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Role of Magnetic Resonance Imaging in Evaluation of Ring Enhancing Lesions in Brain in Correlation with Magnetic Resonance Spectroscopy

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Abstract: ***• Ring enhancing lesions are one of the most commonly encountered neuroimaging abnormalities. • A wide range of etiologies may present as cerebral multiple ring enhancing lesions. • On neuro imaging, these lesions appear as hypodense or isodense mass lesions on non-contrast computed (plain) tomography studies. • After contrast administration, there is a ring or a homogeneous disk like enhancement within the region of hypodensity. • MRI's clinical advantage in early detection of disease is visually demonstrated as unmistakable contrast between gray and white matter and ischaemia / infarct, edema, MS plaques, infection/abscess tumor and hemorrhage. • MR spectroscopy is a potential tool for differential diagnosis between brain abscesses and non-infectious lesions such as primary brain tumor, lymphoma, brain metastasis and tuberculoma. • Magnetic resonance spectroscopy (MRS) provides information about the possible extent and nature of changes on a routine MRI scan by analyzing the presence and / or ratio of tissue metabolites such as NAA, creatine, choline, and lactate etc.***

Keywords: MR SPECTROSCOPY, TUBERCULOMA, NEUROCYSTICERCOSIS, ABSCESS, GLIOBLASTOMA MULTIFORMEA

1. Introduction

1) Ring enhancing lesions are one of the most commonly encountered neuroimaging abnormalities.
2) Widely available imaging techniques, computed tomography and magnetic resonance imaging (MRI) are used to detect these lesions
3) A wide range of etiologies like infections, malignancies, inflammatory, vascular lesions may present as cerebral multiple ring enhancing lesions.
4) It is extremely important to differentiate each lesions from malignancies as it may prevent unnecessary exposure to toxic chemotherapy or radiation or surgery.
5) On neuro imaging, these lesions appear as hypodense or isodense mass lesions on non-contrast computed (plain) tomography studies.
6) After contrast administration, there is a ring or a homogeneous disk like enhancement within the region of hypodensity
7) The enhancing lesions are often of variable sizes and are usually surrounded by a varying amounts of vasogenic edema. Typically, the ring-enhancing lesions are located at the
8) junction of the gray and white matter, but they could be located in the subcortical area, deep in the brain parenchyma or may even be superficial.
9) Contributing to this is MRI's inherent sensitivity as well as its capability to directly image in any place without reformatting, and to be unimpeded or undistorted by bony structures.
10) MRI's clinical advantage in early detection of disease is visually demonstrated as unmistakable contrast between gray and white matter and ischaemia / infarct, edema, MS plaques, infection/abscess tumor and hemorrhage.
11) MR spectroscopy is a potential tool for differential diagnosis between brain abscesses and non-infectious lesions such as primary brain tumor, lymphoma, brain metastasis and tuberculoma.
12) Magnetic resonance spectroscopy (MRS) provides information about the possible extent and nature of changes on a routine MRI scan by analyzing the presence and / or ratio of tissue metabolites such as NAA, creatine, choline, and lactate etc..
13) Widespread usage of faster MRS applications with higher signal-tonoise ratio (SNR) and spatial resolution, allows us to detect functional metabolic changes, which provides more data to understand the exact nature of the tumor and the morphological and physiological changes occurring in surrounding brain parenchyma.
    Longitudinal studies have demonstrated that HMRS is useful in monitoring disease progression and treatment effects.
14) MR spectroscopy also has a prognostic implication

2. Aims & Objectives

a) To study the characteristic imaging findings of various ring enhancing lesions on MRI.
b) To establish a differential diagnosis of the various ring enhancing lesions on conventional MRI.
c) To differentiate neoplastic from non neoplastic brain lesions using conventional and advanced MR imaging techniques.
d) To study the role of MR spectroscopy in the evaluation of various ring enhancing lesions in the brain with single and multi voxel proton MR spectroscopy

3. Methods and Materials

a) 68 Patients of either sex of all age groups who presented to the Department of Radio-diagnosis, Rangaraya Medical College & General Hospital with clinically

suspected and identified on neuro imaging of cerebral ring enhancing lesions during the period AUGUST 2017 to MAY 2018 were analysed retrospectively.

