

Endoscopic Endonasal Transclival Approaches: Case Series and Outcomes for Different Clival Regions

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Abstract

Objective Transclival endoscopic endonasal approaches to the skull base are novel with few published cases. We report our institution's experience with this technique and discuss outcomes according to the clival region involved.

Design Retrospective case series.

Setting Tertiary care academic medical center

Participants All patients who underwent endoscopic endonasal transclival approaches for skull base lesions from 2008 to 2012.

Main Outcome Measures Pathologies encountered, mean intraoperative time, intraoperative complications, gross total resection, intraoperative cerebrospinal fluid (CSF) leak, postoperative CSF leak, postoperative complications, and postoperative clinical course.

Results A total of 49 patients underwent 55 endoscopic endonasal transclival approaches. Pathology included 43 benign and 12 malignant lesions. Mean follow-up was 15.4 months. Mean operative time was 167.9 minutes, with one patient experiencing an intraoperative internal carotid artery injury. Of the 15 cases with intraoperative cerebrospinal fluid (CSF) leaks, 1 developed postoperative CSF leak (6.7%). There were six other postoperative complications: four systemic complications, one case of meningitis, and one retropharyngeal abscess. Gross total resection was achieved for all malignancies approached with curative intent.

Conclusions This study provides evidence that endoscopic endonasal transclival approaches are a safe and effective strategy for the surgical management of a variety of benign and malignant lesions.

Level of Evidence 4.

Keywords

- ▶ clivus
- ▶ skull base surgery
- ▶ endoscopic endonasal approach
- ▶ CSF leak

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Introduction

The clivus is the unpaired basilar portion of the occipital bone extending obliquely from the anterior aspect of the foramen magnum to join the basisphenoid bone just inferior to the dorsum sellae. Traditionally, lesions of the clivus and surrounding structures have been approached via extended subfrontal transbasal, anterior transfacial, lateral transtemporal, far-lateral approaches, and staged approaches.^{1–7} These approaches are limited in that they often require extensive bone removal and brain retraction while placing critical neurovascular structures between the surgeon and the site of pathology. It has been proposed that these limitations are mitigated with the use of endoscopic endonasal transclival approaches to the skull base. This paradigm shift has been facilitated by advances in rigid endoscopic instrumentation, neuronavigation, and the development of a collaborative model for skull base surgery involving both otolaryngologists and neurosurgeons. Initial outcomes data from small case series for these approaches have been promising, particularly for the treatment of clival chordomas,^{6–12} with several reports describing the feasibility and limitations of the extended endoscopic endonasal transclival approach with respect to regional anatomy.^{4,9,11,13–15}

Because so few cases of endoscopic endonasal transclival approaches have been published, the goal of this study is to continue to investigate this surgical technique's safety and efficacy. Clinical outcomes for a diverse group of benign and malignant lesions are presented here based on the clival region involved, and salient cases are discussed to underscore critical regional anatomical considerations and lesion characteristics necessary for surgical planning.

Materials and Methods

Study Subjects

This retrospective chart review was approved by the institutional review board at the University of North Carolina at Chapel Hill. All patients undergoing endoscopic endonasal transclival approaches between 2008 and 2012 were identified consecutively from the clinical practice of the senior author. Patient data including demographics, clinical presentation, pathology, mean intraoperative time, intraoperative complications, gross total resection, intraoperative cerebrospinal fluid (CSF) leak, postoperative CSF leak, postoperative complications, and postoperative clinical course were recorded. The follow-up period was defined as the time between surgery to the latest clinical appointment or death.

Surgical Management

Preoperatively, either computerized tomography or magnetic resonance imaging (MRI) localized the clival lesion and defined the patient's anatomy for surgical planning. Intraoperatively, patient positioning and initial endoscopic endonasal approach to the clivus were performed as was previously described with image guidance utilized in all cases.^{5,6,13–15} Briefly, the neuro-navigation system was registered and precision confirmed in three planes. Image guidance was used for the duration of the

case. Oxymetazoline-soaked pledgets were placed in bilateral nasal cavities. The patient was prepped and draped in standard fashion. The abdomen was prepped and draped in sterile fashion for cases requiring harvest of a fat graft. Diagnostic bilateral nasal endoscopy was performed at the start of the case using the 0-degree endoscope. Turbinates were lateralized or harvested for free mucosal graft. A pedicled nasal septal flap was harvested in standard fashion and stored in the nasopharynx. A wide view of the sphenoid rostrum was attained by performing a posterior septectomy and bilateral sphenoidotomies using Kerrison rongeurs and Tru-Cutting instruments. A diamond burr was used to drill the sphenoid rostrum bilaterally and planum sphenoidale. The clivus was drilled as dictated by the lesion characteristics. All cases requiring intradural dissection involved collaboration with a neurosurgeon.

