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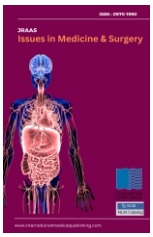

Research Article

Section: Pathology

Clinicopathological Spectrum of Intracranial Space-Occupying Lesions: A Tertiary Care Center Experience

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HIGHLIGHTS

- Neoplastic lesions predominated in cohort
- Gliomas constituted major tumor burden
- Headache most common presenting symptom
- Significant symptom lesion associations observed
- High grade gliomas more frequently

Key Words:
Intracranial space-occupying lesion
CNS tumors
Histopathology
Glioma
Meningioma
WHO grading

ABSTRACT

Introduction: Intracranial space-occupying lesions (ICSOLs) comprise a heterogeneous group of neoplastic and non-neoplastic conditions with variable clinical presentation and biological behavior. Histopathological examination remains the gold standard for definitive diagnosis and grading, which directly influence management and prognosis. **Aim & Objectives:** To evaluate the demographic profile, clinical presentation, histopathological spectrum, and WHO grade distribution of ICSOLs in a tertiary care center, and to assess associations between clinical features, lesion type, and tumor grade. **Material & Methods:** This descriptive observational study included 100 consecutive ICSOL cases received in the Department of Pathology in collaboration with Neurosurgery. Clinical details and radiological information were recorded. Tissue specimens obtained by biopsy or excision were processed routinely and stained with hematoxylin and eosin; special stains and immunohistochemistry were performed where required. Lesions were classified according to WHO CNS tumor classification, and gliomas/meningiomas were graded as per WHO criteria. Data were analyzed using descriptive statistics, and χ^2 tests were applied to examine symptom–lesion associations and compare grade distribution; $p < 0.05$ was considered significant. **Results:** Mean age was 41.3 ± 18.7 years (range 2–70), with a peak in 31–40 years (22%). There was marginal male predominance (52%). Neoplastic lesions predominated (95%). Gliomas were most common (30%), followed by meningiomas (24%) and schwannomas (15%). Headache was the commonest symptom (62%), followed by seizures (34%) and visual disturbance (28%). Significant symptom associations were observed for headache, seizures, visual disturbance, focal neurological deficit, and fever ($p < 0.05$). WHO grade distribution differed significantly between gliomas and meningiomas, with high-grade tumors (Grade III–IV) significantly more frequent among gliomas ($\chi^2 = 14.22$, $p = 0.00016$). **Conclusion:** ICSOLs in this cohort were predominantly neoplastic, with gliomas and meningiomas forming the major tumor burden. Clinicopathological correlations and WHO grading provide valuable diagnostic and prognostic insights, reinforcing the central role of histopathology in resource-limited settings.

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INTRODUCTION

Intracranial space-occupying lesions (ICSOLs) represent a heterogeneous group of pathological entities that include neoplastic and non-neoplastic conditions affecting the central nervous system (CNS). These lesions constitute a significant cause of neurological morbidity and mortality worldwide and pose diagnostic as well as therapeutic challenges due to their diverse clinical presentation, histopathological spectrum, and biological behavior [1-3]. Advances in neuroimaging have improved lesion detection; however, histopathological examination remains the gold standard for definitive diagnosis and classification [4].

CNS tumors account for approximately 1–2% of all malignancies, yet they contribute disproportionately to cancer-related mortality and long-term disability [5,6]. The incidence and distribution of CNS tumors vary according to age, sex, geographic region, and socioeconomic factors [7]. In adults, gliomas and meningiomas constitute the most common primary intracranial tumors, whereas embryonal tumors and certain glial neoplasms are more frequent in the pediatric population [8,9]. Non-neoplastic lesions such as abscesses and inflammatory conditions may clinically and radiologically mimic neoplasms, further emphasizing the importance of tissue diagnosis [10].

The World Health Organization (WHO) classification of CNS tumors provides a standardized framework for tumor classification and grading based on histological and molecular features [11,12]. WHO grading is of particular clinical relevance, as it correlates with tumor aggressiveness, therapeutic strategy, and prognosis [13]. Gliomas exhibit a wide spectrum of biological behavior, ranging from indolent low-grade tumors to highly aggressive high-grade lesions, whereas meningiomas are predominantly low-grade with a more favorable outcome [14–16]. Comparative evaluation of WHO grades among different tumor categories offers insight into disease burden and expected clinical course.

