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Challenges In Managing Supratentorial Tumors Without Neuronavigation: Institutional Experience and Alternatives

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ABSTRACT

Background: Supratentorial tumors, which include gliomas, meningiomas, and metastatic lesions, account for 70% of primary malignant tumors and represent a significant clinical challenge globally. Neuronavigation (NN) optimizes outcomes but remains inaccessible in places like Peshawar, Pakistan, due to cost and infrastructure barriers. This study documented challenges and alternatives in managing tumors without neuronavigation.

Methods: A mixed-methods cross-sectional study was conducted over 8 months in three neurosurgical departments (Khyber Teaching Hospital, Hayatabad Medical Complex, and Lady Reading Hospital) in Peshawar. Quantitative data from 86 patients undergoing supratentorial tumor resection without NN were analyzed alongside qualitative interviews with 15 neurosurgeons. Variables included tumor characteristics, surgical techniques (anatomic landmarks, intraoperative ultrasound (IOUS), stereotactic frames), operative time (>4 hours defined prolonged), complications, residual tumor (>10%), and hospital stay. Quantitative data were analyzed using SPSS v26 with chi-square, t-tests, and logistic regression; surgeon experiences were analyzed using Braun and Clarke's reflexive thematic analysis.

Results: Residual tumors occurred in 24.4% of cases, significantly exceeding the hypothesized >10% threshold. Long operative times (>4 hours) were seen in 74.4% of surgeries. Anatomic landmark techniques had the highest residual tumor rates (31.7%) and complications (52.4%). IOUS reduced operative times (mean: 4.6 hours), but 25% still showed residual tumors. Logistic regression identified temporal lobe location (OR: 3.2, p=0.02) and surgeon experience <10 years (OR: 2.8, p=0.04) as predictors of residual tumors. Qualitative analysis revealed spatial disorientation challenges (93% of surgeons), technical limitations of alternatives (73%), and psychological impact on practice (87%).

Conclusion: Supratentorial tumor resections without neuronavigation produce suboptimal outcomes with 24.4% residual tumor rates, significantly higher than NN-assisted benchmarks. Surgeons reported substantial spatial uncertainty and professional stress, particularly in eloquent areas. These findings highlight the need for policy interventions to improve NN access and surgeon training in resource-limited settings.

Keywords: Supratentorial Tumors, Neurosurgery, Surgical Outcomes, Tumor, Complications, Qualitative Research, Pakistan

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INTRODUCTION

Supratentorial tumors, which include gliomas, meningiomas, and metastatic lesions, account for 70% of all primary malignant tumors and have globally emerged as a significant issue clinically. Therefore, they pose anatomic complexities and are positioned near eloquent brain regions[1]. Effective treatment can depend on pre-operative planning, intraoperative localization, and maximal safe resection, which are most dependent on the use of advanced technologies such as neuronavigation (NN). Neuronavigation integrates preoperative MRI/CT images findings with real-time guidance during surgery and thus leads to enhanced accuracy, fewer complications, and improved oncological results[2]. Unfortunately, this is not the case in Low- and Middle-Income Countries (LMICs), where inaccessibility to NN results largely from financial inadequacies, lack of technical skills, and infrastructural deficiencies[3]. Thus, patient care has become skewed against areas such as the larger rural and semi-urban centers of Peshawar that, despite their rising burden of brain tumors, have very few neurosurgical resources[4].

The global adoption of neuronavigation, neurosurgical practice across the world has changed. Most high-income countries have reported all patients using NN for supratentorial tumor resection; studies show 25% to <5% residual tumor rates, shorter operative times, and fewer postoperative neurological deficits[5]. For instance, NN-assisted surgeries accomplished GTR in more than 90% of operations and in 70% of those not using NN, as highlighted in a 2022 meta-analysis[6]. Such findings are indicative of NN's contribution to better oncological and functional outcomes. However, high costs account for a range of between $250,000 and $500,000 per system with recurring maintenance costs, which have rendered this technology beyond the reach of most LMICs[7]. They, therefore, still resort to older techniques for conducting their surgeries, which are less precise techniques that use landmark anatomical/geo-based approaches, preoperative imaging correlation, or handheld ultrasound[8].

