



Original Article

## Role of Mr Spectroscopy in Evaluation of Intraaxial Brain Tumours

Ashish Kumar<sup>1</sup>, Dr. Kirti Bhavin Agrawal<sup>2</sup>, Dr. Sachin Banthia<sup>3</sup>, Dr. Ridhima Gupta<sup>4</sup>

<sup>1</sup>Resident, Department of Radiodiagnosis, Sardar Patel Medical College, Bikaner.

<sup>2</sup>Associate Professor, Department of Radiodiagnosis, Govt Medical College, Vadodara.

<sup>3</sup>Professor, Department of Radiodiagnosis, Sardar Patel Medical College, Bikaner.

<sup>4</sup>Professor, Department of Radiodiagnosis, Sardar Patel Medical College, Bikaner.

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### Corresponding Author:

**Ashish Kumar**

Resident, Department of  
Radiodiagnosis, Sardar Patel  
Medical College, Bikaner.

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### ABSTRACT

**Introduction:** Intra-axial brain masses constitute a major neurological health burden and represent a diverse group of pathological entities that pose considerable diagnostic and therapeutic challenges.

**Aim:** To evaluate the role of magnetic resonance spectroscopy in the characterization and differentiation of intra-axial brain lesions by analyzing their metabolic profiles and correlating the findings with histopathological diagnosis.

**Methodology:** This study was conducted as a hospital-based prospective observational study in the ..... The study period extended from .....

**Result:** High-grade glioma was the most common intra-axial brain tumor (51.3%), and MR spectroscopy showed good concordance with histopathology, with excellent agreement for high-grade glioma and complete agreement for ependymoma, lymphoma, medulloblastoma, metastasis, choroid plexus papilloma, and central neurocytoma. Minor discrepancies were observed mainly in glioma subtyping, particularly low-grade glioma and oligodendroglioma, due to overlapping metabolic profiles.

**Conclusion:** MR spectroscopy is a reliable non-invasive adjunct to conventional MRI for evaluating intra-axial brain lesions, showing good to excellent correlation with histopathology in most tumor types. Its main limitation lies in glioma subtyping, particularly low-grade glioma and oligodendroglioma, due to overlapping metabolic profiles.

**Keywords:** Magnetic Resonance Spectroscopy (MRS), Intra-axial Brain Lesions, Glioma, Histopathological Correlation, Brain Tumor Differentiation.

### INTRODUCTION

Intra-axial brain masses constitute a major neurological health burden and represent a diverse group of pathological entities that pose considerable diagnostic and therapeutic challenges.<sup>1</sup> These lesions encompass a wide pathological spectrum, including primary brain neoplasms of varying grades, secondary metastatic deposits, primary central nervous system lymphoma, tumefactive demyelinating lesions, infective processes such as abscesses, and inflammatory conditions like encephalitis.<sup>2</sup> Accurate characterization of these lesions is essential, as management strategies and prognostic outcomes differ significantly across these entities.<sup>3,4</sup> However, overlapping clinical presentations and imaging features often make definitive diagnosis difficult using conventional techniques alone. Recent years have witnessed a paradigm shift in neuroimaging, moving beyond the mere depiction of anatomical structures toward the assessment of tumor biology and physiology. Imaging now plays a pivotal role not only in lesion detection but also in guiding clinical decision-making throughout the continuum of intracranial tumor management.<sup>5</sup> Magnetic resonance (MR) imaging has emerged as the modality of choice for the evaluation of intra-axial brain tumors due to its superior soft-tissue contrast, multiplanar capability, and lack of ionizing radiation. The role of MR imaging in the assessment of intra-axial tumors can be broadly categorized into tumor diagnosis and classification, treatment planning, and post-treatment surveillance.<sup>6</sup> While conventional MR imaging sequences provide valuable information regarding lesion location, size, morphology, signal characteristics, and contrast enhancement patterns, they often fall short in accurately determining tumor grade or differentiating neoplastic from non-neoplastic lesions. To address these limitations, a variety of advanced MR imaging techniques have been introduced into clinical practice, with several others remaining subjects of ongoing research.<sup>7</sup> These advanced techniques provide insights into tissue perfusion, cellularity, microstructural integrity, metabolic activity, and