Outcome Assessment by Clival Segments Involved in Approach

An endoscopic endonasal transclival approach may only involve a segment of the clivus, as required by the location and extension of a particular skull base pathology. Depending on which segment of the clivus is involved in the approach, different neurovascular structures are placed at risk. Thus, to evaluate the outcomes of endoscopic endonasal transclival approaches more specifically, three regions of the clivus were defined. The upper third lies inferior to the dorsum sellae and posterior clinoid processes and superior to the petrous apex, the middle third lies at the level of the petrous segments of the internal carotid artery (ICA), and the inferior third extends from the jugular tubercle to the foramen magnum.^{16,17} Structures at risk for each involved clival segment are shown in ►Table 1. Outcomes were examined according to the involved clival segments.

Results

Forty-nine patients underwent 55 endoscopic endonasal transclival surgeries for 43 benign and 12 malignant lesions (►Table 2). Mean patient age was 49.5 years (standard deviation [SD]: 19.0). Twenty-nine patients were female and 20 were male. Mean operative time was 167.9 minutes with the creation of large skull base defects (>2 cm) necessary for 85.5% of procedures. CSF leaks were observed in 15

Table 1 Structures at risk for each involved clival region during expanded endoscopic endonasal transclival approaches

Clival region	Key anatomy	Potential sequelae
Superior	Cavernous sinus contents	CN III/IV/V1/V2/V6 palsies; intracavernous carotid artery hemorrhage
Middle	Petrous portion of the ICA	ICA hemorrhage
Inferior	Eustachian tube	Eustachian tube dysfunction

Abbreviations: CN, cranial nerve; ICA, internal carotid artery.

Table 2 Pathology presented in chart review of 49 patients undergoing 55 endoscopic endonasal transclival approaches: 43 benign and 12 malignant lesions

Pathology	Cases, <i>n</i>	Pathology	Cases, <i>n</i>
Invasive pituitary adenoma	13	Hemangiopericytoma	1
Meningioma	4	Lymphoma	1
Mucocele	4	Spindle cell cancer	1
Invasive fungal sinusitis	3	Squamous cell cancer	1
Chordoma	3	Basilar invagination	1
Metastatic disease	2	Encephalocele	1
Allergic fungal sinusitis	2	Clival abscess	1
Cyst	2	Follicular lymphoid hyperplasia	1
Fibrous dysplasia	2	Fungus ball	1
Foreign body	2	Granuloma	1
Inflammatory mass	2	Osteoma	1
Adenoid cystic carcinoma	2	Tornwaldt cyst	1
Malignant peripheral nerve sheath tumor	1	Teratoma	1

procedures with 10 noted to be high flow. One patient experienced an intraoperative ICA injury. The rate of postoperative to intraoperative CSF leaks was 1 of 15 (6.7%). Postoperatively, there were four systemic complications, one case of meningitis, and one retropharyngeal abscess. Mean follow-up was 15.4 months (SD: 13.2). Clinical characteristics and outcomes according to involved clival region are shown in ►Table 3.

Superior Clivus

Nine transclival approaches involved only the superior clivus. Pathology included five invasive pituitary adenomas, one meningioma, one metastatic adenocarcinoma, one inflammatory mass, and one Tornwaldt cyst with cervical spinal extension. Four procedures required intradural dissection.

Intraoperatively, mean surgical time was 146.3 minutes (SD: 34.8). Mean blood loss was 208.3 mL (SD: 131.1) with no significant neural or vascular intraoperative complications. Postoperatively, mean hospital stay was 2.9 days (SD: 1.5). There was one pulmonary embolism on postoperative day 10. No postoperative infections, CSF leaks, or other systemic complications occurred.

Superior-Middle Clivus

Eleven transclival approaches involved the superior-middle clivus. Pathology included six invasive pituitary adenomas, one chordoma with extension to sella and planum sphenoidale, one malignant peripheral nerve sheath tumor with extension to petrous apex and infratemporal fossa, one metastatic poorly differentiated squamous cell cancer, one spindle cell cancer, and one allergic fungal sinusitis. Seven procedures required intradural dissection.