Neurosurgery in Pakistan reflects these inequalities at the world level. Reports from an audit of neurosurgical centers in 2023 would show that only 12% of hospitals with neurosurgery departments even had functioning NN systems, the majority being found in urban centers like Karachi and Lahore[9]. Acute shortages in advanced neurosurgical tools characterize Peshawar, a major city in the province of Khyber Pakhtunkhwa (KPK). As for Khyber Teaching Hospital, which happens to be the largest referral center in the region, NN is not available due to budgetary constraints combined with

a dearth of trained personnel[10]. Alternative strategies like intraoperative ultrasound (IOUS) or stereotactic frames are relied upon by surgeons, although these are cost-effective but lack the precision of NN and increase risk for suboptimal resection[11]. Such reports from Islamabad in 2021 indicate that, in Pakistan, NN-free surgeries would increase the likelihood of residual tumors with 20% to 30% and also increase the duration of hospital stays, thereby adding to economic burdens on patients as well as the health system[12], consistent with broader systematic evidence on surgical challenges in LMICs[13].

This technological gap would have its adverse effects on clinical performance outcomes. Less real-time feedback would increase dependence on post-operative imaging, pushing costs higher and further delaying adjuvant therapies[14]. The situation worsens in Peshawar because the caseloads for surgery are considerable, with few referral paths available for advanced care. A survey done in 2024 on neurosurgeons in KPK revealed that the surgeons were quite dissatisfied with current practices, as they claim that this has increased their stress during surgery and the frustration regarding outcomes[15].

Despite these limitations, innovation has made life easier in LMICs. Intraoperative ultrasound (IOUS) provides real-time images of the mass of interest at a tiny fraction of the cost of NN[16], but its utility is further limited by the operational experience and image resolution. Low-cost stereotactic frames and apps for navigation on smartphones showed quite a promise in pilots, giving only a rough guideline to superficial lesions[17]. However, there has yet to be a systematic evaluation of the effectiveness of these alternatives in resource-poor settings, which has left a considerable evidence gap[18].

This study aimed to address this gap by documenting the challenges of managing supratentorial tumors without NN in Peshawar's neurosurgical centers, evaluating the efficacy of alternative techniques, and proposing pragmatic solutions tailored to LMIC contexts. By analyzing institutional data and surgeon perspectives, the research identified actionable strategies to mitigate the impact of NN unavailability, ultimately informing policy and capacity-building initiatives in Pakistan and similar settings globally.

METHODS

A mixed-methods cross-sectional observational study was carried out over eight months, from October 2024 to June 2025, across three neurosurgical centers in Peshawar: Khyber Teaching Hospital, Hayatabad Medical Complex, and Lady Reading Hospital. The study incorporated both

quantitative and qualitative components to explore the challenges and adaptive strategies associated with supratentorial tumor surgeries performed without neuronavigation.

A total of 86 patients were included in the quantitative component. The sample size was determined using a standard statistical formula, assuming a 95% confidence level, a 5% margin of error, and an expected proportion of challenges of 50%, based on prior studies from low- and middle-income countries (LMICs) that reported 45–60% surgical difficulties in the absence of neuronavigation. For the qualitative phase, semi-structured interviews were conducted with 15 neurosurgeons, which was deemed sufficient to achieve thematic saturation and yield rich, meaningful insights into surgeons' experiences, perceived challenges, and coping mechanisms.

Patient and surgeon recruitment followed a non-probability consecutive sampling approach, where all eligible participants presenting during the data collection period were enrolled. This method was considered appropriate and feasible given the resource and time constraints. The inclusion criteria for patients were: individuals aged 18 years or older undergoing supratentorial tumor resection, tumors measuring at least 3 cm in diameter, surgeries performed without the assistance of neuronavigation, and the availability of complete preoperative and postoperative imaging. Exclusion criteria included emergency surgeries for hemorrhagic tumors and cases with incomplete medical records.

