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EVALUATION OF RING ENHANCING LESIONS USING 3 TESLA MRI

Radio-Diagnosis

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ABSTRACT

Aims & Objectives: To evaluate the role of MR imaging [conventional and contrast-enhanced MRI in conjunction with advanced MRI techniques (such as MR spectroscopy and perfusion in few cases)] in verification and differentiation of different brain ring enhancing lesions, for better diagnostic purpose and management outcome. To establish a differential diagnosis of the various ring enhancing lesions on conventional MRI. To differentiate neoplastic from non-neoplastic brain lesions using conventional and advanced MR imaging techniques. **Settings and Design:** A prospective observational study was conducted on 50 patients referred to the department of Radio-diagnosis from different departments of Shri Ram Murti Smarak Institute of Medical Sciences, Bareilly from April 2021 to March 2022 with complains of seizures, headache, fever and others with MRI findings suggestive of presence of a ring enhancing lesion. **Patients and methods:** All the 50 patients were subjected to 48 channel MRI machine Siemens Magnetom Skyra of 3 Tesla field strength. Conventional spin echo sequences, axial T1, T2 and FLAIR: Coronal T2; Sagittal T1; Post contrast axial, coronal and sagittal; DWI; T2 GRE Single voxel spectroscopy was performed at TE of 144. The voxel is placed on the lesion so that it covers the maximum area of the lesion in a single voxel. Special sequences such as CISS 3D were used as and when required. The findings of MRI were then reviewed. **Result:** 50 cases were evaluated by magnetic resonance imaging irrespective of their age which included 31 males and 19 females. Of these, 44 patients (accounting for 88% study population) had non-neoplastic lesions and 6 patients (accounting for 12% of study population) had neoplastic lesions.Out of the 44 patients with non-neoplastic lesions, tuberculomas (44%) is the most common pathology followed by NCC (32%), Abscesses (10%), metastasis (10%), primary brain tumour (2%) and tumefactive demyelination (2%). In cases of neoplastic lesions, metastasis from known primary are more common than primary brain tumour. **Conclusion:** MRI provides an accurate assessment of the brain changes in various ring enhancing lesions, for accurate diagnosis and introduction of immediate treatment. Multiplanar capability of MRI with high-quality soft-tissue resolution was helpful in identifying precise anatomical location and the exact extent of lesions, thereby helping the neurophysicins and the neurosurgeons to make a road map for the treatment.

KEYWORDS

Ring enhancing lesion, 3T MRI, Tuberculomas, Neurocysticercosis

INTRODUCTION

Ring enhancing lesions are one of the most common neuro-imaging abnormalities encountered by the radiologists.[1,2] A variety of infective and non-infective processes display a pattern of ring enhancement on neuro-imaging, which often prohibits a reliable diagnosis and their clinical correlation is essential. In developing countries often it is not possible to perform brain biopsies because of limited neurosurgical and neuropathological facilities. Various imaging modalities like computed tomography (CT) and magnetic resonance imaging (MRI) are used to detect these lesions.[3]

Causes of multiple ring-enhancing lesions of the brain:

A. Infectious

I. Bacterial-
- Pyogenic abscess, Tuberculoma and tuberculous abscess, etc.

II. Fungal-
- Nocardiosis, Actinomycosis, Histoplasmosis, Aspergillosis, etc.

III. Parasitic-
- NCC, Toxoplasmosis, Amoebic brain abscess, etc.

B. Neoplastic

I. Metastases
II. Primary brain tumour
III. Primary CNS lymphoma

C. Inflammatory and Demyelinating
- Multiple sclerosis, Acute disseminated encephalomyelitis, Sarcoidosis, etc.[4]

PATIENTS AND METHODS

The présent study was a prospective observational study conducted betweenJune 2021 to January 2022in SRMSIMS, Bareilly, UPafter obtaining approval from the institutional ethical committee. An informed written consent was obatained for participation in the study. The study was conducted on patients with clinical suspicion of lesions involving the brain who were referred to the department of Radiodiagnosis.

