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## Original Article

# Verification of brain ring enhancing lesions by advanced MR techniques



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## ABSTRACT

**Purpose:** To evaluate the role of MR Spectroscopy in verification and differentiation of different brain ring enhancing lesions, for better diagnostic purpose and management outcome.

**Patients and methods:** 25 patients were included in this study, 15 of them were males and 10 were females, with age ranging between 21 and 75 (mean  $46 \pm 14$ ). All patients were presented with variable symptoms, some of them have known primary disease entity and others presented with headache, visual disorders or disturbed level of consciousness. MRI was done to all the patients including conventional and contrast sequences, as well as MR Spectroscopy. Some did MR perfusion and DTI in order to further characterize their nature.

**Patients and methods:** Histopathological findings and results of clinical follow up were our reference standard.

**Results:** Among the 25 patients, MR Spectroscopy was able to specify 22 lesions (88%), DTI was performed in 13 out of 25 lesions and MR perfusion was performed in 8 out of 25 lesions.

**Conclusions:** Characterization of ring enhancing lesions of the brain has increased accuracy by applying advanced MRI techniques. In this study, MR Spectroscopy combined with DTI and MR perfusion sequences in some cases improved verification of different ring enhancing brain lesions.

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## 1. Introduction

Ring-enhancing intracranial lesions are considered as common and quite puzzling diagnostic dilemma<sup>1</sup>.

To diagnose such lesions; many imaging techniques, including computed tomography and magnetic resonance imaging (MRI) are used<sup>2</sup>.

These lesions may present as solitary or multiple on a brain MRI, and are characterized by a contrast enhancing halo with a non-enhancing center<sup>1</sup>.

It is still a challenge to differentiate different ring enhancing lesions like abscess, cystic glioblastomas and metastases even with the use of MRI<sup>3</sup>.

Clinical presentations are usually nonspecific and hardly lead to a final diagnosis. For therapy, it is essential to differentiate cerebral abscesses from cystic tumor to initiate adequate early medical and surgical treatments<sup>3</sup>.

Intracranial ring enhancing lesions of different etiologies have a similar appearance on conventional MRI. Differential diagnosis of ring enhancing cystic mass lesions includes primary and secondary

brain tumors, metastases, non-neoplastic cysts, and brain abscesses<sup>4</sup>.

Routine brain MR imaging is very sensitive in the identification of ring enhancing lesions but it lags some specificity, for instance it cannot distinguish between neoplastic and non-neoplastic lesions, in a large percentage of these cases. Frequently, the differentiation of a tumor from an infection is quite difficult, based solely on conventional MRI<sup>5</sup>.

Diseases causing multiple ring-enhancing lesions of the brain are infectious, neoplastic, inflammatory or vascular in origin. Several types of primary and secondary brain neoplasms, such as glioblastomas, low-grade gliomas, lymphomas and brain metastases can also present as multiple ring-enhancing lesions. Many non-neoplastic neurological disorders can mimic brain neoplasms. These lesions may include tuberculosis, cysticercosis, demyelinating disorders, pyogenic abscess, toxoplasmosis, fungal infections, sarcoidosis, Behcet disease, radiation encephalopathy, and some vasculitic disorders<sup>6</sup>.

Therefore, advanced MR techniques as proton Magnetic Resonance Spectroscopy (1HMRS), Perfusion weighted imaging and Diffusion tractography imaging (DTI) have been employed in the differential diagnosis of these lesions, with variable success rates<sup>7</sup>.

The purpose of this study was to examine intracranial ring enhancing mass lesions with advanced MRI techniques and to

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evaluate the contribution of these techniques to differential diagnosis. For this purpose conventional MR sequences, MR Spectroscopy, DTI and MR perfusion findings were described. The results were compared between different types of ring enhancing lesions for accurate characterization.

## 2. Patients and methods

### 2.1. Patient selection

25 patients were selected, between October 2014 and March 2015, 15 of them were males (60%) and, 10 were females (40%) with age range between 21 and 75 (mean  $46 \pm 14$ ).

All patients were presented with variable symptoms, 8 of them with headache, 5 out of 25 were presented with limb weakness, and another 5 with disturbed level of consciousness, 4 out of 25 patients were presented with visual disorders, and 3 were already known to have primary brain tumor. 15 (60%) of cases were referred from neurologist, and 10 (40%) were referred from neurosurgeon. Other investigations were requested for further confirmation of the diagnosis like CSF aspiration for oligoclonal bands and inflammatory cells, tuberculin test, visual evoked potential as well as histopathology. The results of these investigations were our references to prove our diagnosis. All patients were subjected to MRI study.

