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Multimodal MRI Approach for Differentiating Ring-Enhancing Brain Lesions: Integration of DWI and MR Spectroscopy

Dr. Akshay.B[1], Dr. Bharath Kakileti[2], Dr. Abhilash.M[3], Dr. Gali Varalakshmi[4], Dr. Tharunkrishna Khambhampati[5], Dr. S. Srujan[6], Dr. Abhishekratan. T[7]

[1] PROFESSOR, HOD, Department of Radio Diagnosis, KIMS& RF, AMALAPURAM.

[2] Assistant professor, Department of Radio Diagnosis KIMS &RF, AMALAPURAM.

[3] POST GRADUATE, Department of Radio diagnosis, KIMS&RF, AMALAPURAM.

Email ID: abhilashreddymaryala70@gmail.com

[4]POST GRADUATE, Department of Radio Diagnosis, KIMS&RF, AMALAPURAM.

[5]POST GRADUATE, Department of Radio Diagnosis, KIMS&RF, AMALAPURAM.

[6]POST GRADUATE, Department of Radio diagnosis, KIMS&RF, AMALAPURAM.

[7]POST GRADUATE, Department of Radio Diagnosis, KIMS&RF, AMALAPURAM.

[*]**Corresponding author:**

Dr. Abhilash.M

Email ID: abhilashreddymaryala70@gmail.com

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ABSTRACT

Background: Ring-enhancing brain lesions present a diagnostic challenge, as they can be caused by various pathologies, including neoplastic, infectious, and inflammatory conditions. Conventional MRI alone often lacks specificity in differentiating these lesions.

Objective: This study aims to evaluate the role of advanced MRI techniques—Diffusion-Weighted Imaging (DWI) and Magnetic Resonance Spectroscopy (MRS)—in conjunction with conventional MRI for the characterization of ring-enhancing brain lesions.

Methods: A cohort of patients with radiologically confirmed ring-enhancing lesions underwent MRI, including DWI and MRS. Apparent Diffusion Coefficient (ADC) values and metabolic spectra were analyzed to distinguish between neoplastic and non-neoplastic lesions. Correlation of imaging findings with histopathology or clinical follow-up was performed to assess diagnostic accuracy.

Results: DWI and ADC mapping provided crucial insights into lesion cellularity, aiding in the differentiation between abscesses and tumors. MRS findings, including choline/N-acetylaspartate (Cho/NAA) and choline/creatine (Cho/Cr) ratios, further enhanced specificity in distinguishing malignant from benign lesions. The combined approach significantly improved diagnostic accuracy compared to conventional MRI alone.

Conclusion: Integrating DWI and MRS with conventional MRI enhances the diagnostic capabil ity in assessing ring-enhancing brain lesions. This multimodal approach offers improved differentiation of infectious, inflammatory, and neoplastic conditions, thereby guiding appropriate clinical management.

Keywords: *MRI, DWI, MR Spectroscopy, Ring-Enhancing Lesions, Brain Tumors, Abscess, ADC, Choline/NAA*

1. INTRODUCTION

Multiple ring-enhancing lesions are one of the most common neuro imaging abnormalities.

Ring-enhancing intracranial lesions are considered as commonand quite puzzling diagnostic dilemma(1) .To diagnose such lesions; many imaging techniques, includingcomputed tomography and magnetic resonance imaging (MRI)are used (2).

These lesions may present as solitary or multiple on a brainMRI, and are characterized by a contrast enhancing halo with anon-enhancing centre It is still a challenge to differentiate different ring enhancinglesions like abscess, cystic glioblastomas and metastases even withthe use of MRI (3).

Diseases causing multiple ring-enhancing lesions of the brainare infectious, neoplastic, inflammatory or vascular in origin. Severaltypes of primary and secondary brain neoplasms, such asglioblastomas, low-grade gliomas, lymphomas and brain metastasescan also present as multiple ring-enhancing lesions.

Manynon-neoplastic neurological disorders can mimic brain neoplasms.

These lesions may include tuberculosis, cysticercosis, demyelinatingdisorders, pyogenic abscess, toxoplasmosis, fungal infections,sarcoidosis, Behcet disease, radiation encephalopathy, and somevasculitic disorders(4).

Therefore, advanced MR techniques as proton MagneticResonance Spectroscopy (1HMRS), Perfusion weighted imagingand Diffusion tractography imaging (DTI) have been employed Magnetic resonance imaging, Diffusion weighted imaging (DWI), Magnetic resonance spectroscopy(MRS) may help in differentiating imaging characteristics of these various etiologies.

