Role of MRI in Characterisation of Intracranial Ring Enhancing Lesions in correlation with MR Spectroscopy

Rounaq Mishra[1], Jigyasa Puri[2], Sheikh Burgees Ismail[3], Rajesh Sharma[4]

ABSTRACT

Introduction: Multiple ring enhancing lesions is a commonly encountered dilemma in neuroimaging. Ring enhancing lesions are one of the most commonly encountered abnormalities on neuroimaging. A wide variety of etiological factors may present as multiple ring enhancing lesions of brain (Omuro et al., 2006; Cunliffe et al., 2009). Aim: To study the characteristic imaging findings of various ring enhancing lesions on MRI and to establish a differential diagnosis of various ring enhancing lesions on MRI.

Material and Methods: The study included all the Patients referred to the Department of Radiodiagnosis who are being evaluated for specific neurological symptoms and pathologies and underwent Magnetic resonanceimaging/ spectroscopy (brain) for the detection and diagnosis of the same.

Results: In the present study, most common lesion seen was NCC in 37.5% followed by tuberculoma in 25%. Abscess was found in 9.4%, demyelination and neurotoxoplasmosis each in 3.1%, glioblastoma in 6.3% and metastasis was found in 5.6% patients.

Conclusion: This study demonstrates that the most prevalent lesion seen in patients, according to the findings of the current investigation, was NCC, followed by tuberculoma. Other pathologies found in ring enhancing lesions included metastatic lesion, abscess, glioblastoma, demyelination, and neurotoxoplasmosis

Keywords: MRI, Intracranial Ring Enhancing Lesions, MR Spectroscopy

INTRODUCTION

Causes of ring enhancing lesions in the brain:

Bacterial

- Pyogenic abscess
- Tuberculoma and tuberculous abscess
- Mycobacterium avium- intracellulare infection
- Syphilis
- Listeriosis

Fungal

- Nocardiosis
- Actinomycosis
- Rhodo–coccosis
- Zygomycosis
- Histoplasmosis
- Coccidioidomycosis
- Aspergillosis
- Mucor mycosis
- Para coccidioidomycosis
- Cryptococcosis

Parasitic

- Neurocysticercosis
- Toxoplasmosis
- Amoebic brain abscess
- Echinococcosis
- Cerebral spanginosis
- Chaga's disease

Neoplastic

- Metastases
- Primary brain tumor
- Primary CNS lymphoma

Inflammatory and demyelinating

- Multiple sclerosis
- Acute disseminated encephalomyelitis
- Sarcoidosis
- Neuro – Behcet's disease
- Whipple 's disease
- Systemic lupus erythematous

In majority of the cases, gliomas and metastatic lesions are single whereas abscesses and multiple sclerosis lesions are multiple. Metastatic deposits are often solid nodular lesions that may become ring-enhancing possibly because of central necrosis (Schwartz, Erickson and Lucchinetti, 2006). In developing and poor countries, the spectrum of etiologies of multiple ring-enhancing lesions of the brain is likely to be different as infective pathologies are more frequently encountered.

The most common radiological abnormality seen in young Indian patients with epilepsy is single small ring enhancing lesion. The two most common differential diagnosis in clinical practice include neurocysticercosis and tuberculomas (Shetty et al., 2014). In an immunocompetent host, the most common differential diagnosis include neoplastic lesions, pyogenic brain abscess or demyelination. On the other hand,

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cerebral toxoplasmosis, neurocysticercosis, primary CNS lymphoma and CNS fungal infections are differential in immunocompromised patients (Cheo et al., 2019).

