The extradural temporopolar approach: a review of indications and operative technique

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Object. The extradural temporopolar approach is used for enhanced exposure of the cavernous sinus and petroclival regions in the treatment of complex lesions not amenable to sole treatment via radiosurgical or endovascular methods. The authors' objective was to review the indications, surgical experience, and operative technique in a series of patients who underwent surgery with this approach.

Methods. The authors conducted a retrospective review to identify patients who underwent a temporopolar approach from 1992 to 2008. An orbitozygomatic craniotomy was frequently used, followed by extradural retraction of the temporal lobe. A sequential progression of bone removal at the anterior and middle skull base, followed by opening the layers of the lateral wall of the cavernous sinus was next performed to safely retract the brain and widen the exposure to the cavernous sinus, interpeduncular fossa, and upper petroclival regions.

Results. Sixty-six patients were identified and included in the study. The mean patient age was 49 years. The main indications for surgery were as follows: meningioma (25 patients, 38%), basilar artery aneurysm (11 patients, 17%), trigeminal schwannoma (7 patients, 11%), chordoma (5 patients, 7%), hemangioma (3 patients, 5%), pituitary adenoma (3 patients, 5%), superior cerebellar artery aneurysm (3 patients, 5%), and other lesions (9 patients, 14%). Complications included hemiparesis in 4 patients (6%), infarcts in 4 patients (6%), transient aphasia in 1 patient (1.5%), and cranial nerve paresis in 20 patients (30%).

Conclusions. The extradural temporopolar approach offers a relatively safe and wide exposure of the sphenocavernous and petroclival regions. Mobilization of the cranial nerves and internal carotid artery allow gentle brain retraction and maximal preservation of venous outflow. This is an advantageous approach to large tumors in these regions and for complex upper basilar artery or superior cerebellar artery aneurysms. *(DOI: 10.3171/FOC.2008.25.12.E3)*

Key Words • **cavernous sinus** • **cerebral aneurysm** • **meningioma** • **skull base**

Hakuba and Dolenc recognized early the benefits of extradural brain retraction in the management of complex vascular lesions residing near the central cranial base.[10,16] Subsequently, extradural approaches have been described for a wide variety of surgical lesions of the sphenocavernous and petroclival regions.[4,6,7,9–12,14] Although initial management with radiosurgery is rapidly becoming a first-line treatment for many smaller cavernous sinus and petroclival lesions, patients harboring complex skull base tumors continue to present with advanced-stage disease not currently amenable to radiosurgical intervention. Such patients often require primary surgical debulking prior to radiosurgical management of residual disease. In selected cases, the extradural temporopolar approach provides a safe and optimal exposure of the parasellar and retrosellar compartments, making it our preferred approach to selected skull base tumors with cavernous sinus or petroclival involvement.

Similarly, endovascular strategies are not always effective or preferable for aneurysms of the basilar bifurcation or upper basilar trunk.[24] The extradural temporopolar approach virtually eliminates obstruction by the temporal lobe and retraction-related complications in the surgical management of these pathological entities. The major benefit afforded by extradural retraction of the temporal and frontal lobes is preservation of the temporal tip bridging veins and thus an improved margin of brain protection compared with intradural techniques.[5,10] Furthermore, this approach improves visualization of the BA complex above the origin of the SCA compared with a standard pterional exposure, by providing a wider aperture and working angle. For this reason, the temporopolar exposure is frequently used to gain access to the basilar apex or upper basilar trunk to sufficiently control and ligate aneurysms of the upper BA or SCA that cannot be treated by endovascular means.[6–8,17]

Abbreviations used in this paper: BA = basilar artery; CN = cranial nerve; ICA = internal carotid artery; SCA = superior cerebellar artery; SOF = superior orbital fissure.