Clinical presentation of ICSOLs depends on tumor location, size, growth rate, and associated mass effect. Common presenting symptoms include headache, seizures, focal neurological deficits, visual disturbances, and features of raised intracranial pressure [17,18]. Certain symptoms show predilection for specific tumor types, and correlation between clinical presentation and histological diagnosis may aid in preoperative assessment and management planning [19].

Despite the availability of global data, regional studies remain important to understand local patterns of disease presentation, histological distribution, and tumor grading, particularly in resource-limited settings [20]. The present study aims to analyze the demographic profile, clinical presentation, histopathological spectrum, and WHO grade distribution of intracranial space-occupying lesions in a tertiary care center, and to assess the association between clinical features, lesion type, and tumor grade.

MATERIALS & METHODS

This descriptive observational study was conducted in the Department of Pathology in collaboration with the Department of Neurosurgery at a tertiary care teaching hospital. A total of 100 consecutive cases of intracranial space-occupying lesions (ICSOLs) received during the study period were included. Patients of all age groups and both sexes were studied. Both neoplastic and non-neoplastic lesions were analyzed.

Clinical details, including age, sex, presenting symptoms, and relevant radiological findings, were obtained from hospital records and specimen requisition forms. Tissue specimens obtained by biopsy or surgical excision were fixed in 10% neutral buffered formalin, processed routinely, and embedded in paraffin. Sections of 4–5 µm thickness were stained with hematoxylin and eosin. Special stains and immunohistochemistry were performed where necessary for confirmation of diagnosis.

Histopathological classification was carried out according to the World Health Organization (WHO) Classification of Tumors of the Central Nervous System. Neoplastic lesions were categorized into major histological groups, including gliomas, meningiomas, schwannomas, embryonal tumors, ependymal tumors, sellar region tumors, mesenchymal tumors, and lymphomas. Gliomas and meningiomas were further graded according to WHO grading criteria.

Data were entered into Microsoft Excel and analyzed using SPSS software. Descriptive statistics were expressed as frequencies and percentages. The Chi-square (χ^2) test was applied to assess associations between clinical presentation and lesion type and to compare WHO grade distribution between gliomas and meningiomas. A p-value < 0.05 was considered statistically significant.

RESULT

A total of 100 cases of intracranial space-occupying lesions were evaluated. The analysis focused on age and gender distribution, clinical presentation, histopathological diagnosis, and WHO grading of tumors. Comparative statistical analysis was undertaken to assess the relationship between clinical presentation and lesion type, and to compare WHO grade distribution between gliomas and meningiomas.

The study population demonstrated a wide age distribution, with a mean age of 41.3 ± 18.7 years, reflecting the occurrence of intracranial space-occupying lesions across all age groups. The highest frequency was noted in the 31–40-year age group, suggesting a peak incidence in early to mid-adulthood. A near-equal gender distribution was observed, with only a marginal male predominance. The overwhelming predominance of neoplastic lesions (95%) highlights the major burden of tumor-related intracranial pathology encountered in the study setting, while non-neoplastic lesions constituted a small minority of cases **(Table 1)**. Gender-wise analysis of CNS lesions revealed notable variation across histological categories. Gliomas, which