molecular composition. Currently employed advanced MR techniques include perfusion imaging, diffusion-weighted imaging and diffusion tensor imaging, MR spectroscopy, blood oxygen level-dependent (BOLD) imaging, and emerging molecular imaging approaches. Magnetic resonance spectroscopy (MRS) is a powerful, non-invasive technique that enables the in vivo assessment of tissue biochemistry by measuring specific metabolites within a selected volume of interest.<sup>8</sup> Proton MR spectroscopy has gained recognition as a safe and reliable diagnostic adjunct to conventional MRI, allowing for the correlation of anatomical findings with underlying metabolic and physiological alterations<sup>9</sup>. By evaluating metabolites such as N-acetyl aspartate (NAA), creatine, choline, lactate, and myo-inositol, MRS provides valuable information regarding neuronal integrity, cellular proliferation, membrane turnover, and anaerobic metabolism. The analysis of metabolite ratios further enhances lesion characterization and helps in differentiating tumor types, grading gliomas, and distinguishing neoplastic lesions from inflammatory or demyelinating processes<sup>10,11</sup>. Thus, MR spectroscopy, when used in conjunction with conventional and other advanced MR imaging techniques, significantly enhances diagnostic accuracy and contributes meaningfully to the comprehensive evaluation of intra-axial brain masses.

### AIM

To evaluate the role of magnetic resonance spectroscopy in the characterization and differentiation of intra-axial brain lesions by analyzing their metabolic profiles and correlating the findings with histopathological diagnosis.

### METHODOLOGY

This study was conducted as a hospital-based prospective observational study in the ..... The study period extended from ..... A total of 39 patients with suspected intra-axial brain lesions detected on clinical evaluation and conventional magnetic resonance imaging were included in the study. All patients underwent detailed MRI of the brain using standard imaging sequences along with proton magnetic resonance spectroscopy. The MR spectroscopy findings were analyzed with respect to metabolite patterns and ratios, and wherever available, these findings were correlated with histopathological diagnosis obtained from surgical specimens or biopsy, which was considered the reference standard.

Patients of all age groups and both genders presenting with intra-axial brain lesions on MRI were included in the study. Inclusion criteria comprised patients with imaging features suggestive of primary intra-axial brain tumors, metastatic lesions, lymphoma, tumefactive demyelinating lesions, or infective lesions such as abscesses. Patients who were clinically stable and able to undergo MRI examination were also included. Exclusion criteria included patients with extra-axial brain lesions, purely intraventricular tumors, prior history of surgical intervention, radiotherapy or chemotherapy to the brain, contraindications to MRI such as pacemakers or metallic implants, and patients with poor image quality or incomplete imaging data. Patients who did not provide informed consent were also excluded from the study.

### RESULT

**Table 1: Age distribution of participants**

Age group	Frequency	Percentage
<10	7	17.9%
11-20	5	12.8%
21-30	2	5.1%
31-40	8	20.5%
41-50	6	15.4%
51-60	3	7.7%
61-70	5	12.8%
>70	3	7.7%

The majority of patients were distributed in the 31–40 years age group (20.5%), followed by children below 10 years (17.9%) and those aged 41–50 years (15.4%). Fewer cases were observed in the 21–30 years age group (5.1%), with a gradual decline in frequency noted in the older age groups.

**Table 2: Gender distribution of participants**

Gender	Number	Percentage
Male	29	74.4%
Female	10	25.6%

The study population showed a clear male predominance, with 29 male patients (74.4%) compared to 10 female patients (25.6%). This indicates a higher prevalence of intra-axial brain lesions among males in the present study.

**Table 3: Anatomical Distribution of Intra-axial Brain Lesions**

Location	Number	Percentage
Supra tentorial	27	69.2%
Infra tentorial	12	30.8%

The majority of intra-axial brain lesions were located in the supratentorial compartment (29 cases), while a smaller proportion were found in the infratentorial region (8 cases). This demonstrates a predominant supratentorial involvement in the study population.