Metastatic lesions are typically sub-cortical, occurring in or near gray matter-white matter (cortico-medullary) junction, whereas primary tumors are usually deeper (Pederson et al., 1989). Deep white matter ring enhancing lesions, especially those with mass effect and surrounding edema, are most 5 often primary neoplasm (eg,glioblastoma multiforme) or abscesses. The ring enhancing lesion of a cerebral abscess is classically described as having a smooth inner margin and a smooth outer margin. Imaging features of a necrotic neoplasm include a thick irregular ring with a shaggy inner margin, multilocular and complex ring pattern and a wall that is thicker than 10mm (at least in some areas) (Smirniotopoulos et al., 2007). An incomplete ring may be seen in active demyelination, both in multiple sclerosis and in tumefactive demyelination (Masdeu et al., 1996).

MATERIALS AND METHODS

Selection of patients: -Patients referred to the Department of Radiodiagnosis who are being evaluated for specific neurological symptoms and pathologies and underwent Magnetic resonanceimaging/ spectroscopy (brain) for the detection and diagnosis of the same

Study design– Hospital based Prospective observational study

Study duration– From November 2020 to October 2021

Sample size: - Sample size was taken 32

Inclusion criteria

- All cerebral ring enhancing lesions detected on contrast MR Studies.
- Patients giving consent

Exclusion criteria

- Patients with contraindications to conventional MRI
- Patients with renal insufficiency.
- Patients with motion disorder and claustrophobia
- Patients not capable of giving consent

Sampling technique

A convenient sampling technique was used to enroll the patients in study till the sample size completion and 32 patients were selected for the study.

Methodology

All the patients gave consent for study and were asked about socio-demographic details and Imaging was performed on SEIMENS MAGNETOM Essenza 1.5 T Magnetic Resonance Scanner.

Sequences

Conventional spin echo sequences, axial T1, T2 and FLAIR; Coronal T2; Sagittal T2; Post contrast axial; DWI; T2 GRE Single voxel spectroscopy was performed. Magnetic Resonance Imaging was performed in Axial, Sagittal and Coronal axis using standard T1 weighted and T2 weighted spin echo sequences and special sequences wherever required. T1 and T2 weighted images were obtained in different planes and analyzed. Plain imaging was followed by intravenous contrast study using Gadolinium on T1 weighted 30 sequence. The dose of contrast was 0.2mmol/kg body weight. The patient was observed for adverse contrast reaction and managed accordingly. Contrast enhanced images was followed by single voxel MR spectroscopy. The voxel was placed on the lesion so that it covers the maximum area of the lesion in a single voxel

In the present study, out of 32, maximum participants i.e. 14 were in age group of > 60years.

In our study, out of 32 participants, 20 were male participants and 12 were female participants.

In the present study, out of 32 participants, maximum i.e. 21 were have headache followed by 13 participants had seizure episodes.

RESULTS

Current study was a hospital based prospective study and conducted in the Department of Radiodiagnosis and Imaging, Acharya Shri Chander College of Medical Sciences and Hospital, Sidhra, Jammu (J&K).

- This study was aimed to find out the characteristic imaging findings, differential diagnosis and role of

Mean	**55.38**
Median	51.00
Std. Deviation	20.440
Minimum	25
Maximum	90

Table 1: Age distribution of study participants:

Age (years)	Frequency	Percent
25-40 years	9	28.1
41-50 years	5	15.6
51-60 years	4	12.5
>60 years	14	43.8
Total	32	100.0

Table 2: Distribution of study participants according to age group:

Gender	Frequency	Percent
Female	12	37.5
Male	20	62.5
Total	32	100.0

Table 3: Distribution of study participants according to gender:

Clinical features	Frequency	Percent
Seizure	13	40.6
Headache	21	65.6
Ataxia	2	6.3
Weakness	4	12.5
Vomiting	5	15.6
Visual disturbance and fatigue	1	3.1

Table 4: Distribution of study participants according to clinical features:

NEUROCYSTICERCOSIS

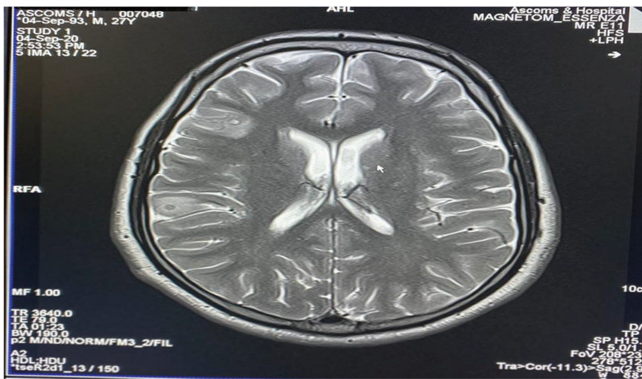

Figure-1: 2W image reveals small hyperintense nodular lesions in right frontal and parietal region with surrounding perilesional edema.

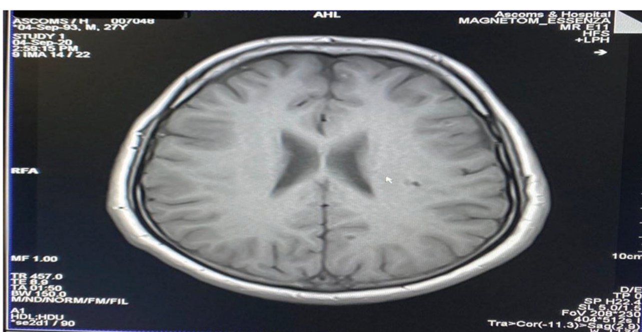

Figure-2: T1WI shows subtle hypointensity in right frontal and parietal region with surrounding perilesional edema.

METASTASIS

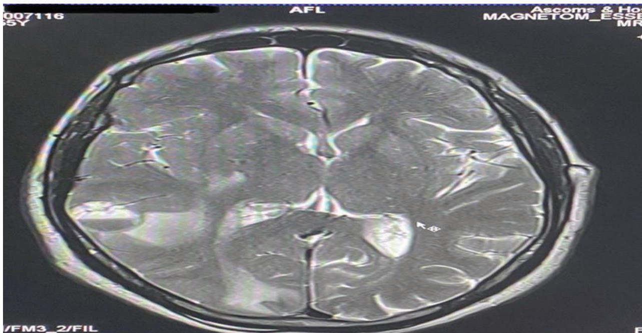

Figure-3: T2WI reveals a well defined heterogeneous signal intensity lesion in right parietal region. Blood fluid level is seen within the lesion. Perilesional edema is seen surrounding the lesion.

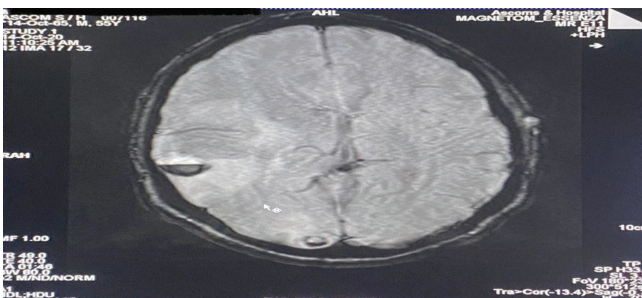

Figure-4: SWI reveal blooming within the lesion. Another small lesion with blooming is seen in right occipital region

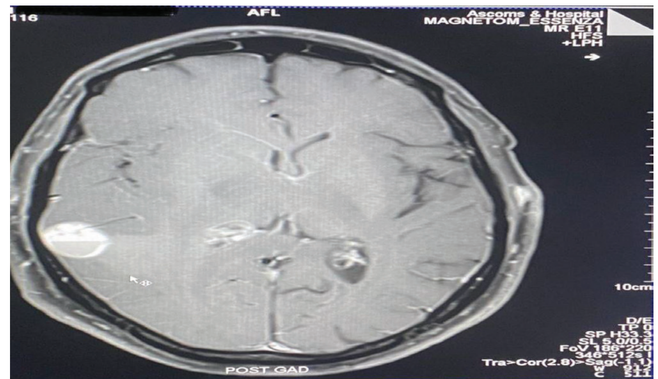

Figure-5: Post contrast images reveals peripheral ring enhancement of the lesion.