Intraoperatively, mean surgical time was 264.9 minutes (SD: 223.2). Mean blood loss was 377.3 mL (SD: 334.2). Intraoperative injury to the petrous portion of the left ICA

occurred with resection of a malignant peripheral nerve sheath tumor. The ICA injury was treated with case cessation and embolization by interventional radiology. The patient experienced transient right gait disturbances that had improved significantly at 6 months. Postoperatively, mean hospital stay was 4.6 days (SD: 5.6). One postoperative low-flow CSF leak occurred on postoperative day 4 in the patient with ICA injury. A second patient underwent subsequent planned middle fossa craniotomy for staged resection of residual tumor lateral to the carotid artery. No other postoperative infections or systemic complications occurred.

Middle Clivus

Twenty-two transclival approaches involved the middle clivus. Pathology included three meningiomas, two invasive pituitary adenomas, two adenoid cystic carcinomas, two fibrous dysplasia with extension to orbit, two mucoceles, two foreign bodies, one hemangiopericytoma, one granuloma, one osteoma with extension to bilateral ICA, one teratoma, one encephalocele, one invasive fungal sinusitis, one fungus ball with extension to the petrous apex, orbit, and cavernous sinus, one allergic fungal sinusitis, and one inflammatory mass. Three procedures required intradural dissection.

Intraoperatively, mean surgical time was 125.3 minutes (SD: 65.5). Mean blood loss was 125.2 mL (SD: 103.0) with no significant neural or vascular intraoperative complications. Postoperatively, mean hospital stay was 7.5 days (SD: 20.5). One patient remained intubated following resection of invasive fungal sinusitis, developed recurrent aspiration pneumonias requiring tracheostomy and gastrostomy tube placement, and was later noted to have a subacute infarct during a subsequent hospital admission. Another patient was readmitted within 30 days for acute renal failure due to dehydration and amphotericin renal toxicity. No other postoperative infections, systemic complications, or CSF leaks occurred.

Table 3 Clinical characteristics of 49 patients undergoing 55 procedures via an endoscopic endonasal transclival approach for lesions of various permutations of clival regions^a

Clival region	No. of procedures (n = 55)	Intradural procedures	Malignant pathology (n = 12)	Extension beyond clivus, n (%)	Intraoperative high-flow CSF leak	Intraoperative low-flow CSF leak	Skull base defect ≥2 cm	Postoperative CSF leak	Intraoperative lumbar drain	Postoperative complication	Postoperative hospital days	Complication comments
Superior	9	4	1	7 (78)	1	2	8	0	0	1	2.8	PE on POD 10
Superior-middle	11	7	4	7 (64)	5	1	10	1	1	1	4.6	Intraoperative ICA injury and postoperative CSF leak
Middle	22	3	3	3 (14)	2	2	18	0	0	2	7.5	Pt 1: Postoperative aspiration PNA, tracheostomy placement, subacute infarct; pt 2: Readmitted for ARF
Middle-inferior	4	1	2	2 (50)	1	0	4	0	0	2	12	Pt 1: PE on POD 5; pt 2: Clival osteoradionecrosis and retropharyngeal abscess
Inferior	6	1	2	3 (50)	1	0	4	0	0	0	2.6	-
Entire clivus	3	0	0	1 (33)	0	0	3	0	0	0	5	-

Abbreviations: ARF, acute renal failure; CSF, cerebrospinal fluid; ICA, internal carotid artery; PE, pulmonary embolism; POD, postoperative day; PNA, pneumonia; pt, patient.
^aSuperior third, middle third, and inferior third.

Middle-Inferior Clivus

Four transclival approaches involved the middle-inferior clivus. Pathology included a two-stage chordoma operation notable for extension to the spine and two mucoceles. One procedure required intradural dissection. One patient with a remote history of clival chordoma resection via transpalatal approach with adjuvant radiation therapy underwent a transclival approach for a mucocele. One year later the patient developed a retropharyngeal abscess and was noted to have clival osteoradionecrosis requiring complete resection of the clivus with an adipofascial radial forearm flap.

Intraoperatively, mean surgical time was 256 minutes (SD: 227.8). Mean blood loss was 325 mL (SD 206.2) with no significant neural or vascular intraoperative complications. Postoperatively, mean hospital stay was 12 days (SD: 7.8). There was one pulmonary embolism on postoperative day 5. No other postoperative infections, CSF leaks, or systemic complications occurred.