**Table 4: Signal Characteristics of Intra-axial Brain Lesions on T1- and T2-Weighted MRI**

T1w	Number	Percentage
Iso intense	8	20.5%
Hyponintense	17	43.6%
Hyper intense	0	00
Hetero intense	14	35.9%
T2w		
Iso intense	3	7.7%
Hyponintense	0	00
Hyper intense	13	33.3%
Hetero intense	23	59%

On T1-weighted imaging, most lesions appeared hypointense (43.6%), followed by heterointense (35.9%) and isointense (20.5%), with no hyperintense lesions observed. On T2-weighted imaging, the majority of lesions were heterointense (59%), followed by hyperintense (33.3%), while only a few appeared isointense (7.7%).

**Table 5: Associated Imaging Findings and Tumor Components on MRI**

Findings	Number	Percentage
Present	28	71.8%
Absent	11	28.2%
GRE		
Bleed	9	23.1%
Calcification	2	5.1%
Components of brain tumor		
Solid/cystic	27	69.2%
Solid	11	28.2%
Cystic	1	2.6%

Perilesional edema was present in the majority of cases (71.8%), indicating aggressive or infiltrative pathology. Most tumors demonstrated a solid-cystic composition (69.2%), with hemorrhage seen in nearly one-fourth of cases on GRE imaging.

**Table 6: Degree of contrast enhancement**

Degree of contrast	Number	Percentage
Mild	8	20.5%
Moderate	7	17.9%
Intense	22	56.4%
Absent	2	5.1%

The majority of lesions showed intense contrast enhancement (56.4%), followed by mild (20.5%) and moderate enhancement (17.9%), while a small proportion showed no enhancement. This pattern suggests a predominance of lesions with high vascularity and blood–brain barrier disruption.

**TABLE 7: MR Spectroscopy Metabolic Profile of Intra-axial Brain Lesions**

MR spectroscopy		Number	Percentage
Choline	Increased	39	100%
NAA & Creatinine	Reduced	39	100%
Lipid & Lactate	Present	23	59%
	Absent	16	41%
Myoinositol	Increased	4	10.3%
Cho/Cr ratio	Increased	39	100%
Cho/NAA ratio	Increased	39	100%
NAA/Cr ratio	Reduced/ Absent	39	100%

MR spectroscopy demonstrated universally increased choline with reduced NAA and creatinine (100%), along with elevated Cho/Cr and Cho/NAA ratios in all cases. Lipid–lactate peaks were present in 59% of lesions, while increased myo-inositol was seen in a smaller proportion (10.3%), reflecting varied tumor biology and metabolic activity.

**TABLE 8: Comparison of Histopathological Diagnosis and MR Spectroscopy Diagnosis of Intra-axial Brain Tumors**

Diagnosis	Number	Percentage	Number	Percentage
High-grade glioma (Grade 3 & 4)	20	51.3%	21	53.8%
Low-grade glioma (Grade 1 & 2)	8	20.5%	6	15.4%
Oligodendroglioma	2	5.1%	3	7.7%
Ependymoma	3	7.7%	3	7.7%
Lymphoma	2	2.6%	2	5.1%
Medulloblastoma	1	2.6%	1	2.6%
Metastasis	1	2.6%	1	2.6%
Choroid Plexus Papilloma	1	2.6%	1	2.6%
Central	1	2.6%	1	2.6%

Neurocytoma				
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High-grade gliomas constituted the largest proportion on both histopathology (51.3%) and MR spectroscopy (53.8%). Minor discrepancies were observed in low-grade gliomas and oligodendrogliomas, reflecting overlapping metabolic features on MR spectroscopy.

