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Role of Magnetic Resonance Imaging in evaluation of ring enhancing lesions in brain

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Abstract

Introduction: Intracranial Ring enhancing lesions are commonly encountered radiological abnormality. Wide range of neoplastic and non-neoplastic etiologies has made its diagnosis challenging. Various radiological modalities including MRI help to diagnose and characterize these lesions.

Aims: To evaluate the characteristic imaging findings of various ring enhancing lesions of brain on MRI, age and sex prevalence and assessment of site and nature of the lesions.

Methodology: The study was conducted at Department of Radiodiagnosis, Guru Nanak Dev hospital, Amritsar. During a period of two years, fifty patients with clinical history or CT findings suspicious of ring enhancing lesions were evaluated. The cases were randomly selected from the referred patients. MRI was performed using SIEMENS Magnetom Aera1.5T.

Results: Majority cases were in age group 21-30 years and 41-50 years. Sex prevalence showed male predominance (66.6%). Commonest presenting complaints were seizures (72%). Tuberculomas (52%) were the commonest etiology followed by neurocysticercosis (32%). 50% cases showed multiple lesions. Majority (72%) lesions were located supratentorially. 28% cases involved multiple sites followed by parietal lobe involvement in 24% cases. Contrast study observed thin ring enhancement in 82% cases followed by irregular ring in 10% cases and 8% cases showed thick ring enhancement. MRS performed in 23 cases showed 43.47% cases with lactate peak followed by reduced NAA in 21.73% cases.

Conclusion: The study establishes infective etiologies with TB as the leading cause of ring enhancing lesions in Indian setup. MRI serves as a paramount non-invasive modality in diagnosis and evaluation of these lesions.

Keywords: MRI, Ring enhancing lesions, Tuberculomas, Neurocysticercosis

Introduction

MAGNETIC RESONANCE IMAGING (MRI) has made significant advances in the detection and characterization of brain lesions without the invasiveness or risk of iodinated intravenous contrast agents or the inherent problem of the radiation effect of X-rays. Advanced MR imaging techniques including diffusion-weighted imaging, and MR spectroscopy with conventional MR imaging findings has helped to make a more specific diagnosis for various neurological conditions¹.

Ring-enhancing lesions in Brain are one of the most commonly encountered neuroimaging abnormalities. Widely available imaging techniques, computed tomography and magnetic resonance imaging (MRI) are used to detect wide range of etiologies that present as cerebral multiple ring-enhancing lesions. Clinically, the patients manifest with recurrent seizures, focal neurological deficit, raised intracranial pressure (severe headache, vomiting and papilledema) and loss of sensorium².

On neuroimaging, these lesions are hypodense or isodense on non-contrast computed tomography studies. After contrast administration, there is a ring or a homogeneous disk-like enhancement within the region of hypodensity (which could represent perilesional edema). MRI shows varied signal intensity patterns on T1 and T2 weighted sequences and ring like enhancement on post contrast images. The enhancing lesions are usually surrounded by a varying amount of perifocal vasogenic edema. Typically, these lesions are located at the junction of the gray and white matter, but they could be located in the sub cortical area or deep in the brain parenchyma. Variety of appearance of ring enhancing lesions depending on its etiology, in Contrast Enhanced MRI aids in narrowing down the differentials and in diagnostic accuracy of ring enhancing brain lesions².

Causes of multiple ring enhancing lesion of the brain

I. Infective:

- **Bacterial-** a) Pyogenic abscess b) Tuberculoma c) Mycobacterium avium- intracellulare infection d) Syphilis e) Listerosis
- **Fungal-** a) Nocardiosis b) Actinomycosis c) Rhodococcosis d) Zygomycosis e) Histoplasmosis f) Coccidioidomycosis g) Aspergillosis h) Mucormycosis i) Paracoccidioidomycosis j) Cryptococcosis

- **Parasitic-** a) Neurocysticercosis b) Toxoplasmosis c) Amoebic brain abscess d) Echinococcosis e) Cerebral spanginosis f) Chaga's disease

- II. Neoplastic:** a) Metastases b) Primary brain tumor c) Primary CNS lymphoma

- III. Inflammatory and demyelinating:** a) Multiple sclerosis b) Acute disseminated encephalomyelitis c) Sarcoidosis d) Neuro – Behcet's disease e) Whipple's disease f) Systemic lupus erythematosus².

