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Original Research Article

Perioperative Outcomes of Patients Undergoing Frame Based Stereotactic Brain Biopsies

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Abstract: *Frame-based stereotactic brain biopsy is an established minimally invasive neurosurgical technique for obtaining tissue diagnosis of intracranial lesions, particularly when lesions are deep-seated or surgically inaccessible. Its safety and efficiency in resource-limited settings require continued local evaluation.* ***Objective:*** *To assess perioperative outcomes, including complication rates, operative time, and length of hospital stay in patients undergoing frame-based stereotactic brain biopsy at a tertiary care hospital in Pakistan.* ***Methods:*** *This descriptive cross-sectional study was conducted over six months from September 2024 to February 2025 at the Department of Neurosurgery, Nishtar Hospital, Multan. Ninety-seven patients aged 20 to 65 years who underwent frame-based stereotactic brain biopsy were enrolled using non-probability consecutive sampling. Demographic data, lesion characteristics, operative time, duration of hospital stay, and perioperative complications were recorded on a structured proforma. Data were analyzed using SPSS version 25. Quantitative variables were expressed as mean and standard deviation, while qualitative variables were presented as frequencies and percentages. Associations between complications and patient or lesion characteristics were assessed using the chi-square test, with p-values <0.05 considered statistically significant.* ***Results:*** *The mean age of patients was 46.7 ± 12.1 years, with a male-to-female Ratio of 1.5:1. The most common lesion locations were the frontal lobe (22.7%) and the parietal lobe (18.6%). Mean operative time was 46.2 ± 10.8 minutes, and the average hospital stay was 3.4 ± 1.6 days. Perioperative complications were observed in 14 patients (14.4 percent), including intracranial hemorrhage in 7 patients (7.2 percent) and new onset neurological deficits in 7 patients (7.2 percent). Higher complication rates were noted among older patients and those with deep-seated lesions, though these differences were not statistically significant (p > 0.05).* ***Conclusion:*** *Frame-based stereotactic brain biopsy is a safe and effective diagnostic procedure with acceptable operative time, short hospital stay, and low complication rates in a tertiary care setting in Pakistan. These findings support its continued use as a reliable neurosurgical diagnostic modality in resource-constrained environments.*

Keywords: Biopsy; Brain Neoplasms; Neurosurgery; Pakistan; Postoperative Complications; Stereotactic Techniques

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Introduction

Stereotactic brain biopsy has emerged as a pivotal investigational tool for diagnosing intracranial lesions, especially when traditional imaging does not yield conclusive results. The development of stereotactic techniques, including frame-based systems, has led to increased diagnostic accuracy and reduced morbidity rates associated with this minimally invasive procedure (1, 2). Frame-based stereotactic brain biopsy employs a rigid frame affixed to the patient's skull, enhancing precision in targeting brain lesions (1, 3). This method contrasts with frameless approaches, which utilize advanced imaging modalities and navigation systems to guide biopsy instruments. The efficacy of frame-based techniques has been established through studies indicating that they yield diagnostic results in approximately 90-95% of cases (4, 2).

The advantages of frame-based biopsies are underscored by their ability to reach deep-seated brain lesions while maintaining a low complication profile. A meta-analysis by Kesserwan et al. highlighted that the overall complication rate for stereotactic biopsies remains under 10%, attributable to various factors that help mitigate risks such as hematoma and infection (1, 2). Moreover, the role of image-guidance in planning and executing these biopsies is critical. Enhanced imaging technologies, such as intraoperative CT and MRI, are increasingly integrated into biopsy workflows, leading to improved target verification and lower surgical morbidity (5, 6).

However, the choice between frame-based and frameless stereotactic methods often revolves around the specific clinical context and nature of the lesions involved. Recent studies have indicated that while frameless systems are gaining traction for their flexibility and ease of use, the enduring legacy of frame-based techniques remains strong, particularly in hospitals with established neurosurgical programs (7, 8). A systematic review comparing both approaches emphasized that frame-based procedures offer a comprehensive pathway for histological diagnosis, which is crucial for therapeutic decision-making, particularly in oncological care (9).

The applicability of frame-based stereotactic biopsies within the Pakistani healthcare environment requires consideration of several factors, including local healthcare infrastructure, access to imaging technology, and the prevalence of neurological disorders. Pakistan, like many developing nations, faces challenges related to healthcare accessibility; however, advancements in neurosurgical techniques and the increasing availability of sophisticated imaging can potentially bridge this healthcare gap. The establishment of specialized neurosurgical centers is vital to ensure optimal patient outcomes and reduce the morbidity associated with neurological surgeries (10, 11). Furthermore, given the diverse population and varying incidence of brain lesions, a localized study on the outcomes of frame-based biopsies can significantly contribute to the field, providing valuable insights that inform clinical practices and shape future research directions (12, 13).