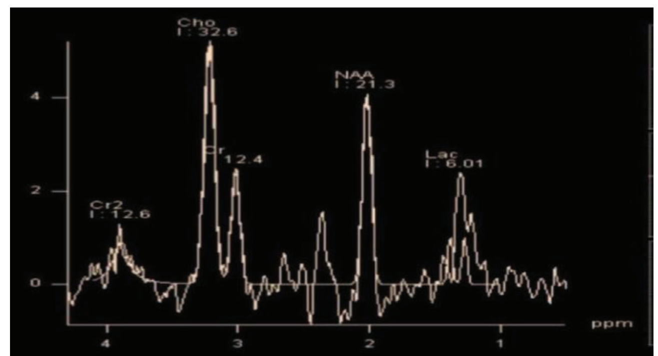

Figure-6: Metastasis. MR spectroscopy shows choline peak at 3.2ppm and lipid/lactate peak at 1.33 ppm.

TUBERCULOMA

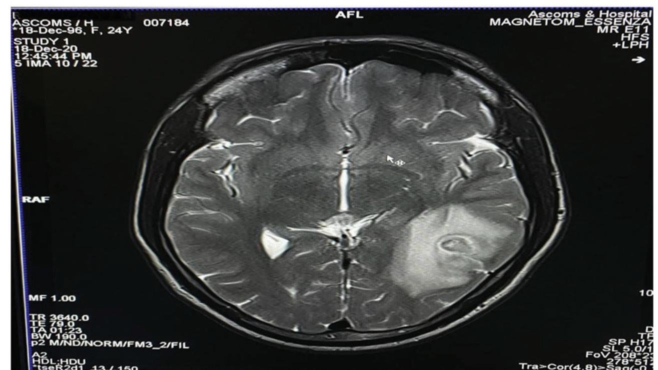

Figure-7: T2WI reveals a heterogeneous predominantly hypointense lesion in left temporal region. Extensive surrounding perilesional edema is seen.

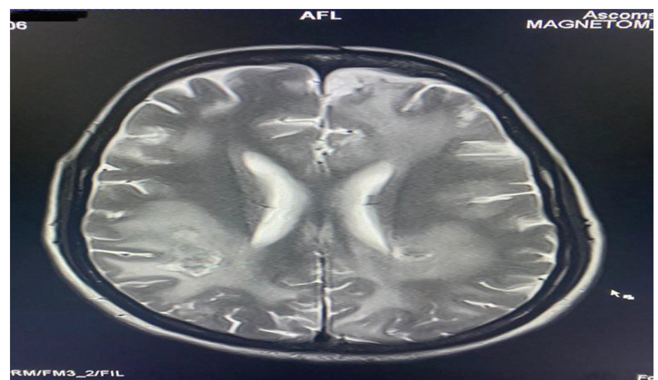

Figure-8: In a known case of HIV, T2WI shows multiple ill defined hyperintense lesions in bilateral cerebral hemispheres with extensive surrounding perilesional edema.

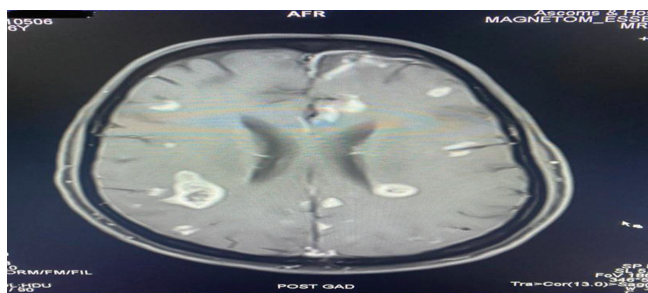

Figure-9:

MR spectroscopy in various ring enhancing lesions on MRI. The study population consisted of 32 patients. The summary of the findings is as follows:

- Mean age of study participants was 55.38 years with SD of 20.44. Youngest participant was 25 year old while oldest participant was 90 year old and out of 32, maximum participants i.e. 14 were in age group of > 60 years.
- 62.5% were male participants and 37.5% were female participants.
- Most common lesion seen was NCC in 37.5% followed by tuberculoma in 25%. Abscess was found in 9.4%, demyelination and neurotoxoplasmosis each in 3.1%, glioblastoma in 6.3% and metastasis was found in 5.6% patients.
- Most common symptom was headache (65.6%) followed by seizure episodes (40.6%). Others clinical features reported by patients were ataxia, weakness, vomiting and visual disturbance and fatigue.
- Mean size of lesion was 2.9 cm with SD of 1.6 and out of 32 participants, 14 (43.8%) were have lesion size 2-4 cm while > 4cm size was found in 6 (18.8%) patients and rest had lesion size of 2-4 cm.
- Maximum patients had multiple lesions (53.1%).
- Bilateral lesions were seen in maximum patients (37.5%) followed by left side lesion in 34.4% patients.
- Hypointensity on T2W images with lipid/ lactate peak on MRS favor the diagnosis of tuberculoma.
- T2 hypointense rim with diffusion restriction on DW images with lactate and amino acid peak on MRS favour the diagnosis of abscess.
- Multiple small sized lesions with T2 hyperintensity, presence of scolex and succinate peak on MRS suggest NCC.
- Presence of hemorrhage as evidenced by T1 hyperintensity and blooming on SW images with choline peak and reduced NAA peak suggest metastasis and glioblastoma.
- Thick irregular rim with elevated choline levels favour the diagnosis of Glioblastoma.
- Incomplete rim of enhancement with the non-enhancing surface facing the cortex with reduced NAA peak favor the diagnosis of demyelination.
- In the present study, 2 abscess lesion, 1 demyelination, 2 metastatic, 10 NCC, 1 neurotoxoplasmosis and 3 tuberculoma lesion showed hyperintense T2 morphology on MRI
- In the present study, all 3 abscess lesion, 2 glioblastoma, 4 metastatic, 1 NCC and 2 tuberculoma lesion showed restriction diffusion on MRS.

DISCUSSION

In our study, mean of study participants was 55.38 years with SD of 20.44. youngest participant was 25 year old while oldest participant was 90 year old and out of 32, maximum participants i.e. 14 were in age group of > 60 years. In our study, out of 32 participants, 20 (62.5%) were male participants and 12 (37.5%) were female participants.

Clinical features and Lesion size and location

In the present study, out of 32 participants, maximum i.e. 21 (65.6%) were have headache followed by 13 (40.6%) participants had seizure episodes. Others clinical features reported by patients were ataxia, weakness, vomiting and visual disturbance and fatigue. In the present study, mean size of lesion was 2.9 cm with SD of 1.6 and out of 32 participants, 14 (43.8%) were have lesion size 2-4 cm while > 4cm size was found in 6 (18.8%) patients and rest had lesion size of 2-4 cm. In our study, maximum i.e. 17 (53.1%) patients had multiple lesions. In our study, maximum i.e. 12 (37.5%) patients had bilateral lesions followed by left side lesion in 11 (34.4%) patients.

Diffusion restriction

In the present study, out of 32 patients, 12 (37.5%) patients showed diffusion restriction lesions while 20 (62.5%) did not show diffusion restriction.

In study by Sachin L et al. (2018), out of 50 patients, 27(54%) of patients show diffusion restricting lesions (partial/complete) and 23(46%) of cases shows no diffusion restriction and in study by Patil et al. (2021), out of 50 patients, 26 patients (52%) showed diffusion restriction whereas 24 patients (48%) did not show any diffusion restriction on DWI.