b) MRI scan was performed on MRI GE HDxt 1.5 Tesla

Study procedure (Sequences)

a) Conventional spin echo sequences, axial T1&T2 weighted. Coronal T2; SagittalT1; Post contrast axial, coronal and sagittal; DWI; T2 GRE single and multi voxel spectroscopy was performed at TEof144.

b) The voxel is placed on the lesions that it covers the maximum area of the lesion in both single and multivoxel.

c) PRESS and T1post contrast sequence as localization sequence with 5mm thickness. Other sequences were used as and when required.

d) All cerebral ring enhancing lesions detected on contrast MR studies are taken up for spectroscopy.

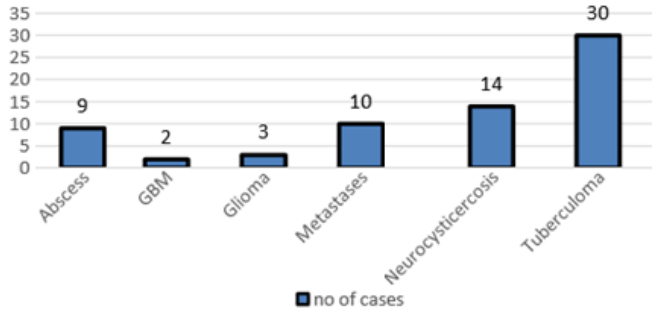
e) All patients with incidentally diagnosed ring enhancing lesion by CT were included in the study

4. Observations and Results

Incidence of various pathologies presenting as Ring enhancing lesions

Lesions	No of cases
• Abscess	9
• Glioblastoma multiforme	2
• Gliomas	3
• Metastases	10
• Neurocysticercosis	14
• Tuberculoma	30

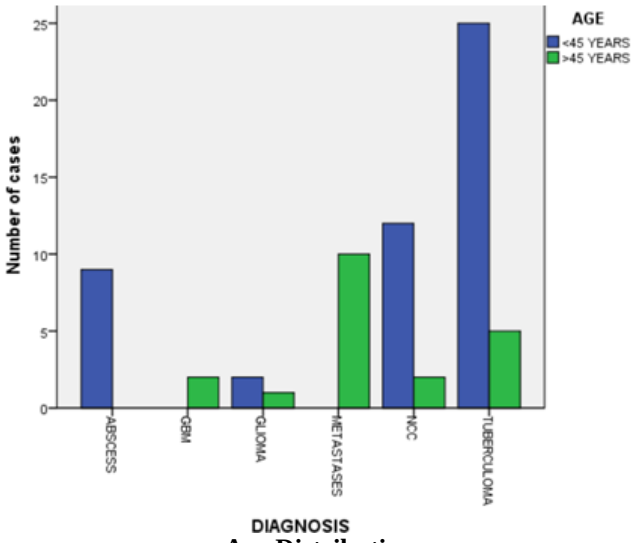
Incidence of various pathologies presenting as ring enhancing lesion



Represents that tuberculomas 30(44.1%) is the most common pathology followed by NCC 14(20.5 %), Abscesses 9(13.2%), metastasis 10(14.7%) and primary brain tumours 5(7.3%).

Age Distribution

	Age		Total
	<45 Years	>45 Years	
Abscess	9	0	9
Glioblastoma multiforme	0	2	2
Gliomas	2	1	3
Metastases	0	10	10
Neurocysticercosis	12	2	14
Tuberculoma	25	5	30
	48	20	68

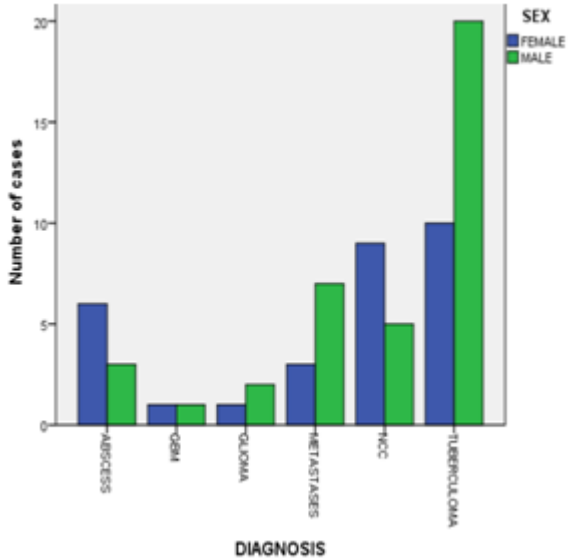


Age Distribution

Represents highest incidence of REL's were found in below 45 years age group accounting for 70.5% of cases and least seen in above 45 age group constituting 29.5%.