**Table 9: Association Between MR Spectroscopy Diagnosis and Histopathological Diagnosis**

MR spectroscopy	Histology matched	Others	Total	P value
High-grade glioma (Grade 3 & 4)	20	1	21	
Low-grade glioma (Grade 1 & 2)	6	2	8	
Oligodendroglioma	2	1	3	
Ependymoma	3	0	3	
Lymphoma	2	0	2	
Medulloblastoma	1	0	1	
Metastasis	1	0	1	
Choroid Plexus Papilloma	3	0	3	
Central Neurocytoma	1	0	1	

MR spectroscopy showed excellent concordance with histopathology for most tumor types, with 100% matching observed in ependymoma, lymphoma, medulloblastoma, metastasis, choroid plexus papilloma, and central neurocytoma. Lower concordance was seen in low-grade glioma and oligodendroglioma, likely due to overlapping metabolic profiles.

## DISCUSSION

In our study The age distribution of patients showed a wide range, indicating that intra-axial brain lesions can occur across all age groups. The highest incidence was observed in the 31–40-year age group (20.5%), followed by patients below 10 years of age (17.9%) and those between 41–50 years (15.4%). The least number of cases were seen in the 21–30-year age group (5.1%). Elderly patients above 70 years constituted 7.7% of the study population.

In our study The study population showed a clear male predominance, with 29 patients (74.4%) being males and 10 patients (25.6%) being females. This indicates that intra-axial brain lesions were more commonly observed in males in the present study. The male-to-female ratio was approximately 3:1. Similar male predominance has been reported in several previous neuroimaging studies. Musawar et al<sup>12</sup> In current study, mean age of patients was 40.88±11.47 years. There were 69.3% male and 30.7% female patients.

In our study The majority of intra-axial brain lesions in the present study were located in the supratentorial region, accounting for 29 cases, indicating a clear predominance of supratentorial involvement. Infratentorial lesions were comparatively fewer, with 8 cases identified. This distribution highlights the higher frequency of intra-axial tumors occurring in the supratentorial compartment of the brain. The observed pattern is consistent with previously reported literature on intracranial tumor localization.

In our study On T1-weighted imaging, most intra-axial brain lesions appeared hypointense (43.6%), followed by heterointense signals (35.9%), while isointense lesions accounted for 20.5% of cases; none of the lesions were hyperintense on T1-weighted sequences. On T2-weighted imaging, a predominantly heterointense signal pattern was observed in 59% of cases, reflecting internal lesion heterogeneity. Hyperintense signals on T2-weighted images were seen in 33.3% of lesions, whereas isointense signals were less common (7.7%). No lesions demonstrated hypointensity on T2-weighted imaging. Overall, the signal characteristics on T1- and T2-weighted sequences highlighted the varied composition of intra-axial brain lesions.

In our study Perilesional edema was observed in 28 cases, while 11 cases showed no surrounding edema. On GRE sequences, intralesional blooming suggestive of hemorrhage was noted in 9 cases, and calcification was identified in 2

cases. Evaluation of tumor composition revealed that the majority of lesions were solid with cystic components (27 cases). Purely solid tumors were seen in 11 cases, whereas purely cystic lesions were rare, observed in only 1 case. These imaging features provided additional information regarding the nature and behavior of intra-axial brain tumors. Pravin Arvind Lamdhade et al<sup>13</sup> The majority of the study subjects (43.33%) had a hypointense signal on T2 and 60% had a heterogeneous signal on T2. Out of 30 study subjects, 14 (46.67%) had blooming on the gradient, out of which the most common cause was bleed (92.8%) followed by calcification within the tumor (7.14%). It is observed that most of the brain tumors 24 (80%) present with Perilesional edema.

In our study Contrast enhancement was observed in the majority of intra-axial brain lesions in the present study. Intense enhancement was the most common pattern, seen in 22 cases (56.4%), suggesting high vascularity and aggressive tumor behavior. Mild enhancement was noted in 8 cases (20.5%), while moderate enhancement was seen in 7 cases (17.9%). Only 2 lesions showed no post-contrast enhancement, indicating relatively less vascular or non-enhancing pathology. The predominance of intense enhancement highlights the usefulness of contrast-enhanced MRI in lesion characterization. Soorya PS, et al<sup>14</sup> On contrast enhancement, heterogeneous enhancement in 5 (33.3%), peripheral enhancement was seen in 4 (26.7%) and was absent in 6 (40%).

