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Original Research Article

Intracranial lesions: Histopathological and radiological correlation

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ABSTRACT

Background: Intracranial space-occupying lesions (ICSOLs) include neoplastic and non-neoplastic lesions of the central nervous system. "In India, central nervous system neoplasms account for approximately 1.9% of all malignant tumours." Biopsy and histopathology are essential for accurate diagnosis and preventing incorrect therapeutic interventions.
Aim and Objective: The study aims to correlate histopathological and radiological diagnosis of intracranial lesions. Epidemiological parameters of various neoplastic and non-neoplastic intracranial lesions according to age, sex and site are assessed.
Materials & Methods: The retrospective and prospective descriptive study, conducted at the tertiary care centre, analysed 104 cases of ICSOLs. The study utilised preoperative radiological reports, MRI (Primarily) or CT scan. The statistical analysis was performed using STATA (14.2). Frequencies and the chi-square test were used for calculation.
Results: In the present study, neoplastic lesions (93.27%) were more common than non-neoplastic lesions (6.73%), with a male predominance (Male: Female = 1.36:1). Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of radiological diagnosis in neoplastic lesions were 98.97%, 28.57%, 95.04%, 66.67% and 94.23% respectively, compared to histopathological diagnosis. P-value <0.05 suggests statistically significant results.
Conclusion: The study found a higher incidence of neoplastic intracranial lesions, likely due to the institute's fully functional oncology department. Radiological techniques offer non-invasive insights into lesion characteristics, while histopathological examination provides a definitive cellular-level diagnosis. Together, these methods enhance diagnostic accuracy, guide treatment decisions, and improve patient outcomes.

1. Introduction

An "intra-cranial space-occupying lesion" (ICSOL) is defined as a mass lesion in the cranial cavity with a diverse aetiology like benign or malignant neoplasm, inflammatory or parasitic lesion, haematoma, or arterio-venous malformation.[1] Central nervous system neoplasms represent a unique, heterogeneous population of neoplasms, constituting 1.9% of all malignant tumours in India.[1] The Central Brain Tumour Registry of the United States (CBTRUS) statistical report suggests that the average annual age-adjusted incidence rate (AAAIR) of all malignant and non-malignant brain and other CNS tumours was 25.34 per 100,000 population between 2017 and 2021.[2]

Imaging, especially MRI, plays a significant role not only in diagnosing but also in prognosticating brain tumours.[3] MR imaging has delivered remarkable advances in the information available from the vast array of MR imaging

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techniques.[3]

Space-occupying lesions [SOLs] of the Central Nervous System [CNS] are an important cause of neurological morbidity and mortality.[4–6] Brain tumours are a diverse group of primary CNS tumours and secondary neoplasms arising either from the brain or from haematogenous spread from distant sites.[7] Pathologists can use radiological findings to narrow down the differential diagnosis.[6,8] However, radiological diagnosis of SOL requires confirmation by histopathology.[5,6] Radiological investigation is supportive of an accurate histopathological diagnosis.[5,6] Hence, histopathology is considered the gold standard for diagnosing CNS lesions.[5,6]

At the moment, however, oncologists and radiotherapists are still looking to pathologists for assistance in tumour diagnosis.[9] Indeed, they cannot proceed with plans for therapy without a tissue diagnosis, nor are they able to discuss the prognosis with the patient or the patient's family.[9] Under the circumstances, the pathologist's decision is pivotal to the patient, the clinician, and the investigator.[9]

2. Materials and Methods

The study was carried out at the Surgical Pathology Section of the Central Diagnostic Laboratory, Pathology Department, at a tertiary care hospital of Central Gujarat, from June 2018 to June 2024, for a period of six years. It was retrospective and prospective descriptive study. Total 104 cases were analyzed.

We obtained patient data from the Hospital Information System and Laboratory Information System. The study has included all the CNS biopsies received at the Surgical Pathology Section of the Central Diagnostic Laboratory. All the CNS biopsies have been evaluated for location, margin, morphology, and grade of the tumour.

Presurgical radiological reports were selected for study, primarily MRI, and if MRI is unavailable, then CT. Radiological reports of intracranial lesions will be selected for study from online registers or computers after getting approval from the competent authority.

Radiological investigative modalities in the present study were MRI and CT. In 88 cases, MRI was carried out, and in 16 cases, CT was carried out.

2.1. Inclusion criteria

Cases with clinical and morphological features suggestive of intracranial lesions, whose biopsies were received in the surgical pathology section of Pramukhswami Medical College, Karamsad, were considered for the study.