### 2.2. Methods

Patients were examined with 1.5 T MR imaging unit (Siemens, symphony magnetom) with eight-channel head coil. All cases performed axial T1WI, T2WI, FLAIR sequences, sagittal T1WI and coronal T2WI. Sagittal T2WI for the cervical spine was done if multiple sclerosis (MS) was suspected to rule out any cord lesions. Intravenous Contrast enhanced images:

11 cases were referred only for conventional MRI, but when examined by the radiologist, Contrast enhanced sequences were requested for better delineation of the lesions.

Diffusion weighted images (DWI) and ADC map. MR Spectroscopy: was done based on contrast enhanced images, with voxel placement on the most enhancing part of the lesion.

DTI was performed in 13 out of 25 lesions and MR perfusion was performed in 8 out of 25 lesions.

### 2.3. Image interpretation

All data were referred to the PACS system to be interpreted by two experienced radiologists with at least 5 years' experience in

neuroradiology. The lesions were described regarding site, size, and intensity pattern on T1WI and T2WI, surrounding edema, enhancement pattern on contrast enhancing images. The pattern of MR Spectroscopy profiles was described. DTI and MR perfusion patterns were analyzed for the cases that did these sequences. A weekly meeting panel including radiologist with the referral neurologists and neurosurgeons was hold for cases discussion where the laboratory data were correlated with radiological finding to narrow the differential diagnosis and reach final diagnosis.

## 3. Results

We relayed on descriptive statistical method in our study results.

25 patients were selected, during the period from October 2015 till March 2016, 15 of them were males (60%) and, 10 were females (40%) with age range between 21 and 75 (mean age  $46 \pm 14$ ).

Patients were presented with variable symptoms, 7 of them with headache, 4 out of 25 were presented with limb weakness, and another 4 with disturbed level of consciousness, 2 out of 25 patients were presented with visual disorders, and 3 were already known to have primary brain tumor (Table 1).

15 (60%) of cases were referred from the Neurology clinic and 10 (40%) were referred from Neurosurgery clinic. Radiological studies together with other laboratory investigations were requested based on the clinical suspicion.

Laboratory investigations, including CSF aspiration for oligo clonal bands and inflammatory cells, tuberculin test, visual evoked potential as well as histopathology were requested for further confirmation of the diagnosis. The results of these investigations were our references to prove the diagnosis.

MRI of the brain without contrast were initially requested in 19 (76%) patients, MRI with contrast was initially requested in 6 (24%) patients. All patients with history of brain tumor did MRI with contrast study from the start. The images were interpreted by one Neuroradiologist and one general Radiologist for deciding the next step.

The final diagnosis was set in the initial examination in 10 cases (40%) (Anaplastic meningioma, subacute hematoma, basal meningeal tuberculosis and brain metastasis), but with a confidence level, about 80% based on the Radiologist subjective evaluation.

MR spectroscopy was requested for 22 out of 25 cases excluding the subacute hematoma. The results of MRS, as shown in Table 2, were diagnostic of malignant lesion in 11 cases (44%) (Fig. 1), benign etiology in 11 cases (44%). Cases of hematoma were not submitted to MRS examination.

**Table 1**

The clinical presentation and final diagnosis of the examined population. MRS: MR spectroscopy. DTI: Diffusion Tensor Imaging.

Age	Complaint	Imaging	Added tests	Final diagnosis
35, 60 & 70	Rt. UL heaviness	MRI with contrast, Perfusion	Improved with anti TB medications	Tuberculoma
33, 40 & 44	Bilateral UL numbness	MRI with contrast, MRS DTI	+ve oligoclonal bands	Multiple sclerosis
45&55	Known GBM	MRI with contrast, MRS MR perfusion	Histopathologically proven recurrent GBM	Recurrent GBM
50–62	Headache	MRI with contrast, MRS DTI	Histopathologically proven brain stem glioma	Brain stem glioma
57	Headache	MRI with contrast MRS	Histopathologically proven	Anaplastic meningioma
57,67 & 69	Disturbed level of consciousness	MRI with contrast MRA	Follow up shows resolution	Subacute hematoma
54&63	Disturbed level of consciousness	MRI with contrast, MRS MR perfusion, DTI	Histopathologically proven fungal abscess	Fungal abscess
46&64	Imbalance, headache	MRI with contrast, MRS MR perfusion	Histopathologically proven tuberculosis	Tuberculosis
22&47	Headache	MRI with contrast, MRS	+ve anti cysticercosis antibodies	Cysticercosis
39–65 & 66	Right eye dropped vision	MRI with contrast MRS DTI	Histopathologically proven adenocarcinoma metastasis from the lung	Metastases from bronchogenic carcinoma
43 & 52	Known glioma Gr III resected	MRI + C, MRS, DTI	Histopathologically proven	Recurrent glioma