Sex Distribution

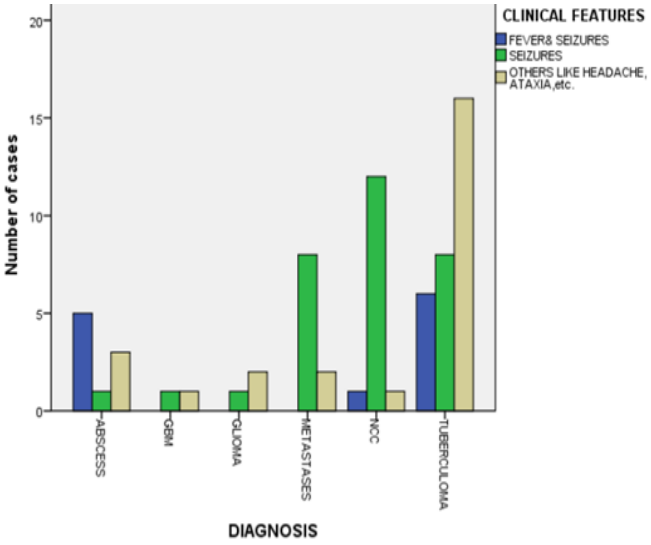
	Sex		Total
	Female	Male	
Abscess	6	3	9
Glioblastoma multiforme	1	1	2
Gliomas	1	2	3
Metastases	3	7	10
Neurocysticercosis	9	5	14
Tuberculoma	10	20	30
	30	38	68



Depicts sex distribution in which 38 (55.9%) were males and 30 (44.1%) were females.

Clinical Features

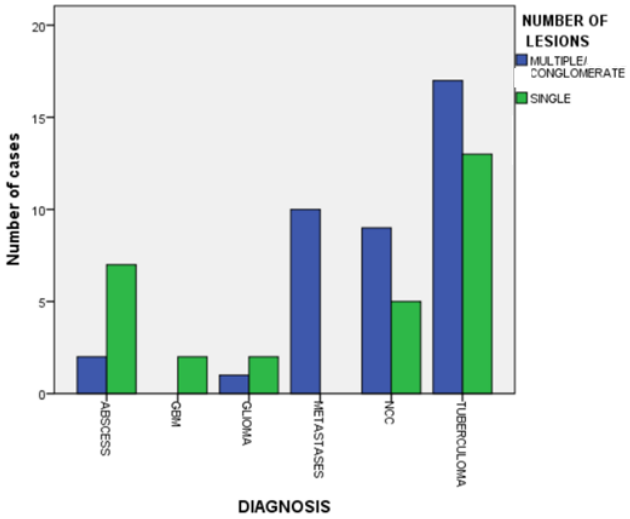
	Clinical Features			Total
	Fever & Seizures	Seizures	Others	
Abscess	5	1	3	9
Glioblastoma multiforme	0	1	1	2
Gliomas	0	1	2	3
Metastases	0	8	2	10
Neurocysticercosis	1	12	1	14
Tuberculoma	6	8	16	30
	12	31	25	68



Depicts clinical features of patients presenting with RELs. In which Seizures are the most common presenting complaint seen in 31cases (45.5%). Fever with seizures seen in 12 cases (17.6%) other presentations were headache, vomiting, ataxia and motor weakness seen in 25 cases (36.7%).