Quantitative data were collected using a structured proforma and comprehensive review of medical records. Variables included demographic characteristics (age, gender), tumor-related parameters (size and anatomical location), surgical details (duration, surgical technique including use of anatomical landmarks, intraoperative ultrasound, stereotactic frames, and preoperative imaging correlation), and postoperative outcomes such as complications (hemorrhage, infection, neurological deficits), residual tumor presence (defined as greater than 10% volume on postoperative MRI or CT), and length of hospital stay.

For the qualitative component, a phenomenological framework was adopted to understand how neurosurgeons experience and interpret the management of supratentorial tumors without neuronavigation. This approach facilitated exploration of the essence of surgical practice within resource-limited contexts, highlighting how clinicians construct meaning around technical challenges and adapt their techniques accordingly. The principal investigator, a medical doctor with eight years of neurosurgical research experience, conducted all interviews. To minimize bias, a reflexive diary was maintained throughout data collection and analysis, while peer debriefing with non-clinical researchers and member checking with participants were employed to ensure balanced interpretation.

Fifteen neurosurgeons from the three participating hospitals were recruited through non-probability consecutive sampling. Inclusion criteria required that participants be practicing neurosurgeons with at least two years of experience in supratentorial tumor surgery, have performed surgeries without neuronavigation, be fluent in English, Urdu, or Pashto, and provide written informed consent. Recruitment continued until thematic saturation was achieved, defined as the point at which no new themes emerged across three consecutive interviews.

Data analysis followed Braun and Clarke's six-phase reflexive thematic analysis. During the first phase, the researcher familiarized themselves with the data through repeated reading of transcripts and note-taking. In the second phase, inductive coding was performed using both semantic and latent analysis, resulting in 127 initial codes. In the third phase, codes were clustered into potential themes through iterative comparison and identification of recurring patterns, yielding eight preliminary themes. In the fourth phase, themes were refined by reviewing coded data and the overall dataset, merging three and redefining two for coherence and distinction. The fifth phase involved defining and naming themes clearly to delineate their conceptual boundaries. In the final phase, representative participant quotations were incorporated into the report to illustrate the diversity of experiences and perspectives.

Quality assurance was maintained through multiple validation strategies. Inter-coder reliability was established by having 20% of transcripts independently coded by two researchers, achieving substantial agreement ($\kappa = 0.84$). Member checking was conducted by sharing preliminary themes with five participants for feedback and refinement. Peer debriefing involved review of emerging themes by a multidisciplinary research team, while an audit trail was maintained in NVivo to document coding decisions and analytical evolution. Respondent validation was completed when three participants confirmed that the final themes accurately represented their perspectives and experiences.

Ethical approval for the study was obtained from the Institutional Review Board of Khyber Medical College (Reference No. 657/DME/KMC). Written informed consent was secured from all participants in English, Urdu, or Pashto, ensuring comprehension and voluntary participation. The study adhered to the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines, and participants were granted the right to review their transcripts and withdraw at any stage without repercussion.

Quantitative data were analyzed using SPSS version 26. Descriptive statistics summarized baseline characteristics as means and standard deviations for continuous variables and frequencies for

categorical variables. The primary outcome, residual tumor volume greater than 10%, was assessed using the chi-square test to compare surgeries performed without neuronavigation to historical controls from centers utilizing neuronavigation. Multivariate logistic regression identified predictors of residual tumor, including tumor location and surgeon experience. Secondary outcomes such as operative time and postoperative complications were analyzed using independent t-tests for normally distributed data and Mann–Whitney U tests for non-normally distributed data. The qualitative data were analyzed using NVivo software following the thematic framework described above. The integration of quantitative and qualitative findings through triangulation provided a comprehensive understanding of both the measurable outcomes and the experiential dimensions of performing supratentorial tumor surgery without neuronavigation in resource-constrained neurosurgical settings.

