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MRI Scan in Evaluation of Intracranial Ring Enhancing Lesions

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Abstract: ***Introduction**: Multiple ring-enhancing lesions are commonly encountered neuroimaging abnormalities. On neuroimaging, these lesions appear as hypodense or isodense space occupying lesions on non-contrast computed tomography studies. After contrast administration, there is a ring- or a homogeneous disk-like enhancement within the region of central hypodensity. Owing to MRIs high inherent soft tissue contrast and its ability to image in multiple planes, MRI has a clinical advantage in early detection of disease as it can differentiate various causes. MR spectroscopy employs the principle of chemical shift imaging to detect metabolites within a ring enhancing lesion and serves as a potential tool for differentiating between various RELs. **Results**: In present study most common lesion seen was tuberculoma (35%) followed by neurocysticercosis (20%), abscess (12%), metastasis (10%), glioblastoma multiforme (8 %) ,toxoplasmosis (6%),multiple sclerosis (5%), radiation necrosis (2%) and subacute infarct (2%). Irregular type of ring enhancement is the most common feature noted in most of the lesions. ears was the most common age group involved (40% of cases) and more than 60 years was the least common age group involved(3% of cases) . Seizure was the most common presenting complaint (70%) followed by headache (29%) and fever (15%). 80 % of cases were presented with multiple lesions and 20% cases were with single lesion. **Conclusion**: MRI is definitive, sensitive, accurate, though costly but very specific, non-invasive, radiation free modality for of intracranial ring enhancing lesions – RELs*

Keywords: MRI, MRI Spine, intracranial ring enhancing lesions – RELs

1. Introduction

Multiple ring-enhancing lesions are one of the commonly encountered neuroimaging abnormalities .Non-invasive imaging techniques like computed tomography and magnetic resonance imaging (MRI) are used to detect these lesions. Ring enhancing lesions may result from a wide range of etiologies. On neuroimaging, these lesions appear as hypodense or isodense space occupying 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 central hypodensity. The enhancing lesions are often of variable size and are usually surrounded by a varying amount of perifocal vasogenic edema. Typically, the ring-enhancing lesions are located at the junction of the gray and white matter, but they could be located in the sub-cortical area, deep in the brain parenchyma or may even be superficial. Owing to MRIs high inherent soft tissue contrast and its ability to image in multiple planes, MRI has a clinical advantage in early detection of disease as it can differentiate tumor , ischemia/infarct, edema, MS plaques, infection/abscess and hemorrhage. MR spectroscopy employs the principle of chemical shift imaging in order to detect metabolites within a ring enhancing lesion and serves as a potential tool for differentiating between various RELs. Magnetic resonance spectroscopy (MRS) analyses the presence and/or ratio of tissue metabolites such as NAA, creatine, choline, and lactate etc. This provides more data to understand the exact nature of the tumour and the morphological and physiological changes occurring in the surrounding brain parenchyma. Longitudinal studies have demonstrated that HMRS is useful in monitoring disease progression and treatment effects. MR spectroscopy also has a prognostic implication.

2. Aims and Objectives

Study the characteristic imaging findings of various ring enhancing lesions on MRI. Establishing a differential diagnosis of the various ring enhancing lesions on conventional MRI. Differentiating neoplastic from non-neoplastic brain lesions using conventional and advanced MR imaging techniques. Study the role of MR spectroscopy in the evaluation of various ring enhancing lesions in the brain with a single voxel proton MR spectroscopy.

3. Literature Survey

Researchers RR. Archana, P. Sunil Kumar, and Anurudh Kishore conducted a study in 2018, evaluating 40 patients over a 2-year period. Their findings revealed a varied distribution of intracranial ring-enhancing lesions (RELs), including 18 tuberculomas, 10 neurocysticercosis (NCC), 4 abscesses, 4 metastases, 2 primary brain tumors, and 2 cases

of toxoplasmosis. Notably, the highest incidence of RELs occurred in the 21-30 age group, constituting 10 cases, while the least were observed in the age group >60 years, accounting for 5%. The study emphasized the pivotal role of MRI as the most sensitive modality for characterizing these lesions, providing crucial diagnostic insights based on characteristic imaging findings.

