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Lateral Supraorbital Craniotomy: Neurosurgical Approach for Anterior Cranial Fossa Lesion

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ABSTRACT

Background: The lateral supraorbital (LSO) craniotomy is a limited-exposure frontal–basal approach used for anterior cranial fossa (ACF) lesions. Evidence evaluating effectiveness and safety from Indian tertiary centres remains sparse.

Objective: To evaluate effectiveness and safety of LSO for ACF pathology in a single-centre cohort, reporting radiological, peri-operative, and functional outcomes.

Methods: We conducted a retrospective observational cohort at a tertiary teaching hospital. Consecutive adults (18–75 years) with imaging-confirmed ACF lesions selected for LSO were included. Data were abstracted from operative records, imaging, and clinic follow-up. Outcomes were extent of resection (EOR: gross-total resection [GTR] vs subtotal resection [STR]), predefined complications (e.g., CSF leak, infection, transient deficits), ICU/hospital stay, and functional status (Karnofsky Performance Status [KPS], Glasgow Outcome Scale [GOS]).

Results: The study included 120 patients (mean age 52.4 ± 12.1 years; 56.7% male). Early postoperative imaging showed GTR in 81.7% (98/120) and STR in 18.3% (22/120). Complications were infrequent: CSF leak 4.2% (5/120), infection 2.5% (3/120), transient neurological deficits 7.5% (9/120); revision surgery occurred in 1.7% (2/120). Mean operative time was 145.2 ± 30.6 minutes, and mean hospital stay 5.8 ± 2.3 days. Functional outcomes (KPS, GOS) were captured at discharge and follow-up; values will be reported in structured tables based on the master dataset.

Conclusions: In this single-centre experience, LSO provided effective access to ACF lesions with high rates of gross-total resection, low early complication frequencies, and short hospitalization. Findings support LSO as a practical skull-base option in resource-aware settings when case selection and postoperative imaging are standardized. Prospective multicentre studies with uniform patient-reported outcomes and volumetric measures are warranted.

KEYWORDS: Lateral supraorbital craniotomy; anterior cranial fossa; skull-base surgery; gross-total resection; postoperative complications; Karnofsky Performance Status; Glasgow Outcome Scale; radiological outcomes; hospital length of stay.

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INTRODUCTION

The anterior cranial fossa (ACF) contains critical neurovascular structures that constrain surgical exposure and margin for error.[1,2] Approaches that shorten the working distance while preserving soft tissue are preferred when pathology, laterality, and extension permit.[3,4] The lateral supraorbital (LSO) craniotomy provides a frontal–basal route through a limited supraorbital bone window.[5–7] It aims to maintain visualization of the optic apparatus and anterior circulation while reducing temporalis dissection and incision length.[8] Comparative series have reported beneficial cosmesis and recovery with LSO without a clear penalty in extent of resection when applied to well-selected ACF lesions e.g., meningioma and olfactory groove pathology.[9,10]

Evolving adjuncts i.e., microscopy, neuronavigation, and in select cases endoscopic assistance - support LSO by improving trajectory planning and illumination.[11] Even with these tools, outcome quality depends on case selection, corridor planning, and reliable postoperative imaging to confirm extent of resection.[12] In many Indian tertiary centres the approach is also determined by resource availability, operating room throughput and follow-up logistics.[13,14] Techniques that shorten operative time and hospital stay without compromising safety align with these practical considerations.[15]

Our study aimed to address two gaps in the regional literature. (A) Single-centre data on LSO for ACF lesions in an Indian public teaching hospitals is limited (B) Standardization of reporting across radiologic, peri-operative, and functional domains is inconsistent and hence complicates the comparisons with international studies. In our study we evaluated the effectiveness and safety of LSO for ACF lesions in a single tertiary centre by reporting (i) radiologic outcomes with extent of resection (ii) peri-operative metrics (iii) postoperative complications and hospital course and (iv) functional outcomes at discharge and follow-up.