2.2. Exclusion criteria

Those patients who are on treatment and require a rebiopsy have been excluded from the study. Hematomas and traumatic lesions have been excluded.

All the data were collected according to the proforma, and the data analysis was done. Basic patient demographics were analyzed for age and gender preponderance. The frequency distribution of the site, morphology, and grading of the tumours were obtained. Further descriptive analysis was done to obtain the prevalence and subtyping of tumours.

The statistical analysis was performed using STATA (14.2). Descriptive statistics will be used to portray the baseline profile of the study population. Frequencies and the chi-square test were used for calculation.

3. Results

Intracranial lesions categorized into two main types: non-neoplastic and neoplastic. Out of the 104 cases analyzed, 7 (6.73%) patients were diagnosed with non-neoplastic lesions, while 97 (93.27%) patients were diagnosed with neoplastic lesions.

(Figure 1) represents gender wise distribution of intracranial space-occupying lesions in 104 cases. Sixty male patients and forty-four female patients with intracranial lesions were analyzed. The male-to-female ratio is 1.36:1.

There were 46 patients diagnosed with gliomas, glioneuronal tumours, and neuronal tumours; the majority of the patients were 30 years of age and older. There were 20 patients diagnosed with meningiomas, and the majority of the patients were 40 years of age or older. There were 12 patients diagnosed with tumours of the sellar region, and the majority of the patients were 30 years and older. There were 10 patients diagnosed with metastasis to the CNS, and the majority of the patients were 50 years of age or older. The mean age for diagnosis of a non-neoplastic lesion was 45 years. The mean age for diagnosis of a neoplastic lesion was 49.02 years.

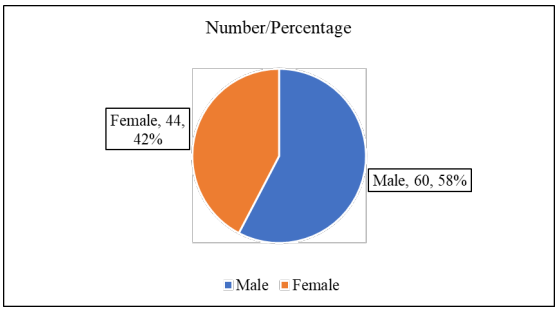

Figure 1: Gender wise distribution of intracranial space-occupying lesions (n=104).

(Figure 2) represents the site wise distribution of neoplastic and non-neoplastic brain lesions in 104 cases. The frontal lobe was the most common primary site, accounting for 21.15% of cases. The second most common site was the sellar and suprasellar regions, which account for 12.5% of cases.

Table 1: Histomorphological diagnosis and grade wise distribution of neoplastic intracranial lesions (n=97).

No.	Brain tumours	Grade	No.	Percentage
1	**Gliomas, glioneuronal tumours and neuronal tumours**			
	Astrocytoma	Grade II	07	16.49%
		Grade III	08	
		Grade IV	01	
	Oligodendroglioma	Grade II	06	8.24%
		Grade III	02	
	Glioblastoma / Gliosarcoma	Grade IV	17	17.52%
	Ependymoma	Grade II	01	3.09%
		Grade III	02	
	Pilocytic astrocytoma	Garde I	02	2.06%
2	**Embryonal tumours**			
	Medulloblastoma	Grade IV	02	2.06%
3	**Cranial and paraspinal nerve tumours**			
	Schwannoma		01	1.03%
4	**Meningiomas**			
	Meningothelial / Transitional / Fibroblastic meningiomas	Grade I	12	12.37%
	Atypical meningioma	Grade II	06	6.18%
	Papillary / Anaplastic meningiomas	Grade III	02	2.06%
5	**Hematolymphoid tumours**			
	CNS lymphoma		04	4.12%
6	**Germ cell tumour**			
	Mixed germ cell tumour		01	1.03%
7	**Tumours of the sellar region**			
	Adamantinomatous craniopharyngioma	Grade I	01	1.03%
	Papillary craniopharyngioma	Grade I	01	1.03%
	Pituitary adenoma / PitNET		10	10.30%
8	**Metastases to the CNS**			
	Metastatic adenocarcinoma		03	3.09%
	Metastatic squamous cell carcinoma		02	2.06%
	Metastatic clear cell carcinoma		01	1.03%
	Metastatic neuroendocrine tumour		01	1.03%
	Metastatic papillary carcinoma		01	1.03%
	Metastatic small cell carcinoma		01	1.03%
	Metastatic granulocytic sarcoma (Extra medullary myeloid tumour)		01	1.03%
9	Benign lesion: Acoustic neuroma		01	1.03%
	Total		97	100%

Table 2: Statistical analysis of radio-pathological concordance in neoplastic lesions (using 2×2 table and calculating chi square test) (n=104).