In another investigation, Rakesh K. Gupta, Mahesh Prakash, Ashit M. Mishra, Mazhar Husain, Kashi N. Prasad, and Nuzhat Husain explored the role of diffusion-weighted imaging (DWI) in distinguishing intracranial tuberculomas and abscesses from cysticercus granulomas. Their study, comprising over 100 lesions in 43 cases, revealed that 93.3% of tuberculoma cases exhibited DWI restriction, contrasting with only 15.3% in cysticercus granulomas.

Dr. Jernail Singh Bava, Dr. Ashwini Sankhe, and Dr. Swapnil Patil delved into the diverse etiologies of multiple ring-enhancing lesions in the brain. They particularly highlighted the potential of MR spectroscopy for molecular-level analysis, assessing tissue metabolites like NAA, creatine, choline, and lipid. Their case study of 50 patients emphasized the utility of MR spectroscopy as an adjuvant to conventional MRI. The study showcased varied incidences across age groups, with the highest occurrence in the 11-20 age group (28%) and the least in those aged >61 years (2%). Tuberculomas (36%) were identified as the most common pathology, followed by NCC (34%), abscesses (12%), primary brain tumors (10%), metastasis (6%), and toxoplasma infection (2%).

Nikhil Parvatkar, P. Zala, and C. Raychaudhary conducted a study on 38 patients with clinical suspicion of infective CNS lesions. Their investigation revealed that tuberculomas were the most common pathology encountered (57%), followed by neurocysticercosis (29%) and brain abscesses (13%).

In a study spanning from November 2009 to November 2011, Sachin L., Jeevika M U., Gurumurthy B, and Fahid Rahman CH aimed to study the characteristic imaging findings of various ring-enhancing lesions using MRI. Among the 50 patients evaluated, tuberculomas were again identified as the most common pathology (22 cases), followed by NCC (16), abscesses (5), metastasis (5), a case of glioblastoma multiforme (GBM), and a case of multiple sclerosis (MS). The study concluded that MRI stands out as the most sensitive modality for characterizing intracranial ring-enhancing lesions, providing valuable insights through characteristic imaging findings.

4. Problem Defination

Ring enhancing lesions of the brain can be caused by different pathological conditions. The common lesions being some granulomas, primary brain tumors, abscess etc. Diagnosis of them remains a concern especially when clinically not suspecting one.

5. Material and Methods

This observational (cross-sectional) study was conducted on 100 patients for one and half years from october 2020 to march 2022 in Department of Radiology in PDU Gov. Medical college and Civil hospital, Rajkot, Gujarat; after taking proper consent from them. The indication and details of the radiological procedure is explained to the patient. A written consent is obtained either from patient or his/her relatives. Each patient had undergone MRI as indicated. Findings of different imaging modalities are correlated with surgical & clinical outcomes whenever available. Sample size: 100, Study design: observational study, Type of study: retrospective, Duration of study: 1.5 years (October 2020 to March 2022), Place of study : PDU Medical College and Civil Hospital, Rajkot, Instruments used: 1.5 T MRI (2156158-143) GE

Method of Collection of Data
The main source of data for the study were patients referred to the department of Radio diagnosis for MRI brain and Contrast MRI brain, at tertiary care level hospital.

Inclusion Criteria
The study includes, Cerebral ring enhancing lesions detected on contrast MR studies were taken up.

Equipment and Technique Used
The MRI scan was performed using dedicated head coil. It possesses a Ultra compact, Active shielded superconducting magnet with a magnetic field strength of 1.5 T Contrast enhanced scan were performed using Gadolinum-DTPA. The dose of contrast given was 0.1 mmol/kg of body weight.

Sequences
Parameters of MRI include echo time (TE), repetition time (TR), matrix size, field-of-vision (FOV), slice thickness and number of excitations. T1W and T2W images are affected by TR and TE. Conventional spin echo sequences, axial T1W, T2W and FLAIR; Coronal T2W;Sagittal T1W; Post contrast axial, coronal and sagittal; DWI; T2W FFE. Single voxel spectroscopy was performed at TE of 140. The voxel is placed on the lesion so that it covers the maximum area of the lesion in a single voxel. We used PRESS (Point Resolved Spectroscopy) and T1 post contrast sequence as localization sequence with 5 mm thickness. Spectroscopy was avoided in small lesions close to the bone.