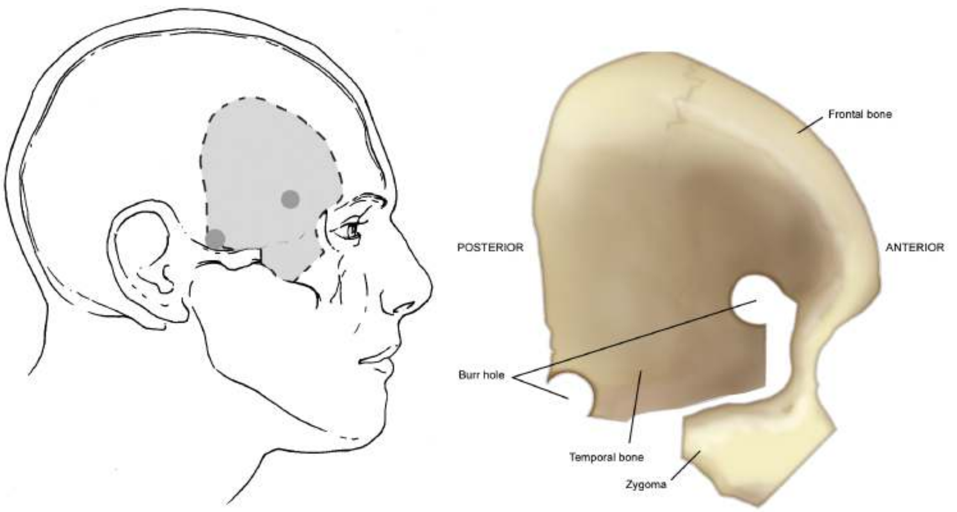

Fig. 1. Depictions of the extent of bone removal in the standard orbitozygomatic frontotemporal craniotomy used in the majority of temporopolar approaches *(left)* and the bone flap with the attached orbital rim and zygoma in the 1-piece orbitozygomatic construct *(right)*.

To adequately and safely retract the frontal and temporal lobes in an extradural fashion and maximize the exposure offered by this approach, an extensive unroofing and untethering of neurovascular structures traversing the skull base is required. Depending on the region of interest, several CNs and the ICA may require untethering from their dural sleeves for better mobilization, so that sufficient retraction and exposure of structures such as the cavernous sinus and interpeduncular fossa is achieved.

We retrospectively reviewed our combined experience in the surgical treatment of 66 patients who underwent a temporopolar approach to tumors of the central skull base and aneurysms of the upper basilar region. In this report, we review this series of patients and describe the operative technique used in these cases.

Methods

The medical records of 66 patients who underwent surgery via the temporopolar approach performed by the senior authors (JDD and SLG) between 1992 and 2008 were retrospectively reviewed. Pertinent information from clinic notes, operative reports, and radiographic studies was reviewed and entered into a patient database for subsequent analysis. The present study was preapproved by the institutional review board at each author's institution.

Operative Technique

The patient is positioned in the supine position with the head fixed at an angle of ~ 45° away from the operative side. The malar eminence is positioned at the highest point in the operative field. In selected cases, a method for drainage of cerebrospinal fluid, either via a lumbar drain or ventriculostomy catheter, is placed prior to positioning. A standard frontotemporal curvilinear incision is made starting 5-mm anterior to the tragus and extending to the midline, curving behind the hairline. The scalp is opened in 2 layers to preserve the frontalis branch of the facial nerve. A standard subperiosteal exposure is performed with anterior retraction of the scalp flap and exposure of the supraorbital rim, frontozygomatic suture, and zygomatic process. In some cases, a vascularized frontal pericranial flap can be preserved for closure. The scalp is retracted using fishhooks and a Leyla bar. The temporalis fascia is then divided superiorly, ~ 5 mm below the superior temporal line, and anteriorly, behind the supraorbital rim and frontozygomatic suture, to allow inferior and posterior retraction of the muscle.