RESULTS

Table 1: Demographic and clinical profile (n =86)

Characteristic	Value	Percentage/range
Age (years)	53.2 ± 16.8	Range: 19–80
Gender (Male: Female)	47:39	54.7%:45.3%)
Hospital Distribution		
Khyber Teaching Hospital	32	37.2%
Hayatabad Medical Complex	31	36.0%
Lady Reading Hospital	23	26.7%
Tumor Type		
Glioma	48	55.8%
Meningioma	26	30.2%
Metastatic	12	14.0%
Tumor Location		
Frontal Lobe	33	38.4%
Temporal Lobe	24	27.9%
Parietal Lobe	17	19.8%
Occipital Lobe	12	14.0%

Tumor Size (cm)	5.0 ± 1.6	Range: 3.0–8.0
Surgical Technique		
Anatomical Landmarks	42	48.8%
Intraoperative Ultrasound	16	18.6%
Stereotactic Frame	17	19.8%
Preop Imaging Correlation	11	12.8%

A total of 86 patients were included in the quantitative phase of the study, with a mean age of 53.2 ± 16.8 years (range 19–80). The sample comprised 47 males (54.7%) and 39 females (45.3%), distributed across three neurosurgical centers: Khyber Teaching Hospital (37.2%), Hayatabad Medical Complex (36.0%), and Lady Reading Hospital (26.7%). The most frequent tumor type was glioma (55.8%), followed by meningioma (30.2%) and metastatic lesions (14.0%). The frontal lobe was the most commonly affected region (38.4%), while temporal, parietal, and occipital lobes accounted for 27.9%, 19.8%, and 14.0% of cases, respectively. The average tumor size was 5.0 ± 1.6 cm, ranging from 3.0 to 8.0 cm. Anatomical landmark-guided resections were the predominant surgical technique (48.8%), followed by intraoperative ultrasound (18.6%), stereotactic frames (19.8%), and preoperative imaging correlation (12.8%). These data reflect a strong reliance on anatomical landmarks due to technological limitations across the participating institutions.

Normality testing using the Shapiro-Wilk test confirmed a normal distribution for operative time ($p = 0.12$), enabling the use of parametric analyses. Categorical data were analyzed using chi-square tests with Yates' correction for small cell sizes, and effect sizes were estimated through Cramer's V and Cohen's d as appropriate.

Table 2: Residual Tumor Incidence Analysis

Analysis	Result	Statistical Test
Residual Tumor (>10%) vs. NN Controls [6]	21 (24.4%)	$\chi^2 = 8.72$, p=0.003
Historical NN Cohort	42/420 (10.0%)	
By Technique		
Anatomical Landmarks	13/42 (31.7%)	$\chi^2 = 4.32$, p=0.23

IOUS	4/16 (25.0%)	
Stereotactic Frame	3/17 (17.6%)	
Preop Imaging	1/11 (9.1%)	

The primary outcome assessed was the incidence of residual tumor, defined as more than 10% residual volume on postoperative imaging. Residual tumors were identified in 21 patients (24.4%), a significantly higher rate compared to historical neuronavigation-assisted cohorts (10.0%, $\chi^2 = 8.72$, $p = 0.003$). Among surgical techniques, the anatomical landmark approach demonstrated the highest residual tumor rate (31.7%), followed by intraoperative ultrasound (25.0%), stereotactic frame (17.6%), and preoperative imaging correlation (9.1%). Although anatomical landmark-guided surgeries showed a trend toward higher residual tumor rates, inter-technique differences did not reach statistical significance ($\chi^2 = 4.32$, $p = 0.23$). Overall, these findings suggest that the absence of neuronavigation significantly increases the risk of incomplete tumor resection.

