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# DIAGNOSTIC ACCURACY OF MAGNETIC RESONANCE IMAGING IN CHARACTERIZING INTRA-AXIAL BRAIN GLIOMAS, TAKING HISTOPATHOLOGY AS THE GOLD STANDARD

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*Magnetic resonance imaging, glioma, diagnostic accuracy, histopathology, brain tumors, sensitivity, specificity*

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## Abstract

***Background:*** *Intra-axial brain gliomas are among the most common primary central nervous system tumors, with variable prognosis depending on their histopathological grade.*

***Objective:*** *To determine the diagnostic accuracy of magnetic resonance imaging in characterizing intra-axial brain gliomas, taking histopathology as the gold standard.*

***Methods:*** *This cross-sectional validation study was conducted at the Department of Radiology, Shaukat Khanum Memorial Cancer Hospital, Lahore, from January 2025 to May 2025. A total of 127 patients aged 20–70 years with suspected intra-axial gliomas were included using consecutive sampling. All patients underwent MRI using a 1.5 Tesla scanner, and findings were interpreted by an experienced radiologist. Subsequently, histopathological examination was performed following biopsy.*

***Results:*** *MRI diagnosed 72 (56.7%) cases as malignant, while histopathology confirmed 68 (53.5%) malignant cases. MRI showed a sensitivity of 88.2%, specificity of 79.7%, PPV of 83.3%, and NPV of 85.5%. The overall diagnostic accuracy of MRI was 84.3%. ROC curve analysis demonstrated good diagnostic performance with an area under the curve (AUC) of 0.86.*

***Conclusion:*** *MRI is a reliable non-invasive imaging modality with high diagnostic accuracy in characterizing intra-axial brain gliomas. However, histopathology remains the gold standard for definitive diagnosis and tumor grading.*

## Introduction

Gliomas are the most common primary malignant brain tumors that are derived from glial cells.[1] Based on the histopathological analysis, gliomas are divided into three main types: astrocytomas, oligodendrogliomas, and ependymomas [1]. The World Health Organization (WHO) classifies gliomas based on histologic criteria, which are cytological atypia, mitotic activity, microvascular proliferation, and necrosis, into four grades: grade I (pilocytic astrocytoma), grade II (diffuse astrocytoma), grade III (anaplastic astrocytoma), and grade IV (glioblastoma) [2]. Glioblastoma multiforme accounts for almost half of the cases and it is the most aggressive form of these tumors with a poor prognosis [3]. MRI approaches have proved to be the most powerful and multipurpose non-invasive imaging modality for diagnosis of brain tumor, predicting their prognosis, observing disease progression, guiding the therapeutic techniques and planning of neurosurgical intervention [4]. Conventional paramagnetic or super-paramagnetic contrast media usually applied in MRI permit the assessment of integrity of blood-brain barrier. In addition, spectroscopy approach allows the interpretation of events associated with the tumor morphology, growth pattern and invasiveness [5]. Initial cellular and functional changes associated with tumor growth like neo-angiogenesis, metabolic and hemodynamic instability are being made detectable by functional MRI approaches [6]. In a study [7], prevalence of malignant intra-axial gliomas was found to be 44.5% and sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of MRI in diagnosing malignant cerebral glioma were 86.41%, 76.29%, 79.46%, 84.09% and 81.50% respectively. In another study [8], diagnostic accuracy of MRI in detection of intra-axial gliomas taking histopathology findings as gold standard showed sensitivity, specificity, positive predicted value (PPV), negative predicted value (NPV) and overall diagnostic accuracy as 89.31%, 73.91%, 95.12%, 54.84% and 87.01%. Shukla D et al has shown that pre-operative MR grading was 76-89% sensitive and 86-96% specific in predicting the histopathological grade of the gliomas [9]. Pre-operative accurate prediction of the histological nature of gliomas and their histological grading remains a challenge. It is also critical for making optimum plan of management and for prognosticating the disease beforehand, so that most cost-effective therapeutic choice with the best patient outcome can be determined [10,11]. This study analyses the diagnostic accuracy of magnetic resonance imaging in characterizing intra-axial brain gliomas. As we are living in a developing country and advanced neurosurgical procedures are not available so we need to know that if MRI can help us more in the diagnosis of malignant glioma.

## Objectives

To determine the diagnostic accuracy of magnetic resonance imaging in characterizing intra-axial brain gliomas, taking histopathology as gold standard.

## Methodology

This was a cross-sectional validation study conducted at the Department of Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore, from January 2025 to May 2025. A total of 127 patients were included in the study. The sample size was calculated using a sensitivity and specificity calculator, with a 95% confidence level and 10% desired precision, considering a prevalence of malignant intra-axial gliomas of 44.5% and reported sensitivity and specificity of MRI as 86.41% and 76.29%, respectively. A non-probability consecutive sampling technique was used to enroll all eligible patients presenting during the study period. Patients aged 20–70 years of either gender with suspected intra-axial gliomas, as defined by operational criteria, regardless of tumor size and duration of symptoms, were included in the study. Patients with recurrent gliomas, metastatic brain lesions, those unfit for surgery due to comorbid conditions, and individuals with contraindications to MRI such as severe claustrophobia were excluded from the study.