Demographic characteristic and clinical presentation of each patient was noted. All patients had presented with variable symptoms, some of them have known primary disease entity and others presented with headache, seizures, vomitting, limb weakness, abnormal behaviour and body movements, visual disorders or disturbed level of consciousness.50 patients for the undergoing study who were meeting the inclusion criteria were included and were subjected to MRI brain.

Sequences that were acquired for each examination include conventional spin echo sequences, axial T1, T2 and FLAIR: coronal T2; sagittal T1; post contrast 3D MPRAGE, coronal and sagittal; DWI; T2 GRE MR spectroscopy.

Study Definitions:

Ring enhancing lesion: Lesions showing peripheral contrast enhancement in a ring like manner and no enhancement in centre.

Hypointense: Lesion appears less brighter on MRI than surrounding tissues.

Hyperintense: Lesion appear more brighter than surrounding tissues.

Isointense: Lesion appear in similar brightness as of its surroundings.

Mass effect: Compression of surrounding structures like ventricles, CSF spaces etc.

Inclusion Criteria

The study includes-
- All patients with suspicion of cerebral ring enhancing lesions like tuberculoma, metastasis, brainabscess etc.
- All patients with incidentally detected ring enhancing lesions on MRI brain.
- All patients with ring enhancing lesion detected by CT.
- Patients of all ages including children and adults and both genders.

Exclusion Criteria

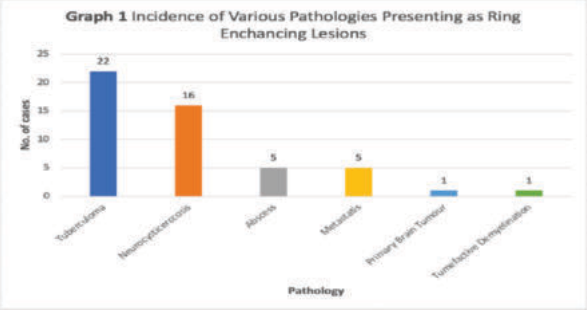
The study will exclude-
- Patients with non ring enhancing lesions of brain.
- Patient having history of claustrophobia.
- Patient having history of metallic implants insertion, cardiac pacemakers and metallic foreign body in situ.
- Patients with contrast allergy and medical renal disease.
- Unwillingness of persons to participate in this study or give informed consent.

RESULTS

The study included a total of 50 patients: 28 males and 22 females, with age ranging from 15 to 60 years. Majority of the patients had presented with seizures and headache.

Table 1: Incidence of various ring enhancing lesions

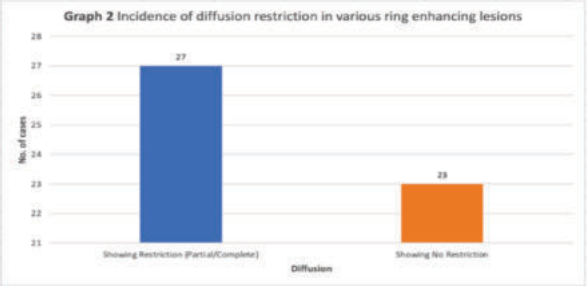
Lesions	No. of Cases
Neurocysticercosis	16
Tuberculoma	22
Abscess	5
Metastasis	5
Primary Brain Tumor	1
Tumefactive Demyelination	1



Graph 1: Incidence of various ring enhancing lesions

Table 2: Incidence of diffusion restriction in various ring enhancing lesions

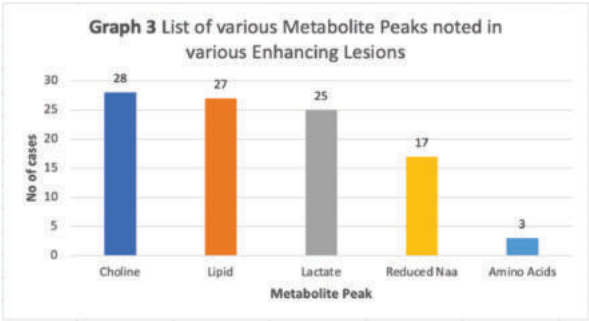
Diffusion	No. of Cases
Showing Restriction (Complete/ Partial)	27
Showing No Restriction	23