In summary, frame-based stereotactic brain biopsies represent an indispensable component of the diagnostic framework for brain lesions, boasting a high diagnostic yield with manageable risks. This study aims to contribute to the existing body of literature by examining the

perioperative outcomes of these procedures in the Pakistani population, addressing both immediate implications for patient care and broader public health perspectives. The present study is particularly relevant for the Pakistani healthcare context, where consistent and reliable diagnostic pathways for brain pathologies are critical, given the rising incidence of neurological disorders. The country's healthcare system is continuously evolving. With the installation of advanced neurosurgical technologies in major hospitals, the results of this research could substantiate the significance of frame-based stereotactic biopsies in the effective management of brain lesions. By highlighting the safety, efficacy, and patient outcomes achieved with such techniques, this study will serve as a foundational resource for future practices and aid in establishing probabilistic models of care that reflect the unique demographic and clinical challenges in Pakistan.

Methodology

This descriptive cross-sectional study was conducted at the Department of Neurosurgery, Nishtar Hospital, Multan, over six months, from September 2024 to February 2025, following institutional ethical approval. The study aimed to evaluate perioperative outcomes in patients undergoing frame-based stereotactic brain biopsies. A total of 97 patients, both male and female, aged between 20 and 65 years, were included using non-probability consecutive sampling. Patients who underwent planned stereotactic biopsy procedures for radiologically detected intracranial space-occupying lesions were enrolled. Patients with known coagulopathies, unstable vitals, or prior cranial surgeries were excluded to avoid confounding outcomes.

All procedures were carried out under sterile conditions using a standard stereotactic frame system under general anesthesia. Preoperative imaging, including contrast-enhanced CT or MRI, was utilized for localization. The stereotactic coordinates were calculated using dedicated planning software. Biopsies were obtained using a twist-drill craniostomy technique, and tissue samples were sent for histopathological analysis. Postoperative CT scans were performed within 24 hours to detect complications such as hemorrhage or edema.

Data were collected on patient demographics, lesion location, preparatory time, operative time, duration of hospital stay, and perioperative complications, including new neurological deficits or intracranial hemorrhage. The data were recorded using a structured proforma and analyzed using SPSS version 25.0. Descriptive statistics were applied to calculate means and standard deviations for continuous variables, while frequencies and percentages were calculated for categorical data. Inferential analysis was performed using chi-square tests to assess associations between complications and clinical variables, with p-values < 0.05 considered statistically significant.

Results

This descriptive study included 97 patients undergoing frame-based stereotactic brain biopsies at the Department of Neurosurgery, Nishtar Hospital, Multan. The patients' ages ranged from 20 to 65 years, with a mean of 46.7 ± 12.1 years. There was a slight male predominance, with 58 males (59.8%) and 39 females (40.2%).

The mean operative time was 46.2 ± 10.8 minutes, and the preparatory time averaged 35.1 ± 8.4 minutes. The mean hospital stay was 3.4 ± 1.6 days. Overall, 14 patients (14.4%) developed perioperative complications, including new intracranial hemorrhage (n = 7, 7.2%) and new neurological deficits (n = 7, 7.2%). (Table 1).

This table details the anatomical locations of intracranial lesions identified during stereotactic biopsy. The most frequent site was the frontal lobe (22.7%), followed by the parietal (18.6%) and temporal lobes (16.5%). (Table 2)Table 3 provides the mean perioperative metrics, including preparatory time, operative time, total procedure duration, and length of hospital stay. The total procedure averaged 81.3 minutes, and the average hospital stay was 3.4 days. (Table 3) Table 5 shows the relationship between postoperative complications and demographic or lesion characteristics. Although trends were observed, none of the variables, including gender, age, or lesion depth, showed statistically significant associations with complications. (Table 5) Postoperative complications, with new intracranial hemorrhage and neurological deficits each occurring in 7.2% of patients. The overall complication rate was 14.4%. (Table 4). The mean hospital stay was modest (3.4 days), and the overall complication rate was 14.4%, comparable to international findings. The most common lesions biopsied were located in the frontal and parietal lobes. Complication rates were slightly higher in older patients and those with deep-seated lesions, though statistical significance was not achieved ($p > 0.05$).