Inferior Clivus

Six transclival approaches involved the inferior clivus. Pathology included one squamous cell cancer, one lymphoma with extension to nasopharynx, one basilar invagination with extension to spine, two cysts, and one follicular lymphoid hyperplasia. One cyst required combined endoscopic endonasal transclival and transoropharyngeal approaches for extension to the cervical spine. One procedure required intradural dissection.

Intraoperatively, mean surgical time was 91.8 minutes (SD: 65.9). Mean blood loss was 266.7 mL (SD: 230.7) with no significant neural or vascular intraoperative complications. Postoperatively, mean hospital stay was 2.3 days (SD: 3.3). No postoperative infections, systemic complications, or CSF leaks occurred.

Entire Clivus

Three transclival approaches involved the entire clivus. Pathology included two invasive fungal sinusitis resections and one clival abscess. No procedures required intradural dissection.

Intraoperatively, mean surgical time was 223.3 minutes (SD: 94.1). Mean blood loss was 128.3 mL (SD: 202.4) with no significant neural or vascular intraoperative complications. Postoperatively, mean hospital stay was 5 days (SD: 3). No postoperative infections, systemic complications, or CSF leaks occurred.

Malignant Conditions

Eleven patients underwent endoscopic endonasal transclival approaches for skull base malignancies. Clinical characteristics and outcomes for these patients are shown in **Table 4**. Mean preoperative MRI size was 3.8 cm (SD: 1.3). Gross total resection (GTR) was achieved in all cases where curative intent was the goal. Mean follow-up for patients undergoing surgical resection for curative intent was 19.7 months (SD: 12.3). Four of these patients had no evidence of disease recurrence at the time of this study. One patient developed local recurrence of adenoid cystic carcinoma at 18 months.

Table 4 Clinical characteristics of 11 patients undergoing 12 endoscopic endonasal transclival approaches for malignant lesions of various etiologies^a

Age, y	Sex	Pathology	Clival region	Preoperative MRI size, cm	Intent	Intraoperative CSF leak	Extent of resection	Extension	Closure	Operative time, min	Postoperative hospital days	Complications	Follow-up, mo	Follow-up status (clinical/radiographic)
68	M	Metastatic poorly differentiated SCC	Superior-middle	4.2	Biopsy	-	-	-	-	82	2	-	5.8	Deceased, disease progression
56	F	Malignant nasopharyngeal SCC, local recurrence	Inferior	4.4	Biopsy	-	-	-	-	16	0	-	0.3	Received palliative care at another institution
48	M	Metastatic colon adenocarcinoma, distant recurrence	Superior	2.5	Biopsy	-	-	-	-	160	4	-	1.5	Deceased, disease progression
47	F	Diffuse large B cell lymphoma	Inferior	3.7	Debulking	-	GTR	Nasopharynx	-	107	1	-	12.8	Referred for CRT
43	M	Malignant peripheral nerve sheath tumor	Superior-middle	6.2	Debulking	Low flow	80%	ITF, Petrous apex	NS flap; mucosal and fat grafts	796	20	Intraoperative ICA injury; POD 4 low-flow CSF leak, 13 d in ICU	6.6	Residual disease stable radiographically, adjuvant stereotactic RT
38	F	Malignant nasopharyngeal adenoid cystic carcinoma, distant recurrence	Middle	2.5	Debulking	-	GTR	-	-	111	1	-	23.6	GTR achieved; pt was on CRT for lung metastases; no local recurrence
84	F	Malignant nasopharyngeal hemangiopericytoma	Middle	5.4	Curative	-	GTR	-	-	66	2	-	1.4	No evidence of complications at 6-wk postoperative visit. Did not return for follow-up visits
50	M	Chordoma	Middle-inferior	3.5	Curative staged resection	High flow	GTR	Spine	NS flap, middle turbinate-free graft	304	6	-	32.3	Adjuvant proton beam RT; no evidence of recurrence
58	F	Spindle cell cancer, local recurrence	Superior-middle	3.1	Curative	High flow	GTR	-	Fat graft, NS flap, middle turbinate-free graft	506	4	-	27.2	Adjuvant radiation therapy; no evidence of recurrence
75	F	Malignant nasopharyngeal adenoid cystic carcinoma	Middle	2	Curative	-	GTR	-	-	203	1	-	24.2	Recurrence 18 mo (local), 24 mo (metastatic); referred for CRT
23	M	Chordoma	Superior-middle	4.6	Curative	High flow	GTR	Sella, planum	NS flap, middle turbinate-free graft	432	5	-	13.5	Adjuvant proton beam RT; no evidence of recurrence

Abbreviations: CRT, chemoradiotherapy; CSF, cerebrospinal fluid; DI, diabetes insipidus; GTR, gross tumor resection; ICA, internal carotid artery; ICU, intensive care unit; ITF, infratemporal fossa; MRI, magnetic resonance imaging; NS, nasal septal; POD, postoperative day; RT, radiation therapy; SCC, squamous cell carcinoma.