Aims and Objectives

1. To study the characteristic imaging findings of various ring enhancing lesions of brain on MRI.
2. To establish a differential diagnosis of the various ring enhancing lesions on MRI.
3. To differentiate neoplastic from non-neoplastic brain lesions using MR imaging techniques.

Materials and Methods

The present study was conducted on fifty patients in the Department of Radiodiagnosis, Guru Nanak Dev hospital, Amritsar. Cases with clinical history or CT findings suspicious of cerebral ring enhancing lesions over a period of 2 years were randomly selected for the study.

Inclusion criteria: Patients of all age groups with clinical suspicion of ring enhancing lesions were included in the study.

Exclusion criteria: claustrophobic patients, patients having metallic implants.

Imaging was done with SIEMENS MagnetomAera1.5 tesla. The examination included pre contrast and post contrast T1, T2, FLAIR sequences in axial, coronal and sagittal planes. Susceptibility, diffusion weighted imaging and MR spectroscopy were included in the study as and when required. Routine investigations, laboratory investigations, ultrasonogram and CT were done whenever required.

Observations

Amongst the total of 50 patients presenting with ring enhancing lesions on MRI, it was found that, 26 (52%) cases had Tuberculomas being the commonest cause, followed by Neurocysticercosis which presented in 16 (32%) cases. Cerebral abscesses were seen in 4 (8%)

cases and brain metastasis were found in 3 (6%) cases. Only 1 (2%) case presented with primary brain tumor (Table 1). The maximum number of patients were of age group 21-30 years (20%) and 41-50 years with 10 (20%) cases each, followed by age group of 31-40 years that is, 8 (16%) cases. The minimum age of patient included in the study was 5 years and the maximum age was 82 years. In our study, ring enhancing lesions were seen predominantly in males, comprising 33 (66.66%) cases and male to female ratio was 2:1, as depicted in Table 2. Majority of the patients presented with seizures followed by headache, fever and focal neurological deficits. Multiple lesions were observed in 50% cases, whereas single lesions presented amongst 44% cases and multiple conglomerate lesions were seen in 6% cases. Predominantly, lesions were of size more than 2 cm with most common shape of lesions being round (70% cases), however irregular and oval shapes were also noted. Distribution of the lesions showed supratentorial predilection accounting for 72% cases. Infratentorial involvement and both supra and infratentorial involvement were noted amongst 14% cases each. Table 3 illustrates multiple sites were involved in majority cases 28%, followed by parietal region, that is 12%, while frontal, temporal and cerebellum involvement were found in 12% cases each. On diffusion sequences, no restriction was observed in 43 cases, whereas 5 cases showed restriction and central hypointense dot was observed in 2 cases. Post contrast T1 weighted sequences showed thin ring enhancement in 41 cases, thick ring was noted in 4 cases and irregular ring enhancement was observed among 5 cases. Out of the 23 cases in which MR spectroscopy was performed, lactate peak was seen in most of the patients followed by lipid peak, reduced NAA, choline peak and raised amino acids as shown in table 4.

Tuberculoma

In our study, out of 50 patients evaluated, Tuberculomas were seen in 26 (52%) of the cases. The majority of the patients were in the age group 21-30 years and 41-50 years with 5 cases each. Amongst them, 17 (65.38%) were males and 9 (34.61%) were females. Seizure was the most common clinical complaint; seen in 21 cases followed by headache and fever; seen amongst 16 and 15 cases respectively. Single lesions were seen in 11 (42.31%) cases, multiple lesions were seen in 12 (46.15%) cases, whereas multiple conglomerate lesions were present in 3 (11.53%) cases. Majority lesions were supratentorial

in location; that is 18 (69.23%) cases. Multiple sites were most commonly involved; observed amongst 8 (30.76%), followed by parietal region involvement seen in 7 (26.92%) cases. Most of the lesions were of size more than 2 cm; seen in 17 (65.38%) cases, whereas tuberculomas of size less than 2 cm were seen in 9 (34.61%) cases. Round shaped lesions were the most common morphological appearance amongst the cases of tuberculomas followed by irregular shape and oval shaped lesions. The lesions were mainly iso to hypointense on T1 and hyper to isointense on T2 and FLAIR. No restriction was seen in any of the cases. On contrast enhanced study, thin ring enhancement was noted in 25 cases (96.15%), whereas single case showed irregular ring enhancement (3.84%) with multiple conglomerate appearance. Most commonly associated finding with tuberculomas in our study was perilesional edema; seen in 23 cases, whereas associated meningeal enhancement was noted in 8 cases. Hydrocephalus and mass effect were seen in 4 cases each.

