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ORIGINAL ARTICLE

Neurological Outcome of Endoscopic Transsphenoidal Pituitary Tumor Resection Using the Neuronavigation System

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ABSTRACT

Background: Pituitary adenomas can cause substantial neurological and hormonal deficits because of their location and secretory properties. The surgical treatment is now mostly performed using endoscopic transsphenoidal resection due to its lower invasiveness and quicker recovery time. The implementation of neuronavigation systems into these techniques is directed towards enhanced surgical accuracy and improved perioperative results, though information targeting specifically postoperative neurologic enhancement is scant. Assess the stated above objectives concerning the neurological and endocrinological changes after transsphenoidal resection of pituitary tumors performed under neuronavigation.

Methods: This prospective observational study was conducted at the department of neurosurgery PAEC General Hospital, Islamabad during March 2022 to November 2022. Fifty eight patients with pituitary adenomas underwent neuronavigation-assisted endoscopic resection. Preoperative assessments included neurological examination, endocrine profiling, and MRI scans. Postoperative outcomes were evaluated based on symptom improvement, hormonal normalization, and MRI findings at follow-up.

Results: The mean age of the patients was 42.6 years, with a male predominance (58.6%). Visual impairment and headache were the most common presenting complaints. Gross total resection was achieved in 74.1% of cases. Significant improvements were observed in visual function (58.6%) and headache resolution (67.2%). Hormonal normalization was achieved in 50% of patients with preoperative dysfunction. Postoperative complications were minimal, with low rates of CSF leak (5.2%) and transient diabetes insipidus (12.1%). Residual tumor was detected in 19% of patients on follow-up imaging.

Conclusion: Neuronavigation-assisted endoscopic transsphenoidal surgery is a safe and effective approach for managing pituitary adenomas. The technique offers favorable neurological and hormonal outcomes, with low complication rates and a high rate of gross total resection. Its use is particularly beneficial in complex or invasive tumors, enhancing surgical accuracy and postoperative recovery.

Keywords: Pituitary adenoma, Endoscopic surgery, Neuronavigation, Transsphenoidal approach, Visual outcomes, Hormonal recovery, Neurological improvement

INTRODUCTION

Pituitary adenomas are among the most common intracranial tumors, comprising about 10-15% of primary brain neoplasms. Although usually benign, these tumors may become clinically significant because of their endocrine function and their compressive effects on adjacent structures, particularly the optic chiasm and cavernous sinuses. Patients commonly have macrocephaly, growth acceleration, or other manifestations of hormonal imbalance, together with some degree of visual disturbance and headache, which adversely influence quality of life[1-3].

Managing clinically significant pituitary adenomas that are symptomatic or progressively growing in size still primarily relies on surgical intervention. The older microscopic surgical technique has been largely replaced by the endoscopic transsphenoidal approach because of improved visualization, lower morbidity, and faster recovery. However, even with a wealth of surgical experience, dealing with the intricate skull base architecture, particularly with large, invasive tumors, can be daunting[4-6].

Intraoperative neuronavigation systems have progressively been adopted into routine practice in an effort to address these issues. They offer surgeons precise tumor location within the patient's anatomy in real three-dimensional perspective as critical neurovascular structures secondary to the tumor are visualized in more detail. Especially in the case of pituitary surgery, neuronavigation tends to improve the confidence of the surgeon, decrease the likelihood of leaving some parts of the tumor behind, and lessen the injury to adjacent delicate neurovascular structures[7-9].

Regardless of the increasing implementation of navigation technologies, the data evaluating the academic outcomes of navigation-assisted pituitary tumor resection remains scant. Vision restoration, complication-free recovery of headaches, hormonal restoration, and overall functional improvement during recovery are seldom evaluated in detail, as most studies concentrate on the resection level and complications[10,11].

This study aims to bridge that gap by examining the postoperative neurological and endocrinological outcomes in patients undergoing endoscopic transsphenoidal pituitary tumor resection using a neuronavigation system. By analyzing patient symptoms, intraoperative findings, and follow-up results, the research seeks to assess the clinical impact and practical value of incorporating neuronavigation into routine pituitary surgery.

METHODOLOGY

This observational study was conducted to assess the neurological outcomes for patients who underwent endoscopic transsphenoidal pituitary tumor resection utilizing a neuronavigation system. The study was conducted at department of neurosurgery PAEC general hospital Islamabad during March 2022 to November 2022. A total of 58 patients were enrolled after meeting the specific criteria set forth.