METHODOLOGY

This study evaluated clinical, radiological, and functional outcomes after lateral supraorbital (LSO) craniotomy for anterior cranial fossa (ACF) lesions at a single tertiary neurosurgical centre.

Study design and setting: We conducted a retrospective observational cohort at Gauhati Medical College and Hospital (Assam, India). Consecutive patients who underwent LSO craniotomy for ACF pathology were identified from operative records and departmental databases. Imaging and follow-up data were retrieved from hospital PACS and clinic notes.

Participants and eligibility: 120 **a**dults aged 18–75 years with imaging-confirmed ACF lesions (e.g., meningioma, olfactory-groove or planum lesions, selected parasellar/skull-base tumors) who were managed with an LSO approach were eligible. Patients were included when the lesion's size, laterality, and access corridor were suitable for LSO as determined in multidisciplinary review. Individuals were excluded for any of the following: severe systemic disease that contraindicated surgery, significant coagulopathy, prior neurosurgical procedures that materially altered skull-base anatomy or would confound outcomes, or inability to complete early postoperative assessment or planned follow-up. Preoperative anaesthetic risk was documented using ASA physical status (I–III eligible).

Surgical technique and peri-operative care: All procedures were performed via a lateral supraorbital craniotomy using standard microsurgical technique. Patient positioning, skin incision, bone flap creation, and dural opening followed the departmental protocol for the LSO corridor. Intraoperative adjuncts (operating microscope; navigation or endoscopic assistance where indicated) were used at the surgeon's discretion. Haemostasis, dural closure, and bone flap reconstruction adhered to skull-base principles to reduce CSF-related complications. Postoperative care included routine ICU observation where indicated, early neurochecks, and protocolized analgesia and DVT prophylaxis per institutional policy.

Data collection and variables: From the medical record, we abstracted demographic data (age, sex, comorbidities), presentation (symptoms), lesion characteristics (category, side, size), and operative metrics (approach details, operative time, estimated blood loss, transfusion, adjuncts). Radiological assessments were obtained from pre- and postoperative CT/MRI. Hospital course variables included ICU stay and length of stay, and predefined complications (e.g., CSF leak, infection, new neurological deficit, wound issues, 30-day readmission). Functional outcomes were captured using Karnofsky Performance Status (KPS) and Glasgow Outcome Scale (GOS) at discharge and at the last documented follow-up (target 12 months where available).

Outcome definitions: Primary radiological outcome: extent of resection (EOR), categorized as gross-total resection (GTR) or subtotal resection (STR) based on early postoperative MRI/CT. Safety outcomes: surgical and medical complications during index admission and within 30 days. Functional outcomes: KPS and GOS at discharge and at follow-up, alongside return to usual activity and cosmetic satisfaction where recorded.

Statistical analysis: Data were summarized using counts/percentages and means with standard deviations or medians with interquartile ranges, as appropriate. Between-group comparisons used chi-square or Fisher's exact tests for categorical variables and t-tests or non-parametric equivalents for continuous variables. Associations between predictors and binary outcomes were evaluated with logistic regression to estimate odds ratios with 95% CIs. Time-related endpoints (if applicable) were explored using Cox proportional hazards models. Two-sided $\alpha = 0.05$ defined statistical significance. Analyses were conducted in SPSS (data management, inferential tests) and R (graphics and modelling).

Ethics: Approval was obtained from the Institutional Ethics Committee; data were de-identified prior to analysis. For retrospective review of existing records - the need for individual consent was addressed per IEC guidance. If prospective follow-up contact was required, written informed consent was obtained from patients or legal guardians.

RESULTS

Demographic & baseline profile: We summarized baseline characteristics for the cohort undergoing LSO craniotomy for anterior cranial fossa lesions. Variables were aligned to downstream outcomes and are presented below.