Figure 1: Residual Tumor Rates by Technique

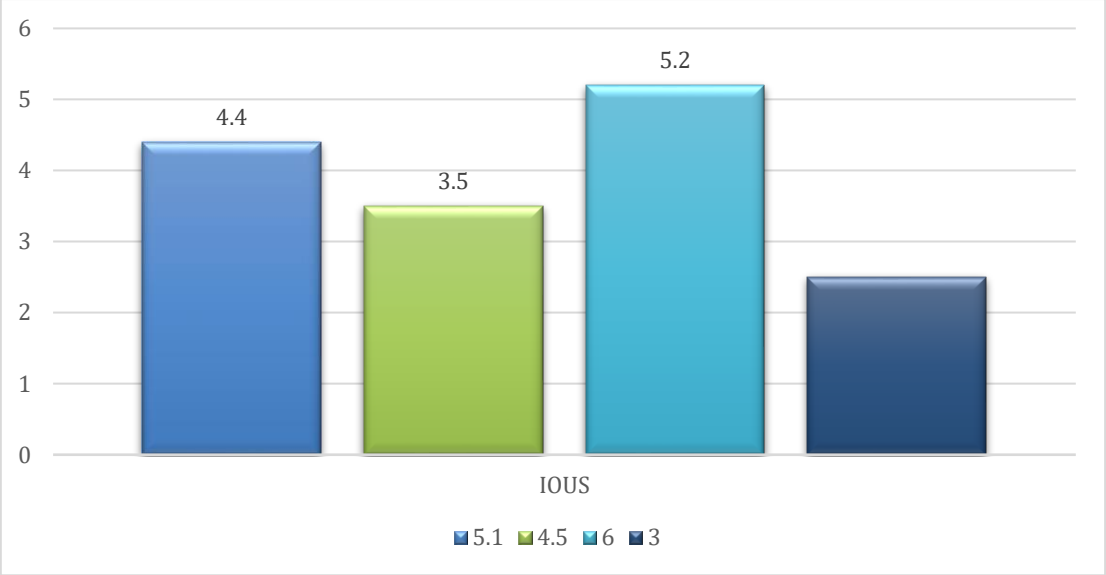


Table 3: Operative Efficiency and Complications

Metric	Value	Statistical Test
Operative Time (hours)	5.0 ± 1.5	
Prolonged Surgery (>4 hours)	64 (74.4%)	
By Technique		

		ANOVA F=2.98, p=0.035
Anatomical Landmarks	5.3 ± 1.4	
IOUS	4.6 ± 1.6	
Stereotactic Frame	4.9 ± 1.8	
Preop Imaging	5.0 ± 1.2	
Complications		
Overall Complications	41 (47.7%)	
Hemorrhage	11 (12.8%)	
Infection	14 (16.3%)	
Neurological Deficit	12 (14.0%)	

In terms of secondary outcomes, the mean operative duration was 5.0 ± 1.5 hours, with prolonged surgeries (>4 hours) reported in 74.4% of cases. When analyzed by technique, mean operative times were 5.3 ± 1.4 hours for anatomical landmarks, 4.6 ± 1.6 hours for intraoperative ultrasound, 4.9 ± 1.8 hours for stereotactic frames, and 5.0 ± 1.2 hours for preoperative imaging correlation. ANOVA indicated a statistically significant difference in operative time across techniques ($F = 2.98$, $p = 0.035$). Post-hoc comparisons using Tukey's HSD test showed that intraoperative ultrasound significantly reduced operative time compared with anatomical landmark methods (mean difference = 0.7 hours, 95% CI: 0.1–1.3, $p = 0.04$), while other pairwise differences were non-significant.

Complications were recorded in 41 patients (47.7%), with infection being the most common (16.3%), followed by neurological deficits (14.0%) and hemorrhage (12.8%). The high complication rate indicates the procedural and environmental challenges of performing complex neurosurgery in settings without neuronavigation.