Neurocysticercosis

Out of 50 patients evaluated, Neurocysticercosis was seen in 16 (32%) cases, out of which 11 (68.75%) were male and 5 were females (31.25%) with all the cases of intra parenchymal form. The majority of the patients were of the age group between 21- 30 years; that is 5 (31.25%) cases. The most common presenting complaint amongst the patients was of seizures; seen in 11 (68.75%) cases followed by headache; seen in 9 (56.25%) cases. Multiple lesions were seen in 10 (62.5%) cases, whereas a single lesion was seen in 6 (37.5%) cases. Morphologically, all lesions were round in shape. The lesions were hypo to isointense on T1 and on T2 weighted sequences, 7 (43.75%) cases showed central/eccentric dot representative of scolex. Perilesional edema was the most common associated finding whereas no patient showed any mass effect/midline shift. In contrast study, all these lesions showed thin smooth rim of ring enhancement. MRS was done in 7 cases and showed a lipid peak in 6 out of these 7 cases.

Abscess

Our study showed that, out of 50 patients, abscesses were found in 4(8%) cases, out of which 3 were males and 1 was female. Amongst these patients, fever and headache were the presenting complaints of all the 4 cases; whereas 3 cases also presented with focal neurological deficit and 2 cases presented with

seizures. All the cases showed the size more than 2 centimeters and lesions were hypointense on T1 weighted images and hyper intense on T2 weighted images. On contrast study 3 (75%) cases showed thick ring enhancement, whereas thin ring enhancement was seen in 1 (25%) case. All the cases depicted diffusion restriction, and MRS study conducted in 2 of these cases, showed lactate and amino acid peak. Significant associated perilesional edema was noted in all the cases followed by mass effect seen in 3 out of 4 cases.

Metastasis

In our study, 3 (6%) cases were of metastasis, with known primary of carcinoma breast, lung and prostate, out of 50 observed subjects. Two cases showed metastasis in supratentorial region; whereas one of the metastatic lesion was observed in infratentorial region. Amongst the three cases of metastasis; 2 patients were of age more than 60 years. All the cases were of size more than 2 centimeters. Multiple lesions were seen in

two of these cases. All these lesions were hyperintense on T2 weighted images and showed no restriction of diffusion studies. On contrast administration, all the 3 cases showed irregular ring enhancement. MRS study was done in 2 of these cases and showed increased choline with reduced NAA.

Primary brain tumor

Our study observed a single case of Primary brain tumor, which was a proven case of Glioblastomamultiforme. This mass lesion was more than 2 centimeter in size with heterogenous signal intensity showing both solid and cystic components. Partial diffusion restriction and areas of blooming were seen in diffusion weighted sequences and susceptibility weighted sequences respectively. On contrast study, irregular ring enhancement of the cystic component was noted. Mass effect in the form of midline shift of 7mm was seen.

Table 1 Incidence of various ring enhancing lesions (n=50)

Etiology	No. of cases	Percentage (%)
Neurocysticercosis	16	32
Tuberculoma	26	52
Abscesses	4	8
Metastasis	3	6
Primary Brain Tumor	1	2
Total	50	100

Figure 1 Sex distribution of cases (n=50)

