findings are in close agreement with earlier Indian studies. R.K. Gupta et al. (1993, Neuroradiology) and A. Jena (1990, Neuroradiology) both reported tuberculoma as the most frequent cause of intracranial ring-enhancing lesions in endemic regions, with neurocysticercosis (NCC) as the second most common etiology. Similarly, J.-L. Zhao et al. (2012, Journal of Neuroradiology) highlighted NCC as a major contributor to ring-enhancing lesions in developing countries, especially in younger populations.

The age distribution in our cohort mirrors previous observations—infective lesions such as tuberculoma and NCC are more common in younger patients, while neoplastic lesions dominate in older age groups. The tendency for tuberculoma and NCC to present with multiple lesions, as seen in our study, is consistent with the imaging profiles reported by earlier authors.

Abscess: T1 hypointense core with T2 hyperintense center and hypointense capsule, uniform diffusion restriction, and smooth ring enhancement. Often associated with infectious focus such as otitis or mastoiditis.

Regarding advanced imaging, our results reaffirm G. Luthra et al. (2007, Neuroradiology), who demonstrated the utility of diffusion-weighted imaging (DWI) in differentiating pyogenic abscesses from necrotic tumors. The presence of a scolex within a cystic lesion, a hallmark finding in NCC, was

also frequently encountered in our cases, corroborating previous literature.

Metastasis: T1 hypointense, T2 hyperintense, often multiple and located at the gray–white junction, with irregular thick ring enhancement. DWI findings varied according to tumor histology.

In contrast, studies from Western cohorts show a predominance of neoplastic etiologies. Sanjay K. Singh et al. (2000, American Journal of Neuroradiology) reported brain metastases as the leading cause in older adults

Primary Brain Tumors: Usually solitary, T2 hyperintense, with heterogeneous enhancement and variable diffusion restriction. Infiltrative margins helped distinguish them from infectious etiologies.

A study from Martia Martucci et al. (2015, Journal of Neuro-Oncology) emphasized primary brain tumors—particularly gliomas—as common sources of solitary ring enhancement in non-endemic settings. These differences underscore the role of regional epidemiology, socioeconomic factors, and infection prevalence in determining lesion patterns.

Infectious lesions typically show a smooth, thin, regular rim in abscesses, while tuberculomas may have an irregular or nodular rim with central T2 hypointensity. Malignant lesions, such as metastases or glioblastomas, usually exhibit a thick, irregular, often nodular rim with heterogeneous enhancement.

Clinical Implications

Accurate radiological characterization of ring-enhancing lesions impacts patient care by:

1. Reducing unnecessary surgical interventions in cases of infective etiology.
2. Guiding targeted antimicrobial therapy for tuberculosis, NCC, or abscesses.
3. Expediting oncological management for neoplastic lesions.
4. Given the high prevalence of tuberculosis and NCC in our setting, MRI plays a pivotal role in empirical treatment planning. Whole-brain imaging is essential to detect multiplicity and avoid missed diagnoses.

Limitations

Limitations of the study include its single-center design and absence of histopathological confirmation in all patients. Some diagnoses were made on clinico-radiological grounds and follow-up imaging. However, the strong concordance between imaging findings and clinical profiles provided high diagnostic reliability.

CONCLUSION

MRI is highly effective in characterizing intracranial ring-enhancing lesions, with irregular rim enhancement being the most common feature. In our study, tuberculoma (40%) was most frequent, followed by neurocysticercosis (33%), metastases (12.5%), abscesses (10%), and primary brain tumors (4.4%). Infective lesions predominated in younger patients, while neoplastic lesions were more common in older adults. Key differentiating features included T2 signal patterns, diffusion restriction, and rim morphology—infectious lesions often displayed a smooth, thin, regular rim (abscess) or irregular/nodular rim with central T2 hypointensity (tuberculoma), whereas malignant lesions typically had a thick, irregular, nodular rim with heterogeneous enhancement. Multiparametric MRI with clinical correlation proved invaluable for accurate diagnosis and treatment planning.

REFERENCES

1. Ramachandra V, et al. A study to find the characteristic imaging findings of various ring-enhancing lesions using MR imaging. Int J Med Res Rev. 2020;8(2):2228-33.
2. Gleichman S, et al. Differentiation of ring-enhancing brain lesions by magnetic resonance imaging. Neuroradiol J. 2018;31(2):151-66. doi:10.11138/NRJ-2017-0182.
3. Lakhan R, et al. MRI characteristics of ring-enhancing intracranial lesions: A pictorial review. Insights Imaging. 2019;10(3):54. doi:10.1186/s13244-019-0721-1.
4. Mehta BM, et al. MRI features of ring-enhancing intracranial lesions: A pictorial review. Indian J Radiol Imaging. 2016;26(3):274-82. doi:10.4103/0971-2448.188422.
5. Smirniotopoulos JG, Murphy FM, Rushing EJ, Rees JH, Schroeder JW. Patterns of contrast enhancement in the brain and meninges. Radiographics. 2007;27:525-51.
6. Garg RK, Sinha MK. Multiple ring-enhancing lesions of the brain. AJNR Am J Neuroradiol. 2012;33(8):1534-8.
7. Garg RK, Desai P, Kar M, Kar AM. Multiple ring enhancing brain lesions on computed tomography: an Indian perspective. J Neurol Sci. 2008;266(1-2):92-6.
8. Amukotuwa SA, Bershad EM, Suarez JI, et al. Ring-enhancing lesions in the immunocompromised patient. Semin Ultrasound CT MR. 2018;39(3):272-87.
9. Osborn AG, Hedlund GL, Salzman KL, Barkovich AJ. Diagnostic Imaging: Brain. 4th ed. Philadelphia: Elsevier; 2021.
10. Cunliffe CH, Fischer I, Monoky D, Law M, Revercomb C, Elrich S, et al. Intracranial lesions mimicking neoplasms. Arch Pathol Lab Med. 2009;133:101-23.
11. Chapman S, Nakielny R. Aids to Radiological Differential Diagnosis. 7th ed. Philadelphia: Elsevier; 2019.
12. Stiles J, Jernigan TL. The basics of brain development. Neuropsychol Rev. 2010;20(4):327-48.