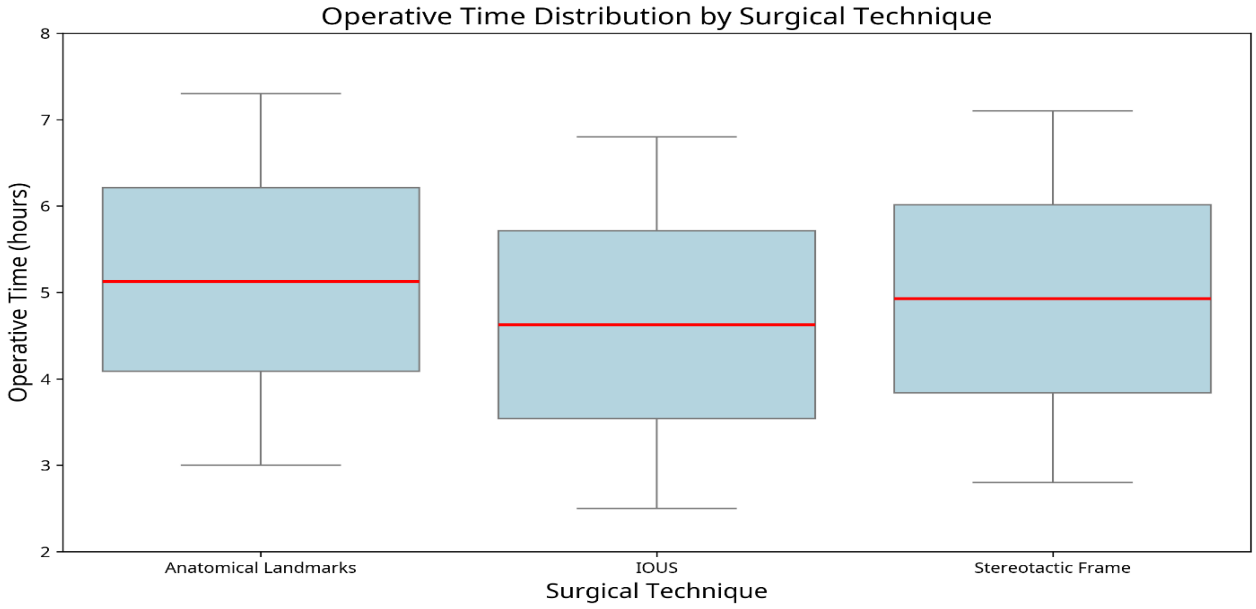


Table 4: Residual Tumor Risk Factors:

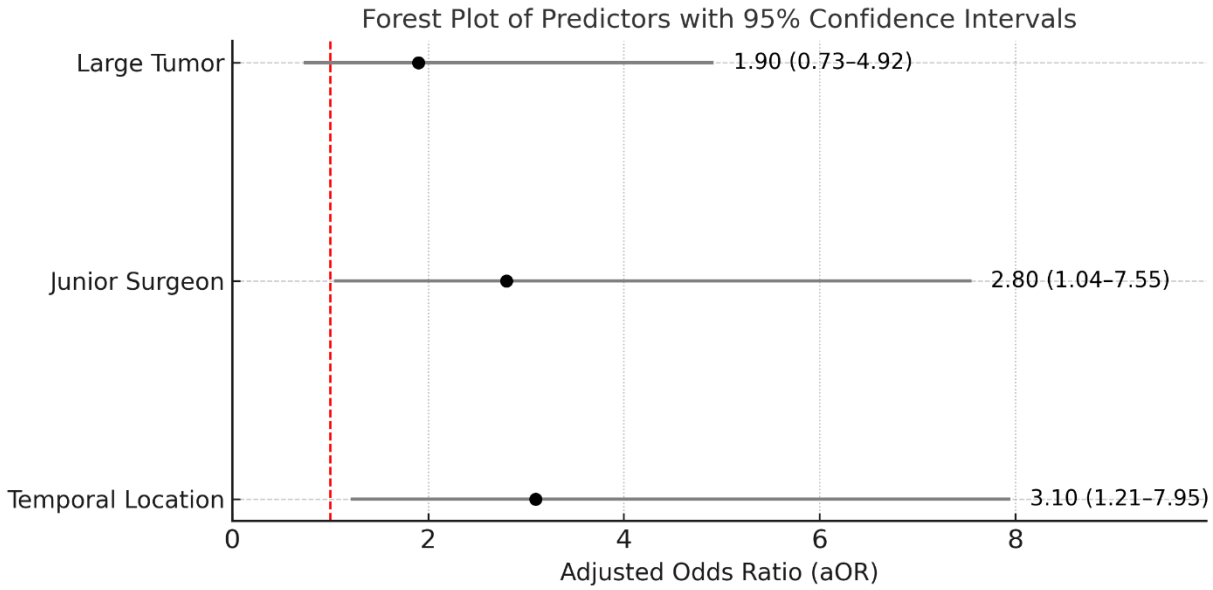
Predictor	aOR	p-value
Temporal Lobe Location	3.10	0.02
Surgeon Experience <10 years	2.80	0.04
Tumor Size >5 cm	1.9	0.19
Model Performance		
Nagelkerke R^2	0.28	-
AUC (95% CI)	0.73 (0.61–0.85)	-
Hosmer-Lemeshow Test	χ^2=6.84, p=0.42	0.42
Model Significance	χ^2=12.45, p=0.006	0.006