Intracranial lesion		**Histopathologically diagnosed**		**Total**
		Neoplastic	**Non-neoplastic**	
Radiologically diagnosed	**Neoplastic**	96 (TP)	05 (FP)	101
	Non-neoplastic	01 (FN)	02 (TN)	03
Total		97	07	104

Table 3: Statistical analysis of radio-histopathological concordance in high-grade gliomas and low-grade gliomas in radiologically diagnosed cases (using 2×2 table and calculating chi square test) (n=32).

Intracranial lesion		**Histopathologically diagnosed**		**Total**
		High-grade glioma	**Low-grade glioma**	
Radiologically diagnosed	**High-grade glioma**	19 (TP)	05 (FP)	24
	Low-grade glioma	00 (FN)	08 (TN)	08
Total		19	13	32

Table 4: Discrepancies in histopathological and radiological diagnosis of neoplastic lesions (other than gliomas) (n=6).

Radiology diagnosis	Histopathology diagnosis
Meningiomas	
Neoplastic lesion, ? Germinoma	Fibrous meningioma (Later diagnosed as atypical meningioma with focal rhabdoid features and brain invasion, grade 2, on immunohistochemistry)
vestibular schwannoma	Fibroblastic meningioma (Later diagnosed as atypical meningioma, grade 2, on immunohistochemistry)
Hematolymphoid tumours	
Glioblastoma multiforme	Primary CNS lymphoma
Neoplastic lesion	High grade Non-Hodgkin's lymphoma
Metastases to the CNS	
Neoplastic lesion	Metastatic adenocarcinoma
Benign lesion	
Space-occupying lesion	Acoustic neuroma

Table 5: Radiological and histopathological correlation of non-neoplastic lesions diagnosed on histopathology (n=7).

Radiology diagnosis	Histopathology diagnosis
Low grade glioma	Normal cerebellum with focal areas of gliosis
Mass lesion	Cerebellar tissue with reactive gliosis
Neoplastic lesion	Normal cerebellar tissue
Low to intermediate grade glioma	Chronic granulomatous inflammation suggestive of mycobacteriosis
Infective etiology- Tuberculosis most likely	Tuberculoma
Glioblastoma multiforme	Suppurative inflammation with reactive gliosis
Epidermal cyst	Epidermal cyst

Table 6: Comparison of frequency, commonly affected age group, commonly affected site and commonly encountered grade of intracranial lesions with previous studies.

Sr. No.	Author	Frequency		Commonly affected age group	Commonly affected site	Commonly encountered grade
		Non-neoplastic lesion	Neoplastic lesion			
1	Hema NA et al.[1]	19.4%	80.6%	31-40	—	Grade I
2	Jindal N et al.[4]	23.7%	76.2%	31-50	Frontal lobe	—
3	Rathod V et al.[10]	36%	64%	—	—	—
4	Jaiswal J et al.[11]	—	—	40-49	—	—
5	Ghanghoria S et al.[12]	—	—	—	—	Grade I
6	Krishnatreya M et al.[13]	—	—	—	Frontal lobe	—
7	Thambi R et al.[14]	—	—	40-60	Frontal lobe	—
8	Kanthikar SN et al.[15]	—	—	41-50	—	—
9	Deshpande NS et al.[16]	—	—	31-60	Frontal lobe along with fronto-parietal lobe	Grade I
10	Chaudhary P et al.[17]	—	—	—	—	Grade I
11	Joshi H et al.[18]	35.4%	64.6%	—	—	—
12	Shah HK et al.[19]	10%	90%	—	Frontal lobe	—
13	Lakhani MB et al.[20]	21.74%	78.26%	—	—	—
14	Present study	6.73%	93.27%	40-49	Frontal lobe	Grade II and IV

Table 7: Comparison of statistical analysis of radio-pathological concordance in neoplastic lesions for radiological diagnosis with previous studies.

