Section: Pathology

Original Research Article

DIAGNOSTIC CONCORDANCE BETWEEN INTRAOPERATIVE FROZEN SECTION AND HISTOPATHOLOGICAL EVALUATION IN CENTRAL NERVOUS SYSTEM TUMOURS: A RETROSPECTIVE STUDY

Abhishek Rajawat[1], Poonam Woike[1], Manjari[1], Geeta Mukhiya[2]

[1]*Assistant Professor, Department of Pathology, Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India*
[2]*Professor and Head, Department of Pathology, Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India*

Received *: 10/11/2025*
Received in revised form *: 29/12/2025*
Accepted *: 16/01/2026*

Corresponding Author:
Dr. Poonam Woike,
Assistant Professor, Department of Pathology Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India.
Email: poonamwoike20@gmail.com

DOI: 10.70034/ijmedph.2026.1.161

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (1); 910-914

ABSTRACT

Background: Intraoperative frozen section examination is an essential diagnostic tool in neurological practice, providing rapid pathological assessment while surgery in progress. Central nervous system tumours often exhibit overlapping clinical and radiological features, making immediate tissue diagnosis crucial for intraoperative decision-making. When combined with squash smear cytology, frozen section evaluation aids in distinguishing neoplastic from non-neoplastic lesions and in broadly grading tumours. This study aimed to assess the diagnostic concordance between intraoperative frozen section diagnosis and final histopathological evaluation of CNS tumours.

Materials and Methods: A retrospective analysis of 47 CNS tumour cases subjected to intraoperative consultation over a three-year period was conducted at a tertiary care centre. Fresh, unfixed tissue samples were examined intraoperatively using frozen sections and squash smear cytology. These findings were later correlated with diagnosis established on formalin fixed, paraffin embedded sections. Diagnostic accuracy, sensitivity, specificity and predictive values were calculated.

Results: High grade gliomas constituted the most frequent intraoperative diagnosis, followed by low grade gliomas and metastatic tumours. Final histopathology revealed glioblastoma as the most common lesion. Frozen section examination demonstrated a sensitivity of 91.2%, specificity of 90.9% and an overall diagnostic accuracy of 91.5%. Most discrepancies were attributed to sampling limitations and overlapping histomorphological features.

Conclusion: Intraoperative frozen section examination shows high diagnostic accuracy and strong agreement with final histopathology in CNS tumours. Despite occasional discrepancies, it remains reliable and valuable tool for guiding neurosurgical management.

Keywords: Frozen section, Central nervous system tumours, Intraoperative diagnosis, Histopathology, Diagnostic accuracy.

INTRODUCTION

Frozen section is an intraoperative pathological technique in which a small portion of surgically excised tissue is rapidly frozen, thinly cut, stained, and examined under a microscope within a short period of time. The method allows the pathologist to provide an immediate provisional diagnosis while the surgery is still in progress. Unlike routine histopathology, which requires tissue processing over several hours, frozen section offers real-time diagnostic support to the operating surgeon.

CNS tumours often present with overlapping clinical and radiological features, making intraoperative confirmation essential. Intraoperative frozen section helps in distinguishing neoplastic from non-

neoplastic lesions, identifying tumour versus normal brain tissue and broadly categorizing the lesions as high grade or low grade.

Over the past two decades, refinements in diagnostic armamentarium—encompassing squash and imprint cytology, intra-operative frozen section (IOFS), molecular profiling, electron microscopy, high-resolution neuro-imaging and stereotactic biopsy—have markedly shortened the interval between clinical suspicion and definitive classification.[1]

The concept of cutting unfixed tissue at sub-zero temperatures pre-dated the 20th century, yet the discipline of rapid intra-operative consultation was truly galvanised by Louis B. Wilson's 1905 description of the frozen-section technique at the Mayo Clinic.[2]

IOFS has since become integral to neurosurgical oncology, where it serves four imperatives: (i) verifying specimen adequacy, thereby preventing non-representative sampling; (ii) furnishing a provisional tissue diagnosis to tailor the extent of resection; (iii) guiding adjunctive procedures such as cortical mapping or implant placement; and (iv) framing immediate post-operative planning.[3]