2. AIMS AND OBJECTIVES

- To differentiate neoplastic from non neoplastic lesions of brain using conventional & advanced MRI techniques
- To study characteristic MR imaging findings of various ring enhancing lesions.
- To establish differential diagnosis of various ring enhancing lesions on conventional MRI
- To study the role of MR spectroscopy in evaluation of various ring enhancing lesions of brain

3. MATERIALS & METHODS

Study Area: Department of Radiodiagnosis ,Konaseemainstitute of medical sciences and research foundation

Sample Size: 40 cases

Study duration: 18 months (February 2023to August 2024).

Source of Data: All patients referred to the department of Radio diagnosis with clinically suspected cerebral ring enhancing lesions

Inclusion criteria:

All ring enhancing lesions of brain detected on contrast MR studies.

All patients with diagnosed ring enhancing lesion by CT incidentally

All age groups irrespective of sex

Exclusion criteria: Patient with claustrophobia.

Contraindication to MR

Methodology:

Patients with suspected intracranial ring enhancing lesions on MR imaging assessed with MR spectroscopy, DWI using Philips Provida 1.5 T MRI machine.

4. DISCUSSION

- Males were predominantly affected (67.5%) than females (32.5 %).
- T2 , DWI and MRS plays important role in differentiating neoplastic from non neoplastic brain lesions
- Most common clinical presentation was seizures.
- T2 Hypointensity with partial/complete restriction on DWI, MRS showing lipid peak suggests Tuberculoma.
- T2 Hyperintensity with no diffusion restriction, presence of eccentric scolex and MRS revealed choline and lipid lactate peaks suggests NCC.
- In ourstudy, abscess showed absence of Cho, Cr, and NAA and increased

concentrations of various amino acids (acetate, alanine, lactate) inMRS, while in glioma, there was high choline/NAA ratio, highcholine in the surrounding oedema, this was supported by a studydone by Lai et al.8 in 2002 that showed increased amino acids, lactatesand lipids in abscess and it showed also peaks of lipids andlactates in cystic glioma in addition to the

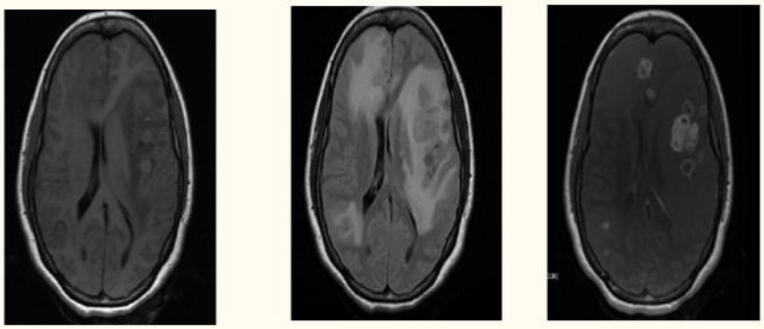
peak of choline and highcholine/NAA ratio. (5)

- Abscesses show irregular ring enhancement with contrast , complete diffusion restriction. MRS showing Lactate and Amino Acids.
- In 2001, Hartmann et al.10 strongly suggested that the diagnosisof a brain abscess can be made if there is restricted diffusion withina cystic ring-enhancing cerebral lesion with low ADC values .(6)
- Gupta et al.11 and Shetty et al.12 studied MRS in differentiationbetween tuberculoma versus neurocystocercosis and found thatMRS of brain tuberculomas commonly detects peaks of lipidsattributable to large lipid fractions in tuberculosis bacillus. It willalso have increased choline levels and decreased N acetyl aspartateand creatine (7)
- Well defined T2 hyperintense lesions, MRS showing high choline peak & raised choline/NAA ratios on MRS suggests metastasis.