A standard frontotemporal (pterional-based) craniotomy is performed, with bur holes placed in the frontal and temporal regions. A temporal craniectomy is frequently done to facilitate maximal exposure across the floor of the middle fossa. The temporopolar approach is often performed in conjunction with either removal of the zygoma (transzygomatic approach) or after an orbitozygomatic craniotomy, to enhance the inferior-to-superior viewing trajectory.[16,17,27] The orbitozygomatic construct can be removed in a 1- or 2-piece fashion. Osteotomies are required in 3 locations: 1) at the lateral orbital rim extending to the frontozygomatic suture; 2) at the root of the zygoma parallel to the temporal squama; and 3) at the malar eminence (Fig. 1). To optimize the cosmetic outcome, titanium microplates are often fitted and placed prior to the removal of the orbitozygomatic construct.

Following initial exposure, several structures of the middle skull base are sequentially unroofed to untether and retract the temporal and frontal lobes extradurally to expose the middle fossa and posterior petroclival region. A progression of extradural drilling, untethering, and retraction is carried out, including: 1) flattening of the sphenoid wing and unroofing the lateral aspect of the SOF; 2) removal of the anterior clinoid process; 3) unroofing of the optic canal; 4) mobilization of the carotid by freeing it at the Perneczky ring; 5) unroofing of the foramina rotundum and ovale; 6) mobilization and retraction of the temporal tip extradurally by detaching the temporal dura propria from the lateral wall of the cavernous sinus;

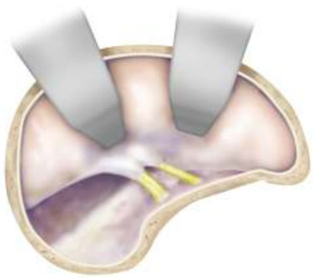

Fig. 2. Illustration demonstrating the lateral exposure offered with extradural elevation of the temporal pole, prior to dural opening. The second and third divisions of the trigeminal nerve are seen entering their respective foramina.

and 7) reduction of the posterior clinoid process. Each individual case must be tailored to the underlying pathological entity and approach required, as not all structures require untethering and mobilization in each case.

The temporal dura is retracted to expose the SOF and foramen rotundum. The middle meningeal artery is identified in the foramen spinosum and can be ligated there. The foramina ovale and rotundum are carefully unroofed using a high-speed drill, exposing approximately 5 mm of CNs V2 and V3 (Fig. 2). The sphenoid wing is drilled down, followed by unroofing of the lateral wall of the SOF, which is skeletonized to gain access to the junction of the dural sleeve and the dura propria covering the tip and undersurface of the temporal lobe. The meningoorbital vessels are coagulated and divided. The optic canal is unroofed and the anterior clinoid process is removed extradurally. The temporal tip is retracted to expose the junction of the dura propria over the temporal lobe and the true inner cavernous membrane as they form the lateral wall of the cavernous sinus. This dural plane is then carefully developed sharply and with special attention paid to preserving the sheaths over CNs III, IV, and V. This dissection is continued posterior to the foramen ovale and medial to the tentorium. As the outer layer of the cavernous sinus is dissected, hemostasis is maintained with gentle packing of Surgicel.

The dura is opened over the Sylvian fissure and continued to the optic sheath, incising the falciform ligament and releasing the optic nerve from the confines of its dural covering. The dural incision is extended in an L-shaped fashion over the inferior frontal lobe. The Perneczky fibrous dural ring is opened laterally to allow mobilization of the ICA. Following transsylvian dissection, the temporal and frontal lobes are gradually retracted in posterolateral and posteromedial directions, respectively, to facilitate exposure of the petroclival region.