Success hinges on meticulous triage of tissue, deft cryostat technique and, crucially, correlation with radiographic and clinical context to mitigate misclassification.[4] Numerous audits report overall concordance rates exceeding 90 %, attesting to the method's reliability; discordant cases commonly involve lymphomas mimicking high-grade gliomas, reactive gliosis or sampling from tumour margins.[3]

IOFS offers superior architectural context relative to smear preparations, yet practical limitations persist—friable neural parenchyma complicates sectioning, specialised equipment inflates cost, and ice-crystal artefacts may obscure cytological detail.[4]

Frozen section interpretation assists the neurosurgeon in making precise judgment regarding the nature of lesion and line of management on the operating table.[5,6]

Some centres only employ cytology smears prepared by the "squash method," while others employ both cytology and frozen sections.[9]

The soft consistency of most primary CNS neoplasms facilitates the preparation of smears, and smear cytology has been used with great success for the intraoperative diagnosis of CNS neoplasms,[8-12] especially astrocytomas, oligodendrogliomas, and small round cell tumors.[13]

Frozen sections are mainly useful for the firmer, rubbery neoplasms such as meningiomas, ependymomas, and most metastatic tumours from which it is difficult to prepare good cytology smears.8,9 Studies have shown that a combination of the two techniques is most beneficial.[14] Studies have reported the diagnostic accuracy of CNS intraoperative consultation in the range of 85% to 90%.[13,12,15-20]

Aim and Objective

To evaluate the diagnostic accuracy of intraoperative frozen section examination in cases of central nervous system (CNS) tumours by correlating frozen section diagnosis with final histopathological diagnosis.

MATERIALS AND METHODS

This retrospective study was conducted over a period of three years and included all cases of central nervous system tumours for which intraoperative frozen section analysis was performed in the Histopathology section, Department of Pathology, Geetanjali Medical College and Hospital between January 2018 and December 2020.

Inclusion criteria:

All frozen section cases that were later subjected to definitive histopathological evaluation using permanent paraffin-embedded sections were included in the study.

Exclusion criteria:

Cases were excluded from the study if either fresh, unfixed tissue for intraoperative frozen section or formalin-fixed tissue for final histopathological diagnosis was unavailable.

Methodology: A total of 47 cases submitted for intraoperative consultation over a three-year period were included in the study. Fresh, unfixed tissue samples received in normal saline during surgery were evaluated intraoperatively, followed by examination of the corresponding formalin fixed specimens processed for routine histopathology. Intraoperative diagnosis was rendered using a combined approach of squash smear cytology and frozen section analysis, depending on the nature and adequacy of the tissue received. The findings from intraoperative assessment were later correlated with the final histopathological diagnosis obtained from paraffin-embedded sections.

Frozen-section technique: Fresh tissue samples were properly oriented and embedded in optimal cutting temperature (OCT) compound. Sections measuring 3.5–4.5 µm were cut using a LEICA CM1860 cryostat at −27 °C and immediately stained with haematoxylin and eosin (H&E). The pathologist provided a preliminary diagnosis to the neurosurgeon within 30 minutes.

Formalin Fixed Permanent Paraffin Embedded Section Technique: The corresponding biopsy or resection specimens were fixed in 10% neutral-buffered formalin and embedded in paraffin. Sections of 3.5–4.5 µm thickness were prepared and stained with H&E. Final diagnoses were made in accordance with the 2021 World Health Organization (WHO) Classification of Central Nervous System tumours.

Statistical analysis: The data were entered and analysed using descriptive statistical methods. Diagnostic concordance between intraoperative frozen section/ squash smear findings and the final histopathological diagnosis was calculated and expressed in percentages. The overall accuracy rate was determined by dividing the number of concordant cases by a total number of cases

examined. Discrepant cases were also identified and analysed in terms of frequency and proportion. Results were summarized using simple percentages.

RESULTS

The most common diagnosis rendered intraoperatively was high-grade glioma, reported in 16 cases (34.0%), Low grade gliomas were identified in 10 cases (21.3%), Metastatic tumours were diagnosed in 5 cases (10.6%), Granulomatous lesions were reported in 3 cases (6.4%), while ependymoma, medulloblastoma, meningioma, normal brain tissue and tumour necrosis were each noted in 2 cases (4.3%). Less commonly encountered diagnosis on frozen section included high grade ependymoma, schwannoma, and spindle cell tumour each comprising 1 case (2.1%).