Table 1: Commonly Used Sequences

	T1	T2	Flair	Diffusion	SWI
TR	600	6000	8000	3000	27
TE	10	107	116	91	27
TI	-	-	2500	-	-
Four Read	230	230	230	230	230
Four Phase	70	120	150	-	15
Slice Thickness	5 mm	5 mm	5 mm	5 mm	5 mm
Distance Factor	20%	20%	20%	20%	20%

In Patients who presented with complain of seizures, epilepsy protocol was used, in which IR (Inversion Recovery) sequences were taken.DWI are taken to determine diffusivity of water proton molecule & cellularity of the lesion.T2 FFE sequence was utilized to rule out any hemorrhagic component within the lesion.MR Spectroscopy was done to study metabolic characteristic of brain lesion. Special sequences such as CISS 3D was used as and when required.MRI findings were noted and recorded. The results

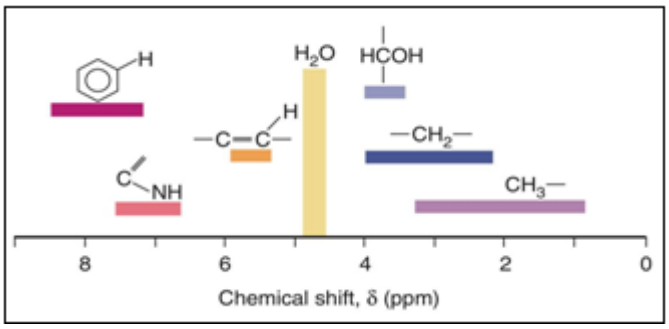
were analyzed and compared with other available study in literature.

Magnetic Resonance Spectroscopy

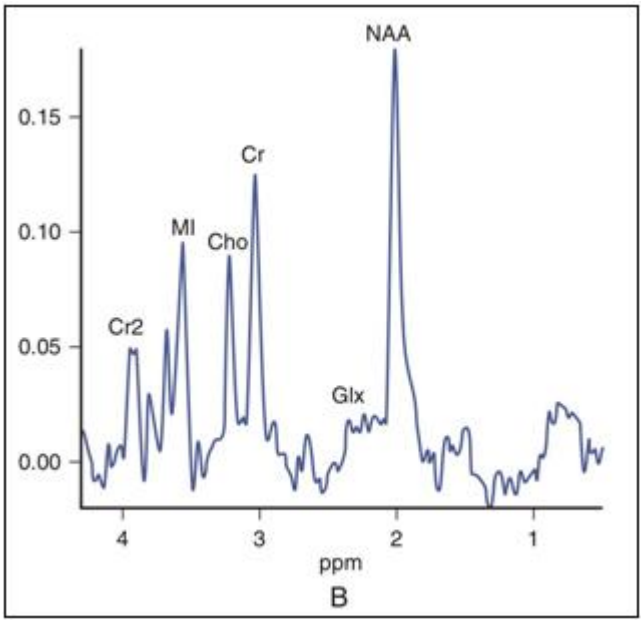
Magnetic resonance spectroscopy (MRS) is a means of non-invasive physiological imaging of the brain that measures absolute and relative levels of various brain tissue metabolites. MRI and MRS differ only in the manner in which the data obtained are analyzed and the type of information provided. In the case of MRI, data collected are analyzed in the time domain (namely, free induction decay signal; signal intensity vs. time) to obtain relaxation time (TR) information (namely, T1 [spin-lattice] and T2 [spin-spin]) of the nuclei. The data from the time domain information is then used to generate an anatomic image.In MRS, the time domain information is converted to the frequency domain (signal intensity vs. frequency) via Fourier transformation of the free induction decay time domain signal.