Graph 2: Incidence of diffusion restriction in various ring enhancing lesion

Table 3: List of various Metabolite Peaks noted in various Enhancing Lesions

Metabolite Peak	No. of Cases
Choline	28
Lipid	27
Lactate	25
Reduced NAA	17
Amino Acids	3



Graph 3: List of various Metabolite Peaks noted in various Enhancing Lesion

DISCUSSION

Magnetic resonance imaging is a noninvasive, multiplanar and highly accurate method with better inherent contrast that demonstrates the lesion accurately. MRI provides an accurate assessment of the brain changes in various ring enhancing lesions, for accurate diagnosis and introduction of immediate treatment.[2,6]

This was a prospective study done in the Department of Radio diagnosis and imaging at SRMSIMS which is aimed at studying the MR appearances in various ring enhancing lesions of the brain indifferent 50 patients. Seizures are the most common presenting complaint in 84% of cases. Headache (22%), fever (18%), vomiting (6%), ataxia (8%) and motor weakness (6%) were the other presenting complaints.

Out of the 50 patients who were evaluated, tuberculomas (44%) is the most common pathology followed by NCC (32%), Abscesses (10%), metastasis (10%), primary brain tumour (2%) and tumefactive demyelination (2%).The higher incidence of tuberculomas is probably due to the higher prevalence of tuberculosis in India.

Neurocysticercosis

It is the most common parasitic infection in the world. When cysticercosis infects the CNS, it is termed neurocysticercosis (NCC).A "cysticercus" cyst in the brain is actually the secondary larval form of the parasite. The "scolex" is the head-like part of a tapeworm, bearing hooks and suckers. Patients may have multiple lesions at different stages of evolution.[7]

MR in colloidal vesicular stage [Figure 1] shows that the cyst fluid is mildly hyperintense to CSF on T1WI and that the scolex appears hyperintense on FLAIR. Moderate to marked surrounding edema is present. Enhancement of the cyst wall is typically intense, ring-like, and often slightly "shaggy". Restricted diffusion in the scolex and viscous degenerating cyst can be present.[7]

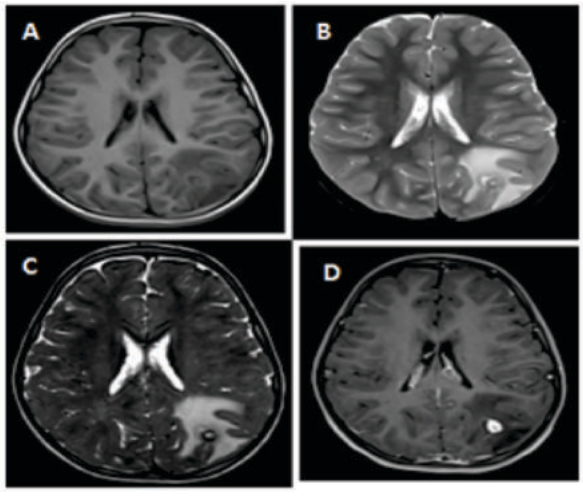


Figure 1: The case demonstrates neurocysticercosis lesion in colloidal vesicular stage (dying scolex).(a) T1W image shows a iso- to hypointense lesion in left posterior parietal lobe with significant perilesional hypointensity. (b) The content of the lesion is displaying CSF signal intensity appearing hyperintense on T2 with a hypointense

peripheral rim and significant perilesional hyperintensity. (c)3D CISS image suggest an eccentric dependent hypointensity in the posterolateral aspect, suggestive of nidus. (d) The lesion is showing smooth thick peripheral rim enhancement on post-contrast study.