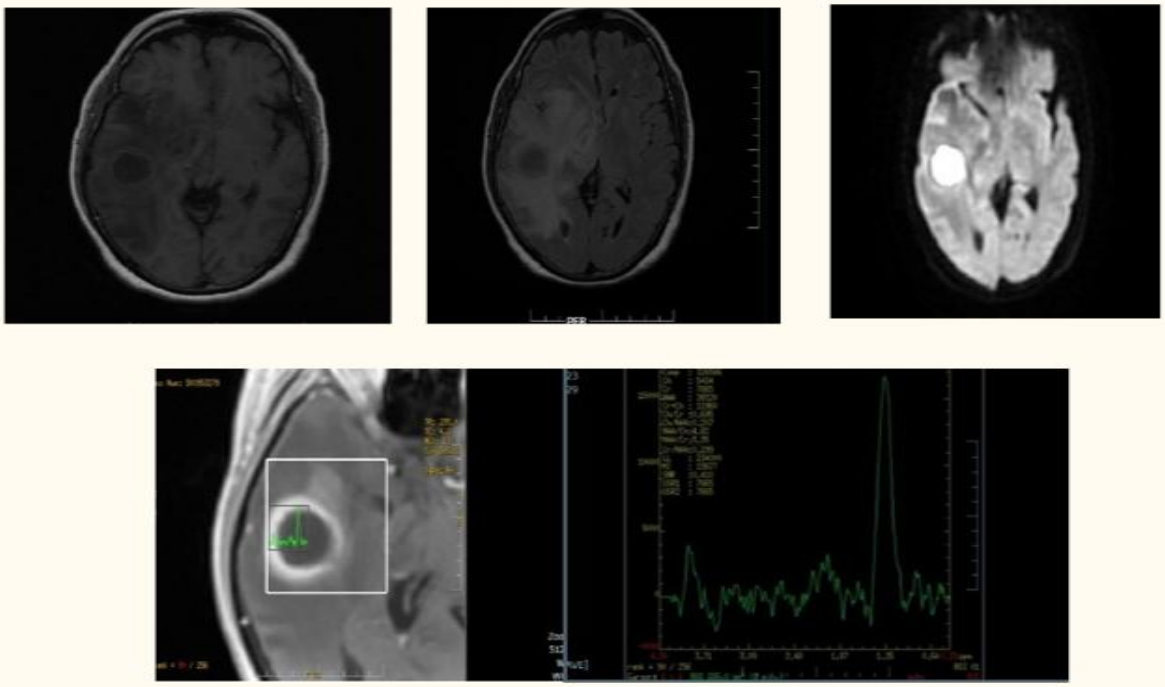
Table 2
Characteristics of MRS in different ring enhancing brain lesions: NAA: N-acetyl aspartate. Cho: Choline. Cr: Creatinine.

Lesion	MRS findings
Glioma	High choline/NAA ratio High choline in the surrounding oedema
Metastases	Mild elevation choline/NAA ratio and increased lipids and lactate. Choline is not elevated in the surrounding edema
Tuberculosis	Prominent decrease NAA/Cr and slight decrease Cho/NAA Lipid/lactate peaks are usually elevated
Fungal abscess	Absence of Cho, Cr, and NAA and also the increased concentrations of various aminoacids (acetate, alanine, lactate)
Cysticercosis	Elevated Choline, lactate and succinate Reduced NAA
Multiple sclerosis	Slightly increased Cho, decreased concentration of NAA, Glutamate peak and presence of lipid-lactate peaks
Meningioma	Prominent Choline and alanine. Absent or low NAA and Cr

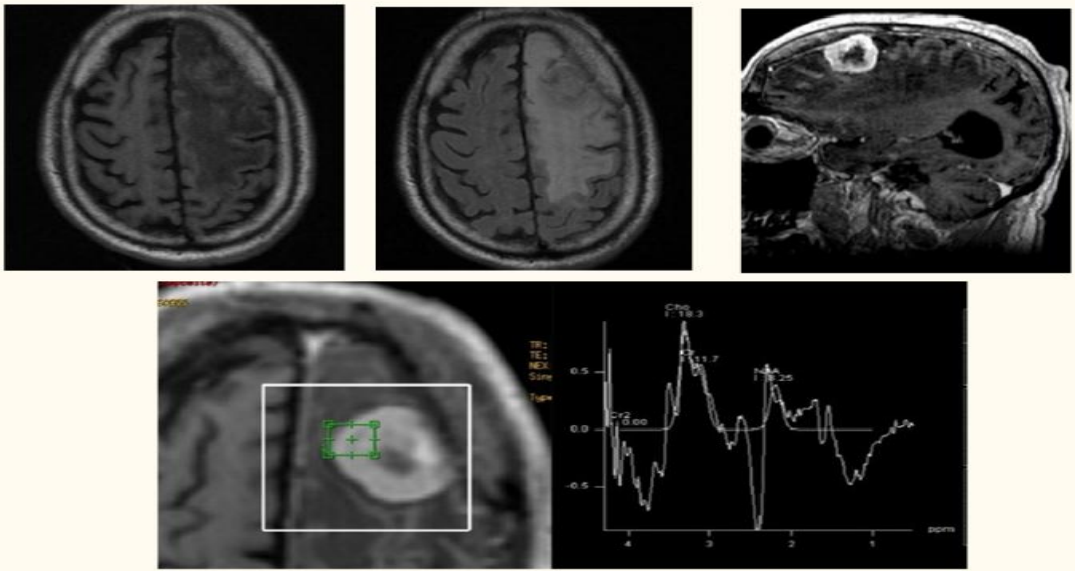
Multiple ring enhancing lesions, MRS revealed lipid lactate, choline peaks suggestive of tuberculoma.