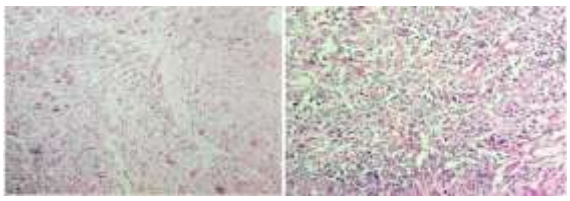

Figure 1: Glioblastoma on frozen section(left) and HPE (right) at 10X magnification

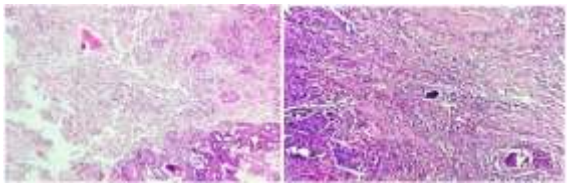

Figure 2: Meningioma on frozen section(left) and HPE (right) at 10X magnification

Table 1: Diagnosis of various CNS lesion on frozen section.

S.no	Diagnosis on frozen section	No. of cases
1	Ependymoma	2
2	Ependymoma High Grade	1
3	Granulomatous Lesion	3
4	High Grade Glioma	16
5	Low Grade Glioma	10
6	Medulloblastoma	2
7	Meningioma	2
8	Metastatic Tumour	5
9	Normal Brain Tissue	2
10	Schwannoma	1
11	Spindle Cell Tumour	1
12	Tumour Necrosis	2
	Grand Total	47

Table 2: Diagnosis of various CNS lesion on Histopathological evaluation

S.no	HPE Diagnosis	No. of cases
1	Anaplastic Astrocytoma	1
2	Anaplastic Ependymoma	1
3	Astrocytoma	4
4	Cavernous Hemangioma	1
5	Ependymoma	2
6	Ganglioglioma	2
7	Glioblastoma	15
8	Granulomatous Lesion	4
9	Medulloblastoma	2
10	Meningioma	2
11	Metastatic Tumour	5
12	Normal Brain Tissue	1
13	Oligodendroastrocytoma	1
14	Oligodendroglioma	3
15	Osteoblastoma	1
16	Schwannoma	01
17	Spindle Cell Tumour	01
	Grand total	47

On final histopathological evaluation Glioblastoma emerged as the most common diagnosis, accounting for 15 out of 47 cases (31.9%). This was followed by metastatic tumours, seen in 5 cases (10.6%). Astrocytomas and granulomatous lesions were observed in 4 cases each (8.5%). Oligodendroglioma constituted 3 cases (6.4%), while ependymoma, ganglioglioma, medulloblastoma and meningioma were each diagnosed in 2 cases (4.3%). Several lesions were infrequent, with anaplastic astrocytoma, cavernous hemangioma, oligoastrocytoma, osteoblastoma, schwannoma, spindle cell tumour and normal brain tissue contributing 1 case (2.1%).

Table 3: Correlation between frozen section diagnosis and histopathological diagnosis.

Diagnosis on Frozen Section	Diagnosis on HPE	
	CNS Neoplastic Lesion	Other Lesions
CNS Neoplastic Lesion (N = 34)	33	01
Other Lesions (N =13)	03	10
Total	36	11

A total of 47 cases were reviewed. Accuracy of Frozen section was found to be 91.5%, Specificity was 90.9%, Sensitivity was 91.2%, Positive predictive value was 97.1% and Negative predictive value was found to be 77%.

DISCUSSION

Intraoperative frozen section examination plays a crucial role in neurosurgical practice and interpreting frozen sections is among the most difficult tasks faced by a pathologist. In this setting, the pathologist strives to support the neurosurgeon by offering clinically useful information in a very limited time frame. This process is often complicated by several unavoidable factors, including fragile consistency of central nervous system tissue, the small quantity of tissue received for evaluation, high vascularity, necrosis, calcification and typical cellular patterns, all of which can make accurate interpretation challenging.

In our study specificity and sensitivity was 90.9% and 91.2% similar results were obtained by Khoddami et al,[21] (2015) who found specificity and sensitivity of frozen section to be 99.7% and 91.4% respectively.