^aThe procedures were categorized as curative intent, debulking, or biopsy. One patient had an intraoperative carotid injury and postoperative CSF leak. Gross total resection was achieved in all cases where curative intent was the goal.

Adjuvant proton radiation therapy was utilized for both clival chordomas, and there was no evidence of disease at 13.5 and 32.3 months.

Discussion

This retrospective chart review of 49 patients who underwent endoscopic endonasal transclival approaches for a variety of skull base lesions is one of only a few studies demonstrating outcomes by clival region involved. Additionally, there are limited data regarding the use of this approach for benign and malignant intradural lesions. This study provides much needed clinical data for this increasingly utilized approach. The long-term clinical outcomes presented in this case series provide further support for the safety and efficacy of expanded endoscopic endonasal transclival approaches.

Extended endoscopic endonasal approaches to the clivus have been increasingly described by several groups, particularly as an option for the surgical management of

malignancies.^{4–10,13–15} Our postoperative to intraoperative CSF leak rate was 6.7% for all cases and 25% among malignancies. This rate is similar to previously reported rates of up to 33% for clival chordomas.^{6–8,10,19,20} GTR was achieved in 100% of malignant cases approached with curative intent. This included two clival chordomas. Prior case series of the endoscopic endonasal transclival approach to clival chordomas report a GTR rate of 55 to 83%.^{6–8} Additionally, the high rates of disease-free survival demonstrated in this study provide further support for the use of these approaches for the surgical management of malignant lesions.

Important anatomical considerations for the expanded endoscopic endonasal approach to various clival regions has been previously described.^{14,15,18} There was 1 intraoperative ICA injury out of 55 procedures, which was consistent with previously reported rates of up to 2%.¹⁰ This 43-year-old woman with a history of neurofibromatosis type 1 reported a remote history of craniotomy with radiation therapy for a right-sided brain tumor. Medical records were