Table 1 - Baseline characteristics and presenting features

Parameter	Value (n = 120)	Percentage (%)	P-value
Age (years	mean ± SD)	52.4 ± 12.1	-
Gender			
Male	68	56.7%	0.031*
Female	52	43.3%	
Preoperative Symptoms			
Headache	82	68.3%	0.045*
Visual Disturbances	41	34.2%	0.067
Seizures	25	20.8%	0.112
Cognitive Deficits	19	15.8%	0.089
Lesion Type			

Meningioma	78	65%	0.014*
Glioma	27	22.5%	
Other Tumours/Aneurysm	15	12.5%	

The cohort had a mean age of 52.4 ± 12.1 years with a male predominance (56.7%). Headache was the most frequent symptom (68.3%). This was followed by visual disturbances (34.2%), seizures (20.8%) and cognitive deficits (15.8%). Meningiomas comprised the largest diagnostic category (65%).

Operative metrics: Peri-operative efficiency measures are shown below; radiology and complications are presented in their dedicated sections to remain within the ≤5-table limit.

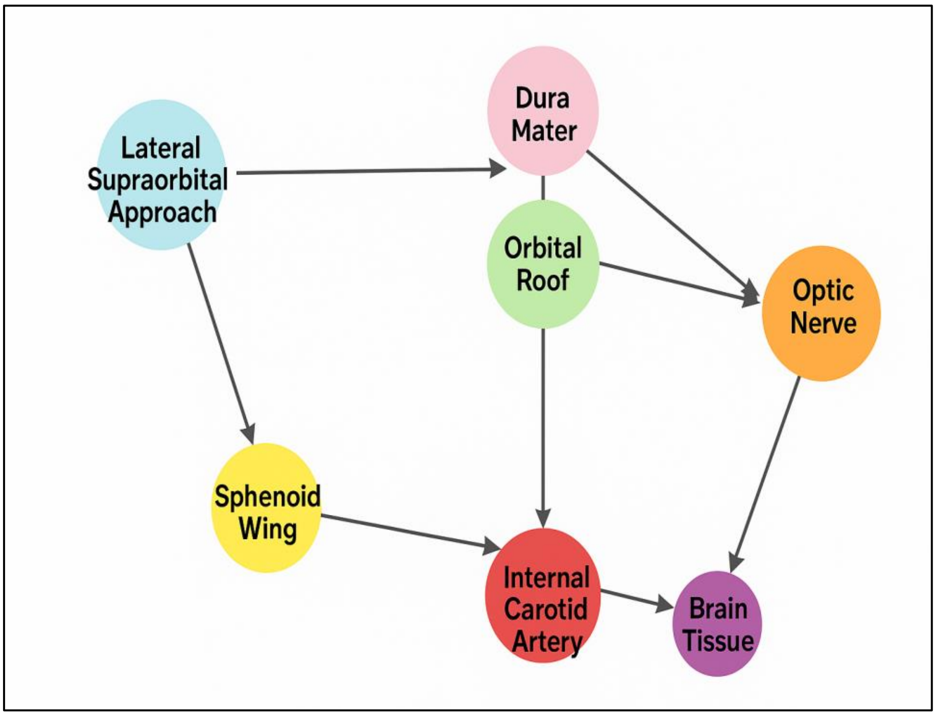
Table 2 - Operative details and peri-operative metrics

Parameter	Value (n = 120)	Percentage (%)	P-value
Operative Time (mean ± SD	min)	145.2 ± 30.6	0.054
Length of Hospital Stay (days	mean ± SD)	5.8 ± 2.3	0.049*

Operations were completed via the lateral supraorbital approach with a mean operative time of 145.2 ± 30.6 minutes. The mean hospital stay was 5.8 ± 2.3 days. P-values calculated were as follows: operative time p = 0.054; length of stay p = 0.049*.