Study	Jindal N et al.[4]	BN K et al.[9]	Taghipour Zahir S et al.[23]		Boni LS et al.[21]	Gohar R et al.[22]	Present study
Radiological investigative modality	MRI and CT scan	MRI and CT scan	CT scan	MRI	MRI	MRI	MRI and CT scan
Sensitivity	90%	96.25%	83%	92%	66.67%	-	98.97%
Specificity	57%	50%	10%	25%	97.78%	-	28.57%
Accuracy	84.2%	-	78%	87%	91.89%	84.3 %	94.23%
PPV	90%	95.06%	93%	93%	87.5%	-	95.04%
NPV	57%	57%	3%	2%	92.63%	-	66.67%
P-value	0.003	<0.005	0.69	0.33	-	-	<0.001

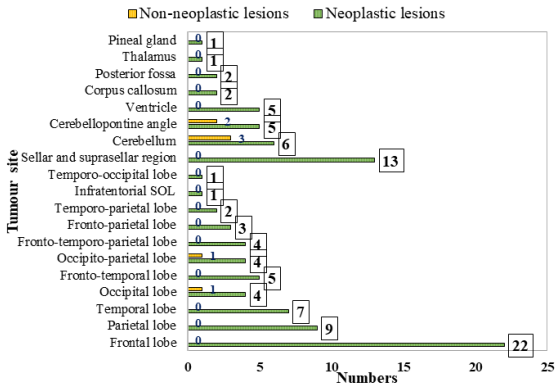

Figure 2: Site wise distribution of neoplastic and non-neoplasticlesions of the brain (n=104)..

(Table 1) represents the histomorphological diagnosis and grade-wise distribution of neoplastic intracranial lesions in 97 cases. Gliomas, glioneuronal tumours, and neuronal tumours account for the largest proportion of malignant brain tumours, with glioblastomas and gliosarcomas being the most prevalent, accounting for approximately 17.52% of cases. Meningiomas account for a significant proportion, with Grade I being the most common, approximately at 12.37%. Tumours of the sellar region constitute 12.37% of cases, with pituitary adenomas being the most common, accounting for approximately 10.30% of cases.

In our study, there were 97 cases of neoplastic lesions, out of which 70 cases were graded on histopathology and 27 cases were not graded. Those 27 cases include 10 cases of pituitary adenoma, 10 cases of metastasis, 4 cases of lymphoma, 1 case of mixed germ cell tumour, 1 case of schwannoma, and 1 case of acoustic neuroma (benign lesion).

Glioblastoma / Gliosarcoma, Grade IV, was the most common and aggressive type, with 17 cases. The second most common tumour was grade I meningioma, accounting for 12 cases.

Overall, WHO grade II and grade IV tumours were the most common, accounting for 20 cases each, followed by grade I tumours in 16 cases. Grade III tumours accounted for 14 cases. This grade-wise distribution highlights the diversity and complexity of neoplastic lesions in the CNS.

(Table 2) represents statistical analysis of radio-pathological concordance in neoplastic lesions, using 2×2 table and calculating the chi square test in histopathologically diagnosed 104 cases. Radiological investigative modalities in the present study were MRI and CT scan. In 88 cases, MRI was carried out, and in 16 cases, CT scan was carried out. Out of 101 suspected neoplastic lesions on radiology, 96 were confirmed on histopathology. The sensitivity was 98.97%, specificity was 28.57%, and accuracy was 94.23% for radiological diagnosis. The positive predictive value was 95.04% and the negative predictive value was 66.67% for radiological diagnosis. The calculated p-value was <0.001, and the result was statistically significant.

A correlation of radiologically and histopathologically diagnosed cases of high-grade gliomas and low-grade gliomas, based on the 2021 WHO classification of CNS tumours, in 46 cases of gliomas was done.

There were radiologically diagnosed 8 cases of low-grade gliomas. However, histopathology confirmed 16 cases of low-grade gliomas. This discrepancy suggests that some low-grade gliomas may not have been detected accurately by radiological methods, potentially leading to overdiagnosis/ underdiagnosis.

There were radiologically diagnosed 24 cases of high-grade gliomas. However, histopathology confirmed 30 cases of high-grade gliomas. The discrepancy suggests that radiological methods may also miss some high-grade gliomas or misclassify them as low-grade.

Radiologically, 32 cases were diagnosed as either low-grade or high-grade gliomas. Histopathologically, 46 cases were diagnosed as either low-grade or high-grade gliomas. In our study, a total of 24 cases were diagnosed as high-grade glioma radiologically, out of which 5 cases were confirmed as low-grade glioma and 19 cases as high-grade glioma on histopathology. This discrepancy highlights the limitations of radiological imaging in accurately diagnosing

all glioma cases.