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

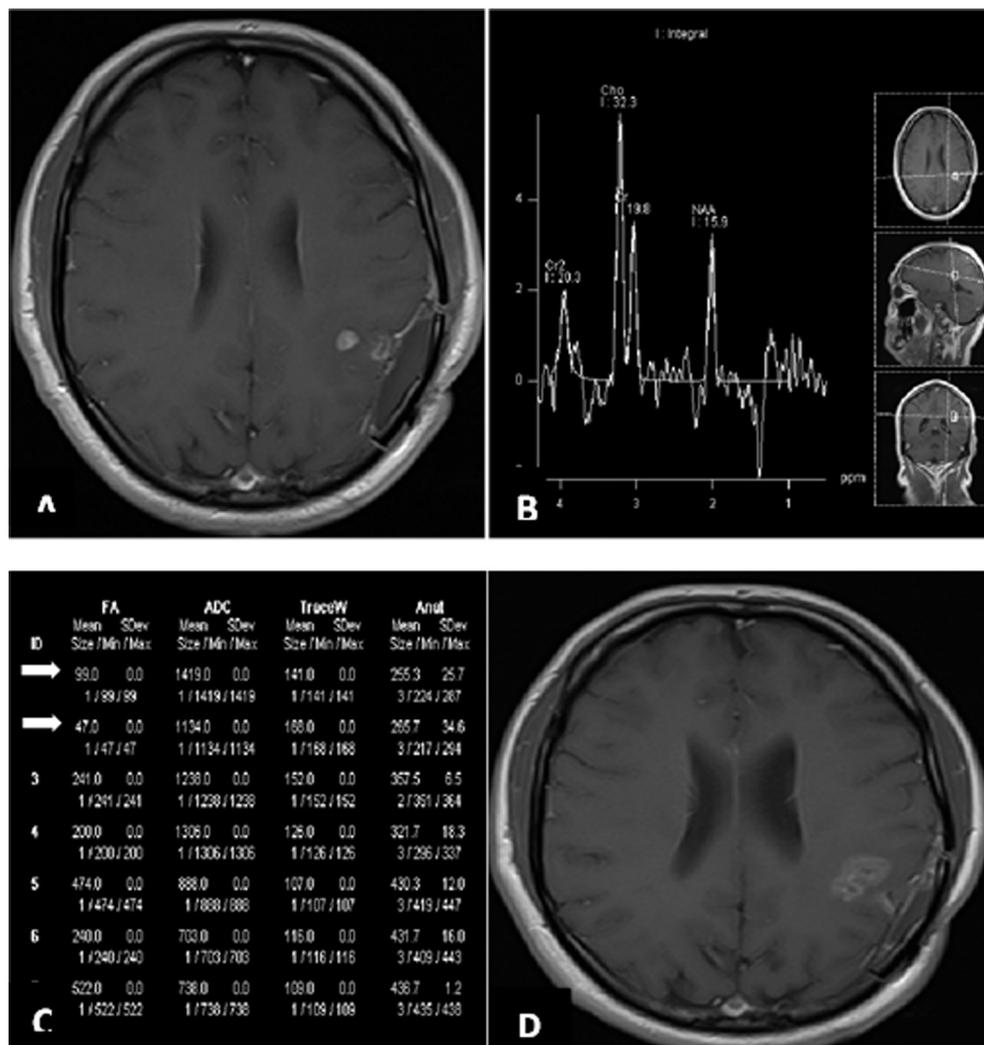
Lesion	MRS findings
Glioma	High choline/NAA ratio High choline in the surrounding oedema
Metastases	Mild elevation choline/NAA ratio and increased lipids and lactate. Choline is not elevated in the surrounding edema
Tuberculosis	Prominent decrease NAA/Cr and slight decrease Cho/NAA Lipid/lactate peaks 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

Moreover, MRS reached the final diagnosis in 8 (32%) cases of these benign lesions including all cases of tuberculosis, meningioma and multiple sclerosis (Fig. 2).