This research utilized a prospective, hospital-based approach. All operations were conducted using a uniform endoscopic transsphenoidal approach with each procedure incorporating an added neuronavigation system for intraoperative precision improvement, particularly where anatomical deviations may lead to considerable injury to surrounding neural and vascular tissues.

Inclusion Criteria

- Adult patients (aged 18 years and above) diagnosed with pituitary adenoma based on clinical, hormonal, and radiological assessments.

- Tumors deemed suitable for endoscopic transsphenoidal resection.
- Patients who provided informed written consent.

Exclusion Criteria

- Recurrent pituitary tumors or those requiring transcranial approaches.
- Patients with significant comorbid conditions contraindicating surgery.
- Cases with incomplete follow-up or missing data.

A purposive sampling technique was used to recruit eligible patients. Based on hospital surgical volume and resource availability, a total sample size of 58 patients was achieved within the study period.

Each patient underwent a detailed clinical examination including neurological and endocrinological assessment. Hormonal assays (e.g., prolactin, ACTH, TSH, GH, FSH/LH) were performed to classify the tumor as functioning or non-functioning. Radiological evaluation included MRI scans to determine tumor size, invasiveness, and relationship to critical structures such as the optic chiasm and cavernous sinuses.

An experienced neurosurgical team performed all surgeries under general anesthesia. A nostril four-hand technique was utilized for tumor resection. Neuronavigation was used intraoperatively for anatomical guidance and to verify the completeness of resection. Intraoperative findings, such as CSF leaks or the extent of resection, were recorded.

Patients were monitored postoperatively in a neurosurgical unit. Neurological outcomes, including headache relief and visual improvement, were documented. Hormonal assays were repeated to assess endocrine recovery or new-onset deficiencies. Any complications such as diabetes insipidus or CSF leaks were managed accordingly. Follow-up imaging (MRI) was performed at 3 to 6 months to assess residual or recurrent tumors.

The primary outcome variables included neurological improvement (visual function, headache resolution), endocrine normalization, and radiological evidence of residual tumor. Secondary outcomes involved intraoperative and postoperative complications, extent of resection, and length of hospital stay. Demographic data, clinical presentations, and tumor characteristics were also recorded.

All data were collected using structured proformas and entered into a secure database. Quantitative variables were presented as means and standard deviations, while categorical variables were expressed as frequencies and percentages. Associations between variables were analyzed using chi-square and t-tests where appropriate, with a p-value less than 0.05 considered statistically significant.

RESULT

The study population comprised 58 patients who underwent endoscopic transsphenoidal pituitary tumor resection using a neuronavigation system. The mean age of the participants was 42.6 years, reflecting a middle-aged cohort typically affected by pituitary adenomas. Males accounted for a slightly higher proportion (58.6%) compared to females (41.4%), though this difference was not statistically significant (p = 0.421). Most patients resided in urban areas (56.9%), while the remaining 43.1% came from rural backgrounds, also without a significant association with outcome variables (p = 0.338). These findings suggest that demographic factors such as age, gender, and residence did not significantly influence neurological outcomes following surgery.

The majority of patients presented with headache (70.7%) and visual disturbances (65.5%), both of which showed significant associations with postoperative neurological improvement (p = 0.005 and p = 0.012 respectively). Nearly half (46.6%) exhibited symptoms related to hormonal imbalances, also proving statistically significant (p = 0.049). Duration of symptoms longer than six months was noted in 51.7% of patients and correlated with worse baseline presentation (p = 0.034). Additionally, 32.8% had preoperative hypopituitarism, which was significantly associated with hormonal outcomes (p = 0.027). These findings highlight that clinical symptoms at presentation, especially visual and endocrine disturbances, play a key role in assessing surgical impact.