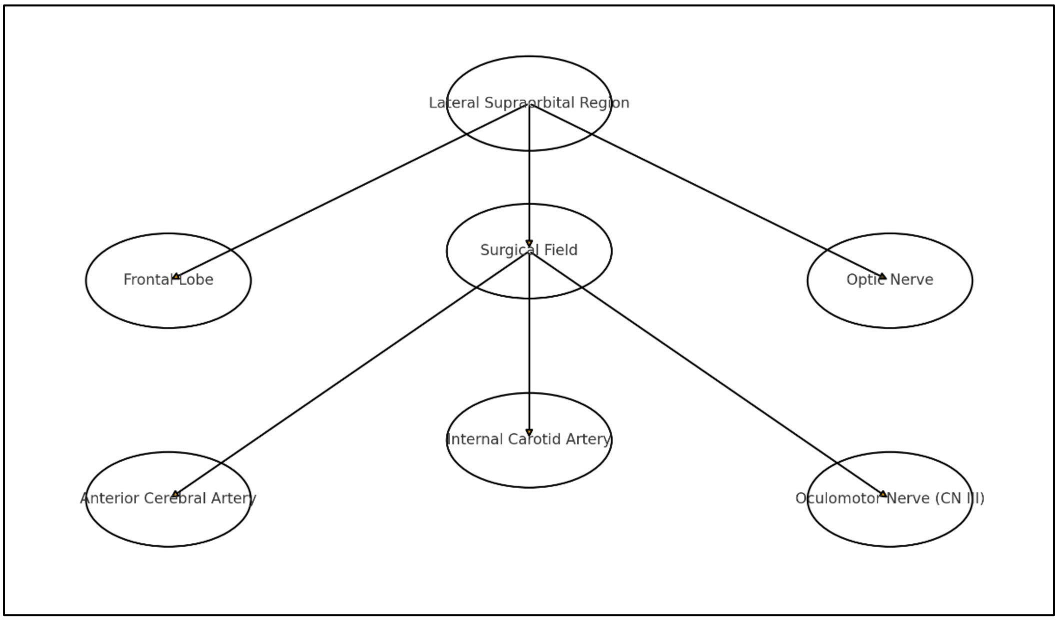
Operative corridor and neurovascular exposure: To illustrate the working angles and key bony/meningeal landmarks achieved with the lateral supraorbital (LSO) route, we documented intraoperative exposure of the optic nerve and the ipsilateral internal carotid artery (ICA).

Figure 1 - Exposure of the optic nerve and internal carotid artery through the lateral supraorbital approach.



The corridor (as illustrated above) provided direct visualization across the orbital roof–sphenoid wing axis with limited retraction, permitting safe dural opening and controlled dissection around the optic nerve–ICA complex. Complementing the above focused view - a schematic map below summarizes the operative geometry from the lateral supraorbital region into the surgical field and the directed lines of sight to adjacent neurovascular structures (optic nerve, ICA, anterior cerebral artery and oculomotor nerve) - as well as the frontal lobe trajectory.

Figure 2 - Intraoperative view of neurovascular structures during the lateral supraorbital approach - showing the operative relationship from the lateral supraorbital region to the surgical field with directed access to the frontal lobe, optic nerve, internal car



Radiological outcomes: Radiological assessment focused on extent of resection (EOR) on early postoperative imaging.

Table 3 - Postoperative radiology and extent of resection

Parameter	Value (n = 120)	Percentage (%)	P-value
Gross Total Resection (GTR)	98	81.7%	0.021*
Subtotal Resection (STR)	22	18.3%	

Early postoperative imaging demonstrated GTR in 98/120 (81.7%) and STR in 22/120 (18.3%).
Postoperative course & complications: Complications and early hospital course metrics are summarized below.