constituted the largest group (30%, n = 30), showed a male predominance with 18 cases (60%) in males and 12 cases (40%) in females. In contrast, meningiomas (24%, n = 24) demonstrated a clear female predominance, with 15 cases (62.5%) in females compared to 9 cases (37.5%) in males. Schwannomas accounted for 15% of cases (n = 15) and showed a near-equal gender distribution (8 males and 7 females). Embryonal tumors comprised 6% of cases (n = 6), with four cases in males and two in females, while ependymal tumors (5%, n = 5) also showed a slight male predominance (3 males vs 2 females). Sellar region tumors accounted for 6% of cases and were equally distributed between males and females (3 cases each). Mesenchymal tumors (4%, n = 4) occurred predominantly in males (3 males, 1 female). Lymphomas were rare (2%, n = 2) and showed equal gender distribution, whereas non-neoplastic lesions (5%, n = 5) demonstrated a slight male predominance (3 males vs 2 females). Overall, despite a near-equal total gender distribution, distinct lesion-specific gender predilections were observed **(Table 2)**. Stacked bar graph illustrating the gender-wise distribution of major histological categories of CNS lesions in the study population (n = 100). Gliomas showed a male predominance, while meningiomas demonstrated a clear female predominance. Schwannomas and sellar region tumors exhibited a near-equal gender distribution. Other lesion categories showed minor variations between males and females, reflecting lesion-specific gender predilections **(Figure 1)**. The histological spectrum of CNS lesions showed gliomas as the most common category (30%), followed by meningiomas (24%) and schwannomas (15%). Gender-wise analysis revealed a male predominance in gliomas (18 males, 12 females), whereas meningiomas demonstrated a clear female predominance (15 females, 9 males), with schwannomas showing a near-equal gender distribution. Other lesion categories, including embryonal, ependymal, sellar region, and mesenchymal tumors, exhibited minor variations between sexes. Clinically, headache was the most frequent presenting symptom, occurring in 62% of patients, followed by seizures (34%) and visual disturbances (28%). Focal neurological deficits were observed in 26% of cases, while vomiting and altered sensorium were present in 22% and 18% of patients, respectively. Fever was an infrequent presentation, noted in only 10% of cases, indicating that raised intracranial pressure–related and focal neurological symptoms were more common than systemic manifestations Line graph depicting the frequency of various clinical presentations among patients with CNS lesions (n = 100) **(Figure 2)**. Analysis of clinical presentation across major histological categories demonstrated several statistically significant associations.

Headache was the most common symptom and showed a significant association with lesion type, being frequently observed in gliomas (22/30) and meningiomas (18/24) (χ^2 = 6.84, p = 0.033). Seizures were significantly more common in gliomas (14/30) and other lesions (12/31) compared to meningiomas and schwannomas (χ^2 = 9.72, p = 0.021). Visual disturbances were predominantly seen in meningiomas (12/24) and showed a strong association with lesion type (χ^2 = 11.26, p = 0.010). Focal neurological deficits were more frequent in gliomas (10/30) and other lesions (10/31) and demonstrated a significant association (χ^2 = 8.14, p = 0.043). Vomiting and altered sensorium did not show statistically significant associations with lesion type. Fever was an infrequent presentation overall but showed a significant association with other lesions, particularly non-neoplastic and inflammatory conditions (χ^2 = 6.02, p = 0.049) **(Table 3)**. Association between Clinical Presentation and Histological Type of CNS Lesions (n = 100) **(Table 4)**. Comparison of WHO grade distribution demonstrated a marked difference between gliomas and meningiomas. Among gliomas, WHO Grade II tumors constituted the largest proportion (36.7%), followed by Grade IV tumors (33.3%), while Grade III and Grade I gliomas accounted for 16.7% and 13.3% of cases, respectively. In contrast, meningiomas were predominantly low-grade, with the majority classified as WHO Grade I (79.2%), and the remaining cases as Grade II (20.8%). No WHO Grade III or IV meningiomas were identified in the study population. Statistical analysis revealed that high-grade tumors (WHO Grade III–IV) were significantly more frequent among gliomas compared to meningiomas (χ^2 = 14.22, p = 0.00016), indicating a substantially more aggressive histological profile for gliomas **(Table 5)**. The diverse histopathological spectrum of intracranial space-occupying lesions encountered in the present study. Meningiomas are characterized by classical whorled arrangements of meningothelial cells, with psammomatous variants showing concentric calcified psammoma bodies. Gliomas display a broad range of morphological features, from low-grade tumors composed of relatively uniform glial cells in a fibrillary background to high-grade lesions exhibiting marked hypercellularity, nuclear pleomorphism, areas of necrosis, and associated inflammatory infiltrates, reflecting increasing biological aggressiveness. Schwannomas show distinctive alternating Antoni A and Antoni B patterns, with Antoni A areas demonstrating compact spindle cell fascicles and Antoni B areas showing loosely arranged cells within a myxoid stroma. Overall, the histological features illustrated emphasize the morphological heterogeneity of intracranial space-occupying lesions and reaffirm the critical role of routine hematoxylin and eosin-stained sections in establishing definitive diagnosis and tumor grading **(Figure 3)**.