Table 2: Normal brain metabolites

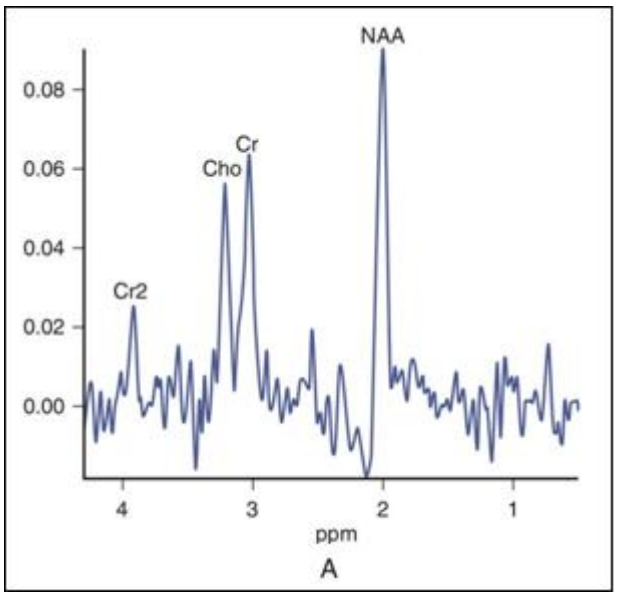
Chemical Compound	Chemical Shift	Comments
N-Acetyl aspartate(NAA)	2	Neuronal marker.
Creatine/phosphocreatine	3	Energy metabolism.
		Supplier of phosphate to convert ADP to ATP.
Choline (cho)	3.2	Cell membrane marker.
Myo-inositol (ml)	3.5	Glial cell marker.
Glutamate (glu)	2.2-2.4	An excitatory neuro-transmitter and regulator
Glutamine (Gln)		
(Glu+Gln=Glx)		
Lipids (lip)	0.9-1.4	Cell break down/ brain destruction Indicator.
Lactate (Lac)	1.3	Anaerobic metabolism.



Normal Single Voxel MR Spectrum



Long Echo



Short Echo

This was a prospective-retrospective study done at tertiary care hospital, aimed at studying the MR appearances in various ring enhancing lesions of the brain. In our study of MRI of ring enhancing lesions of the brain, 100 patients were evaluated.MRI is a non-invasive, 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.

6. Limitations

MRS could not be performed in 8 cases due to presence of lesion close to the bone.MR perfusion and MTR which were not included in the study due to cost factor, are also useful in differentiation of neoplastic and non-neoplastic lesions.

7. Results

Total 100 patients presented with various ring enhancing lesions.

Table 3: Incidence of Various Ring Enhancing Lesions

Lesions	No of Case (out of 100)
Tuberculoma	35
Neurocysticercosis	20
Abscess	12
Metastasis	10
Glioblastoma multiforme	8
Toxoplasmosis	6
Multiple sclerosis	5
Radiation necrosis	2
Subacute infarct	2

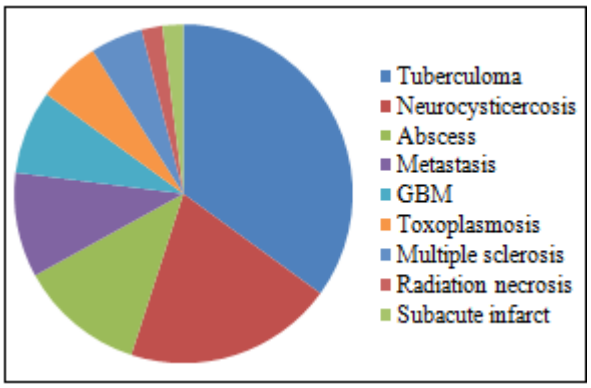
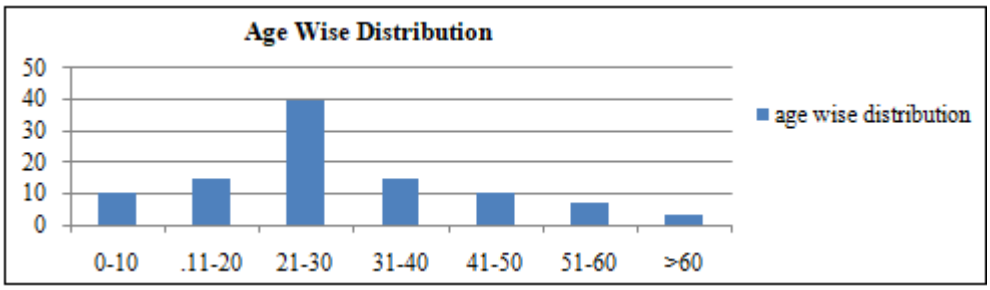