The high sensitivity (91.2%) observed in this study indicates that frozen section is reliable in detecting neoplastic lesions. The specificity (90.9%) further supports its usefulness in excluding neoplasia. The very high positive predictive value (97.1%) suggests that when frozen section identifies a lesion as neoplastic, the diagnosis is almost always confirmed on histopathology.

On final histopathological evaluation Glioblastoma emerged as the most common diagnosis, accounting for 15 out of 47 cases (31.9%). This was followed by metastatic tumors, seen in 5 cases (10.6%). The predominance of gliomas, particularly high-grade gliomas, observed on both frozen section and final histopathology reflects the common surgical burden of these tumors. Frozen section proved especially useful in categorizing gliomas into high grade and low-grade lesions, a distinction that is critical for intra-operative decision making.

Accuracy of Frozen section was 91.5% in our study which is similar to study conducted by Shah et al. (1988)18 and Obeidat et al,[19] (2019) who found accuracy of 90.4% and 88.8%.

Several studies have documented differences between diagnosis made on frozen sections and those established later on histopathological sections. In our study, the relatively lower negative predictive value (77%) highlights a known limitation of frozen section, particularly in cases with sampling error, necrosis, edema, or inflammatory changes which may obscure tumour cells. Misclassification was more likely in lesions with overlapping morphological features, such as granulomatous lesions and low-grade gliomas.

In the present study frozen section correctly identified 33 out of 36 neoplastic lesions, giving a sensitivity of 91.2%. However, 3 neoplastic lesions (8.3%) were misinterpreted as non-neoplastic lesions on frozen section. Among non-neoplastic lesions, 10 out of 11 cases (90.9%) were correctly diagnosed, with 1 case (9.1%) being over diagnosed as neoplastic.

Some studies showed discrepancies in ependymoma, glioblastoma, metastatic tumours, oligodendroglioma, meningioma, and astrocytoma.[20,24] A French study on 1315 cases found most discrepancies were in gliomas, hemangioblastomas, and metastatic tumors.[20] Most of the discrepant cases were spindle cell lesions, astrocytoma versus oligodendroglioma, lymphoma, reactive versus neoplastic process, and tumour overgrading.[13] In a study by Rao et al,5 6% of cases were found to be discordant.

CONCLUSION

Frozen section examination shows high diagnostic accuracy and strong correlation with histopathology, especially for CNS neoplastic lesions. While minor discrepancies exist, frozen section continues to be a dependable method for intraoperative assessment and surgical guidance in CNS tumours.

REFERENCES

1. Mohanty SK, Singh A, Das AK, Shelly D. Correlation of intraoperative frozen section reporting with histopathological diagnosis in central nervous system tumors: a study of 30 cases. J Mar Med Soc. 2024;26(1):68–72.
2. Patel R, Shah I, Goswami H. Correlation of frozen section and routine histopathological findings in brain tumors. Int J Curr Res Rev. 2017;9(20):35–38.
3. Yadav M, Sharma P, Singh V, Tewari R, Mishra PS, Roy K. An audit of diagnostic disparity between intraoperative frozen section diagnosis and final histopathological diagnosis of central nervous system lesions at a tertiary care center. J Lab Physicians. 2022;14(4):384–393.
4. Al-Ajmi R, Al-Kindi H, George M, Thomas K. Correlation of intraoperative frozen section report and histopathological diagnosis of central nervous system tumors: a six-year retrospective study. Oman Med J. 2016;31(6):414–420.
5. Rao S, Rajkumar A, Ehtesham MD, Duvuru P. Challenges in neurosurgical intraoperative consultation. Neurol India 2009 Jul-Aug;57(4):464-468.
6. Plesec TP, Prayson RA. Frozen section discrepancy in the evaluation of central nervous system tumors. Arch Pathol Lab Med 2007 Oct;131(10):1532-1540.
7. Savargaonkar P, Farmer PM. Utility of intra-operative consultations for the diagnosis of central nervous system lesions. Ann Clin Lab Sci 2001 Apr;31(2):133-139.