Table 1: Baseline Characteristics of Study Population (n = 100)

Baseline characteristic	Number of cases (n)	Percentage (%)
Age (years)		
Mean ± SD	41.3 ± 18.7	—
Range	2 – 70	—
Peak age group (31 –40 years)	22	22.0
Sex		
Male	52	52.0
Female	48	48.0
Nature of lesion		
Neoplastic	95	95.0
Non-neoplastic	5	5.0

Table 2: Histological Spectrum of CNS Lesions with Gender-wise Distribution (n = 100)

Histological category	Male (n)	Female (n)	Total cases (n)	Percentage (%)
Gliomas	18	12	30	30.0
Meningiomas	9	15	24	24.0
Schwannomas	8	7	15	15.0
Embryonal tumors (Medulloblastoma)	4	2	6	6.0
Ependymal tumors	3	2	5	5.0
Sellar region tumors	3	3	6	6.0
Mesenchymal tumors (Hemangioblastoma)	3	1	4	4.0
Lymphomas	1	1	2	2.0
Non-neoplastic lesions	3	2	5	5.0
Total	**52**	**48**	**100**	**100.0**

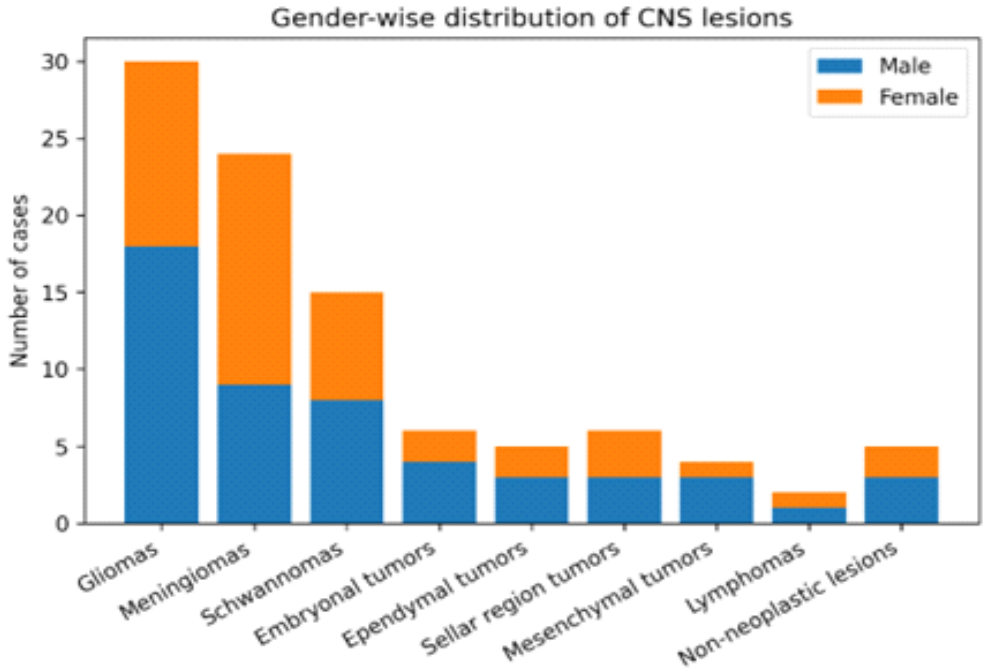

Figure 1. Gender-wise distribution of CNS lesion

Table 3: Clinical Presentation of CNS Lesions (n = 100)

Clinical presentation	Number of cases (n)	Percentage (%)
Headache	62	62.0
Seizures	34	34.0
Visual disturbance	28	28.0
Focal neurological deficit	26	26.0
Vomiting	22	22.0
Altered sensorium	18	18.0
Fever	10	10.0