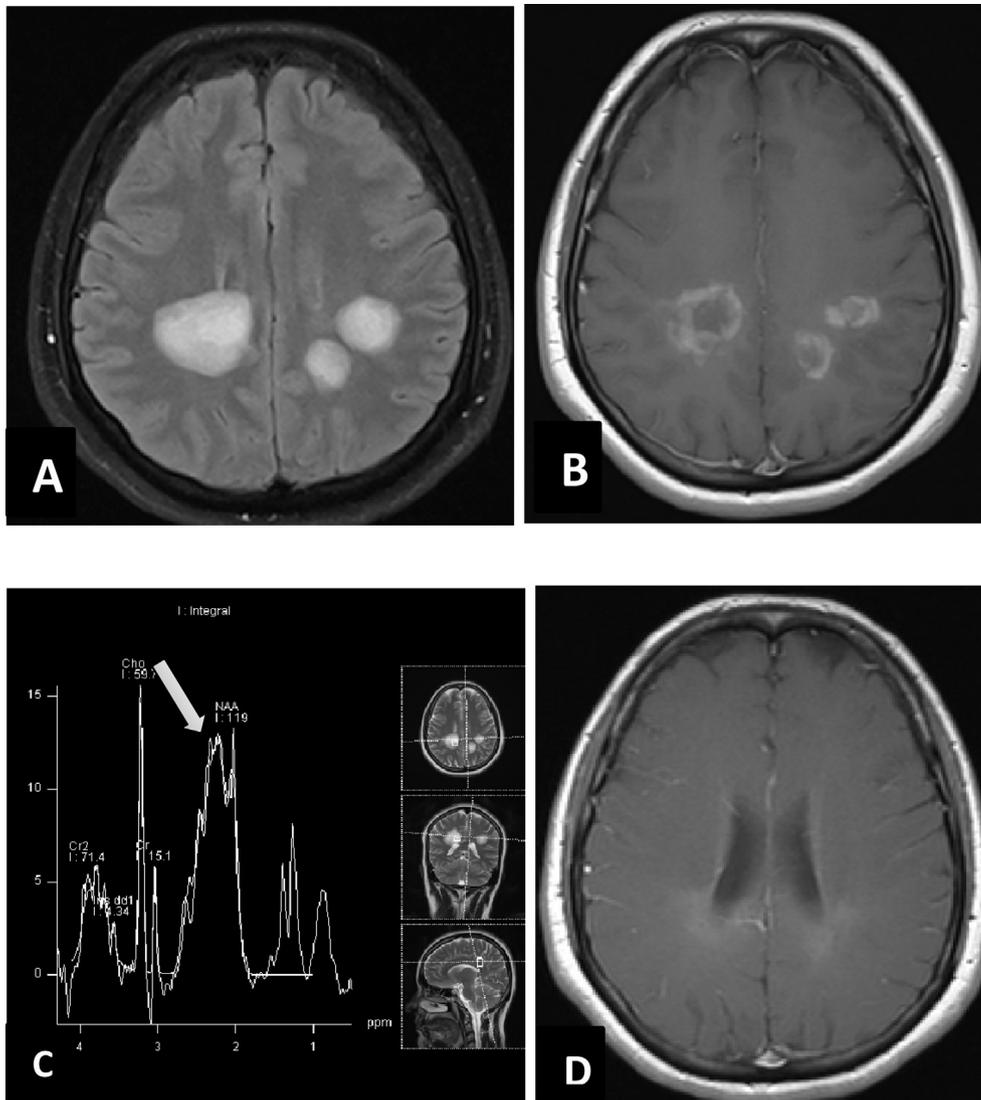
Finally MR perfusion was done for 2 cases (8%) of recurrent GBM to evaluate the areas of hyper perfusion inside the tumor and to dif-

ferentiate active recurrent tumor tissue that revealed high perfusion values from necrosis that revealed low perfusion values.

Preoperative DTI was done for 5 cases (2%) including cases of brain stem glioma and fungal abscess for mapping of the affected fibres.