Following exposure of the ICA, oculomotor and trochlear nerves, the opticocarotid and Liliequist membranes are opened. The oculomotor nerve is sharply unroofed at the oculomotor trigone by incising the edge of the tentorium over the porus oculomotorius. Opening the sheath over the oculomotor nerve in the lateral wall of the cavernous sinus allows lateral mobilization of the nerve to widen the aperture to the upper basilar trunk. The posterior clinoid process is drilled down if necessary to facilitate exposure of the interpeduncular region and

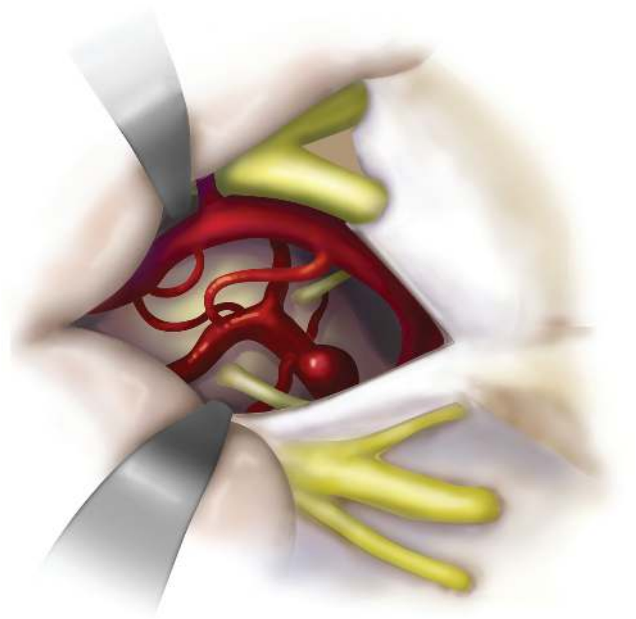

Fig. 3.. Illustration showing final exposure of the upper BA and interpeduncular region after dural opening, drilling of the posterior clinoid process, and mobilization of the oculomotor nerve. A BA trunk aneurysm at the level of the SCA is depicted.

upper BA (Fig. 3). In the case of tumor resection in the cavernous sinus, the various entry corridors between the CN structures are available with the dura propria elevated from the lateral wall.

A meticulous dural closure is performed at the end of the case, using the prepared pericranial flap, fascial graft, and tissue glue or sealant if necessary. Titanium microplates are used to replace the bone flap and orbitozygomatic construct. The temporalis fascia is sutured to its origin on the temporal line. The scalp is closed in the standard fashion.

Results

The mean patient age was 49 years (range 18–84 years). The indications for surgery are shown in Table 1. Of the 51 patients who underwent tumor resection, the majority demonstrated tumor involvement of the cavernous sinus (35 patients, 69%). Tumor involvement of the petroclival region was noted in 27 patients (53%), the sphenoid wing in 16 (31%), and the middle fossa in 11 (22%). Of the 51 cases of tumor resection, 42 had long-term postoperative follow-up. Gross-total resection was achieved in 24 cases (57%,), and subtotal resection in 18 (43%; Fig. 4). Biopsy sampling and partial resection for decompression was the only goal intended in 2 patients with cavernous sinus lymphomas. All 14 aneurysms were obliterated, with complete sacrifice of the SCA required in 1 case.

No patient died after surgery. Four patients (6%) were hemiparetic postoperatively. All 4 had harbored complex petroclival lesions (3 meningiomas, 1 chordoma) with involvement of the brainstem. Four additional patients (6%) had symptomatic infarcts seen on postoperative imaging.