Number of Lesions

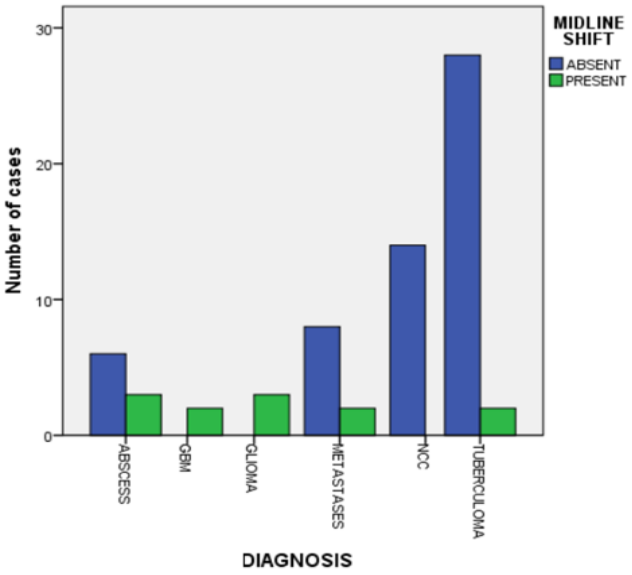
	No. of Lesions		Total
	Conglomerate/ Multiple	Single	
Abscess	2	7	9
Glioblastoma multiforme	0	2	2
Gliomas	1	2	3
Metastases	10	0	10
Neurocysticercosis	9	5	14
Tuberculoma	17	13	30
	39	29	68



Represents number of lesions in which 29(42.6%) of them presented with a single lesion. Multiple or conglomerate lesions were noted in 39(57.4%) of cases

Midline Shift

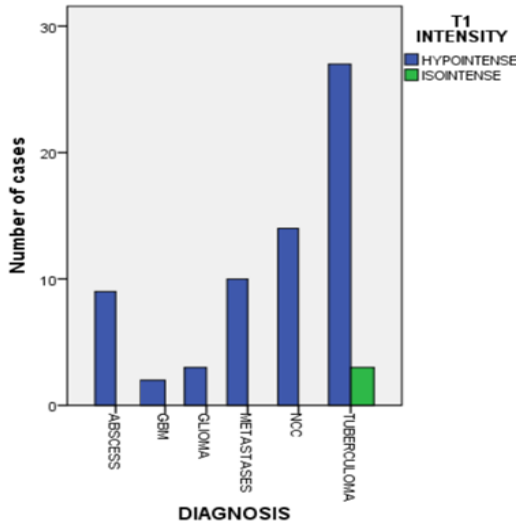
	Midline Shift		Total
	Absent	Present	
Abscess	6	3	9
Glioblastoma multiforme	0	2	2
Gliomas	0	3	3
Metastases	8	2	10
Neurocysticercosis	14	0	14
Tuberculoma	28	2	30
	56	12	68



Depicts midline shift of patients who presented with RELs. Midline shift was not seen in 56(82.3%) of cases and showed midline shift only in 12(17.7%) cases

T1 Signal Intensity

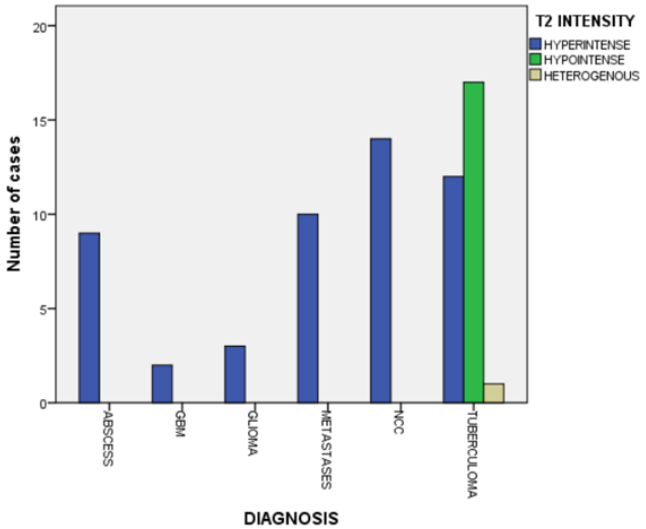
	T1 Signal Intensity		Total
	Hypointense	Isointense	
Abscess	9	0	9
Glioblastoma multiforme	2	0	2
Gliomas	3	0	3
Metastases	10	0	10
Neurocysticercosis	14	0	14
Tuberculoma	27	3	30
	65	3	68



Depicts T1 signal intensity out of which 65(95.5%) cases showed hypointense signal intensity on T1W sequence. Only 3(4.6%) out of 68 cases showed isointense signal intensity on T1W image.