TUBERCULOMA

It is the second most common manifestation of neuro-tuberculosis which is characterised by focal parenchymal infection with central caseating necrosis.Most TB granulomas are solid caseating [Figure 2], necrotizing lesions that appear hypo- or isointense with brain on T1WI and hypointense on T2WI.Mild to moderate round or lobulated ring-like enhancement around a non-enhancing center is the most typical pattern.[7]

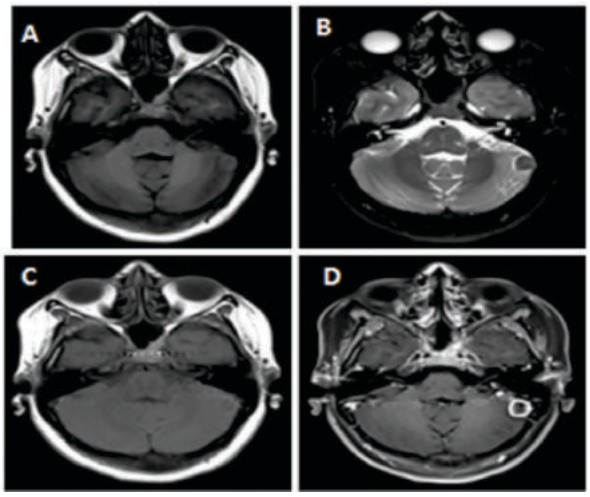


Figure 2: This is a case caseating tuberculoma with a liquefied centre in left cerebellar hemisphere. (a) Axial T1W image shows a well-circumscribed lesion appearing isointense with a hypointense rim. (b) The lesion is predominantly hypointense on T2 WI with this peripheral hyperintense rim. (c) The lesion is showing increased conspicuity on post contrast magnetization transfer imagingwith the rim of the lesion being well-delineated. (d) Post contrast study shows peripheral rim enhancement with non-enhancing internal necrotic areas.

BRAIN ABSCESS

A cerebral abscess is a localized infection of the brain parenchyma. Four general stages are recognized in the evolution of a cerebral abscess: (1) focal suppurative encephalitis/early cerebritis, (2) focal suppurative encephalitis/late cerebritis, (3) early encapsulation, and (4) late encapsulation. Each has its own distinctive pathologic appearance, which in turn determines the imaging findings.[7]

Abscesses in the early capsule stage [Figure 3] are well-delineated round or ovoid masses with liquefied, hyperintense cores on T2/FLAIR. The rims of abscesses are usually thin, complete, smooth, and hypointense on T2WI. A "double rim" sign demonstrating two concentric rims, the outer hypointense and the inner hyperintense relative to cavity contents, is seen in 75% of cases.[7]

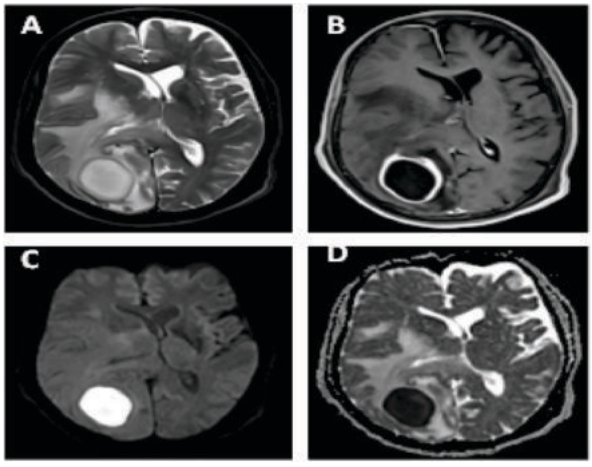


Figure 3: This case demonstrates abscess in its EARLY CAPSULE STAGE. (a)Axial T2W image revealsa well-delineated mass showing classic "double rim" sign with hypointense outer rim and mildly hyperintense inner rim surrounding very hyperintense necrotic core. Note significantperilesional edema and mass edema. (b) the lesion is showing a strongly-enhancing rim that is thinnest on its deepest (ventricular) side. (c) DWI (appearing hyperintense) and (d) ADC(corresponding hypointensity) map in the same case show that necrotic contents of the abscess cavity restrict strongly, whereas the wall of the capsule itself does not.