Table 1: Demographic Characteristics of Study Participants (n = 97)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	58	59.8
Female	39	40.2
Age Group (years)		
20–34	24	24.7
35–49	36	37.1
50–65	37	38.1

Table 2: Lesion Location in Patients Undergoing Stereotactic Biopsy

Location of Lesion	Frequency (n)	Percentage (%)
Frontal lobe	22	22.7
Parietal lobe	18	18.6
Temporal lobe	16	16.5
Occipital lobe	9	9.3
Subcortical nuclei	11	11.3
Corpus callosum	8	8.2
Ventricles	7	7.2
Cerebellum	6	6.2

Table 3: Perioperative Outcomes (n = 97)

Outcome	Mean ± SD
Preparatory Time (min)	35.1 ± 8.4
Operative Time (min)	46.2 ± 10.8
Total Procedure Time (min)	81.3 ± 11.6
Hospital Stay (days)	3.4 ± 1.6

Table 4: Postoperative Complications

Complication	Frequency (n)	Percentage (%)
New intracranial hemorrhage	7	7.2
New neurological deficit	7	7.2
Total complications	14	14.4

Table 5: Association of Complications with Demographic and Clinical Variables

Variable	Complications Present (n = 14)	No Complications (n = 83)	p-value
Male	9 (15.5%)	49 (84.5%)	0.62
Female	5 (12.8%)	34 (87.2%)	
Age > 50	7 (18.9%)	30 (81.1%)	0.33
Deep-seated lesion	9 (19.1%)	38 (80.9%)	0.08
Superficial lesion	5 (9.4%)	48 (90.6%)	

Chi-square test was applied; $p < 0.05$ was considered statistically significant

Discussion

The demographic profile of our study reveals a patient cohort characterized by a mean age of 46.7 years (± 12.1), with a slight male predominance (59.8%). These findings align closely with literature suggesting that the prevalence of neurological lesions necessitating biopsies often skews towards middle-aged males (14, 15). For example, Kesserwan et al. reported similar demographic trends, indicating a consistent pattern across different populations (15). The age distribution in our study suggests that the majority of patients (approximately 75.2%) were aged 35 to 65 years. This is consistent with findings by Neumann et al., which highlighted a concentration of surgical cases in older demographics (16).

The mean operative time in our study was recorded at 46.2 minutes (± 10.8), with an average preparatory time of 35.1 minutes (± 8.4). These figures are comparable to the established norms in the literature, where operative times for frame-based biopsies typically range between 30 and 60 minutes (17, 18). In particular, He et al. indicated a procedural average that aligns with our findings, further supporting the reliability of our operational metrics (19).

Additionally, the average length of hospital stay was reported as 3.4 days (± 1.6), which is consistent with studies indicating that postoperative hospital durations range from 2 to 5 days following stereotactic procedures (20, 21). This is crucial for patient management and healthcare resource allocation, suggesting that our findings reflect common postoperative pathways that physicians can expect in similar hospital settings.

Our findings emphasize the safety and complication profile of frame-based stereotactic biopsies—14.4% of patients experienced perioperative complications, with intracranial hemorrhages and new neurological deficits developing in 7 (7.2%) cases each. Contemporary studies report similar complication rates, reinforcing the notion that while frame-based techniques have satisfactory safety profiles, risks do persist. For instance, Dhawan et al. reported complication rates ranging from 1.9% to 17.8%, depending on the variation in methodologies used in frame-based procedures (22, 23). The results from our cohort align with these studies, showing that despite the risk, the diagnostic benefits of stereotactic biopsies far outweigh potential adverse outcomes.

In our study, the frontal lobe was the most frequently identified site of lesions (22.7%), followed closely by the parietal (18.6%) and temporal lobes (16.5%). This anatomical prevalence is consistent with findings from various studies that describe the frontal lobe as a common site for lesions requiring biopsy, given its involvement in multiple neurological conditions (24, 25). For example, Alam et al. confirmed similar lesion distributions across various cranial locations, indicating that our patient profile reflects broader epidemiological trends in neurological disease (15). Such insights can inform clinicians when deciding on the management of suspected intracranial pathologies.

Our study presents critical insights into the perioperative outcomes of patients undergoing frame-based stereotactic biopsies, aligning closely with the existing literature on demographics, operative times, complication rates, and lesion localization. The characterization of our patient population and their outcomes reinforces the utility of frame-based stereotactic procedures for achieving diagnostic histopathology effectively and safely.

Furthermore, the significance of these findings extends beyond immediate clinical practice. In Pakistan, where access to advanced neurosurgical techniques can be variable, understanding the expected outcomes of such procedures enhances medical practitioners' ability to provide evidence-based care. This study not only augments the existing body of research but also presents opportunities for improved patient management and the development of specialized training programs within the country's neurosurgical field.

Conclusion

This study demonstrates that frame-based stereotactic brain biopsy is a safe and effective diagnostic tool for intracranial lesions, with a complication rate of 14.4% and a short average hospital stay of 3.4 days. The procedure remains relevant and reliable in low-resource tertiary care centers such as Nishtar Hospital, Multan. These findings align with international literature and emphasize the importance of this approach for precise, minimally invasive neurosurgical diagnostics in the Pakistani healthcare system.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)
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Conflict of interest

The authors declared the absence of a conflict of interest.

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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