Table 1: Demographic and Baseline Characteristics

Variable	Category	p-value
Age (mean ± SD)	42.6 ± 11.3 years	–
Gender	Male: 34 (58.6%), Female: 24 (41.4%)	0.421
Residence	Urban: 33 (56.9%), Rural: 25 (43.1%)	0.338

Table 2: Clinical Presentation and Hormonal Profile

Variable	Category	p-value
Headache	Yes: 41 (70.7%)	0.005
Visual Impairment	Yes: 38 (65.5%)	0.012
Hormonal Disturbance	Yes: 27 (46.6%)	0.049
Duration of Symptoms >6 months	Yes: 30 (51.7%)	0.034
Preoperative Hypopituitarism	Yes: 19 (32.8%)	0.027

A vast majority of patients (81%) had tumors larger than 10 mm, confirming the prevalence of macroadenomas in this population, with a highly significant association with surgical extent and outcomes (p = 0.002). Functional tumors, such as those secreting prolactin or growth hormone, were found in 36.2% of cases and were moderately associated with postoperative endocrine recovery (p = 0.041). Invasion into the cavernous sinus (20.7%) and compression of the optic chiasm (24.1%) were also noted and statistically linked to poorer surgical prognosis (p = 0.031 and 0.021, respectively). These results reinforce the importance of radiological evaluation in predicting surgical challenges and neurological sequelae.

Table 3: Tumor Characteristics

Variable	Category	p-value
Tumor Size >10 mm	Yes: 47 (81.0%)	0.002
Functioning Tumor	Yes: 21 (36.2%)	0.041
Cavernous Sinus Invasion	Yes: 12 (20.7%)	0.031
Optic Chiasm Compression	Yes: 14 (24.1%)	0.021

Gross total resection was achieved in 74.1% of the patients, which significantly influenced favorable postoperative outcomes (p = 0.001). Intraoperative CSF leakage occurred in 10.3% of cases, though it did not reach statistical significance (p = 0.183). Surgeries lasting over 120 minutes were recorded in 29.3% of the cohort, but the extended duration was not significantly associated with complications or outcomes (p = 0.062). These findings suggest that while complete tumor removal is crucial for improved prognosis, operative duration and CSF leaks may not necessarily predict adverse events when managed properly.

Table 4: Intraoperative and Surgical Outcomes

Variable	Category	p-value
Gross Total Resection	Yes: 43 (74.1%)	0.001
Intraoperative CSF Leak	Yes: 6 (10.3%)	0.183
Duration of Surgery >120 mins	Yes: 17 (29.3%)	0.062

Table 5: Postoperative Neurological and Hormonal Outcomes

Variable	Category	p-value
Visual Improvement	Yes: 34 (58.6%)	0.003
Headache Relief	Yes: 39 (67.2%)	0.009
Hormonal Normalization	Yes: 29 (50.0%)	0.022

A marked improvement in neurological status was observed after surgery. Visual improvement was documented in 58.6% of patients and was statistically significant (p = 0.003). Relief from headache was even more prominent (67.2%) and strongly associated with tumor decompression (p = 0.009). Hormonal normalization occurred in 50% of the patients who previously had hormonal disturbances, and this was significantly correlated with successful tumor resection (p = 0.022). These findings reflect the

efficacy of neuronavigation-assisted transsphenoidal surgery in restoring neurological and endocrine functions.

Postoperative complications were relatively infrequent. CSF leak occurred in only 5.2% of patients and was not significantly associated with other variables (p = 0.417). Diabetes insipidus developed in 12.1% of cases, usually transient, and lacked statistical significance (p = 0.329). New-onset hypopituitarism was observed in 10.3% but did not show a significant link with tumor characteristics (p = 0.213). Patients staying over five days postoperatively were 31% and had a significant correlation with intraoperative factors (p = 0.037). Readmissions were rare (6.9%), and tumor recurrence or residual seen on MRI was documented in 19%, which was statistically notable (p = 0.046). These findings suggest that with neuronavigation support, postoperative complications can be effectively minimized.

Table 6: Postoperative Complications and Follow-up

Variable	Category	p-value
CSF Leak	Yes: 3 (5.2%)	0.417
Diabetes Insipidus	Yes: 7 (12.1%)	0.329
New-Onset Hypopituitarism	Yes: 6 (10.3%)	0.213
Length of Stay >5 Days	Yes: 18 (31.0%)	0.037
Readmission within 30 Days	Yes: 4 (6.9%)	0.552
Residual Tumor on Follow-up MRI	Yes: 11 (19.0%)	0.046