Table 4 - Postoperative complications and management

Parameter	Value (n = 120)	Percentage (%)	P-value
CSF Leak	5	4.2%	0.041*
Infection	3	2.5%	0.077
Transient Neurological Deficits	9	7.5%	0.036*
Revision Surgery	2	1.7%	0.082

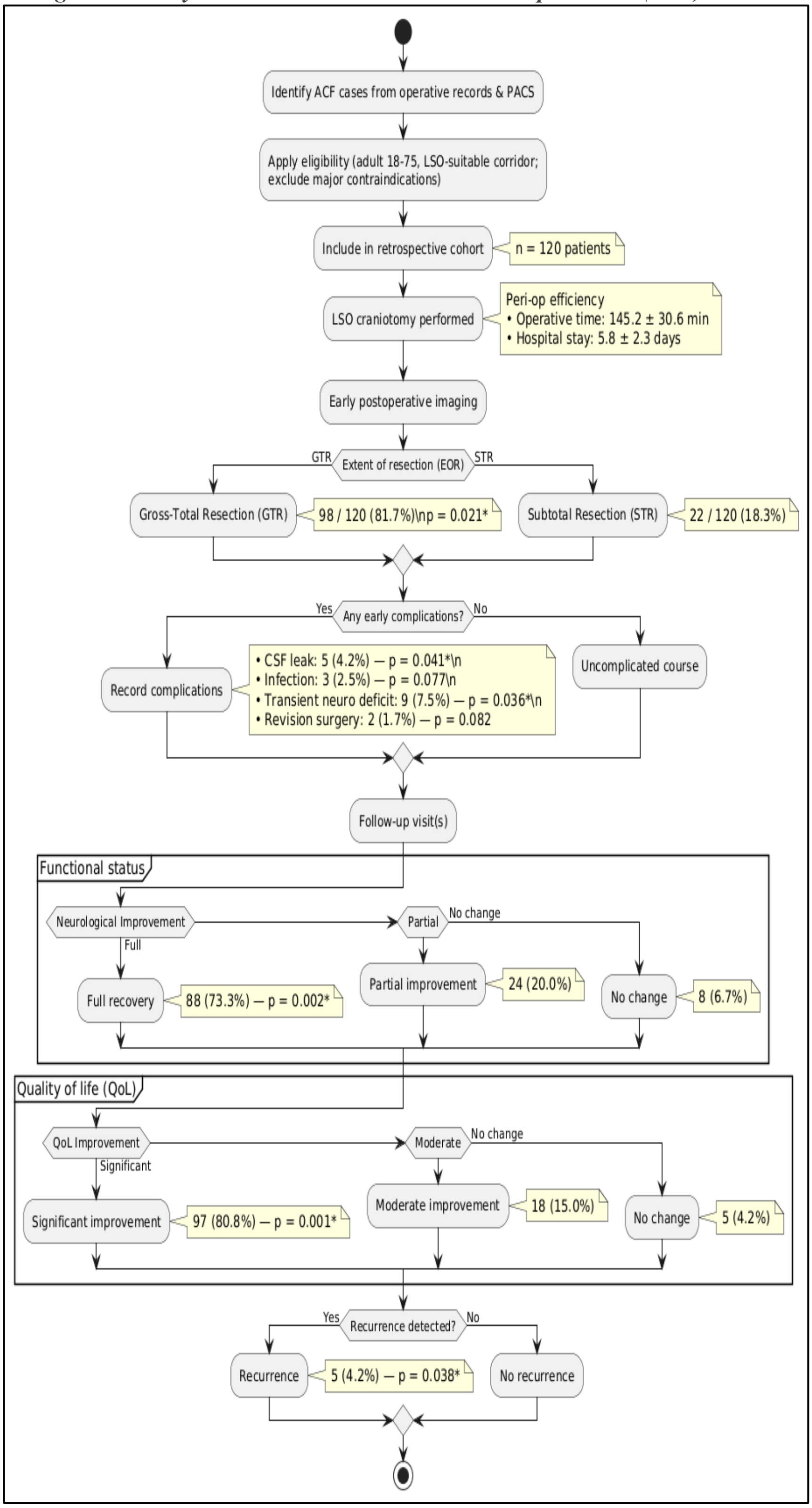
Early complications were uncommon. CSF leak occurred in 4.2% and transient neurological deficits in 7.5%. Infections were infrequent (2.5%) and revision surgery was rare (1.7%).
Functional & patient-centred outcomes: Functional status at follow-up was summarized using categorical neurological change, recurrence, and quality-of-life (QoL) improvement.