Table 4: Age Wise Distribution of Various Ring Enhancing Lesions

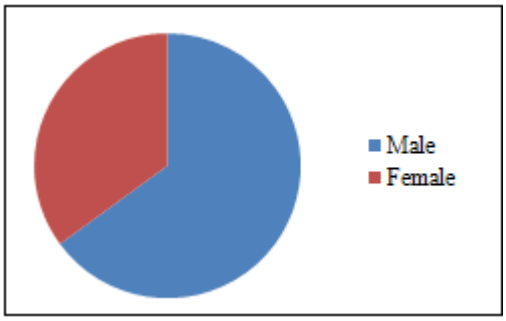
Age (In Years)	No. of Cases (out of 100)
0-10	10
Nov-20	15
21-30	40
31-40	15
41-50	10
51-60	7
> 60	3



Maximum incidence of cases noted in 21-30 years and minimum in more than 60 years.

Table 5: Sex wise Distribution of Various Ring Enhancing Lesions

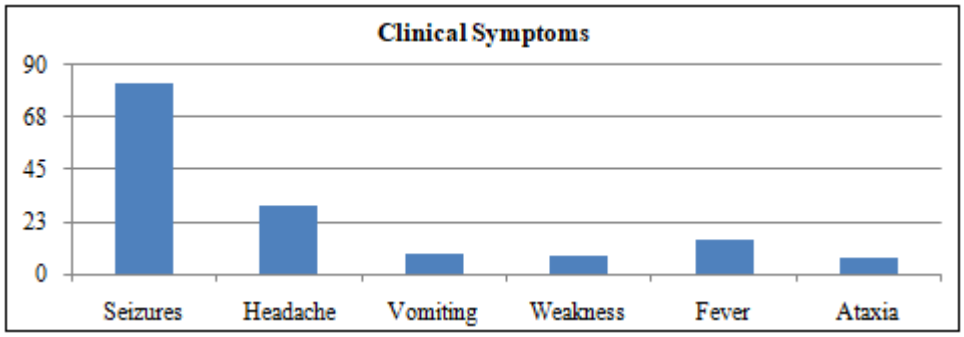
SEX	No. of Cases (out of 100)
Male	65
Female	35



RELs noted predominantly in males

Table 6: Clinical Symptoms Presented by a Patient with Various Ring Enhancing Lesions

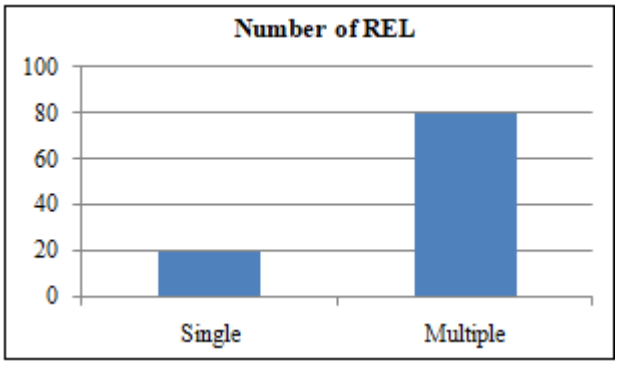
Symptom	**No. of Cases (out of 100)**
Seizures	70
Headache	29
Vomiting	9
Weakness	8
Fever	15
Ataxia	7



Maximum cases presented with seizure among intracranial ring enhancing lesions

Table 7: Number of Ring Enhancing Lesions in a Patient

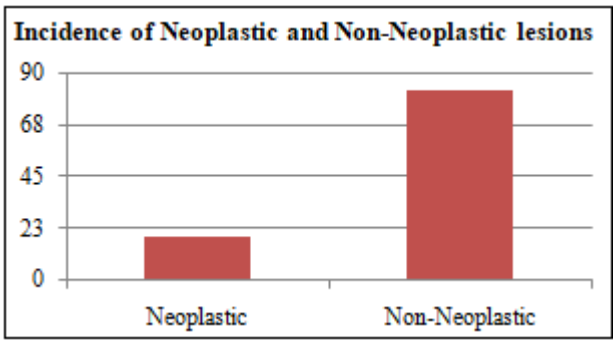
LESIONS	No. of Cases (out of 100)
Single	20
Multiple	80