**Fig. 1.** 45 year old male patient with history of left parietal GBM submitted to surgical excision followed by radiotherapy, he presented with this enhancing parenchymal nodule in post contrast axial T1WI (A) that could be recurrence or radiation necrosis. MRS (B) revealed increase in Choline/NAA ratio and Choline/Cr ratio with mild reduced NAA/Cr ratio. (C) DTI revealed decreased FA value with increased ADC value within the enhancing nodule (arrow) denoting high cellularity of the lesion. (D) Is follow up post contrast T1 after 5 months showing progression in size of the lesion which proved to be recurrent Glioblastoma multiforme (GBM).



**Fig. 2.** 35 year old female patient with multiple patches of deep white matter hyperintensity on axial FLAIR (A), in post contrast axial T1WI (B) these lesions show irregular ring like marginal enhancement, no perifocal edema or mass effect, MR spectroscopy TE 30 from the lesion (C) shows mild elevation of choline/NAA ratio, marked elevation of glutamine peak at 2.1–2.5 ppm (arrow), large lactate peak at 1.3 ppm, and lipid peak at 0.9 ppm, suggesting tumefactive demyelination process. (D) 2 year follow up post contrast axial T1WI after medical treatment of MS shows remarkable regression.

#### 4. Discussion

Brain ring enhancing lesions remain diagnostic challenge as they have wide range of differential diagnoses. New MRI modalities play an important role in verification of brain ring enhancing lesions, preoperative mapping and follow up as well.

Our work was unique in studying wide variety of lesions using different MRI modalities for better accurate verification. In our study, abscess showed absence of Cho, Cr, and NAA and increased concentrations of various amino acids (acetate, alanine, lactate) in MRS, while in glioma, there was high choline/NAA ratio, high choline in the surrounding oedema, this was supported by a study done by Lai et al.<sup>8</sup> in 2002 that showed increased amino acids, lactates and lipids in abscess and it showed also peaks of lipids and lactates in cystic glioma in addition to the peak of choline and high choline/NAA ratio.

Another study was elicited by Lai et al.<sup>9</sup> in 2008 and found that the Cho levels of rim-enhancing regions of abscesses were significantly lower than those of the rim enhancing GBM. Also they noted

that the Cho/Cr ratio is lower than that often seen in GBM. These findings again supported our findings.

In 2001, Hartmann et al.<sup>10</sup> strongly suggested that the diagnosis of a brain abscess can be made if there is restricted diffusion within a cystic ring-enhancing cerebral lesion with low ADC values. Yet, the ADC values between and within different studies varied widely. It is possible that variable concentrations of inflammatory cells and bacteria, different etiologic organisms, and the age of the abscess with variable viscosity of the abscess fluid were responsible for these conflicting data.

The present study demonstrates that brain abscess cavity shows regions of increased FA values with restricted mean diffusivity compared with other cystic intracranial lesions. With an increasing use of DTI in surgical planning of brain-tumor resection, one may become more careful in interpreting these changes as oriented axonal fibers.

Gupta et al.<sup>11</sup> and Shetty et al.<sup>12</sup> studied MRS in differentiation between tuberculoma versus neurocystocercosis and found that MRS of brain tuberculomas commonly detects peaks of lipids

attributable to large lipid fractions in tuberculosis bacillus. It will also have increased choline levels and decreased N acetyl aspartate and creatine levels. The choline/ creatine ratio was greater than 1 in all tuberculomas but not in cysticerci. The Proton-MRS allows for non-invasive identification of tuberculoma with high specificity and may allow early instalment of targeted antimicrobial treatment.

These findings were matched with that in our study, when we elicited that in tuberculosis, there are prominent decrease NAA/Cr and slight decrease Cho/NAA, while Lipid/lactate peaks are usually elevated while in cystocercosis, Choline is slightly elevated, lactate and succinate are elevated and NAA.

Different studies highlighted diagnostic difficulties with conventional investigations in ring enhancing lesions in the brain and role of MRS, DWI and other advanced sequences in order to reach accurate diagnosis.

## 5. Conclusion

Ring enhancing lesions of the brain remain a diagnostic challenging dilemma including a wide differential diagnosis of neoplastic and non-neoplastic lesions. MRI stands as the main diagnostic imaging modality, using conventional as well as advanced sequences can help in accurate verification and differentiation between these lesions for better diagnostic accuracy. Using DTI preoperatively helps to increase postoperative outcome.

**Pitfall:** The study population is less in number as we were very strict in our inclusion criteria for the purpose of results accuracy. This will give chance to more new research fields in the future with increasing study population number.

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