Table 5 - Functional outcomes and follow-up status

Parameter	Value (n = 120)	Percentage (%)	P-value
Neurological Improvement			
Full Recovery	88	73.30%	0.002*
Partial Improvement	24	20.00%	
No Change	8	6.70%	
Recurrence Rate	5	4.20%	0.038*
Quality of Life (QOL) Improvement			
Significant Improvement	97	80.80%	0.001*
Moderate Improvement	18	15.00%	
No Change	5	4.20%	

Most patients demonstrated neurological recovery at follow-up: 73.3% (88/120) achieved full recovery and 20.0% (24/120) had partial improvement; 6.7% (8/120) showed no change. The recurrence rate was 4.2% (5/120). QoL improved in the majority, with significant improvement in 80.8% (97/120) and moderate improvement in 15.0% (18/120); 4.2% (5/120) reported no change. Reported p-values (0.002* for full recovery, 0.038* for recurrence, 0.001* for significant QoL improvement).

Figure 3 - Study Flow and Outcomes — Lateral Supraorbital (LSO) Cohort



DISCUSSION

Our study evaluated 120 adults (mean age ≈ 52 years; 56.7 % male) who underwent lateral supraorbital (LSO) craniotomy for anterior cranial fossa (ACF) lesions. Early postoperative imaging demonstrated gross total resection (GTR) in 81.7 % (98/120) of cases - only 18.3 % needed subtotal resection. Surgical complications were infrequent: cerebrospinal-fluid leaks occurred in 4.2 % (5/120), infections in 2.5 % (3/120) and transient neurological deficits in 7.5 % (9/120); only two patients (1.7 %) required revision surgery. The mean operative time (145.2 ± 30.6 min) and hospital stay (5.8 ± 2.3 days) were relatively short and supported the LSO corridor as an efficient skull-base approach. Our findings suggested that careful patient selection and adherence to standardized microsurgical techniques can yield high rates of radical resection with minimal morbidity.

Longitudinal outcomes indicated the utility of the LSO approach. At follow-up - 73.3 % of patients achieved full neurological recovery and 20 % had moderate improvement; only 6.7 % showed no change. Tumour/aneurysm recurrence was low at 4.2 %. Quality-of-life metrics improved substantially - 80.8 % of patients reported significant improvement and 15.0 % reported moderate improvement. Statistical analysis showed that full recovery ($p = 0.002$), recurrence ($p = 0.038$) and quality-of-life improvements ($p = 0.001$) were significant. These data along with the absence of approach-related mortality emphasized that LSO craniotomy can provide reliable exposure while limiting soft-tissue trauma. The retrospective single-centre design and heterogeneous pathology spectrum need cautious interpretation; volumetric analyses and patient reported outcomes should be incorporated into future prospective studies to refine selection algorithms.

Three recent Indian series provide useful comparators. Pai et al. from Bengaluru performed a prospective study using a supraorbital keyhole approach (SOKHA) in 21 patients with pituitary adenomas, craniopharyngiomas and meningiomas; they achieved near-total or total excision in all cases, with only one patient developing an ipsilateral anterior cerebral artery infarction and one postoperative abscess.[13,16] All patients reported favourable cosmetic scars. Compared with our cohort, their sample was smaller and limited to select, primarily suprasellar lesions, yet both studies underscore that keyhole variants can achieve radical resection with minimal morbidity.