Most of cases presented with multiple lesions in RELs

Table 8: Incidence of Neoplastic and Non-Neoplastic lesions

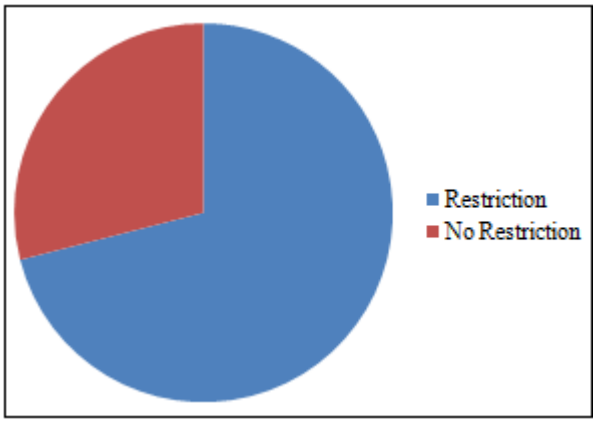
Lesions	No of Cases (out of 100)
Neoplastic	18
Non-Neoplastic	82



Non-neoplastic lesions are more common than neoplastic lesions in intracranial ring enhancing lesions

Table 9: DWI in Ring Enhancing Lesions

Diffusion	No. of Cases (out of 100)
Showing Restriction	71
Showing No Restriction	29



Most of lesions shows DWI restriction among intracranial ring enhancing lesions

8. Discussion

- **Age Distribution:** 100 patients were evaluated, whose age group ranged from 2 to 65 years. The highest incidence of REL's were found in 21-30 years age group accounting for 27% of cases and least was seen in age group of 51-60 years accounting for 3% of cases.
- **Sex Distribution:** 100 patients were evaluated,out of which 65 (65%) were males and 35 (35%) were females.
- **Clinical Features:**Seizures were the most common presenting complaint in 82 % of cases. Headache (29%), fever (15%), vomiting (9%), ataxia (7%) and motor weakness (8%) were the other presenting complaints.
- **Pathologies:** Out of the 100 patients who were evaluated, Tuberculoma (35%) was the most common pathology followed by Neurocysticercosis (20%), Abscesses (12%), Metastasis (10%), Glioblastoma multiforme (8%) , Toxoplasmosis (2%), Multiple sclerosis (5%), Radiation necrosis(2%) and Subacute infarct (2%).
- **Number of Lesions:** 100 patients were evaluated - 20% of them presented with a single lesion and 80% of them presented with multiple lesion.
- **Diffusion Restriction:** 100 patients were evaluated - 71% of patients shows diffusion restriction and 29% of patiens shows no diffusion restriction.
- **MR Spectroscopy:** Out of the 100 patients evaluated, spectroscopy was possible in 92 cases and was not performed in 8 cases because of presence of the lesion close to the skull vault.

Lactate peak was observed in 65 cases, Lipid in 63 cases, Choline in 18 cases and amino acids in 12 cases.

RR. Archana, P. Sunil Kumar, Anurudh Kishore. (2018) has evaluated 40 patients over a period of 2 years

Table 10: Comparision according to age groups

Age	Present study (%)	RR. Archana, P. Sunil Kumar, Anurudh Kishore (%)
21-30	40%	25%
>60	3%	5%

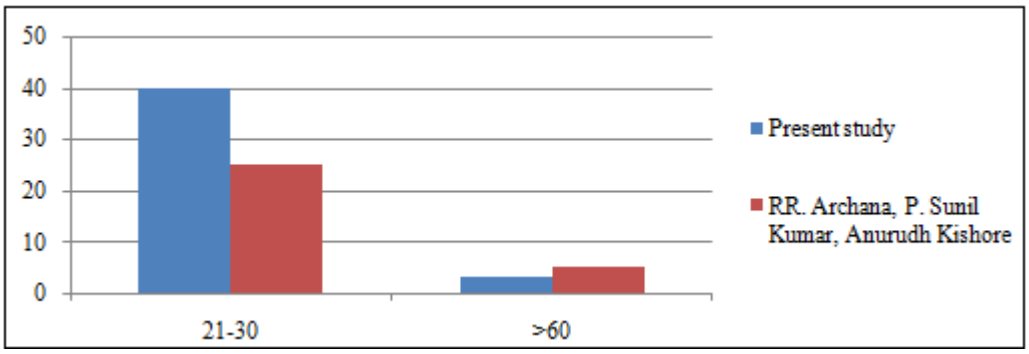


Table 11: Comparision according to clinical feature

Clinical feature	Present study (%)	RR. Archana, P. Sunil Kumar, Anurudh Kishore (%)
Seizure	70%	50%