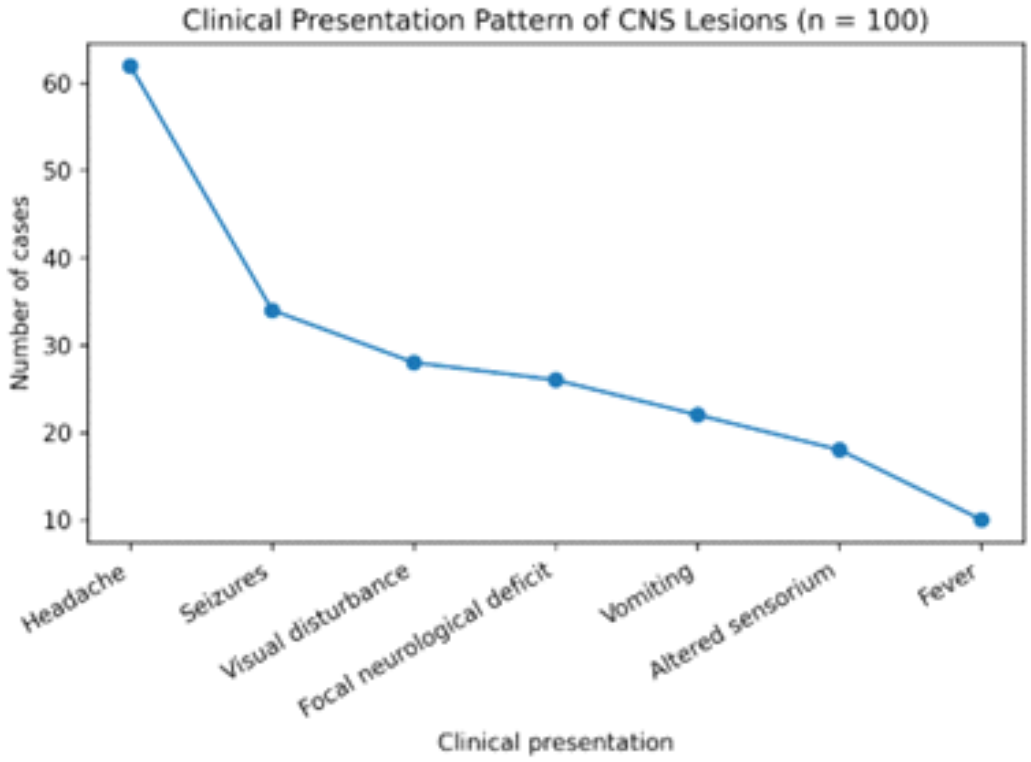

Figure 2: Clinical presentation pattern of CNS lesions

Table 4. Association between Clinical Presentation and Histological Type of CNS Lesions (n = 100)

Clinical presentation	Gliomas (n=30)	Meningiomas (n=24)	Schwannomas (n=15)	Other lesions* (n=31)	χ^2 value	p-value
Headache	22	18	8	14	6.84	**0.033**
Seizures	14	6	2	12	9.72	**0.021**
Visual disturbance	6	12	2	8	11.26	**0.010**
Focal neurological deficit	10	5	1	10	8.14	**0.043**
Vomiting	8	4	1	9	3.92	0.270
Altered sensorium	7	3	0	8	5.61	0.132
Fever	2	1	0	7	6.02	**0.049**

Table 5: WHO Grade Distribution of Gliomas and Meningiomas

WHO grade	Gliomas (%) (n = 30)	Meningiomas (%) (n = 24)
Grade I	13.3	79.2
Grade II	36.7	20.8
Grade III	16.7	0.0
Grade IV	33.3	0.0
Total	**100.0**	**100.0**