Metastasis

Metastases are secondary tumors that arise from primary neoplasms at another site. Parenchymal metastases are secondary tumor implants that involve the brain parenchyma.[7]

Metastases from lung, breast, and melanoma account for at least two-thirds of all brain metastases in adults. The overall most common extracranial primary tumor that metastasizes to the brain parenchyma is lung cancer (especially adenocarcinoma and small cell carcinoma).Breast cancer is the second most common primary tumor source, followed by melanoma, renal carcinoma, and colorectal cancer.[7]

Most metastases are iso- to mildly hypointense on T1WI [Figure 4]. The exception is melanoma metastasis, which has intrinsic T1 shortening and thus appears moderately hyperintense. Subacute hemorrhagic metastases show disordered, heterogeneous signal intensity, often with bizarre-appearing intermixed foci of T1 hyper- and hypointensities. Multiple small hyperintense metastases ("miliary metastases") can be mistaken for small vessel vascular disease unless contrast is administered. Both subacute hemorrhage and melanin cause prominent signal intensity loss ("blooming") on T2* (GRE, SWI) images. Virtually all nonhemorrhagic metastases enhance following contrast administration. Metastasis behavior on DWI is much more unpredictable.With the exception of highly cellular neoplasms such as medulloblastoma and lymphoma, most primary brain tumors do not show restriction on DWI.[7]

The differentiation of primary from solitary metastatic brain tumors using pMR is controversial. Some studies suggest that the diagnostic accuracy of MR- including rCBV measurement—is better at grading glial neoplasms than differentiating high-grade gliomas from solitary parenchymal metastases.[7]

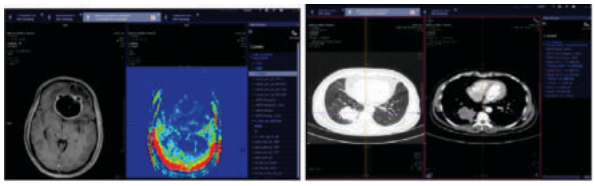


Figure 4: This is a case of cerebral metastasis is a known case of carcinoma lung. Post contrast T1 image shows a ring enhancing lesion from a case of adenocarcinoma of lung.

Primary Brain Tumour

Overall, the most common primary brain tumor in adults is meningioma, followed by astrocytomas and pituitary neoplasms. However, the most common malignant CNS neoplasm is glioblastoma represents about half of all malignant brain tumors and more than 55% of all CNS gliomas in adults.[7]IDH-wild-type glioblastoma (GBM) is the most common and most malignant of all astrocytomas, accounting for over 95% of GBMs. IDH-wild-type GBMs are putative de novo lesions, with no recognizable lower-grade precursor tumor.Three inherited cancer syndromes—namely neurofibromatosis type 1 (NF1), Li-Fraumeni, and Turcot syndrome—demonstrate an enhanced propensity to develop IDH-wild-type GBMs. GBMs are notorious for their ability to spread via multiple routes. Because GBM spreads so rapidly and viable tumor cells are present throughout much of the normal-appearing brain, many neuropathologists and oncologists consider GBM a "whole- brain" disease.

The most common route of GBM spread is through the white matter.MR findings shows a poorly marginated mass with mixed signal intensityon T1W image. Subacute hemorrhage is common. T2/FLAIR shows heterogeneous hyperintensity with indistinct tumor margins and extensive vasogenic edema. T1 C+ shows strong but irregular ring enhancement surrounding a central non-enhancing core

of necrotic tumour.MRS usually shows elevated choline, decreased NAA and mI, and a lipid/lactate peak resonating at 1.33 ppm. pMR shows elevated rCBV in the tumor "rind" and increased vascular permeability.[7]

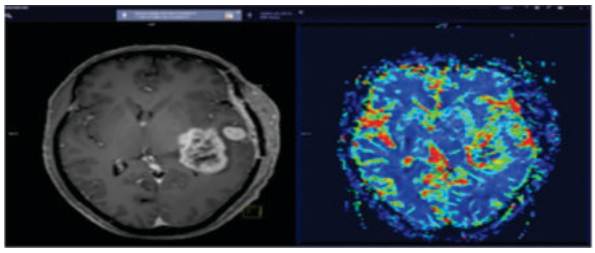


Figure 5: The case included in the study is a histopathologically proven case of Glioblastoma, IDH-Wild-Type. T1 post contrast study reveals a multilobulated space occupying lesionin left cerebral hemisphere with intense peripheral and heterogenous internal enhancement. Moderate to marked rCBV in the peripheral aspect of the lesion on perfusion images is also noted.