MR spectroscopy findings

In our study, out of 32 participants, in maximum i.e. 18 (56.3%) patients lactate peak was observed on MRS. Succinate peak was observed in 5 (15.6%) patients, Lipid peak was found in 8 (25%) patients, rNAA peak was found in 7 (21.9%) patients, Acetate peak was observed in 2 (6.3%) patients and Choline peak was found in 7 (21.9%) patients.

In study by Sachin L et al. (2018), out of 50 patients, spectroscopy was possible in only 46 cases and was not performed in 4 cases because of presence of the lesion close to the bone. Choline peak was observed in 28 cases, Lipid in 27 cases, Lactate in 25 cases, reduced NAA peak in 17 cases and amino acids in 3 cases. In study by Patil et al. (2021), out of the 50 patients evaluated, Choline peak was observed in 32 patients (64%), Lipid in 28 patients (56%), Lactate in 26 patients (52%), reduced NAA peak in 16 patients (32%) and amino acids in 7 patients (14%).

Pathologies

In the current study, out of 32 patients, 12 (37.5%) patients were diagnosed NCC followed by tuberculoma in 8 (25%)

patients. Abscess was found in 3 (9.4%), demyelination and neurotoxoplasmosis each in 1 (3.1%), glioblastoma in 2 (6.3%) and metastasis was found in 5 (15.6%) patients.

Kolakshyapati M et al. (2019) revealed 18 patients with brain abscess, 66 glioblastomas, 46 brain-metastases, and 16 tumefactive multiple sclerosis (MS) were diagnosed. Patil et al. (2021) found that most common pathology among them was neurocysticercosis (NCC) that was seen in 19 patients (38%), followed by tuberculomas in 16 patients (32%), abscesses in 7 patients (14%), metastasis in 4 patients (8%), primary neoplasm in 3 patients (6%) and Tumefactive demyelination in 1 patient (2%). Sachinet al. (2018) found that tuberculomas (44%) is the most common pathology followed by NCC (32%), Abscesses (10%), metastasis (10%), primary brain tumour (2%) and tumefactive demyelination (2%).

MRI and MRS findings in different type of diseases

Neurocysticercosis

In our study out of 12 NCC cases, 10 (83.3%) cases showed hypointense signal on T1 weighted images and 2 (16.7%) showed heterogeneous signal on T1 weighted images on MRI. Out of these 12 patients, 10 (83.3%) patients showed hyperintense signal on T2 weighted images. Scolex was identified in 4 cases using CISS-3D sequences. Out of these patients 8 showed lactate peak and 5 showed succinate peak and only 2 showed acetate peak. Patil et al. (2021) found that all the lesions were low or isointense signal on T1 weighted images and hyperintensity was observed in T2 weighted images. Martinez et al. (1989) reported intraventricular neurocysti-cercosis in 22% of cases. MRI is a better modality compared to CT for detection of parenchymal neurocysticercosis according to our study as compared to the study done by Suss RA et al. (1986). Similar Sachinet al. (2018) found that all the lesions were hypo to isointense on T1 weighted images and 12 cases were hyperintense on T2. Out of these12 lesions 9 lesions showed inversion on FLAIR suggesting that the contents are similar to that of CSF. Intense ring enhancement with surrounding perilesional edema was seen in all cases suggestive of active lesions.

Tuberculoma

In our study, out of 32 patients, 8 were diagnosed as tuberculoma. Among them 8 (100%) cases showed hypointense signal on T1 weighted images. Out of these, 3 (37.5%) patients showed hyperintense signal, 2 (25%) isointense and 3 (37.5%) hypointense signal on T2 weighted images. Out of these patients 5 showed lactate peak and 7 showed lipid peak on MRS. Study by Sachin L et al. (2018) reported similar results and found that conglomerate lesions which are hypointense on both T1 and T2. On T1 weighted images they show iso to hyperintense ring which was seen in 12 cases in our study. They may show partial or complete restriction seen in 17 cases – 77.2 %. MRS showed a Lipid peak in 15 (68.1%) cases and it plays an important role in identification of tuberculomas from other infective granulomas. Patil et al. (2021) supported this and found that most of the multiple tuberculomas were conglomerating type of lesions and appeared low signal on T1W and T2W images whereas few of them had high signal T2W images. There was no or partial restriction seen in 14 cases. All lesions showed a nodular or irregular ring like enhancement. Lipid peak was noted on MR spectroscopy in all 16 cases and it plays a crucial role in identifying tuberculomas from other infective granulomas.