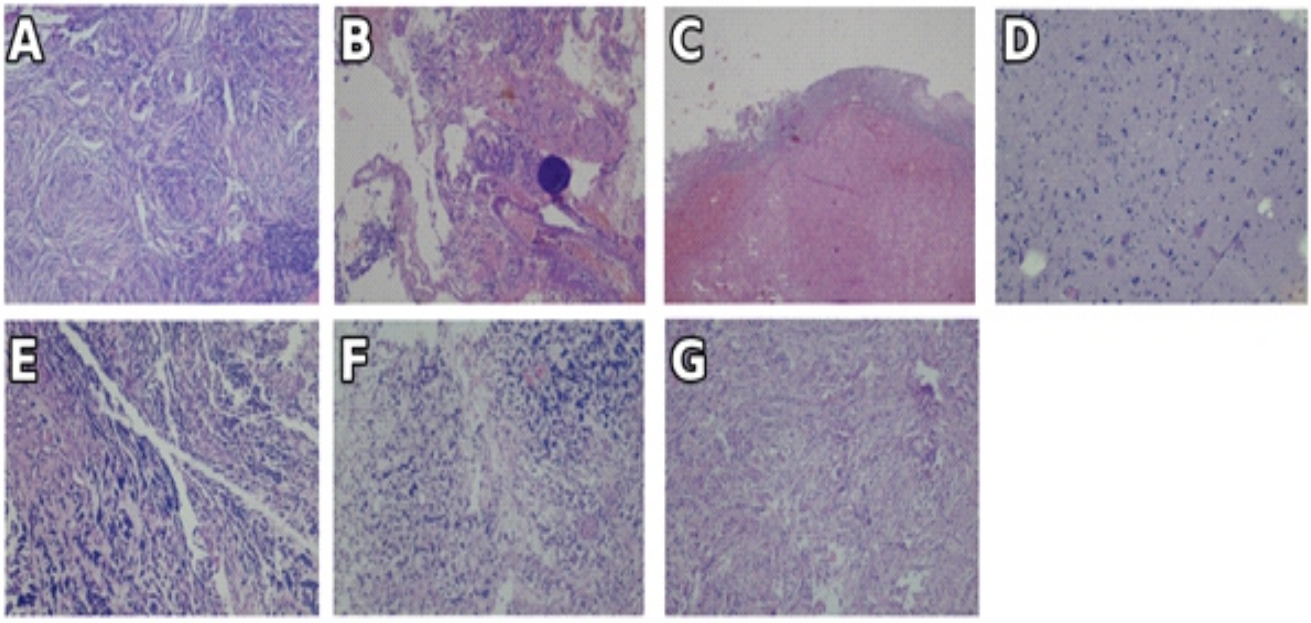

Figure 3. Representative histopathological features of intracranial space-occupying lesions (Hematoxylin and Eosin stain). **(A)** shows a meningioma with characteristic whorled architecture of meningothelial cells. **(B)** demonstrates a psammomatous meningioma with concentric calcified psammoma bodies within tumor whorls. **(C)** illustrates a high-grade glioma displaying geographic necrosis with surrounding hypercellular tumor tissue. **(D)** depicts a low-grade glioma composed of relatively uniform glial cells embedded in a fibrillary background with mild nuclear atypia. **(E)** shows a schwannoma with Antoni A areas characterized by densely packed spindle cells arranged in intersecting fascicles. **(F)** represents a high-grade glioma/glioblastoma with marked cellularity, nuclear pleomorphism, and inflammatory infiltrates. **(G)** demonstrates a schwannoma with Antoni B areas, showing loosely arranged tumor cells in a myxoid stroma.

DISCUSSION

Intracranial space-occupying lesions constitute a diverse group of pathological entities with varied clinical presentation, histological spectrum, and biological behavior. In the present study, neoplastic lesions formed the overwhelming majority (95%), underscoring the substantial burden of tumor-related intracranial pathology in tertiary care settings. Similar observations have been reported by **Louis et al. (2016)** and **McKinney (2004)**, who emphasized the predominance of neoplastic intracranial lesions requiring surgical intervention [1,2]. Large registry-based analyses such as the **CBTRUS report by Ostrom et al. (2020)** further support this trend [5].

The demographic profile in the current study demonstrated a wide age distribution with a peak incidence in the fourth decade of life. Comparable age predilection has been described by **Sung et al. (2021)** and **Wrensch et al. (2002)**, who reported early to mid-adulthood as the most commonly affected age group for primary CNS tumors [6,7].

The near-equal gender distribution observed overall aligns with previous studies; however, lesion-specific gender predilections were evident, consistent with findings by **Whittle et al. (2004)** [19].

Histologically, gliomas constituted the most common category, followed by meningiomas and schwannomas. This pattern mirrors earlier reports by **Ostrom et al. (2014)** and **Weller et al. (2015)**, who consistently identified gliomas and meningiomas as the predominant primary intracranial tumors in adults [14,15]. The male predominance observed in gliomas and the female predominance in meningiomas in the present study are well-documented epidemiological trends and may be related to hormonal and genetic influences, as discussed by **Goldbrunner et al. (2016)** [16].

Clinical presentation analysis revealed headache as the most frequent symptom, followed by seizures and visual disturbances. These findings are in agreement with reports by **Chang et al. (2008)** and **Kirby (2010)**, which highlighted raised

intracranial pressure and cortical irritation as key mechanisms underlying symptomatology in CNS tumors [17,18]. The significant association between seizures and gliomas, and between visual disturbances and meningiomas, reinforces the importance of clinicopathological correlation in preoperative assessment, as emphasized by **Whittle et al. (2004)** [19].