8. Adams HJ, Grahan DI, Doyle D. The Smear Technique for Surgical Biopsies. London: Chapman and Hall, 1981. [Google Scholar]
9. Moss TH, Nicoll JA, Ironside TW. Intraoperative diagnosis of nervous system tumours. London: Arnold; 1997. [Google Scholar]
10. Firlik KS, Martinez AJ, Lunsford LD. Use of cytological preparations for the intraoperative diagnosis of stereotactically obtained brain biopsies: a 19-year experience and survey of neuropathologists. J Neurosurg 1999. Sep;91(3):454-458. 10.3171/jns.1999.91.3.0454 [DOI] [PubMed] [Google Scholar]
11. Mitra S, Kumar M, Sharma V, Mukhopadhyay D. Squash preparation: A reliable diagnostic tool in the intraoperative diagnosis of central nervous system tumors. J Cytol 2010. Jul;27(3):81-85. . 10.4103/0970-9371.71870 [DOI] [PMC free article] [PubMed] [Google Scholar]
12. Roessler K, Dietrich W, Kitz K. High diagnostic accuracy of cytologic smears of central nervous system tumors. A 15-year experience based on 4,172 patients. Acta Cytol 2002. Jul-Aug;46(4):667-674. 10.1159/000326973 [DOI] [PubMed] [Google Scholar]
13. Savargaonkar P, Farmer PM. Utility of intra-operative consultations for the diagnosis of central nervous system lesions. Ann Clin Lab Sci 2001. Apr;31(2):133-139.
14. Reyes MG, Homsi MF, McDonald LW, Glick RP. Imprints, smears, and frozen sections of brain tumors. Neurosurgery 1991. Oct;29(4):575-579. 10.1227/00006123-199110000-00015 [DOI] [PubMed] [Google Scholar]
15. Di Stefano D, Scucchi LF, Cosentino L, Bosman C, Vecchione A. Intraoperative diagnosis of nervous system lesions. Acta Cytologica. 1998 Mar–Apr;42(2):346–356. doi:10.1159/000331614.
16. Brainard JA, Prayson RA, Barnett GH. Frozen section evaluation of stereotactic brain biopsies: diagnostic yield at the stereotactic target position in 188 cases. Arch Pathol Lab Med 1997. May;121(5):481-484. [PubMed] [Google Scholar]
17. Colbassani HJ, Nishio S, Sweeney KM, Bakay RA, Takei Y. CT-assisted stereotactic brain biopsy: value of intraoperative frozen section diagnosis. J Neurol Neurosurg Psychiatry 1988. Mar;51(3):332-341. 10.1136/jnnp.51.3.332 [DOI] [PMC free article] [PubMed] [Google Scholar]
18. Shah AB, Muzumdar GA, Chitale AR, Bhagwati SN. Squash preparation and frozen section in intraoperative diagnosis of central nervous system tumors. Acta Cytol 1998. Sep-Oct;42(5):1149-1154. 10.1159/000332104 [DOI] [PubMed] [Google Scholar]
19. Brommeland T, Lindal S, Straume B, Dahl IL, Hennig R. Does imprint cytology of brain tumours improve intraoperative diagnoses? Acta Neurol Scand 2003. Sep;108(3):153-156. 10.1034/j.1600-0404.2003.00115.x [DOI] [PubMed] [Google Scholar]
20. Regragui A, Amarti Riffi A, Maher M, El Khamlichi A, Saidi A. [Accuracy of intraoperative diagnosis in central nervous system tumors: report of 1315 cases]. Neurochirurgie 2003. May;49(2-3 Pt 1):67-72.
21. Khoddami M, Akbarzadeh A, Mordai A, Bidari-Zerehpoush F, Alipour H, Samadzadeh S, Alipour B. Diagnostic accuracy of frozen section of central nervous system lesions: a 10-year study. Iranian Journal of Child Neurology. 2015;9(1):25.
22. Shah AB, Muzumdar GA, Chitale AR, Bhagwati SN. Squash preparation and frozen section in intraoperative diagnosis of central nervous system tumors. Acta cytologica. 1998 Sep 1;42(5):1149-54.
23. Obeidat FN, Awad HA, Mansour AT, Hajeer MH, Al-Jalabi MA, Abudalu LE. Accuracy of frozen-section diagnosis of brain tumors: An 11-year experience from a tertiary care center. Turkish Neurosurgery. 2019 Jan 1;29(2):242-6.
24. Kini JR, Jeyraj V, Jayaprakash CS, Indira S, Naik CN. Intraoperative consultation and smear cytology in the diagnosis of brain tumours. Kathmandu University Medical Journal (KUMJ). 2008 Oct–Dec;6(24):453–457.