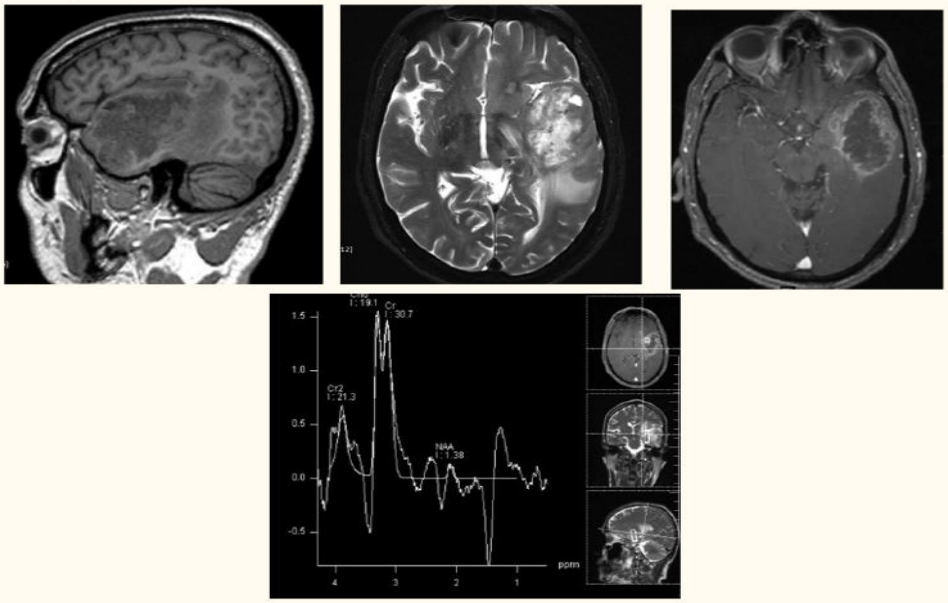
T1 and T2 Flair Hypointense lesions with Hyperintense rim, Ring enhancement on contrast and diffusion restriction, MRS Revealed lactate and amino acids peaks suggestive of abscess.



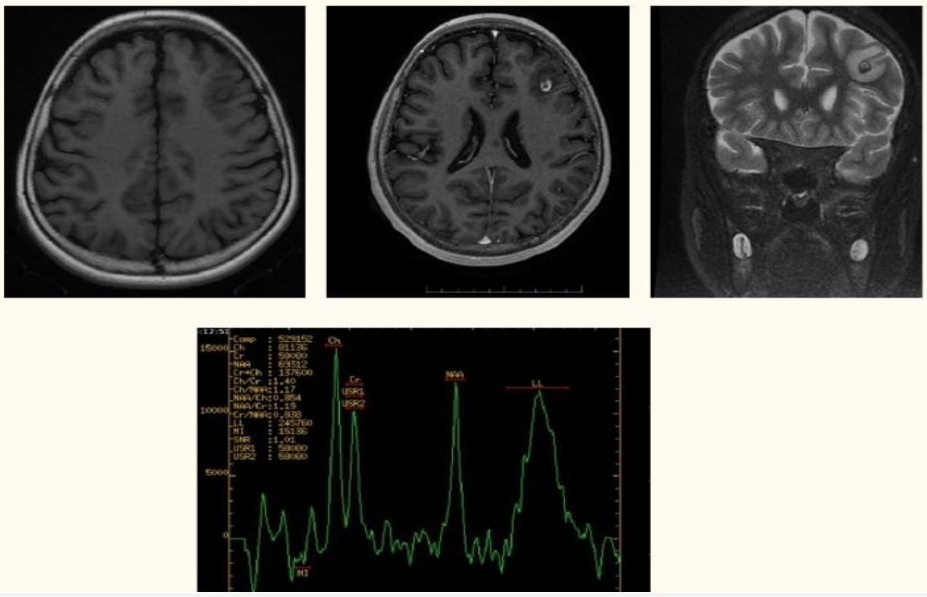
Well defined T1 and T2 Flair thick walled heterogenous ring enhancing lesion with perilesional edema, MRS revealed choline peak with reduced NAA in known case of carcinoma lung s/o metastasis.