WHO grading analysis revealed a marked contrast between gliomas and meningiomas. Gliomas demonstrated a substantial proportion of high-grade tumors, whereas meningiomas were predominantly low-grade. This finding is consistent with the WHO-based classifications outlined by **Louis et al. (2016)** and updated by **Louis et al. (2021)**, which highlight the aggressive biological behavior of high-grade gliomas in contrast to the generally indolent nature of meningiomas [1,12]. The statistically significant association between tumor type and WHO grade observed in the present study further underscores the prognostic value of histopathological grading, as also noted by **Kleihues and Cavenee (1997)** [13].

The histopathological features observed in the present study reflect the well-recognized morphological diversity of intracranial space-occupying lesions. Meningiomas demonstrated classic whorled architecture and psammomatous calcification, features that are characteristic of WHO Grade I tumors and correlate with their generally indolent clinical behavior, as described in standard neuropathology literature [1,11,19]. Gliomas exhibited a broad histological spectrum, ranging from low-grade tumors with relatively uniform glial cells in a fibrillary background to high-grade lesions showing hypercellularity, nuclear pleomorphism, necrosis, and infiltrative growth patterns. These findings are consistent with the WHO classification, which emphasizes histological grade as a key determinant of biological aggressiveness and prognosis in glial tumors [1,12,15]. Schwannomas displayed alternating Antoni A and Antoni B areas, a distinctive feature aiding in their histological diagnosis and differentiation from other spindle cell tumors [8]. The presence of necrosis and inflammatory infiltrates in high-grade lesions further highlights the aggressive nature of certain tumor subtypes. Overall, the histopathological patterns observed in this study reinforce the pivotal role of routine hematoxylin and eosin–stained sections in accurately classifying CNS lesions, particularly in settings where advanced molecular diagnostics may not be routinely available.

Regional studies such as the present one remain important for understanding local disease patterns and resource allocation, particularly in developing healthcare systems, as emphasized by **Jalali et al. (2010)** [20]. Nevertheless, the lack of molecular profiling represents a limitation, especially in the context of evolving WHO classifications that increasingly integrate molecular parameters [12].

CONCLUSION

This study provides a comprehensive clinico-pathological evaluation of intracranial space-occupying lesions encountered in a tertiary care setting. Neoplastic lesions constituted the predominant burden, with gliomas emerging as the most frequent tumor type, followed by meningiomas and schwannomas. Distinct gender predilections were observed, with male predominance in gliomas and female predominance in meningiomas. Headache, seizures, and visual disturbances were the most common presenting symptoms, and significant associations between clinical presentation and lesion type underscore the importance of clinicopathological correlation. WHO grading demonstrated a markedly higher proportion of high-grade tumors among gliomas compared to the predominantly low-grade meningiomas, highlighting its critical prognostic and therapeutic relevance.

The strengths of this study include a well-defined cohort, systematic histopathological evaluation using WHO criteria, and correlation with clinical features supported by statistical analysis. However, limitations include its single-center design, relatively modest sample size, and absence of molecular profiling, which is increasingly relevant in contemporary CNS tumor classification. Despite these limitations, the findings contribute valuable regional data and reinforce the continued importance of histopathological assessment, particularly in resource-limited settings.

LIMITATIONS & FUTURE PERSPECTIVES

The study's limitations include a single-centre setting, a relatively small sample size, and a short study duration, which may limit the broader applicability of the results. Future studies should incorporate multicentre designs with larger populations to enhance validity, assess long-term outcomes, and investigate advanced diagnostic and management approaches. Such efforts will improve overall patient care and help minimize complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of translating scientific observations into meaningful improve-ments in patient care, diagnosis, and treatment outcomes. By highlighting real-world relevance, the study contributes to evidence-based medical practice and supports informed clinical decision-making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

ICSOL: Intracranial Space-Occupying Lesion
WHO: World Health Organization
CNS: Central Nervous System
H&E: Hematoxylin and Eosin
IHC: Immunohistochemistry

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AUTHOR CONTRIBUTIONS
All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST
Authors declared that there is no conflict of interest.

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DATA AVAILABILITY
All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a re-asonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)
The authors confirm that no AI & LLM tools were used in thewriting or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE
This article serves as an important educational tool for the scientific community, offering insights that may inspire future research directions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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