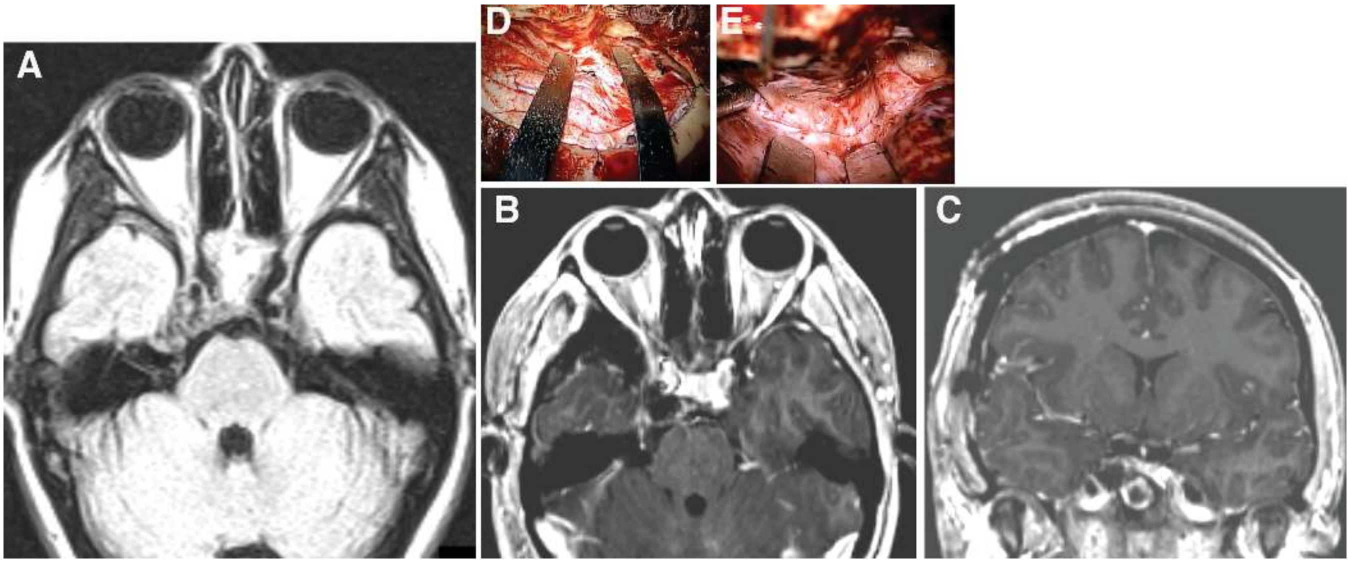

Fig. 4.. A: Preoperative axial (A) MR image demonstrating a recurrent right petroclival chordoma in a 23-year-old woman. Postoperative axial (B) and coronal (C) MR images obtained after resection via the right frontotemporal craniotomy with temporopolar approach. Gross-total resection of the tumor was achieved. D: Intraoperative photo of the initial exposure following right craniotomy and elevation of the temporal lobe. Frontal and temporal extradural retractors are in place. E: The tumor is exposed in the superior petroclival region after unroofing the CNs of the middle skull base.

One patient developed a temporal infarct and transient aphasia following resection of a large sphenoid wing and cavernous sinus meningioma. A hypothalamic infarction developed in another patient after resection of a petroclival chordoma, and a cerebellar infarct arose in another patient after complete occlusion of the SCA in treating a ruptured SCA aneurysm. Finally, a PCA infarction occurred in 1 patient following repeated resection of a petroclival meningioma that enveloped the vessel. Hydrocephalus developed in 5 patients after resection of cavernous sinus and petroclival tumors; delayed shunt insertion was required in all cases. A CSF leak and wound infection occurred in 1 patient each.

Twenty-six new cranial neuropathies developed in 20 patients (30%), of which 11 were transient (Table 2). Four patients had transient oculomotor paresis, 3 of which were following surgery for clip ligation of a BA aneurysm with retraction on the oculomotor nerve. Of the 8 patients with CN V hypesthesia following surgery, 5 had trigeminal schwannomas and the other 3 had cavernous sinus meningiomas. Patients with new abducent nerve paresis included 2 with meningiomas, 1 with a clival chordoma, and 1 with a cavernous sinus hemangioma.

Discussion

Traditional approaches to the cavernous sinus, petroclival region, and interpeduncular cistern were based initially on pterional and subtemporal craniotomies.[13,23] One such modification was the intradural temporopolar approach to the upper BA region, initially described by Sano and colleagues,[25–27] and which also included the transzygomatic modification. Sufficient exposure of these regions was afforded by these intradural approaches, but frequently at the expense of significant and often morbid cerebral retraction. In 1989, Hakuba et al.[16] described an extradural/subdural infratemporal approach to the cavernous sinus based on an orbitozygomatic craniotomy. Similarly, an extradural frontotemporal approach to the cavernous sinus was promulgated by Dolenc in 1994,[10] and has since been described and modified as the preferred surgical approach to such lesions.[5,7,12,14,15,19,20,22,28] The value of extradural approaches in the treatment of aneurysms of the basilar apex and upper basilar trunk has been demonstrated as well.[6,7,17,21]