Metastasis

In our study, out of 32 patients, 5 were diagnosed metastasis. Among them 3 (60%) cases showed hypointense signal and 2 (40%) showed heterogeneous signal on T1 weighted images. Out of these, 2 (40%) patients showed hyperintense signal and 3 (60%) showed heterogeneous signal on T2 weighted images. Out of these patients, all 5 patients showed choline peak, 4 showed reduced NAA peak and 1 showed lactate peak on MRS.

Sachinet al. (2018) reported similar results and revealed that multiple lesions were identified in all the five cases. All the cases showed high Cho /Cr and Cho /NAA levels. All 5 cases were hyperintense on T2 with 2 cases showing inversion on FLAIR suggestive of cystic metastasis. Veith RG et al. (1965) also stated that similar kind of results and found that thick, irregular type of ring enhancement was noted after contrast administration. Patil et al. (2021) found that Out of the 50 patients, 4 cases were metastasis. All four patients showed more than one lesion. All the cases demonstrated high Choline to creatinine ratio and Choline to NAA ratio. All 4 patients showed hyperintensity on T2W images; however 2 patients showed FLAIR suppression which suggested it to be a cystic metastasis.

Abscess

In our study, out of 32 patients, 3 were diagnosed abscess. Among them all 3 (100%) cases showed hypointense signal on T1 weighted images. Out of these, 2 (66.7%) patients showed hyperintense signal and 1 (33.3%) showed heterogeneous signal on T2 weighted images. T2 hypointense rim was seen in 1 case. Out of these patients, 3 showed lactate peak and 1 showed lipid peak on MRS.

Patil et al. (2021) reported that out of the 50 patients, abscesses were found in 7 cases– 14%. All abscesses showed hypointensity on T1W images with a hyperintense ring around it noted in 6 cases. It was having hyperintensity on T2W images with hypointense rim surrounding the lesion. These lesions showed absolute diffusion restriction with corresponding low ADC values within it and high lactate levels in all 7 patients suggesting anaerobic glycolysis with amino acids like valine, leucine and isoleucine peaks seen in 3 cases.

Glioblastoma, Demyelination and neurotoxoplasmosis

In our study, out of 32 patients, 2 were diagnosed glioblastoma. Among them all 2 (100%) cases showed heterogeneous signal on T1 weighted images. Out of these, all 2 (100%) patients showed heterogeneous signal on T2 weighted images. Out of these patients, all 2 showed reduced NAA and choline peak on MRS.

In our study, out of 32 patients, 1 was diagnosed demyelination.

It showed hypointense signal on T1 weighted images and hyperintense signal on T2 weighted images. Incomplete rim of enhancement was seen with the non enhancing segment facing the cortex. It showed reduced NAA levels on MRS.

In our study, out of 32 patients, 1 was diagnosed neurotoxoplasmosis. It showed hypointense signal on T1 weighted images and hyperintense signal on T2 weighted images and showed lactate peak on MRS.

CONCLUSION

The most prevalent lesion seen in patients, according to the findings of the current investigation, was NCC, followed by tuberculoma. Other pathologies found in ring enhancing lesions included metastatic lesion, abscess, glioblastoma, demyelination, and neurotoxoplasmosis. In current study multiplanar capability of MRI was useful in determining the anatomical location and extent of lesions. By providing the proper diagnosis based on typical imaging findings, MRI plays a vital role in patient treatment. MRS aids in the identification of a variety of ring enhancing lesions based on various metabolites leading to accurate diagnosis. However, no lesion can be diagnosed solely on the basis of MRS results.

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