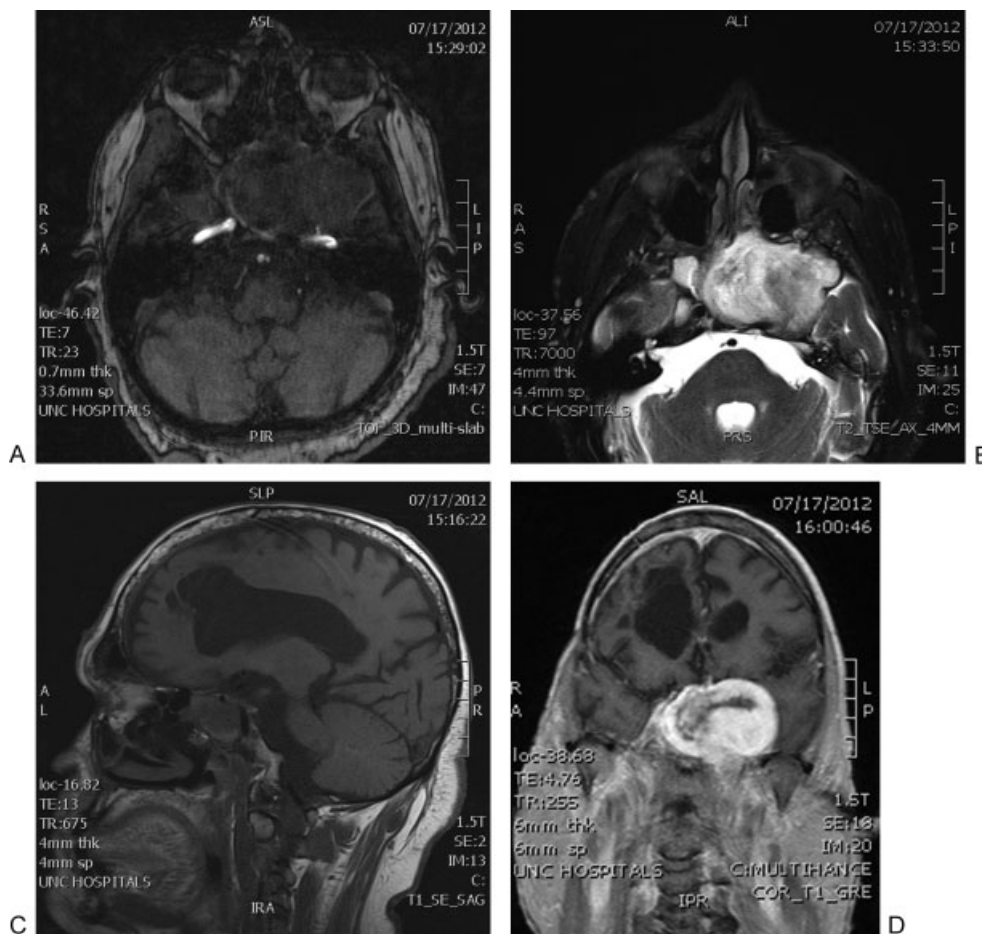


Fig. 1 A 43-year-old woman underwent an endoscopic endonasal transclival approach to a 6.2 cm × 4.0 cm left malignant peripheral nerve sheath tumor. The patient presented with a 2-year history of headaches and progressive left-sided vision loss. Preoperative magnetic resonance imaging (MRI) and angiogram revealed tumor extension to the petrous apex and infratemporal fossa with posterosuperior displacement of the petrous and proximal cavernous portions of the left internal carotid artery (ICA) with 45% narrowing at these segments. Magnetic resonance angiography (MRA) also revealed tumor blush arising directly from the ICA. Intraoperative injury to the petrous portion of the left ICA was treated with case cessation and embolization by interventional radiology. During subsequent attempted clip ligation, tumor invasion into the ICA was noted. MRI demonstrated extension of lesion and relationship to left ICA. (A) Axial three-dimensional time-of-flight MRA. (B) Axial T2. (C) Sagittal T1. (D) Coronal T1 sections.

no longer available. The patient presented to our institution with a 2-year history of headaches and progressive left-sided vision loss. Outside imaging demonstrated a large heterogeneously enhancing mass in the region of the left cavernous sinus. Endoscopic endonasal biopsy showed a grade 2 malignant peripheral nerve sheath tumor. Preoperative MRI and angiogram demonstrated a 6.2-cm lesion extending to the petrous apex and infratemporal fossa with posterior and superior displacement of the petrous and proximal cavernous portions of the left ICA (►Fig. 1). Tumor blush was identified from small arteries arising from the petrous segment of the ICA. Intraoperatively, Doppler probe was used to identify the left parapharyngeal carotid artery as well as the artery posterior to the tumor in the left clival area. Arterial injury at the level of the left carotid second genu occurred during mobilization of the tumor from the artery. Invasion of the carotid artery by the tumor and retrograde blood flow was noted with attempted clip ligation of the proximal cavernous portion of the ICA. In this case, expanded endoscopic endonasal tumor resection was complicated by vascular invasion. A CSF leak was observed on postoperative day 4. This low-flow leak, which was separate from the intact nasal septal flap, was managed with mucosal and fat grafts. Although uncommon, intraoperative ICA injury during endoscopic endonasal transclival approaches has been previously reported as a major limitation to using this approach. Important considerations for the safe and effective use of this approach include size and lateral extension of the lesion relative to the ICA, preoperative surgical intent, and an experienced surgical and interventional radiology team.⁶

This study further supports the safety and efficacy of the endoscopic endonasal transclival approach for a large cohort of patients and stratifies clinical data according to clival region involved. There are limited data regarding the use of this approach for intradural and extradural lesions, and this study provides much needed clinical data for this increasingly utilized approach. In this study, the overall risk of complications was low and comparable with other reports.^{5–8,10} Additionally, the high rates of GTR and the long-term outcomes of this approach, when combined with appropriate adjuvant therapies, demonstrated encouraging rates of progression free-survival and local tumor control.

Study Limitations

Given the retrospective nature of these data, there are several limitations to our study. The small number of malignant conditions limits the statistical power of any conclusions that one may draw from this report. Additionally, the conditions treated by this approach represent a diverse group of pathologies referred to a tertiary care academic medical center with variable degrees of complexity and patient comorbidities. Finally, this review of a single surgeon's operative experience may limit the reproducibility and generalizability of these outcomes.

Conclusion

This study provides evidence that endoscopic endonasal transclival approaches to the clivus are a safe and effective

strategy for the surgical management of benign and malignant lesions with a low risk of complications for carefully selected patients.

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Conflict of Interest

The authors have nothing to disclose.

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