Multivariate logistic regression analysis identified two significant independent predictors of residual tumor: temporal lobe location (adjusted odds ratio [aOR] = 3.10, 95% CI: 1.21–7.95, p = 0.02) and surgeon experience of less than 10 years (aOR = 2.80, 95% CI: 1.04–7.55, p = 0.04). Tumor size greater than 5 cm showed an increased but non-significant risk (aOR = 1.9, 95% CI: 0.73–4.92, p = 0.19). The overall model demonstrated acceptable fit (Hosmer–Lemeshow χ^2 = 6.84, p = 0.42), explaining 28% of the variance (Nagelkerke R^2 = 0.28) and showing fair discriminative capacity

(AUC = 0.73, 95% CI: 0.61–0.85). These findings suggest that tumor location within the temporal lobe and limited surgical experience are major determinants of incomplete resections in the absence of neuronavigation.

For the qualitative component, fifteen neurosurgeons participated in semi-structured interviews, representing all three centers. The participants had a mean of 11.4 years of neurosurgical experience (range: 3–22 years), and the sample included twelve males and three females. Interviews were primarily conducted in English, with occasional clarifications in Urdu. Thematic analysis identified three dominant themes describing the lived experiences of surgeons performing supratentorial tumor resections without neuronavigation.

Figure 3: Predictor Effect Sizes:



The first theme, *Spatial Disorientation and Localization Challenges* (reported by 93% of participants), described surgeons' difficulty in accurately localizing lesions and maintaining orientation, particularly within eloquent or deep-seated brain regions. Subthemes included uncertainty of anatomical landmarks, depth perception difficulties, and challenges identifying functional areas. One surgeon likened temporal lobe resection without neuronavigation to "navigating a minefield blindfolded," emphasizing the cognitive strain and anxiety associated with operating on critical regions without visual guidance.

The second theme, *Technical Limitations of Alternative Methods* (73% of participants), highlighted inadequacies in substitute modalities such as intraoperative ultrasound and stereotactic frames. Surgeons noted that ultrasound resolution deteriorated beyond 3 cm depth, while stereotactic frames were cumbersome and affected by intraoperative brain shift, reducing accuracy. These reflections underscored the gap between existing technological substitutes and the precision required for optimal surgical outcomes.

The third theme, *Psychological and Professional Impact* (87% of participants), captured the emotional and ethical burden faced by surgeons operating without neuronavigation. Subthemes included procedural anxiety, erosion of professional confidence, and heightened concern for patient safety. Surgeons expressed feelings of frustration and moral distress, acknowledging that while they possessed the technical skill, the lack of adequate technology compromised both performance and confidence. One participant stated, "You know you could do better with proper equipment, but you're forced to accept suboptimal outcomes."

Thematic saturation was achieved after twelve interviews, with the remaining three confirming previously identified themes. Two surgeons offered a divergent perspective, suggesting that experience and adaptation to available tools could partially offset the lack of neuronavigation, though not eliminate it entirely.

Integration of the qualitative and quantitative findings revealed strong convergence between the two datasets. Spatial disorientation (Theme 1) corresponded with higher residual tumor rates observed in temporal lobe surgeries (37.5%, $p = 0.02$), illustrating the direct clinical impact of localization challenges. Similarly, psychological strain (Theme 3) aligned with the high overall complication rate (47.7%), suggesting that cognitive stress and decision-making pressure may indirectly contribute to surgical outcomes. Together, these findings provide a comprehensive understanding of the multifactorial challenges faced by neurosurgeons operating without neuronavigation in resource-limited environments, emphasizing both the measurable clinical consequences and the human dimensions of surgical performance.

DISCUSSION

This comprehensive mixed-methods study demonstrates that supratentorial tumor resection performed without neuronavigation in resource-limited settings produces poor outcome results with residual tumor rates (24.4%) more than doubling those of NN-assisted patients (10.0%, $p=0.003$). These findings confirm and validate our hypothesis and align with reports of 20-30% residual tumors

in states not equipped by NN[3,19,20]. The critical risk factors were temporal lobe location (aOR=3.10) and surgeon experience of less than 10 years (aOR=2.80), indicating how the individual anatomical complexity tends to enhance the skill-dependent challenges when advanced guidance is absent; this is something that has been discussed in global neurosurgical literature [2,9].