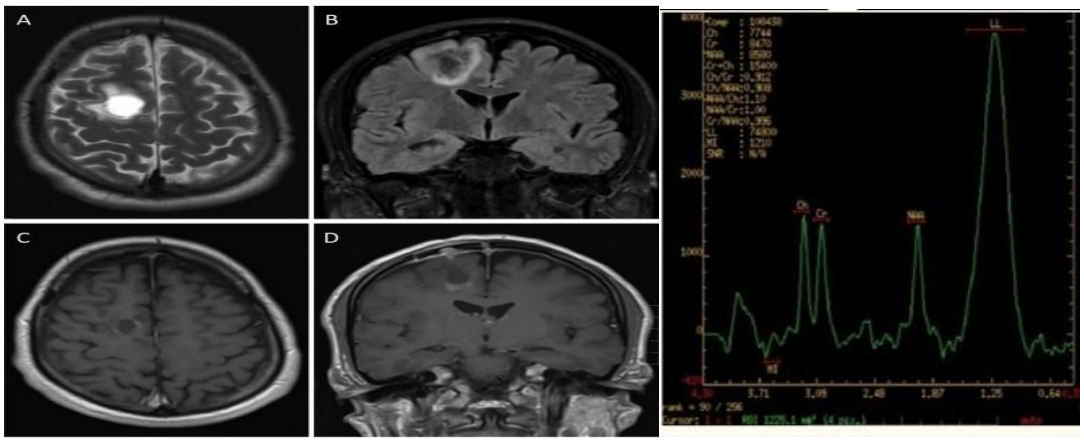


T1 hypointense, T2 hyperintense with areas of diffusion restriction,thick irregular type of ring enhancement. MRS revealed increased choline, reduced NAA and increased choline/naa ratios. Histopathology revealed out to be glioblastoma.



Ring enhancing lesions with T2 eccentric scolex, MRS showing choline and lipid lactate peaks suggests NCC.





5. RESULTS

Out of the 40 patients who were evaluated, 20 cases are tuberculomas (50%) is the most common pathology followed by 12 NCC (30 %), 4 metastasis (8 %), 2 Abscess(5%), 1 primary brain tumour (2.5%) and 1 tumefactive demyelination (2.5%)

Metabolite peaks in various ring enhancing lesions

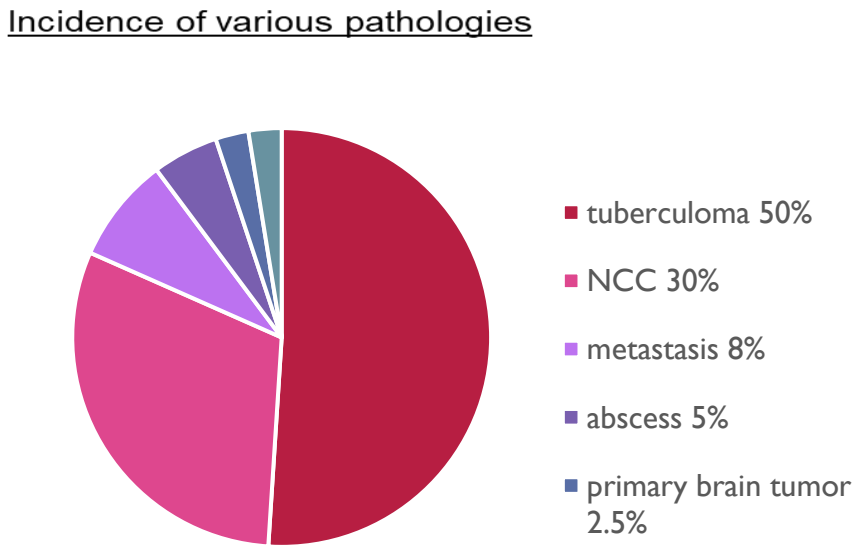
Metabolite peak	No.of cases
Choline	19
Lipid	28
Lactate	25
Reduced NAA	11
Amino acids	2

MRI and MRS	Non-neoplastic	neoplastic	total
Positive	35(TP)	1(FP)	36
negative	0(FN)	4()TN	04
total	35	05	40

The overall sensitivity, specificity, PPV, NPV, accuracy of MRI and MRS to differentiate non neoplastic from neoplastic brain lesions:

Sensitivity = 95% Specificity = 80% Positive Predictive Value = 97.22%

Negative Predictive Value = 100% Accuracy=97.5%



Diffusion	No. of cases
Restriction (Complete / Partial)	22
No Restriction	18

DWI results

6. CONCLUSION

On the basis of this study it can be concluded that Magnetic resonance imaging(MRI) paired with Magnetic resonance spectroscopy(MRS) helps us in accurately differentiating neoplastic from non neoplastic brain lesions and narrows the list of differential diagnosis of ring enhancing lesions in brain.

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