T2 Signal Intensity

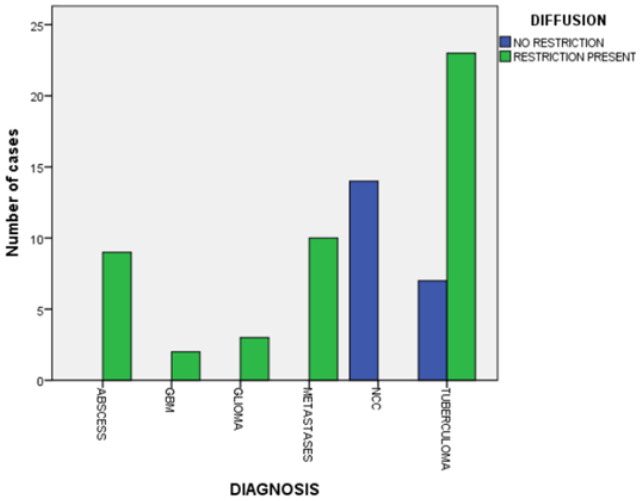
	T2 Signal Intensity			Total
	Hyperintense	Hypointense	Hetrogenous	
Abscess	9	0	0	9
Glioblastoma	2	0	0	2
Gliomas	3	0	0	3
Metastases	10	0	0	10
Neurocysticercosis	14	0	0	14
Tuberculoma	12	17	1	30
	50	17	1	68



Represents T2 signal intensity out of which 50 (73.5%) cases showed hyperintense signal intensity on T2W images. 17(25%) cases showed hypointense signal intensity, all the 17 cases were tuberculomas. 1(1.5%) case showed hetrogenous signal intensity on T2W sequence.

Diffusion Weighted Imaging

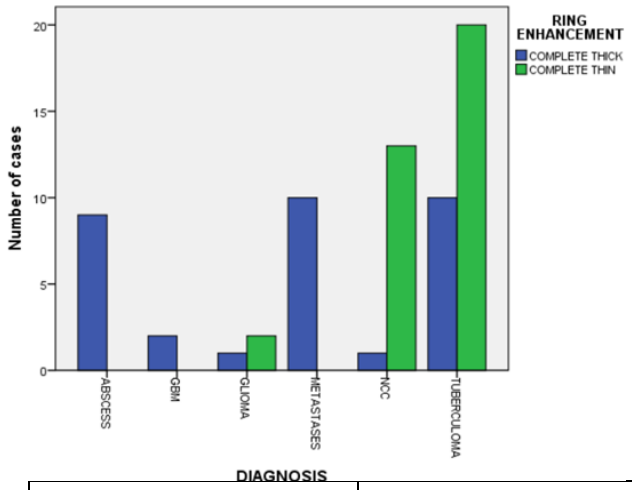
	Diffusion Weighted Imaging		Total
	No Restriction	Restriction Present	
Abscess	0	9	9
Glioblastoma multiforme	0	2	2
Gliomas	0	3	3
Metastases	0	10	10
Neurocysticercosis	14	0	14
Tuberculoma	7	23	30
	21	47	68



Represents DWI of various patients presented with RELs out of which 47(69.1%) of patients show diffusion restricting lesions (partial/complete) and 21 (30.9%) of cases shows no diffusion restriction