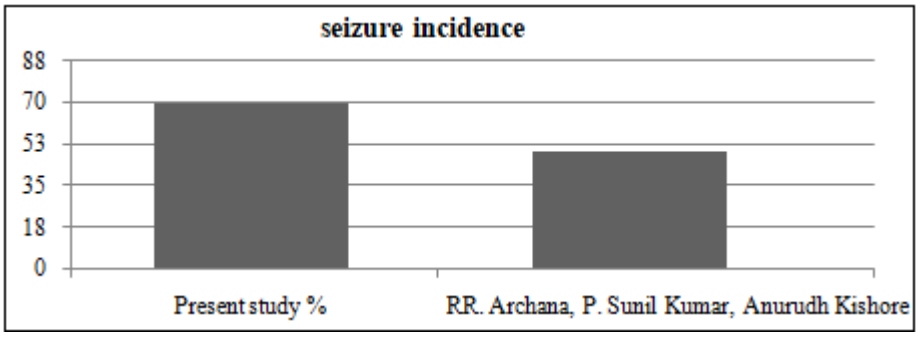


Table 12: Comparision of incidence in common ring enhancing lesions

Lesion	Present study (%)	RR. Archana, P. Sunil Kumar, Anurudh Kishore (%)	Sachin L., Jeevika M U., Gurumurthy B and Fahid Rahman CH	Dr. Jernail Singh Bava , Dr. Ashwini Sankhe , Dr. Swapnil Patil %
Tuberculoma	35%	45%	44%	36%
Neurocysticercosis	20%	25%	32%	34%
Abscess	12%	10%	10%	12%
Metastasis	10%	10%	10%	6%
GBM	8%	5%	2%	10%
Toxoplasmosis	6%	5%	-	2%

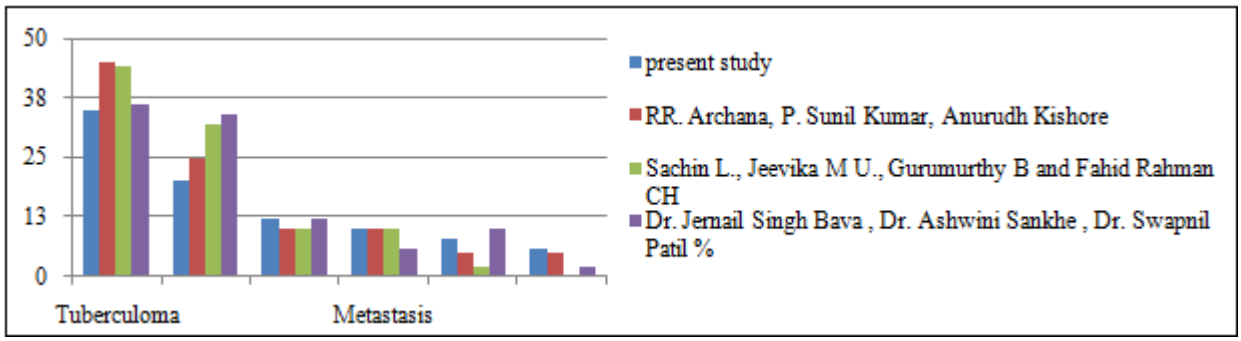
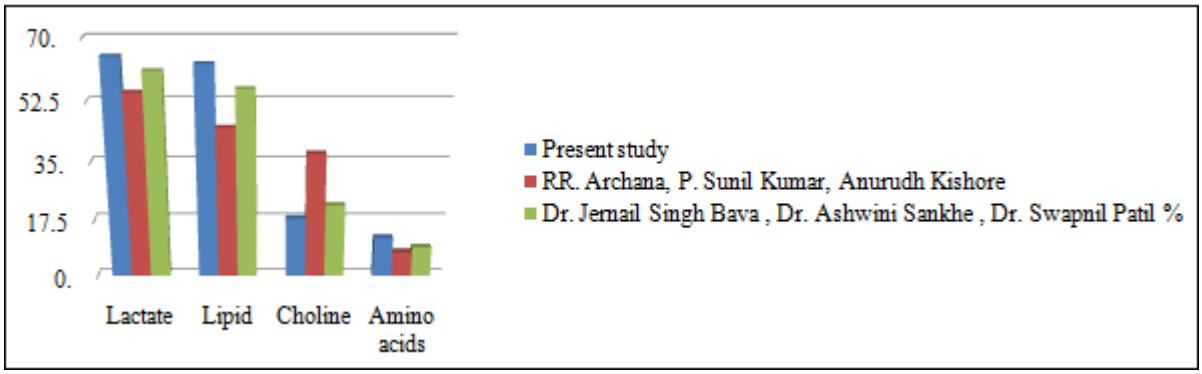