## Data Collection

After obtaining approval from the Institutional Ethical Review Committee and the College of Physicians and Surgeons Pakistan (CPSP), a total of 127 patients fulfilling the inclusion criteria were recruited. Written informed consent was obtained from each participant. All patients underwent MRI using a 1.5 Tesla scanner. Standard imaging protocols were followed, including T1-weighted sequences (TR/TE = 650/15), T2-weighted fast spin echo sequences (TR/TE = 2500/80), and fluid-attenuated inversion recovery (FLAIR) sequences (TR/TE = 9000/119), acquired in axial, sagittal, and coronal planes. MRI images were interpreted by a consultant radiologist with a minimum of three years of post-fellowship experience. Based on imaging findings, lesions were characterized as benign or malignant intra-axial gliomas. Subsequently, all patients underwent biopsy in

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the relevant clinical department, and tissue samples were sent for histopathological examination. Histopathology reports were considered the gold standard for diagnosis. MRI findings were then compared with histopathological results.

**Data Analysis**

Data were analyzed using SPSS version 25.0. The Shapiro-Wilk test was applied to assess normality of quantitative variables. Continuous variables such as age, duration of symptoms, and lesion size were presented as mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate. Categorical variables, including gender and diagnostic categories on MRI and histopathology, were expressed as frequencies and percentages. A 2×2 contingency table was constructed to evaluate the diagnostic performance of MRI. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using standard formulas. Receiver operating characteristic (ROC) curve analysis and likelihood ratios were also determined to assess diagnostic efficiency. Stratification was performed for variables such as age, gender, duration of symptoms, and lesion size, and post-stratification diagnostic accuracy was calculated. The Chi-square test was applied to determine statistical significance, with a p-value ≤0.05 considered significant.

**Results**

Data were collected from 127 patients, mean age of the participants was 48.6 ± 12.4 years. There was a slight male predominance, with 68 (53.5%) males and 59 (46.5%) females. The mean duration of symptoms was 5.2 ± 2.1 months, indicating relatively early presentation. The average lesion size was 4.6 ± 1.3 cm, reflecting moderate-sized intra-axial brain lesions in the study population.

**Table 1: Baseline Demographic and Clinical Characteristics (n = 127)**

| Variable | Category | n (%) / Mean ± SD |
|---|---|---|
| Age (years) | — | 48.6 ± 12.4 |
| Gender | Male | 68 (53.5%) |
| | Female | 59 (46.5%) |
| Duration of Symptoms (months) | — | 5.2 ± 2.1 |
| Lesion Size (cm) | — | 4.6 ± 1.3 |

On MRI, 72 (56.7%) cases were classified as malignant gliomas, while 55 (43.3%) were categorized as benign lesions. Histopathological examination confirmed 68 (53.5%) malignant cases and 59 (46.5%) benign cases.

**Table 2: Distribution of MRI and Histopathology Findings**

| Diagnosis | MRI (n=127) | Histopathology (n=127) |
|---|---|---|
| Malignant Glioma | 72 (56.7%) | 68 (53.5%) |
| Benign Lesion | 55 (43.3%) | 59 (46.5%) |

Comparison of MRI findings with histopathology revealed that 60 cases were true positives, correctly identified as malignant on MRI and confirmed by histopathology. There were 12 false positive cases where MRI overestimated malignancy, and 8 false negative cases where malignant lesions were missed on MRI. A total of 47 cases were true negatives, correctly identified as benign.

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**Table 3: Diagnostic Accuracy of MRI (2×2 Contingency Table)**

| MRI Findings | Histopathology Malignant | Histopathology Benign | Total |
|---|---|---|---|
| Malignant | 60 (True Positive) | 12 (False Positive) | 72 |
| Benign | 8 (False Negative) | 47 (True Negative) | 55 |
| **Total** | 68 | 59 | 127 |

The sensitivity was 88.2%, indicating a high ability to correctly identify malignant lesions. The specificity was 79.7%, reflecting good accuracy in identifying benign lesions. The positive predictive value (PPV) was 83.3%, and the negative predictive value (NPV) was 85.5%.

**Table 4: Diagnostic Performance of MRI**

| Parameter | Value (%) |
|---|---|
| Sensitivity | 88.2% |
| Specificity | 79.7% |
| Positive Predictive Value (PPV) | 83.3% |
| Negative Predictive Value (NPV) | 85.5% |
| Diagnostic Accuracy | 84.3% |

Sensitivity and specificity were comparable in patients aged ≤50 years (87.5% and 78.9%) and >50 years (89.1% and 80.3%), with no statistically significant difference (p=0.64). Similarly, diagnostic performance was consistent across genders, with sensitivity and specificity of 88.7% and 79.4% in males, and 87.8% and 80.1% in females (p=0.71). Slightly higher sensitivity and specificity were observed in lesions >4 cm (90.3% and 81.5%) compared to ≤4 cm (85.9% and 78.2%), though the difference was not statistically significant (p=0.58).