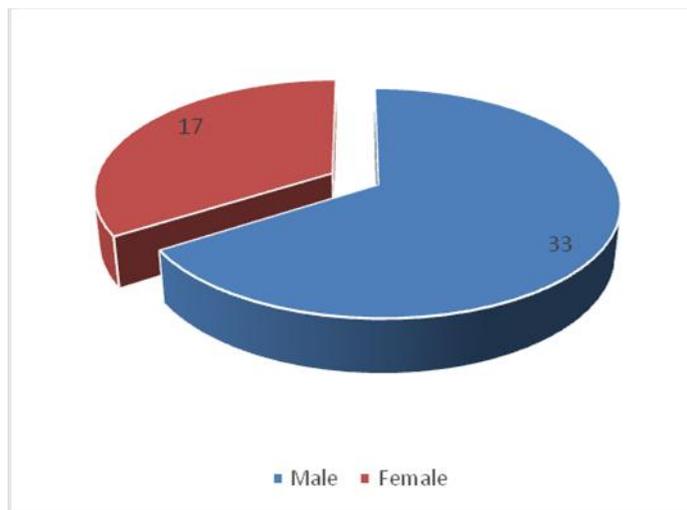


Figure 2

Distribution of the patients according to site of lesions (n=50)

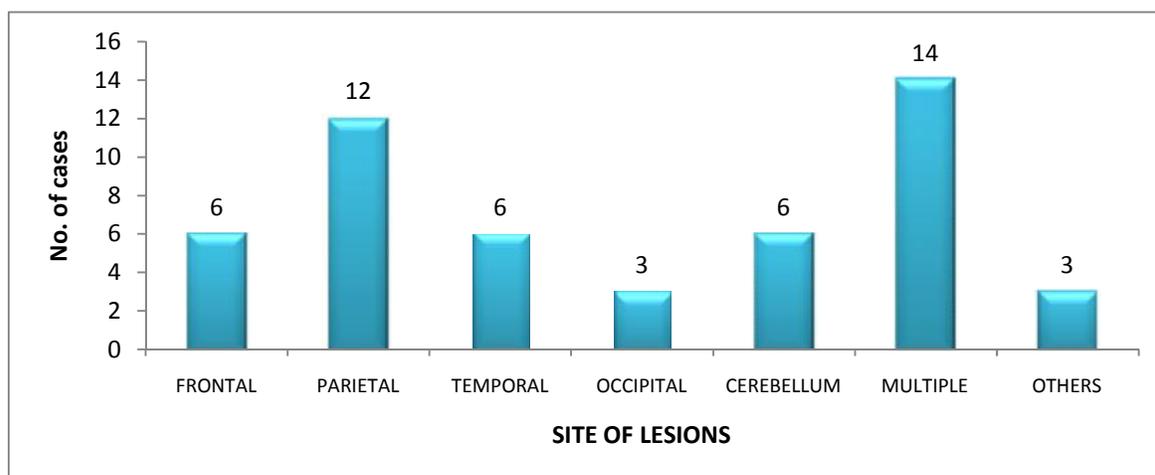


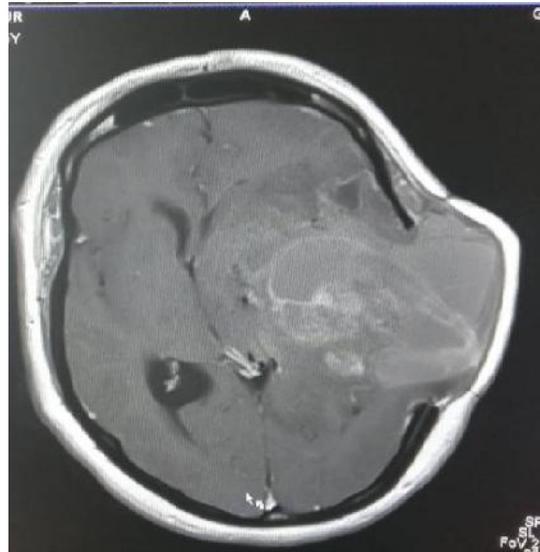
Table 2 MR Spectroscopy findings (n=23)

MRS Findings	No. of patients	Percentage (%)
Lactate	10	43.47
Lipid	7	30.43
Choline	4	17.39
Reduced NAA	5	21.73
Amino Acids	2	8.69