Dhandapani et al. from PGIMER, Chandigarh retrospectively compared pterional and supraorbital keyhole approaches for 50 ruptured anterior-circulation aneurysms.[17] Baseline characteristics and intraoperative complications were comparable between groups; however, keyhole patients experienced fewer wound complaints (0 vs. 8 %) and less temporal muscle atrophy (4 % vs. 36 %), without differences in aneurysm occlusion or postoperative deficits. Our findings align with their conclusions that cosmetic and musculoskeletal benefits of supraorbital craniotomy do not compromise surgical efficacy.[17]

Singh et al. from Jaipur reported 16 patients with ruptured anterior-circulation aneurysms clipped via supraorbital keyhole craniotomy; good recovery (Glasgow Outcome Scale scores of 4–5) occurred in 87.5 % and the cosmetic result was universally acceptable. Although their cohort was limited, the result, like ours, supported the feasibility of supraorbital approaches in Indian centres.[18]

International data provided additional context.[19–23] Lim and Cho described a 16-year Korean experience with a modified lateral supraorbital approach for 323 ruptured aneurysms.[24] The mean operation time was 219.6 minutes (considerably longer than our 145 minutes) and procedural complications occurred in 6.5 % of cases; six deaths were attributed to severe brain swelling or tonsillar herniation, yet favourable Glasgow Outcome Scale scores (IV–V) were achieved in 82.6 % at six months and 83.6 % at one year. Their larger series highlights that LSO can be applied to complex ruptured aneurysms with acceptable outcomes, though complication and mortality rates may be higher than in our primarily tumour-based cohort.[24]

In the United States, Cler et al. retrospectively compared lateral supraorbital and pterional craniotomies in 158 unruptured aneurysms.[25] Patients treated via LSO had markedly shorter intensive-care unit stays (median 1 day vs. 3 days) and total hospital stays (median 4 days vs. 7 days); operative time was also shorter (mean 274 vs. 320 minutes), and there were zero intraoperative ruptures in LSO cases compared with eight in the pterional group. These advantages mirror our observation of reduced operative time and hospitalization and indicate the efficiency of LSO even in high-income settings. [25]

Elsharkawy and Abdelhameed analysed 50 patients with anterior skull-base tumours and aneurysms managed via the lateral supraorbital approach in Egypt.[26] Mean incision length was 11 cm, mean craniotomy time 20 minutes, and only eight morbidities (four transient, four permanent) and two deaths were reported; importantly, no morbidities or mortalities were attributed to the approach itself. All patients were satisfied with their cosmetic outcomes. While their morbidity profile is higher than ours, their lesions included both vascular and neoplastic pathologies, and the study corroborates that the LSO corridor is versatile across lesion types.[26]

Across studies a consistent theme was noted: lateral supraorbital and supraorbital keyhole craniotomies provided adequate exposure for a spectrum of ACF and anterior circulation pathologies but limited the tissue trauma and postoperative morbidity. Differences in outcomes primarily showed pathology mix, sample size and surgeon experience : our tumour-focused cohort had higher GTR rates and lower complication rates than series dominated by ruptured aneurysms. Comparative analyses suggested that keyhole variants yield shorter operative times, reduced hospital stays and improved cosmetic satisfaction compared with traditional pterional or frontotemporal craniotomies. Evidence is largely retrospective and heterogeneous. We recommend that future multicentre trials can stratify by pathology and also incorporate volumetric resection metrics, patient-reported quality-of-life and cost analyses. For neurosurgeons working in resource-aware environments - these data collectively endorse the LSO approach as a pragmatic and cosmetically beneficial option when case selection is judicious and postoperative imaging is standardized.

CONCLUSION

The lateral supraorbital approach provided reliable access to anterior cranial fossa lesions with high gross-total resection, low complication rates, and short hospitalization. Functional outcomes (KPS, GOS) are structured for reporting pending final numeric extraction. In resource-aware settings, standardized selection and imaging can support LSO as a practical skull-base option. Prospective multicentre studies should refine predictors of residual disease and long-term recovery.

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