(Table 3) represents the radiological and histopathological correlation of high-grade gliomas and low-grade gliomas in radiologically diagnosed 32 cases. Sensitivity is 100%, which suggests that the radiological assessment is perfect at detecting high-grade gliomas when they are present. Specificity is 61.54%, which suggests that the radiological assessment is less accurate in identifying low-grade gliomas, resulting in a significant number of false positives. Positive Predictive Value is 79.17%, which suggests that when a glioma is identified as high-grade by radiology, there is a 79.17% chance that it is truly high-grade according to histopathology. The Negative Predictive Value is 100%, which suggests that when a glioma is identified as low-grade by radiology, it is always correctly identified as such according to histopathology. Accuracy is 84.38%, which suggests that histopathology is the gold standard in diagnosing high-grade and low-grade gliomas, while radiology is 84.38% accurate. The p-value is less than 0.001, which suggests that the results were statistically significant.

(Table 4) represents discrepancies in histopathological and radiological diagnosis of neoplastic lesions in 6 cases (other than glioma).

The radiological and histopathological correlation of meningiomas in histopathologically diagnosed 20 cases were done. Grade I meningiomas were the most common in our study, accounting for 12 cases.

The correlation between radiological and histopathological diagnosis of hematolymphoid tumours in histopathologically diagnosed 4 cases were done. Out of total 4 cases of CNS lymphoma, 1 case was radiologically diagnosed as glioblastoma multiforme, 2 cases were radiologically diagnosed as CNS lymphoma, and 1 case was radiologically diagnosed as a neoplastic lesion. This highlights the importance of histopathological confirmation, as treatment strategies for GBM and CNS lymphoma differ substantially.

The radiological and histopathological correlation of metastatic lesions in histopathologically diagnosed 10 cases were done, which suggests the critical role of histopathological analysis in providing specific diagnosis for radiologically identified metastatic lesions.

(Table 5) represents the radiological and histopathological correlation of non-neoplastic lesions in histopathologically diagnosed 7 cases. This table illustrates the essential role of histopathological examination in confirming or refuting radiological diagnosis of non-neoplastic lesions. While radiology is a critical tool for initial diagnosis, histopathology provides definitive confirmation.

4. Discussion

This study involves an analysis of 104 patients treated for intracranial lesions at Shree Krishna Hospital, Karamsad. The primary objectives are to assess and provide detailed information on the histomorphological characteristics of intracranial lesions. The study aims to correlate the findings of radiological diagnosis with histopathological diagnosis, offering a comprehensive overview of the types of intracranial lesions encountered and their diagnostic features. This correlation helps in understanding the accuracy and effectiveness of radiological methods in diagnosing intracranial lesions and provides insights into the various histopathological presentations of these lesions.

(Table 6) represents a comparison of frequency, commonly affected age group, commonly affected site and commonly encountered grade of intracranial lesions with the previous study.

A comparison of the present study with previous studies reveals significant variations in the frequency of non-neoplastic and neoplastic intracranial lesions. The present study reports the highest frequency of neoplastic lesions (93.27%) and the lowest frequency of non-neoplastic lesions (6.73%), which is comparable to the study reported by Shah HK et al.[19]

The current study at a tertiary care hospital may have a higher incidence of neoplastic intracranial lesions compared to other populations studied. This can be because our institute has an oncology department, which acts as a referral centre.

The male-to-female ratio is 1.36:1 in the present study, which is comparable to studies reported by Rathod V et al.[10], Jaiswal J et al.[11] and Shah HK et al.[19]

Comparison of commonly affected age groups among patients with neoplastic lesions across different studies reveals some variation but also notable consistencies. In the present study, the most common age group affected by neoplastic lesions is 40-49 years, which is comparable with Jaiswal J et al.[11] Other studies, such as Hema NA et al.[1] and Jindal N et al.[4], reported a younger age group, while Thambi R et al.[14] indicates a broader range (40-60).

The frontal lobe emerges as the most frequently involved site for neoplastic lesions in the present study, which was comparable with studies reported by Jindal N et al.[4], Krishnatreya M et al.[13], Thambi R et al.[14] and Shah HK et al.[19] The inclusion of the fronto-parietal lobe in the findings by Deshpande NS et al.[16] suggests that while the frontal lobe is predominantly affected, adjacent areas like the parietal lobe can also be involved.

