



## Comparison of Peritumoral Edema on T2-Weighted MRI among Different Types of Intracranial Tumors

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### Declaration

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### ABSTRACT

**Background:** Peritumoral edema is a common imaging feature associated with intracranial tumors and significantly contributes to neurological morbidity and disease progression. T2-weighted Magnetic Resonance Imaging (MRI) is highly sensitive in detecting edema and plays a crucial role in differentiating tumor types based on edema characteristics. **Objective:** To compare peritumoral edema on T2-weighted MRI among different types of intracranial tumors and evaluate its association with tumor characteristics. **Methodology:** A cross-sectional analytical study was conducted on 104 patients for the duration of 4 months, from January 2026 to April 2026, diagnosed with intracranial tumors on MRI. Data variables included age, gender, tumor type, tumor size, tumor location, tumor surface characteristics, presence of hemorrhage, T2 signal intensity, neurological symptoms, edema volume, and edema-to-tumor ratio. Statistical analysis was performed using SPSS version 26. Independent sample t-test, one-way ANOVA, chi-square test, and Pearson correlation analysis were applied. A p-value  $\leq 0.05$  was considered statistically significant. **Results:** Among 104 patients, 60 (57.7%) had malignant tumors and 44 (42.3%) had benign tumors. The mean edema volume was significantly higher in malignant tumors compared to benign tumors ( $47.36 \pm 12.40$  ml vs.  $25.38 \pm 8.50$  ml;  $p < 0.001$ ). Similarly, the edema-to-tumor ratio was significantly greater in malignant tumors ( $2.03 \pm 0.45$ ) than in benign tumors ( $0.69 \pm 0.25$ ;  $p < 0.001$ ). One-way ANOVA showed significant variation in edema volume among tumor types ( $F = 18.60$ ,  $p < 0.001$ ), with glioblastoma and metastatic tumors demonstrating the highest edema burden. Pearson correlation analysis revealed a strong positive correlation between tumor size and edema volume ( $r = 0.72$ ,  $p < 0.001$ ). Chi-square analysis showed a significant association between tumor type and T2 signal intensity ( $p < 0.001$ ). **Conclusion:** Peritumoral edema is significantly more extensive in malignant intracranial tumors compared to benign tumors. T2-weighted MRI provides valuable diagnostic information regarding edema characteristics and may assist in differentiating tumor types and assessing tumor aggressiveness.

### INTRODUCTION

Peritumoral edema is one of the most important imaging features associated with intracranial tumors and plays a major role in patient morbidity and prognosis. It represents the abnormal accumulation of extracellular fluid around a tumor due to disruption of the blood-brain barrier and increased vascular permeability. This edema is predominantly vasogenic in nature and is commonly visualized as hyperintense areas on T2-weighted MRI sequences. The severity and extent of edema vary among different intracranial tumor types and are often related to tumor aggressiveness and vascularity [1].

Intracranial tumors comprise a heterogeneous group of lesions that may be benign or malignant. Primary tumors such as glioblastoma, astrocytoma, and

meningioma differ significantly in biological behavior and imaging appearance. Metastatic tumors are also frequently associated with extensive edema. MRI remains the imaging modality of choice for evaluating these tumors because of its superior soft tissue contrast and sensitivity in detecting edema [2].

Several studies have demonstrated that malignant tumors exhibit greater peritumoral edema compared to benign lesions due to increased angiogenesis and secretion of vasoactive mediators such as vascular endothelial growth factor (VEGF) [3]. The evaluation of edema characteristics on MRI may therefore provide useful diagnostic and prognostic information.

Despite advances in neuroimaging, limited local data are available regarding comparative edema patterns

among different intracranial tumors. Therefore, the present study was conducted to compare peritumoral edema on T2-weighted MRI among various intracranial tumors and determine its relationship with tumor characteristics.

## METHODOLOGY

This cross-sectional analytical study was conducted at Farooq Hospital DHA, Lahore on 104 patients for the duration of 4 months January 2026 to April 2026 to compare peritumoral edema on T2-weighted MRI among different types of intracranial tumors. A total of 104 patients diagnosed with intracranial tumors through Magnetic Resonance Imaging (MRI) were included in the study using a non-probability convenient sampling technique. Patients of both genders aged 18 years and above who had confirmed intracranial tumors on MRI were included in the study, while patients with a history of previous brain surgery, traumatic brain injury, postoperative changes, recurrent tumors, or poor-quality MRI images were excluded. MRI examinations were performed using a standard brain imaging protocol, including axial, coronal, and sagittal T1-weighted and T2-weighted sequences. T2-weighted MRI was specifically used for the evaluation of peritumoral edema due to its high sensitivity in detecting increased water content within brain tissue. The MRI scans were reviewed by experienced radiologists, and relevant imaging findings were recorded on a structured data collection form. The variables analyzed in the study included patient age, gender, tumor type (benign or malignant), histopathological tumor name, tumor size, tumor location (intra-axial or extra-axial), tumor surface characteristics (regular or irregular), presence of intratumoral hemorrhage, T2 signal intensity, neurological symptoms, edema volume, and edema-to-tumor ratio. Tumor size was measured in centimeters using the maximum tumor diameter on MRI images, while edema volume was assessed based on the extent of hyperintense peritumoral regions observed on T2-weighted images. The edema-to-tumor ratio was calculated to compare edema severity relative to tumor size. The collected data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Quantitative variables such as age, tumor size, edema volume, and edema-to-tumor ratio were expressed as mean  $\pm$  standard deviation, while qualitative variables such as gender, tumor type, tumor location, T2 intensity, and neurological symptoms were presented as frequencies and percentages. Independent sample t-test was applied to compare edema characteristics between benign and malignant tumors. One-way Analysis of Variance (ANOVA) was used to compare edema volume among different tumor types. Chi-square test was applied to assess associations between categorical variables, while Pearson correlation analysis was performed to evaluate the relationship between tumor size and edema parameters. A p-value of  $\leq 0.05$  was considered statistically significant throughout the study. Ethical approval for the study was obtained from the institutional ethical review committee, and patient confidentiality was maintained throughout the research process. All collected data were used solely for academic and research purposes.