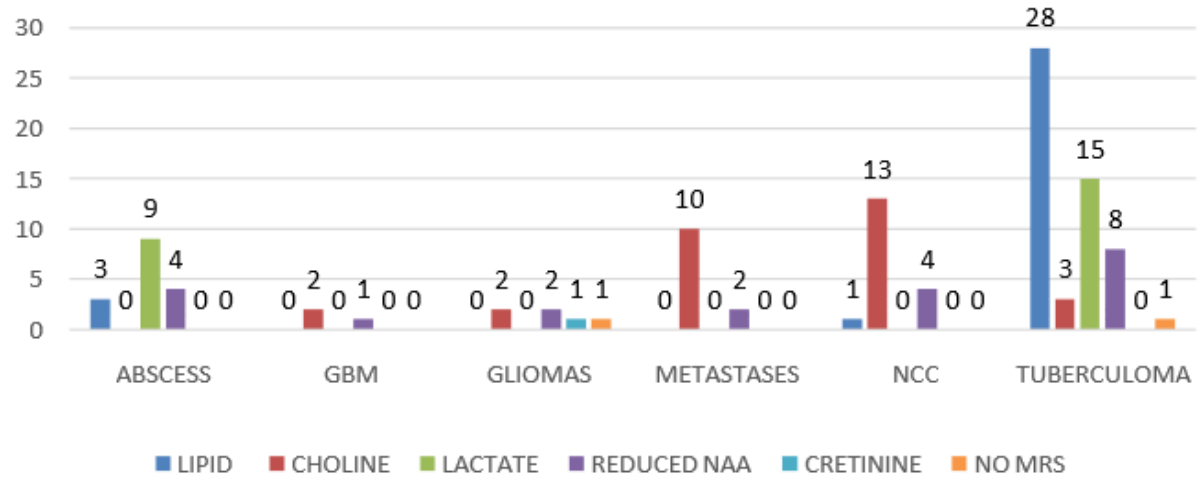
Type of Ring Enhancement

	Ring Enhancement		Total
	Complete Thick	Complete Thin	
Abscess	9	0	9
Glioblastoma multiforme	2	0	2
Gliomas	1	2	3
Metastases	10	0	10
Neurocysticercosis	1	13	14
Tuberculoma	10	20	30
	33	35	68

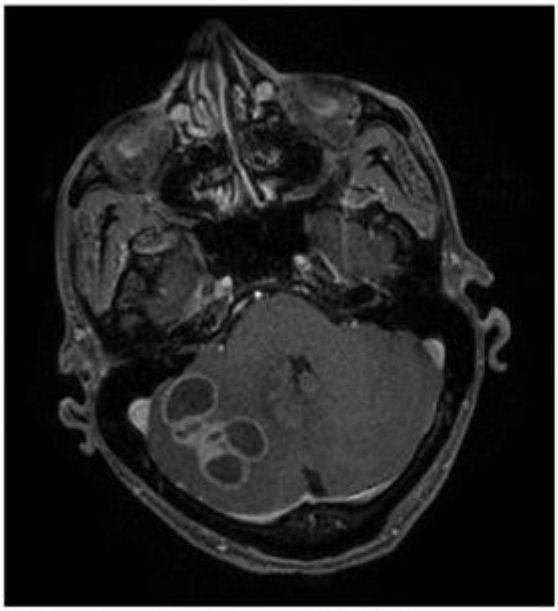


Represents pattern of ring enhancement. Out of Sixty eight patients Sixty eight patients were evaluated, out of which 33(48.5%) cases showed complete and thick ring enhancement and 35(51.5%) cases showed thin ring enhancement

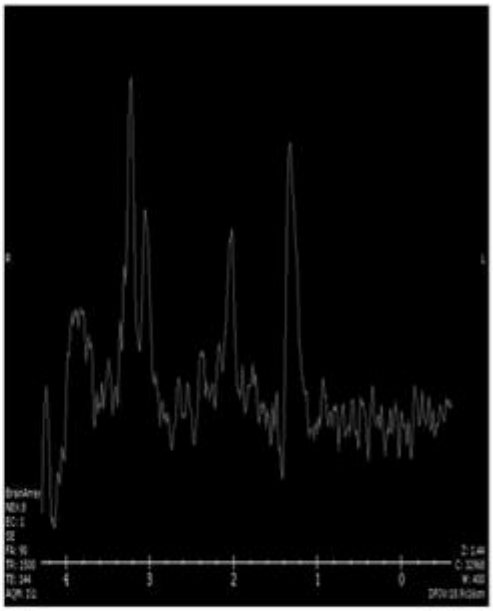
	Metabolites					
	LIPID	CHOLINE	LACTATE	REDUCED NAA	CRETININE	NO MRS
Abscess	3	0	9	4	0	0
Glioblastoma multiforme	0	2	0	1	0	0
Gliomas	0	2	0	2	1	1
Metastases	0	10	0	2	0	0
Neurocysticercosis	1	13	0	4	0	0
Tuberculoma	28	3	15	8	0	1
	32	30	24	21	1	2