Commonly encountered grades were grade II and IV of neoplastic lesions in the present study, potentially due to the fully functional oncology department at our hospital that serves as a referral center. Other studies like Hema NA et al.[1], Ghanghoria S et al.[12], Deshpande NS et al.[16],and Chaudhary P et al.[17] reported that the

most commonly encountered neoplastic lesions were of grade I histopathologically. This discrepancy may be due to differences in study populations, healthcare access, or changes in environmental and genetic factors influencing disease prevalence.

(Table 7) represents comparison of statistical analysis of radio-pathological concordance in neoplastic lesions for radiological diagnosis with previous studies. The studies used various imaging modalities (CT, MRI, or both), which can lead to inconsistent results and difficulties in comparing findings.

The sensitivity of radiological diagnosis in the present study is higher (98.97%) compared to Jindal N et al.[4] and BN K et al.[9] The sensitivity of radiological diagnosis was lower in Boni LS et al.[21] This indicates that radiological diagnosis in the present study is more effective in correctly identifying true positive cases of neoplastic lesions.

The specificity of radiological diagnosis in the present study is lower (28.57%) than Jindal N et al.[4], BN K et al.[9], and Boni LS et al.[21] This suggests that the radiological diagnosis in the present study is less effective in correctly identifying true negative cases (non-neoplastic cases), leading to a higher rate of false positives.

The accuracy of radiological diagnosis in the present study is higher (94.23%) compared to Jindal N et al.[4], BN K et al.[9],Taghipour Zahir S et al.[23], Boni LS et al.[21], and Gohar R et al.[22] This signifies the diagnostic effectiveness of radiological diagnosis in the present study.

The positive predictive value (PPV) of radiological diagnosis in the present study is higher (95.04%) than in Jindal N et al.[4] Taghipour Zahir S et al.[23] and Boni LS et al.[22], but almost similar to the study reported by BN K et al.[9] (95.06%). This means that when the test result is positive (for radiologically diagnosed cases of neoplastic lesion), there is a higher probability that it is histopathologically diagnosed as a neoplastic lesion in the present study.

The negative predictive value (NPV) of radiologically diagnosed non-neoplastic cases in the present study is higher (66.67%) compared to Jindal N et al.[4] BN K et al.[9] and Taghipour Zahir S et al.[23] but lower than Boni LS et al.[21] (92.63%). This indicates that when the test result is negative (for radiologically diagnosed cases of non-neoplastic lesions), there is a higher probability that it is histopathologically diagnosed as a non-neoplastic lesion in the present study.

The P-value is <0.05 in the studies reported by Jindal N et al.[4] BN K et al.[9] and in the present study, indicating strong evidence to reject the null hypothesis with statistically significant results. Taghipour Zahir S et al.[23] reported no statistically significant results with a P-value >0.05.

The present study demonstrates an improvement in sensitivity, accuracy, PPV, and NPV of radiological diagnosis as compared to other studies. However, the specificity of radiological diagnosis is lower in the present study, suggesting a need for further refinement in correctly identifying true negative (non-neoplastic) cases. Despite this, the overall diagnostic performance of radiology has improved, as indicated by the higher accuracy and lower P-value, suggesting the results are statistically significant.

5. Conclusion

The present study at Shree Krishna Hospital shows a higher incidence of neoplastic intracranial lesions as compared to non-neoplastic intracranial lesions in the population under study. This could be attributed to our institute's fully functional oncology department, which serves as a referral center. The present study reveals a male-to-female ratio of 1.36:1, indicating a notable predominance of males.

In the present study, the most common age group affected by neoplastic lesions is 40–49 years, highlighting the need to tailor diagnostic and treatment efforts to the most at-risk populations.

In the present study, the frontal lobe is the most commonly affected site for neoplastic lesions, and the present study found grade II and IV lesions to be more prevalent.

Radiology's overall diagnostic performance has improved, resulting in higher accuracy and statistically significant results.

The correlation between radiological imaging and histopathological examination is crucial for the accurate diagnosis and management of intracranial lesions. Radiological techniques offer non-invasive insights into lesion characteristics, while histopathological examination provides a definitive cellular-level diagnosis. Together, these methods enhance diagnostic accuracy, guide treatment decisions, and improve patient outcomes. The present study highlights significant variations in the frequency and characteristics of intracranial lesions compared to previous studies, emphasizing the importance of understanding demographic and regional differences.

6. Ethical Approval

This study was approved by Institutional Ethical Committee (IEC/BU/143/Faculty/42/87/2023).

7. Conflict of Interest

None.

8. Source of Funding

None.

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