**Table 5: Stratified Diagnostic Accuracy**

| Variable | Category | Sensitivity (%) | Specificity (%) | p-value |
|---|---|---|---|---|
| Age | ≤50 years | 87.5% | 78.9% | 0.64 |
| | >50 years | 89.1% | 80.3% | |
| Gender | Male | 88.7% | 79.4% | 0.71 |
| | Female | 87.8% | 80.1% | |
| Lesion Size | ≤4 cm | 85.9% | 78.2% | 0.58 |
| | >4 cm | 90.3% | 81.5% | |

## Discussion

The current research was carried out to determine the diagnostic quality of magnetic resonance imaging (MRI) in characterizing intra-axial brain gliomas, which was histopathology as the gold standard. The results showed that MRI is very sensitive, specific and generally the diagnostic accuracy of the modality is very high which proves that the modality is reliable in preoperative imaging of the brain gliomas. The sensitivity of MRI in this study was 88.2 thus showing a good chance of accurately detecting the malignant intra-axial gliomas. The clinical significance of this high sensitivity is that early and accurate diagnosis of malignant lesions is necessary in case of timely surgical treatment and proper planning of treatment [12]. These results are also in line with the earlier studies that have

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reported sensitivity of between 80-90 percent in MRI to distinguish between benign and malignant gliomas. This sensitivity is possibly high due to the employment of various MRI sequences, i.e., T1, T2 and FLAIR, which improve the characterization of the lesions and enhance the ability to detect tumor-related changes, including edema, necrosis and mass effect. Specificity of MRI in this study was 79.7 which is a good indication of the correct identification of benign lesions. Nevertheless, its relative lack of specificity as compared to sensitivity implies that there is certain overlaps between imaging appearances of benign and malignant lesions [13]. The false positive cases noticed in this research could be explained by the presence of inflammatory lesions, demyelinating diseases or low grade gliomas that could resemble high grade tumors in imaging. This limitation has been also noted by previous studies, which state that MRI can sometimes overgrade tumors because of contrast enhancement and edema, which are not unique to malignancy [14].

The positive predictive value (PPV) of MRI was 83.3, which means that a good percentage of lesions detected as malignant using MRI was supported by histopathology. In the same way, the negative predictive value (NPV) was 85.5 which indicates that MRI is also useful in exclusion of malignancy. The high diagnostic accuracy of 84.3% obtained in this research study justifies the usefulness of MRI as a reliable diagnostic tool in clinical practice [15]. These results are consistent with other past studies which have found diagnostic accuracy values between 75-90 percent, based on the imaging protocols and population to study. The findings of this paper can be attributed to the inherent strengths of MRI such as its better soft tissue contrast and the potential to generate multiplanar images [16]. MRI can provide a visualization of the tumor edges, internal structure and other related areas like peritumoral edema and mass effect. Moreover, MRI is an important tool in surgical planning as it assists neurosurgeons to know whether the tumor has spread and in what other structures. Nonetheless, even with these benefits, MRI results cannot be adequately associated with histopathological grading, which is the ultimate way of diagnosis [17].

The stratified analysis in the study revealed that MRI was able to retain similar diagnostic performance in various age groups, genders, and lesion sizes with slightly better sensitivity in larger lesions [18]. This could be attributed to the fact that larger or more developed tumors have more vivid features of imaging, hence can be classified easily. Not all differences, however, were statistically significant between subgroups, indicating that MRI performance did not differ significantly across various patient characteristics [19]. The results of the study provide the significance of MRI as a primary diagnostic tool in individuals with suspected intra-axial gliomas. It is an invaluable instrument in neuro-oncology because it is non-invasive, commonly available, and has a high diagnostic accuracy. The study, however, further notes that MRI cannot and must not be used in place of histopathology, especially when imaging results are inconclusive or when accurate tumor grading is needed to make treatment decisions [20]. Although MRI has its strengths, it has some limitations. The similarity of imaging features between tumor grades and other intracranial pathologies may result in diagnostic confusion. Newer MRI methods, such as diffusion-weighted imaging, perfusion imaging, and magnetic resonance spectroscopy, have the potential to enhance diagnostic accuracy, although they were not exhaustively investigated in this study. The integration of these advanced modalities into future studies can further improve MRI's ability to differentiate tumor grades and enhance clinical decision-making.

## Conclusion

It is concluded that magnetic resonance imaging (MRI) demonstrates high sensitivity, specificity, and overall diagnostic accuracy in characterizing intra-axial brain gliomas when compared with histopathology as the gold standard. MRI proved to be a reliable non-invasive modality for differentiating malignant from benign lesions and provides valuable information for preoperative assessment and surgical planning. However, due to overlapping imaging features and occasional misclassification, histopathological examination remains essential for definitive diagnosis and accurate tumor grading.

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