Tumefactive Demyelinating Lesion

Multiple sclerosis plaques are usually multiple although 30% of giant "tumefactive" plaquesinitially occur as solitary lesions. These "tumefactive" MS plaques are relatively more common in children and young adults compared with middle-aged and older patients. Over 95% of patients with clinically definite MS have positive findings on MR scans. Therefore, MR is the procedure of choice for both initial evaluation and treatment follow-up. Most MS plaques are hypo- or isointense on T1WI. The hypointensity ("black holes") correlates with axonal destruction. T1 hyperintensity is an independent predictor of atrophy, disability, and advancing disease. A faint, poorly delineated peripheral rim of mild hyperintensity secondary to lipid peroxidation and macrophage infiltration often surrounds sharply delineated hypointense "black holes." This gives many subacute and chronic lesions a characteristic "beveled" or "lesion-within-a-lesion" appearance. T2WI shows multiple hyperintense linear, round, or ovoid lesions surrounding the medullary veins that radiate centripetally away from the lateral ventricles with variable amounts of peri-lesional edema. A prominent incomplete rim ("horseshoe") of enhancement with the "open" non-enhancing segment facing the cortex can be present, especially in large "tumefactive" lesions. MS plaques demonstrate transient enhancement during active demyelination (Figure 6)**.** Punctate, nodular, linear, and rim patterns are seen. Leptomeningeal enhancement occurs in some cases and may be a surrogate marker for cortical demyelination. Some studies using DTI have reported reduced longitudinal diffusivity in areas of axonal injury. Others have used magnetization transfer imaging (MTI) to detect subtle myelin loss in non-lesional tissue (i.e., normal- appearing white matter).[7]

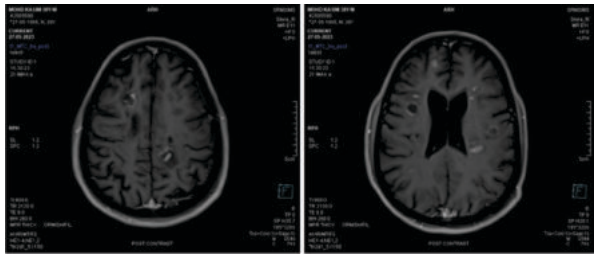


Figure 6: T1 post contrast study is showing hypointense rim of the lesion showing striking but incomplete ring enhancement with significantly non-enhancing internal area.

CONCLUSION

MRI is the most sensitive modality in the characterization of intracranial ring enhancing lesions- RELs. Irregular type of ring enhancement is the common feature noted in most of the lesions. Most common lesion seen is tuberculoma (44%) followed by neurocysticercosis (32%), metastasis (10%), abscess (10%), primary brain tumour (2%) and tumefactive demyelination (2%). MRS helps in characterization of various ring enhancing lesions. However no lesion can be diagnosed based on the findings of MRS as the sole criteria.

Pattern of signal intensity on T2 and FLAIR, DWI and MRS help to differentiate between benign and malignant lesions. CISS3D and MRS are to be routinely used in evaluation of ring enhancing lesions. Multiplanar capability of MRI with high-quality soft-tissue resolution was helpful in identifying precise anatomical location and the exact extent of lesions, thereby helping the neurophysicians and the neurosurgeons to make a road map for the treatment.MRI plays a critical role in patient management by suggesting the correct diagnosis based on characteristic imaging findings.MRI being non invasive and non-radiating is an ideal imaging modality.

Magnetization Transfer Imaging is a technique for improving image contrast in Magnetic Resonance (MR) imaging. It can be used to detect changes in the structural status of brain parenchyma that may or may not be visible with standard MR techniques.

MTC imaging can be used as an additional sequence in effective differentiation of the tubercular and cysticercus granulomas. Use of MTRs may allow subcategorization of multiple sclerosis lesions into those with very low MTR (demyelinated lesions) and slightly decreased MTR (edematous lesions).

In cases of metastatic disease, MTRs of brain lesions indicate structural changes beyond the extent of the lesions seen on standard MR images. These findings may be due to chronic edema, myelin loss, and perhaps previous undetected tumor.

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