Table 13: Comparision of MRS findings

MRS Peak	Present study %	RR. Archana, P. Sunil Kumar, Anurudh Kishore %	Dr. Jernail Singh Bava, Dr. Ashwini Sankhe , Dr. Swapnil Patil %
Lactate	65%	55%	61%
Lipid	63%	45%	56%
Choline	18%	37.50%	22%
Amino acids	12%	7.50%	9%



They concluded that most sensitive modality which can characterize the intracranial ring enhancing lesions is MRI, which based on characteristic imaging findings, plays a pivotal role in patient management by suggesting the correct diagnosis. [59]

9. Conclusion and Summary

Patients with ring enhancing lesion on MRI were evaluated in this study over a period of 1&½ years from October 2020 to April 2022 of various age groups ranging from 2-65 years. MRS was performed in 88 cases. Various parameters of ring enhancing lesion were evaluated. Spectrum of findings on MRI and MRS were assessed.MRI is the most sensitive modality in the characterization of intracranial ring enhancing lesions – RELs.MRI being non-invasive and radiation free imaging modality. CISS 3D and MRS must be used in evaluation of ring enhancing lesions. Multiplanar capability of MRI was helpful in identifying precise anatomical location and the exact extent of lesions.MRI plays a critical role in patient management by suggesting the correct diagnosis based on characteristic imaging findings. Most common lesion seen was tuberculoma (35%) followed by neurocysticercosis (20%), abscess (12%), metastasis (10%), glioblastoma multiforme (8%), toxoplasmosis (6%), multiple sclerosis (5%), radiation necrosis (2%) and subacute infarct (2%). Irregular type of ring enhancement is the most common feature noted in most of the lesions.21-30 years was the most common age group involved (40% of cases) and more than 60 years was the least common age group involved(3% of cases) seizure was the most common presenting complaint (70%) followed by headache (29%) and fever (15%).80 % of cases were presented with multiple lesions and 20% cases were with single lesion.NCC shows hyperintensity on T2 with no diffusion restriction and presence of scolex on CISS 3D.Tubercoloma shows hypointensity on T2 with DWI restriction and lipid-lactate peak on MRS. Abscess shows a hypointense rim on T2 with complete diffusion restriction and lipid- lactate-amino Acid peaks on MRS. Pattern of signal intensity on T2-FLAIR, DWI and MRS helps to differentiate between benign and malignant lesions. Metastasis are well defined hyperintense lesions on T2 which show high choline peak on MRS.

10. Future Scope

We're on a journey to uncover the secrets of intracranial ring-enhancing lesions using new MRI techniques like SWI, MTI, and DTI. These sequences promise to reveal hidden causes, helping us create better and more efficient scanning methods. When we combine MRI and MRS regularly, we get a full picture, allowing doctors to understand these lesions better. For tricky cases, we have advanced tools like metabolite ratio analysis, DTI, and perfusion imaging, giving us hope for early detection of serious threats like high-grade gliomas. These advanced techniques not only help diagnose diseases earlier but also offer a chance to change the course of the illness. When we use DTI to explore the white matter disruption puzzle, we gain a deeper insight into neurological issues. This knowledge can lead to better ways to manage symptoms, improving the quality of life for patients. It's not just about pushing technology boundaries; it's about helping doctors understand the complex world of brain problems, one ring-enhancing lesion at a time.Looking ahead, the future of assessing intracranial lesions is full of exciting possibilities. We're ready to embrace these opportunities, bringing in an era of precise diagnosis and targeted treatments.

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