In our study MR spectroscopy analysis demonstrated increased choline levels in all cases (100%), reflecting increased cellular turnover. N-acetyl aspartate and creatinine were reduced in all patients (100%), indicating neuronal loss and altered energy metabolism. Lipid and lactate peaks were observed in 59% of cases, suggesting necrosis or anaerobic metabolism, while they were absent in 41%. Myo-inositol elevation was noted in 10.3% of patients, commonly associated with low-grade or glial pathology. Metabolite ratios showed a uniform pattern, with increased choline/creatinine and choline/NAA ratios in all cases. Additionally, the NAA/creatinine ratio was reduced or absent in 100% of lesions, supporting the neoplastic nature of the studied lesions. Tiwari S, et al<sup>15</sup> Out of 35 patients scanned, 18 had high-grade glioma and 17 had low-grade glioma. High-grade glioma had a choline/creatine (Cho/Cr) ratio of  $2.44 \pm 0.78$  and a choline/N-acetyl-aspartate (Cho/NAA) ratio of  $2.05 \pm 0.84$ . Low-grade glioma had a Cho/Cr ratio of  $1.48 \pm 0.50$  and a Cho/NAA ratio of  $1.41 \pm 0.19$ . Fourteen out of eighteen high-grade gliomas had raised lipid/lactate peaks. The sensitivity, specificity, positive and negative predictive values (PPV and NPV), and accuracy for diagnosing high-grade glioma with a Cho/Cr ratio cut-off of 1.5 was 83.3 %, 82.4%, 83.3%, 82.4 %, and 82.85% respectively.

The most common intra-axial brain tumor in the present study was high-grade glioma (Grade III & IV), accounting for 20 cases (51.3%) on histopathology, while MR spectroscopy diagnosed 21 cases, indicating slight overestimation. Low-grade gliomas constituted 8 cases (20.5%) on histopathology, whereas MR spectroscopy identified 6 cases, suggesting underestimation in a few patients. Oligodendrogliomas were infrequent, with 2 histopathologically proven cases, while MR spectroscopy suggested 3 cases, reflecting diagnostic overlap. Ependymoma showed perfect concordance, with 3 cases diagnosed by both modalities. Lymphoma, medulloblastoma, metastasis, choroid plexus papilloma, and central neurocytoma were rare entities, each accounting for 1–2 cases, and showed complete agreement between histopathology and MR spectroscopy. Overall, MR spectroscopy demonstrated good correlation with histopathological diagnosis, with minor discrepancies mainly observed in glioma subtyping.

MR spectroscopy demonstrated a strong correlation with histopathological diagnosis in the majority of intra-axial brain tumors. High-grade gliomas showed excellent agreement, with 20 out of 21 cases correctly matched and only one discordant case. Low-grade gliomas also showed good correlation, although two cases were misclassified, reflecting overlapping metabolic patterns. Oligodendrogliomas showed limited concordance, with one mismatched case, indicating reduced diagnostic reliability. In contrast, ependymoma, lymphoma, medulloblastoma, metastasis, choroid plexus papilloma, and central neurocytoma demonstrated complete agreement between MR spectroscopy and histopathology. Overall, MR spectroscopy proved to be a highly reliable non-invasive tool for lesion characterization, with limitations mainly in tumors showing overlapping metabolic profiles.

## CONCLUSION

Magnetic resonance spectroscopy is a valuable non-invasive imaging technique that significantly enhances the characterization of intra-axial brain lesions when used in conjunction with conventional MRI. In the present study, MR spectroscopy demonstrated good to excellent correlation with histopathological diagnosis for the majority of intra-axial brain tumors, particularly high-grade gliomas, ependymoma, lymphoma, medulloblastoma, metastasis, choroid plexus papilloma, and central neurocytoma. The technique was especially useful in identifying tumor grade and metabolic activity through analysis of key metabolite ratios. Minor diagnostic discrepancies were mainly encountered in glioma subtyping, particularly in low-grade gliomas and oligodendrogliomas, likely due to overlapping metabolic patterns. Overall, MR spectroscopy proved to be a reliable adjunct to conventional MRI, aiding in accurate lesion characterization, treatment planning, and reducing the need for invasive diagnostic procedures.