Photographs



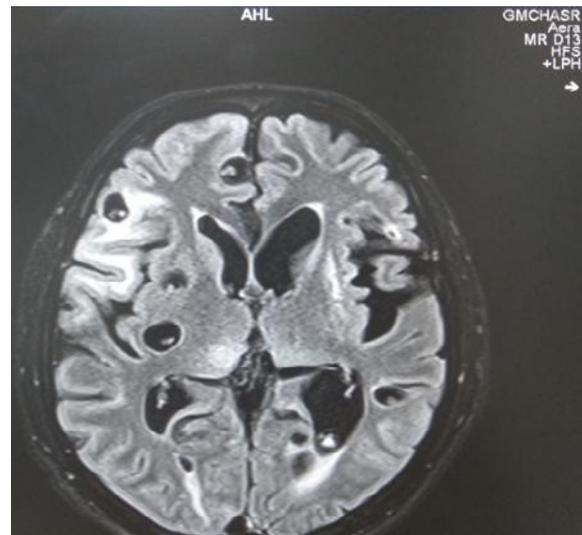
Post contrast axial T1 weighted image
 In a known case of HIV, MRI study Contrast study showed thin irregular enhancement of the conglomerate lesions.



Post contrast axial T1 weighted image
 In a known case of glioblastoma multiforme, MRI study revealed a large irregular heterogenous signal intensity lesion with solid and cystic components causing significant mass effect in form of midline shift. Irregular enhancement of the cystic component was seen in post contrast T1W sequences.



Axial T1 post contrast sequence
 Metastasis was seen in a patient with primary lung carcinoma as an irregular lesion in relation to cerebellum with significant perilesional edema. Contrast study showed thick irregular enhancement of this lesion.



Axial FLAIR sequence
 Neurocysticercosis in a patient, presented as multiple round lesions seen scattered throughout the brain parenchyma, which were hypointense on T1W and FLAIR sequences. T2W sequences showed hyperintensity in these lesions with characteristic central dot (scolex). Perilesional edema was seen around few of these lesions and diffusion restriction was not noted in any of these lesions.

Discussion

In a study conducted by Seth S et al which concluded that in 50 patients evaluated for ring enhancing lesions, tuberculomas were the most common pathology, seen in 20 (40%) cases, followed by neurocysticercosis (30%), abscesses (18%), metastasis (8%) and primary brain tumors (4%)⁴.

Whereas in a study done by Schwartz KM et al. for ring enhancing lesions on MR imaging on 221 patients revealed that, most commonly associated pathologies in their study were gliomas (40%), metastases (30%), abscesses (8%) and multiple sclerosis (6%)⁵. The possible cause for this variation might be due to increased prevalence of infectious etiologies particularly tuberculosis amongst the developing countries.

Sebastian B et al in their study observed that the maximum number of patients were in the age group of 20-40 years (36%) and least in the age group of greater than 60 years (7%). Tuberculomas and Neurocysticercosis were seen maximum in the age group of 20-40 years (59% and 38%, respectively). Metastasis were seen mostly in the age group greater than 60 years (58%)³.

Elsadway ME and Ali HI evaluated 25 patients with ring enhancing lesions on MRI and found 15 (60%) of them were males and 10 (40%) were females⁷. In a study conducted by Seth S et al ring enhancing lesions were seen predominantly in males, comprising 35 cases (70%), while only 15 cases (30%) were seen in females⁴.

Mahato PS et al evaluated that out of a total of 40 patients, 23 (57.5%) patients presented with headache. The second most common presenting complaint was that of seizures in 21 (52.5%) patients; fever was seen in 17 (42.5%) patients, vomiting in 16 (40%) patients and loss of consciousness in 21 patients (52.5%)⁸.

Elsadway ME, Ali HI studied 25 patients with ring enhancing lesions on MRI and MRS. The MRS study showed absence of Cho, Cr, and NAA and increased concentrations of various amino acids (acetate, alanine, and lactate) in abscesses and in tuberculosis, there was prominent decrease NAA/Cr and slight decrease Cho/NAA with elevated Lipid/lactate peak while in neurocysticercosis, lactate and succinate were elevated⁷.

Guner S et al retrospectively reviewed the data of 27 patients with intracranial tuberculomas. Their study consisted of 17 women and 10 men with a mean age of 26 years (14–51 years). A total of 64 tuberculomas were found in these patients, of which 41 were distributed in the cerebral hemispheres, 17 in the cerebellar hemispheres, and 6 in the brainstem⁹.