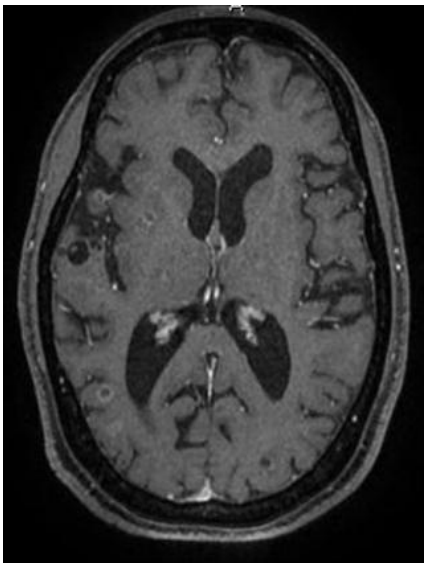
Represents MR Spectroscopy metabolites out of sixty eight cases lipid peak seen in 32(47%) cases out of which 28(41.2%) were tuberculomas. Choline peaks seen in 30(44.1%) cases, reduced NAA seen 21(30.9%) cases and lactate in 24(35.3%)cases.MRS couldn't performed in 2(3%) cases due to lesion proximity to skull vault.



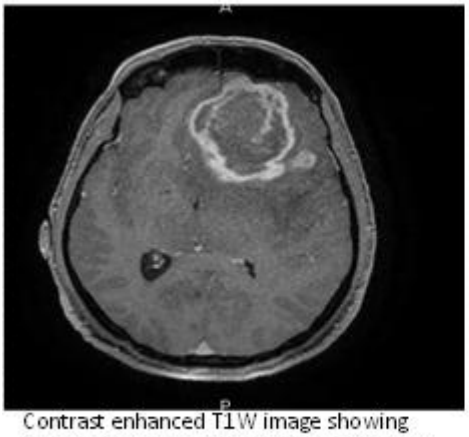
Contrast enhanced T1W image showing multiple conglomerate rim enhancing hypointense lesions in right cerebellar hemisphere –F/S/O TUBERCULOMA



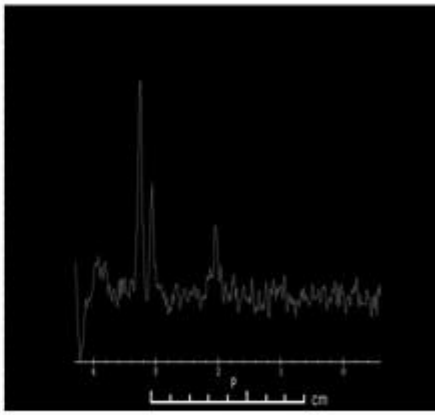
MR spectroscopy showing prominent peak at 1.3 ppm(lipid)



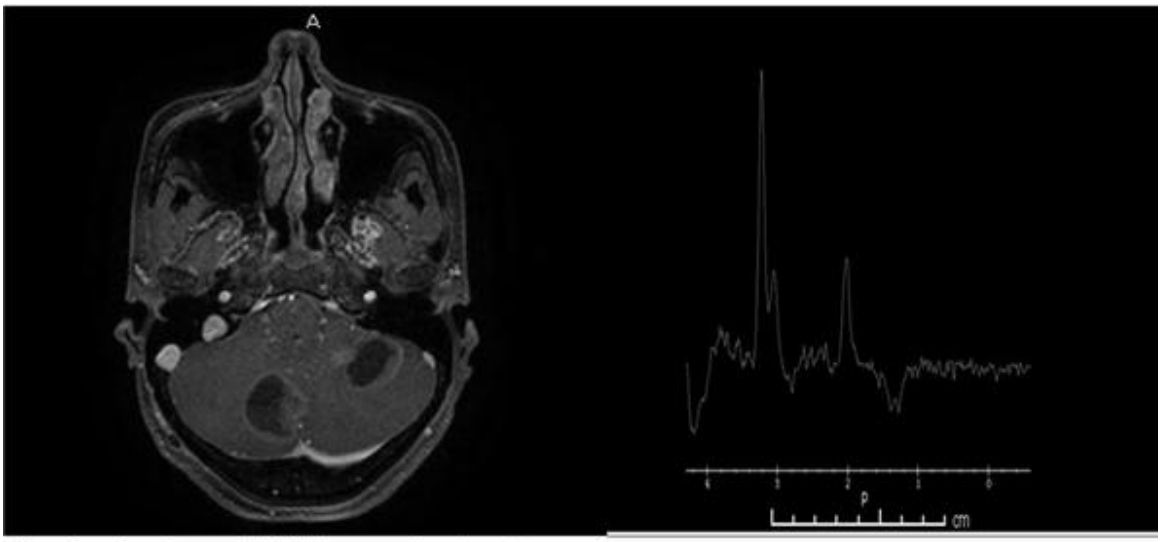
Contrast enhanced T1W image showing multiple well defined rim enhancing round hypointense lesions of varying sizes noted in Rt capsulo ganglionic region, Rt temporal,Rt parietal and Lt occipital region. Lesion in right temporal lobe showing hyperintense focus (SCOLEX) within-F/S/O NEUROCYSTICERCOSIS