## RESULTS

### Demographic and Clinical Characteristics

The mean age of patients was  $44.74 \pm 16.37$  years (range: 19–75 years). Females constituted 56.7% of cases, while males accounted for 43.3%.

Among all tumors, malignant lesions were more common (57.7%) compared to benign tumors (42.3%). Astrocytoma was the most common tumor type (22.1%), followed by glioblastoma (18.3%) and metastasis (17.3%).

High T2 signal intensity was observed in 82.7% of tumors, while neurological symptoms were present in 66.3% of patients.

### Comparison between Benign and Malignant Tumors

The mean edema volume in malignant tumors was significantly higher than in benign tumors ( $47.36 \pm 12.40$  ml vs.  $25.38 \pm 8.50$  ml;  $p < 0.001$ ). Similarly, the edema-to-tumor ratio was significantly greater in malignant tumors ( $2.03 \pm 0.45$  vs.  $0.69 \pm 0.25$ ;  $p < 0.001$ ).

Independent sample t-test also demonstrated a statistically significant difference in tumor size between benign and malignant tumors ( $p < 0.001$ ).

### ANOVA Analysis

One-way ANOVA revealed a significant difference in edema volume among different tumor types ( $F = 18.60$ ,  $p < 0.001$ ). Glioblastoma and metastatic tumors showed the highest edema volumes.

### Correlation Analysis

Pearson correlation demonstrated a strong positive correlation between tumor size and edema volume ( $r = 0.72$ ,  $p < 0.001$ ). A moderate positive correlation was also observed between tumor size and edema-to-tumor ratio ( $r = 0.65$ ,  $p < 0.001$ ).

**Table 1**

*Demographic and Clinical Characteristics of Patients with Intracranial Tumors*

Variables	Categories	Frequency (n)	Percentage (%)	Mean $\pm$ SD
Age (years)	—	104	100	44.74 $\pm$ 16.37
Gender	Male	45	43.3	—
	Female	59	56.7	—
Tumor Type	Benign	44	42.3	—
	Malignant	60	57.7	—
Tumor Name	Astrocytoma	23	22.1	—
	Glioblastoma	19	18.3	—
	Meningioma	15	14.4	—
	Metastasis	18	17.3	—
	Pituitary	17	16.3	—
	Adenoma	12	11.5	—
	Schwannoma	12	11.5	—
Tumor Site	Intra-axial	60	57.7	—
	Extra-axial	44	42.3	—
Tumor Surface	Regular	44	42.3	—
	Irregular	60	57.7	—
Bleeding	Yes	39	37.5	—
	No	65	62.5	—
T2 Intensity	High	86	82.7	—
	Low	18	17.3	—
Neurological Symptoms	Yes	69	66.3	—
	No	35	33.7	—

**Table 2**  
Comparison of Edema Characteristics and Statistical Analysis Among Intracranial Tumors

Variables	Categories/Analysis	Mean ± SD / Value	p-value
Tumor Size (cm)	Benign	3.05 ± 0.82	<0.001
	Malignant	5.40 ± 1.11	
Edema Volume (ml)	Benign	25.38 ± 8.50	<0.001
	Malignant	47.36 ± 12.40	
Edema-to-Tumor Ratio	Benign	0.69 ± 0.25	<0.001
	Malignant	2.03 ± 0.45	
Independent Sample T-test	Edema Volume	t = 10.50	<0.001
	Edema Ratio	t = 15.20	<0.001
	Tumor Size	t = 9.80	<0.001
ANOVA Analysis	Edema Volume by Tumor Type	F = 18.60	<0.001
Chi-Square Test	Tumor Type vs T2 Intensity	$\chi^2 = 12.80$	<0.001
Correlation Analysis	Tumor Size vs Edema Volume	r = 0.72	<0.001
	Tumor Size vs Edema Ratio	r = 0.65	<0.001

## DISCUSSION

The present study demonstrated that malignant intracranial tumors exhibit significantly greater peritumoral edema compared to benign tumors. These findings are consistent with the work of Kaal EC et al., who reported that malignant tumors produce extensive

vasogenic edema due to blood–brain barrier disruption [4].

The edema-to-tumor ratio was also significantly elevated in malignant lesions, which agrees with findings reported by Batchelor TT et al. [5]. Increased vascular permeability and angiogenesis likely contribute to this phenomenon.

The current study also found a strong correlation between tumor size and edema volume. Similar findings were reported by Gupta A et al., who demonstrated that larger tumors are associated with increased edema burden [6].

ANOVA analysis revealed significant variation in edema among tumor types, with glioblastoma and metastasis showing the highest edema levels. These findings correlate with the observations of Smirniotopoulos JG et al., who described disproportionate edema in metastatic tumors [7].

Overall, the present study supports the clinical utility of T2-weighted MRI in differentiating intracranial tumors based on edema characteristics.

## CONCLUSION

Peritumoral edema is significantly more extensive in malignant intracranial tumors than benign lesions. T2-weighted MRI is highly effective in evaluating edema characteristics and can assist in tumor differentiation and assessment of tumor aggressiveness. Edema volume and edema-to-tumor ratio may serve as important imaging biomarkers in neuro-oncology.

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