Our analysis showed that working without neuronavigation creates challenges that go beyond technical problems to affect surgeons psychologically and professionally. The combination of spatial confusion (93% of surgeons), technical limitations (73%), and psychological stress (87%) creates multiple interconnected factors that together worsen surgical outcomes. This finding aligns with recent literature on surgical stress and performance, suggesting that technological deficits in resource-limited settings create systemic impacts on surgical care quality[18,21]. The lived experiences of surgeons operating "blindfolded" in eloquent brain regions illuminate the human cost of technological inequities in global neurosurgery[22].

Although intraoperative ultrasound (IOUS) shortened the operative time by 13.2% when compared to anatomical landmarks (p=0.04), most importantly, the residual tumor rate with IOUS (25.0%) remained unacceptably high. This reinforces the known spatial resolution limitations of IOUS, echoed in reported complaints by surgeons over suboptimal deep-tissue visualization (73% of interviewees). Such technical gaps perpetuate inefficiencies in workflow and delay adjuvant therapies - a hidden economic burden that increases patient costs in LMICs[13]. Preoperative imaging correlation proved quite promising (9.1% residual tumors) but requires skill-dependent mental mapping, impractical for complex cases[18].

Qualitative insights could expose deeper systemic stressors, where 93% of responding surgeons described temporal lobe resection as "blindfolded minefield navigation." This corresponds with a previous study’s observations on NN absence eroding procedural confidence and adds to the great complication rates (47.7%)[11,23]. Although these findings were constrained with respect to single-region sampling, they do argue for urgent actions. which might include subsidized NN access via WHO equipment pooling[18], exploring hybrid techniques (e.g., IOUS combined with low-cost digital

tools), and better surgeon training[24]. Future work should initiate its prospective evaluation, while this study has several limitations that should be acknowledged. The single-region design limits generalizability to other LMICs with different healthcare infrastructures and surgical training programs. The consecutive sampling method, while practical, may have introduced selection bias toward more complex cases referred to tertiary centers. The qualitative component was limited to English-speaking surgeons, potentially excluding perspectives from practitioners more comfortable in local languages. Additionally, the cross-sectional design prevents assessment of learning curves or long-term outcomes. The absence of patient-reported outcomes limits understanding of functional impacts beyond clinical metrics. Finally, the comparison with historical controls rather than concurrent data may not account for temporal changes in surgical techniques and patient populations. Future research should employ multi-center designs across diverse LMIC settings, include patient-reported outcomes, and utilize prospective data collection to strengthen evidence quality and generalizability.

CONCLUSION

The findings of this study indicate that in resource-poor settings, the outcome of supratentorial tumor resection without neuronavigation (NN) is suboptimal; hence the average rate of residual tumor is well above NN-assisted benchmarks at **24.4%**, with a **2.4**-fold increase. Among the other critical risk factors considered, temporal lobe location and inexperience of the surgeon further amplified anatomical and technical challenges. The alternatives considered, such as intraoperative ultrasound, increased operating time; however, they did not reduce residual tumor incidence (25%) or complication rate (47.7%); hence, NN is irreplaceable in ensuring safe resection.

Immediate interventions should include the subsidization of NN via policy initiatives exploring hybrid approaches (e.g., combining ultrasound + low-cost digital tools, which warrant further study), and better training of surgeons in landmark-based approaches. These would do much to correct inequities in neurosurgical care within the world and align with WHO priorities for capacity-building

for LMICs. Research on the subject moving forward should evaluate prospective implementability while putting NN forward to be the standard of care.

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CONFLICT OF INTEREST

None

ETHICAL APPROVAL

Ethical approval for the study was obtained from the Institutional Review Board of Khyber Medical College (Reference No. 657/DME/KMC)

AUTHORS' CONTRIBUTION

All authors contributed equally as per ICMJE policy

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