Contrast enhanced T1W image showing intense irregular peripheral rim enhancing hypointense lesion -F/S/O GLIOBLASTOMA



MR spectroscopy showing peak at choline (3.2 ppm)



Contrast enhanced T1W image showing two irregular well defined hypointense lesions with thin enhancing wall noted in bilateral cerebellar hemispheres- Metastasis

MR spectroscopy showing peak at choline(3.2 ppm) and inverted doublet peak at 1.3 ppm(lactate)

5. Conclusions

a) MRI is the most sensitive modality in the characterization of intracranial ring enhancing lesions RELs.
b) MRI is an excellent, non ionizing imaging modality with multiplanar imaging capabilities for excellent grey white matter differentiation and identifying precise anatomical location and the exact extent of lesions.
c) The data so far indicated MRI findings of selected ring enhancing lesions were significantly correlated with age of patients.
d) Also this study found that bengin RELs were seen predominantly in less than 45 years of age.
e) Thus MRI plays a critical role in patient management by suggesting the correct diagnosis based on characteristic imaging findings and avoiding further investigations.
f) MRI characteristic imaging finding along with MRS can arrive at pathological diagnosis.
g) However no lesion can be diagnosed based on the findings of MRS as the sole criteria.

6. Discussion

Magnetic Resonance Spectroscopy

Magnetic resonance spectroscopy (MRS) is a means of non-invasive physiological imaging of the brain that measures absolute and relative levels of various brain tissue metabolites. MRS and MRI differ only in the manner in which the data are processed and presented. In MRI, the data is collected in the time domain of free induction decay [FID] signal to obtain information about the nuclear relaxation time namely T1 and T2, which is processed to generate an anatomic image. In MRS, time domain information is converted to frequency domain information via Fourier transformation of the FID time domain signal.

Magnetic resonance spectroscopy receives a sum of individual metabolite signal amplitudes versus time in response to radiofrequency (RF) excitation similar to MR imaging. MRS presents the individual information as metabolite peak amplitude versus frequency, where frequency can be expressed in absolute values of hertz or relative units of parts per million. Its relative amount and chemical structure determine the amplitude and frequency of

a particular metabolite peak. The phenomenon of chemical shift forms the basis of the MR spectroscopy. The relative resonance frequency position of each peak on the plot is dependent on the chemical environment of that nucleus and determines subtle chemical shifts in their absolute (Hz) or relative (ppm) resonance frequencies. An advantage of the ppm scale is that it allows relative chemical shifts to be expressed independently of the main magnetic field strength that is used. As spectral resolution improves, chemical shifts narrow into singlets or split into doublets, triplets, and other multiplets because of a phenomenon known as spin –spin coupling or j coupling.

7. Limitations

- MRS could not be performed in 2 cases due to presence of lesions in close proxmity to the skull vault.
- Findings of this small study sample are consistent with larger studies, however large sample study can be done as the current study results cannot be generalised. In this aspect further studies with large sample size needed to further diagnostic specificity.
- MR perfusion and MTR which were not included in the study are also useful in differentiation of neoplastic and non neoplastic lesions.
- Most of our cases were < 4 cm, so single voxel spectroscopy was used, but in larger lesions multivoxel spectroscopy helps in differentiating the characteristics of the internal contents as well as the wall.

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