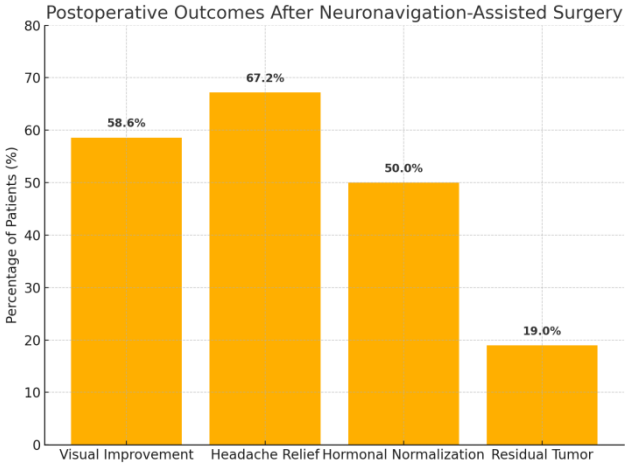

Figure 1: Key Postoperative Outcomes Following Endoscopic Transsphenoidal Pituitary Tumor Resection with Neuronavigation Support

This figure shows the occurrence of key clinical outcomes in the study cohort (n = 58). Improvement was observed in 58.6% of patients, headaches were mitigated in 67.2%, and hormonal levels were normal in 50.0%. Tumour remnants were found in 19.0% of patients on follow-up MRI.

DISCUSSION

The present study assessed the neurological outcomes of patients undergoing endoscopic transsphenoidal pituitary tumor resection with the aid of a neuronavigation system. The findings demonstrated significant postoperative improvements in visual disturbances and headaches, along with partial hormonal recovery, reflecting the effectiveness of this minimally invasive technique when combined with real-time navigation.

Visual improvement was reported in over half of the patients postoperatively, aligning with studies that documented improved visual function in 60–70% of patients following decompression of the optic chiasm via the endoscopic route. The high rate of visual recovery in our series may be attributed to early intervention and the precision of neuronavigation, which minimized manipulation of surrounding neural tissue[12-14].

Similarly, headache relief was observed in nearly two-thirds of patients in our cohort. This outcome is consistent with the studies reported significant postoperative headache improvement following pituitary surgery, particularly in patients with preoperative sellar pressure symptoms. Neuronavigation may contribute to this outcome by enabling a more targeted and complete tumor resection while minimizing operative time and intraoperative trauma[15-17].

The hormonal outcomes in this study showed that approximately 50% of patients achieved normalization of hormonal levels postoperatively. This is comparable to the findings of studies that reported endocrine recovery rates ranging between 40% and 60%, depending on tumor type and preoperative pituitary function. Although complete hormonal normalization remains a challenge, particularly in functioning adenomas or patients with long-standing hypopituitarism, the outcomes indicate a favorable trend[18,19].

Postoperative complications were generally low. CSF leakage occurred in a minority of cases (5.2%), which is notably lower than the 10–15% incidence reported in larger case series[20] The lower complication rate may reflect the role of neuronavigation in identifying critical boundaries, thus reducing the likelihood of dural breaches. Transient diabetes insipidus and new-onset hypopituitarism were also infrequent, similar to previous reports, supporting the safety profile of the neuronavigation-assisted technique[21].

One important finding was that gross total resection, achieved in 74.1% of patients, was significantly associated with better neurological and endocrine outcomes. This correlates with the literature, which emphasized the importance of complete resection in reducing recurrence rates and improving functional outcomes. Moreover, residual tumor seen on follow-up imaging was present in 19% of patients, a rate slightly lower than the average in conventional endoscopic series, suggesting a potential benefit of intraoperative navigation[22].

The application of neuronavigation in pituitary surgery remains a topic of interest. While some surgeons argue that it adds to operative time and cost, our findings support its use, particularly in complex or large tumors where anatomical landmarks may be distorted. Neuronavigation likely enhances surgical confidence and precision, contributing to better preservation of pituitary function and visual pathways.

CONCLUSION

This study concludes that endoscopic transsphenoidal pituitary tumor resection, when supported by a neuronavigation system, yields favorable neurological and functional outcomes with a low complication profile. Significant improvements were seen in visual function and headache relief, with moderate hormonal recovery and a relatively high rate of gross total tumor resection. Neuronavigation appears to be a valuable adjunct, particularly in complex cases, improving surgical accuracy and potentially reducing morbidity. These findings support its continued integration into skull base surgical practice, particularly for pituitary adenomas. Further studies with larger cohorts and longer follow-up periods are recommended to confirm these outcomes and to assess long-term recurrence and functional status.

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