## REFERENCE

1. Ohba S, Nakagawa T, Murakami H, Ushioda T, Shimizu K. Diffusion magnetic resonance imaging for enhanced visualization of malignant cerebral tumours and abscesses. *Neurol India*. 2011;59(5):674.

2. Bulakbasi N, Kocaoglu M, Ors F, Tayfun C, Uçöz T. Combination of single-voxel proton MR spectroscopy and apparent diffusion coefficient calculation in the evaluation of common brain tumours. *AJNR Am J Neuroradiol.* 2003;24(2):225-33.
3. Chiang IC, Kuo YT, Lu CY, Yeung KW, Lin WC, Sheu FO, et al. Distinction between high-grade gliomas and solitary metastases using peritumoural 3-T magnetic resonance spectroscopy, diffusion, and perfusion imagings. *Neuroradiol.* 2004;46(8):619-27.
4. Smith JK, Castillo M, Kwok L. MR spectroscopy of brain tumours. *Mag Resonan Imag Clin North Ame.* 2003;11(3):415-29.
5. Dawoud MAE, Sherif MF, Eltomey MA. Apparent diffusion coefficient and Magnetic resonance spectroscopy in grading of malignant brain neoplasms. *Egypt J Radio Nucl Medi.* 2014;45(4):1215-22.
6. Yamasaki F, Kurisu K, Satoh K, Arita K, Sugiyama K, Ohtaki M, et al. Apparent diffusion coefficient of human brain tumours at MR imaging. *Radiol.* 2005;235(3):985-91.
7. Naser RKA, Hassan AAK, Shabana AM, Omar NN. Role of magnetic resonance spectroscopy in grading of primary brain tumours. *Egypt J Radiol Nucl Medi.* 2016;47(2):577-84.
8. Gupta K, Jain N, Saggat K. Role of diffusion weighted imaging and MR spectroscopy in characterisation of intracranial neoplasms. *Int J Anat Radiol Surg.* 2018;7(3):RO55-61.
9. Louis DN, Perry A, Wesseling P, Brat DJ, Cree IA, Figarella-Branger D, et al. The 2021 WHO classification of tumours of the central nervous system: a summary. *Neuro-Oncol.* 2021;23(8):1231-51.
10. Shokry A. MRS of brain tumours: Diagrammatic representations and diagnostic approach. *Egypt J Radio Nucl Medi.* 2012;43(4):603-12.
11. Darwiesh AMN, Maboud NMAE, Khalil AMR, ElSharkawy AM. Role of magnetic resonance spectroscopy and diffusion weighted imaging in differentiation of supratentorial brain tumours. *Egypt J Radiol Nucl Medi.* 2016;47(3):1037-42.
12. Musawar, Samia & Shaukat, Asma & Manzoor, Amber & Manzoor, Iqra. (2022). Diagnostic accuracy of magnetic resonance spectroscopy (MRS) for diagnosis of focal brain lesions taking histopathology as gold standard.. *The Professional Medical Journal.* 29. 1740-1744. 10.29309/TPMJ/2022.29.11.7094.
13. Pravin Arvind Lamdhade, Amit Pendor and Satyajeet S. Ghodake, 2023. Role of MRS Spectroscopy in Evaluation of Intra-Axial Brain Tumors by 3T MRI with Histopathological Correlation. *Res. J. Med. Sci.,* 17: 209-215, doi:10.59218/makrjms.2023.209.215
14. Soorya PS, Kattoju S. Role of magnetic resonance spectroscopy and diffusion-weighted imaging in characterizing intra axial brain tumours. *Int J Res Med Sci* 2023;11:3722-8.
15. Tiwari S, Gyawali I. Magnetic Resonance Spectroscopy of Intra-axial Gliomas With Histopathological Correlation in a Tertiary Care Center of Eastern Nepal. *Cureus.* 2024 Feb 16;16(2):e54287. doi: 10.7759/cureus.54287. PMID: 38496065; PMCID: PMC10944577.