In the present study, we reviewed the indications for

TABLE 1: Indications of surgery in 66 patients undergoing a temporopolar approach

Lesion Type	No. of Patients (%)
aneurysm	
BA	11 (17)
SCA	3 (5)
meningioma	25 (38)
schwannoma	
trigeminal	7 (11)
oculomotor	2 (3)
chordoma	5 (7)
hemangioma	3 (5)
pituitary adenoma	3 (5)
sarcoma	2 (3)
lymphoma	2 (3)
carcinoma	1 (1)
carotid cavernous fistula	1 (1)
hemangiopericytoma	1 (1)

TABLE 2: Summary of the incidence of transient and persistent cranial nerve paresis after surgery via the temporopolar approach

CN	Transient	Persistent	Total
III	4	6	10
IV	1	3	4
V	2	6	8
VI	3	1	4
total	10	16	26

surgery and our operative experience in a series of 66 patients who underwent surgery for various lesions via an extradural temporopolar approach. This approach allows for a more extensive degree of retraction of the temporal lobe, thus improving the exposure of the posterior cavernous sinus and petroclival region.[5–7] Sufficient exposure was achieved to obliterate all vascular lesions. In tumors in which subtotal resection was achieved, the lesion frequently invaded the cavernous sinus or engulfed the carotid, posterior cerebral, or superior cerebellar arteries. Early in our experience, our goal with this approach was maximal resection of the tumor with an attempt at total resection if at all possible. For multicompartmental tumors, staged approaches including the use of adjuvant radiosurgery have replaced this more aggressive strategy.[3,18]

Only a modest degree of extradural bone removal is required to untether and mobilize the 3 branches of the trigeminal nerve and the carotid artery. The key maneuver is the development of the plane between the dura propria over the temporal lobe and the true cavernous membrane at the lateral wall of the cavernous sinus. This greatly enhances the ability to retract the temporal lobe in an extradural fashion safely. The preservation of the temporal lobe venous outflow via the temporal bridging veins is the major benefit of extradural retraction offered by this technique. In only 1 patient in this series did a temporal lobe complication occur. Several patients experienced transient deficits in mental status and short-term memory that resolved in the majority of cases. Four patients were hemiparetic after surgery; all of these patients had harbored complex lesions of the upper clivus with compression of the midbrain. Perforating artery injury and ICA spasm have been implicated as alternate explanations for hemiparesis in patients after resection of large petroclival and cavernous sinus lesions.[7] The ability to preserve perforating arteries from the proximal posterior cerebral arteries and posterior communicating arteries in this region can be challenging with such locally invasive lesions.

Cranial nerve paresis is an almost obligatory byproduct of treating large and complex vascular and neoplastic lesions of the central cranial base.[1,2] The oculomotor and trochlear nerves are the most vulnerable to this complication, owing to the trajectory through the tentorial incisura or cavernous sinus. Mobilization of the oculomotor nerves for the management of BA aneurysms or engulfment by meningiomas frequently results in transient diplopia and ptosis, no matter which surgical approach is taken. Postoperative CN paresis arose in 30% of patients and was transient in 41%. Eight patients experienced trigeminal hypesthesia following surgery of cavernous sinus lesions, 6 of whom had trigeminal schwannomas.

Conclusions

The extradural temporopolar approach provides a wide surgical exposure for many lesions of the sphenocavernous and petroclival regions, with the major benefit of extradural temporal lobe retraction. Mobilization of the CNs and ICA allow gentle brain retraction and maximal preservation of venous outflow with minimal temporal lobe complications. Radiosurgical treatment is an excellent option in cases in which gross-total resection of invasive tumors cannot be undertaken safely.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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