Kim TK et al observed six patients with intracranial tuberculomas. On T1-weighted images, the granulomas showed a slightly hyperintense rim surrounded by a complete or partial rim of slight hypointensity and central isointensity or mixed isointensity and hyperintensity in five patients and homogeneous isointensity in one patient. On T2-weighted images, the entire portion of the granuloma showed slightly heterogeneous isointensity or hypointensity with small, markedly hypointense foci in five patients, and a hyperintense center surrounded by a hypointense rim in one patient. On postcontrast T1-weighted images, there were single or multiple conglomerate ring enhancements within a tuberculoma in all six patients¹⁰.

Wassay M et al studied 100 patients of intracranial tuberculomas. The age range was 1 to 75 years. 31 patients had solitary lesions, whereas 69 patients had multiple lesions. The diameter of these lesions ranged from 1 mm to 5 cm. Lesions more than 1 cm showed varied enhancement, including irregular shapes, ring like shapes, open rings and lobular patterns. 37 patients had hydrocephalus. Other features included cortical and subcortical infarcts (12 patients), calcification (10 patients), edema (33 patients), meningeal enhancement (12 patients), mass effect, and/or midline shift (18 patients). A hypointense core with a hyperintense rim was the most common signal characteristic on T2-weighted MRI. The central hypointensity on T2-weighted and fluid-attenuated inversion recovery (FLAIR) images reflected extensive necrosis and hypercellularity¹¹.

Patil TB et al evaluated 40 patients of neurocysticercosis. In their study male: female ratio was 2.07 with a mean age of presentation among patients being 29.62 ± 9.08 years. The commonest presentation was seizures in 38 (95%) cases; 29 (72.5%) patients had a single lesion and 11 (27.5%) patients had multiple lesions. Commonest site of the lesion was parietal lobe (45%). Neurocysticercosis lesions usually measure 20 mm or less in their maximal dimension. Majority (60%) of the patients were found to have a maximum lesion diameter less than 10 mm¹².

Leuthardt EC et al reviewed the MRI findings of 5 patients presenting with ring enhancing lesions that ultimately proved to be brain abscesses were retrospectively reviewed. Restricted water diffusion, as indicated by hyperintensity on DWI and low ADC, in ring enhancing lesions assisted in differentiating brain abscess from necrotic tumor. This information facilitated in the stereotactic surgical planning: abscesses should be preferentially centrally aspirated, whereas necrotic brain tumors should have diagnostic tissue biopsy from cavity walls¹³.

Seth S et al studied 4 cases of metastasis on MRI. They observed that most of these lesions were hypointense on T1WI, hyperintense on T2WI and FLAIR with ring enhancement on contrast study. Disproportionate perilesional edema was a notably seen. MRS showed intratumoral choline peak with no choline elevation in peritumoral edema⁴. Mahato PS et al. observed that 71% of metastatic lesions were multiple on neuroimaging. All patients with parenchymal metastases involved the supratentorial brain. All demonstrated perilesional edema to variable degree and were largely confined to the white matter⁸.

Most of the primary tumors are large in size and are often located deep in the white matter. Primary brain tumors frequently cross the midline. For example, glioblastomamultiforme frequently cross the midline by infiltrating the white matter tracts of the corpus callosum².

Conclusion

Ring enhancing lesions in brain are commonly encountered radiological abnormality. Due to its wide range of etiologies including infective, neoplastic, vascular and inflammatory; its diagnosis has always been challenging.

Amongst the present scenario in developing countries, infective etiologies are more common; especially in background of Tuberculosis followed by Neurocysticercosis. However abscess, metastasis and primary brain tumors also contribute to the number of ring enhancing lesions encountered in daily practice. Although a series of tests are required for making definite diagnosis in these cases but MRI being noninvasive and free from radiation risks has become a paramount imaging modality. Multiplanar MRI has helped to precisely identify anatomical location as well as extent of the lesions. Newer imaging techniques such as MR spectroscopy has helped to

characterize these lesions on the basis of various metabolites leading to aid in accurate diagnosis.

Thus, MRI along with its special sequences including MRS has emerged as the most ideal noninvasive modality for detection and characterization of ring enhancing lesions in brain and has helped in establishing its etiology.

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Conflict of interest: None declared

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