Extended orbitozygomatic approach to the skull base to improve access to the cavernous sinus and optic chiasm

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BACKGROUND: **The orbitozygomatic approach to the skull base has evolved over the past century, with a surge in development during the past 20 years. We describe an extension of this technique involving removal of the most inferior portion of the temporal bone to the level of the internal carotid artery as it enters the carotid canal, to further facilitate exposure of tumors in this region.**

METHODS AND MATERIALS: **We performed the extended orbitozygomatic approach in a series of 17 patients with a variety of neoplastic lesions. Our case series was reviewed in a retrospective fashion, and our surgical approach is described. The approach is performed safely and effectively by using the spine of the sphenoid and middle meningeal artery as landmarks and then resecting the temporal bone from the temporal craniotomy site to the carotid canal.**

RESULTS: **The extended orbitozygomatic approach has been performed at our institution over the past 6 years and has provided significantly improved access to this region of the skull base, facilitating tumor extirpation in our patient population without an increase in complications.**

CONCLUSIONS: **The extended orbitozygomatic approach further improves exposure and facilitates surgical dissection in patients with neoplasms of the cavernous sinus, sellar region, interpeduncular region, and upper clivus. The improved access without an increase in complications supports the inclusion of the extended orbitozygomatic approach in the armamentarium of the skull base surgeon.**
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Despite the apparent recent evolution and modification of skull base surgical approaches, the initial development of the lateral approach to the skull base began almost 100 years ago. As early as 1912, McArthur[1] described the removal of the supraorbital rim to access the pituitary. This was followed shortly thereafter in 1913 by Frazier,[2] describing a similar approach. Despite these early beginnings, the technique did not evolve further until the late 1970s.[3,4] In 1982, Jane[5] revitalized the technique by expanding its indications. He advocated its use for exposure of tumors of the lateral anterior cranial fossa and of aneurysms of the anterior communicating artery complex and for access to orbital and retro-orbital neoplasms. In the 1980s and early 1990s, there was a rapid expansion of the technique with multiple variations and developments of the approach,[6-14] including the supraorbital approach,[5] the orbitozygomatic infratemporal approach,[7] the orbitofrontomalar approach,[10] the cranio-orbital approach,[12] the zygomatic approach,[14] the cranio-orbital-zygomatic approach,[13] and the orbitozygomatic approach. The late 1990s and early 2000s have continued to provide further modifications of the technique.[15-18] In keeping with the ongoing evolution of skull base surgery, we present an extension of the orbitozygomatic technique involving removal of the most inferior portion of the temporal bone to the level of the internal carotid artery as it enters the carotid canal. This "extended" orbitozygomatic approach provides improved visualization and facilitates the removal of tumors of the cavernous sinus, upper clivus, and parasellar regions, by widening the exposure in this critical region.

MATERIALS AND METHODS

Operative Technique

The patient is taken to the operating room and placed in the supine position. The patient's head is rotated approximately 30 degrees to the side opposite the tumor, and the head is secured using the Mayfield headrest. We always begin our procedures with a tracheotomy if the frontal sinus is going to be entered at any point during the procedure, to prevent postoperative soiling of the central nervous system with oropharyngeal secretions and to help decrease the incidence of post-operative pneumocephalus. Following the tracheotomy, the procedure is begun with a standard bicoronal incision extending into the preauricular region within a natural rhytid. Dissection is carried down to the level of the pericranium. Subpericranial dissection is then continued with a periosteal elevator between the temporalis muscles bilaterally to the level of the superior orbital rims. The supraorbital neurovascular bundles are released bilaterally to allow further inferior tissue retraction. Over the temporal fossa of the affected side, dissection is carried along the deep temporal fascia to the level of the superficial temporal fat pad. The deep temporal fascia is then incised and dissection is carried just deep to this fascia and superficial to the superficial temporal fat pad to the level of the zygomatic arch. Further subperiosteal dissection is carried along the medial and lateral orbital walls. We next perform preadaptation of the hardware that will be eventually used to rigidly fixate the osteotomized segments at the conclusion of the procedure. Hardware consists of 1.5-mm titanium miniplates adapted across the proposed osteotomy sites at the level of the temporal attachment of the zygomatic arch, the mid-portion of the malar eminence, and the lateral orbital wall across the frontozygomatic suture. Following adaptation, the plates are removed and set aside in precise alignment for later replacement. At this point, a frontotemporal craniotomy is performed on the affected side. We next use a straight cutting bur to perform an osteotomy across the posterior zygomatic arch and malar eminence. Next, the globe and periorbita are gently retracted inferomedially and the intraorbital osteotomies are performed with care to avoid injury to the infraorbital nerve along the floor of the orbit. The cut along the floor passes across the junction between the zygoma and maxilla. A cut is made along the articulation of the greater wing of the sphenoid in the lateral wall of the orbit and brought up to meet the cuts along the rim and malar eminence. Osteotomes are then used to disarticulate this segment. The temporalis muscle is reflected inferiorly into the infratemporal fossa pedicled to the coronoid process for preservation of blood supply (Fig 1). The coronoid process may be osteotomized to improve the range of movement of this muscle if required. As the condylar fossa is lateral to the vertical segment of the petrous portion of the internal carotid artery (ICA), a condylectomy may be performed if mobilization of the ICA in its extracranial course is required. With the bone flaps removed, we next proceed to remove the bone from the inferior aspect of the craniotomy to the level of the internal carotid artery as it enters the carotid canal with a large round bur, using the spine of the sphenoid and middle meningeal artery as key surgical landmarks for this portion of the dissection (Fig 2). Generous bone removal at this level provides for safe exposure and proximal control of the ICA as well as allowing for its safe retraction or mobilization. In addition, this exposure converts a deep and narrow approach into a broad and shallow one, improving access to the chiasm and cavernous sinus and minimizing retraction of the brain (Fig 3). The foramen spinosum is unroofed and the middle meningeal artery divided at this level. The greater wing of the sphenoid is then removed to unroof the second and third divisions of trigeminal nerve. At this point the dura is opened, exposing the Sylvian fissure from lateral to medial. The dura over the lesser wing of the sphenoid is now opened facilitating removal of the anterior clinoid. This will allow the surgeon to open the roof of the optic canal and the superior orbital fissure if this is required. This widely opens the space defined by the oculomotor nerve inferolaterally, the optic nerve medially, and the clinoidal ICA inferiorly. The carotid artery can now be followed intracranially with excellent exposure of the cavernous sinus and optic chiasm (Fig 4).

After tumor extirpation, the dura is reapproximated with suture. Any dural dehiscence is repaired with an onlay graft of tensor fascia lata or a xenograft dural patch, which is set in place with suture fixation and fibrin sealant. If there is a significant dead space remaining at the base of the brain after tumor extripation, the temporalis muscle is pedicled into the base of the middle cranial fossa, effecting separation of the intracranial from extracranial compartments. It is held in position by suspending it to the edges of the craniotomy with suture. If the ipsilateral frontal

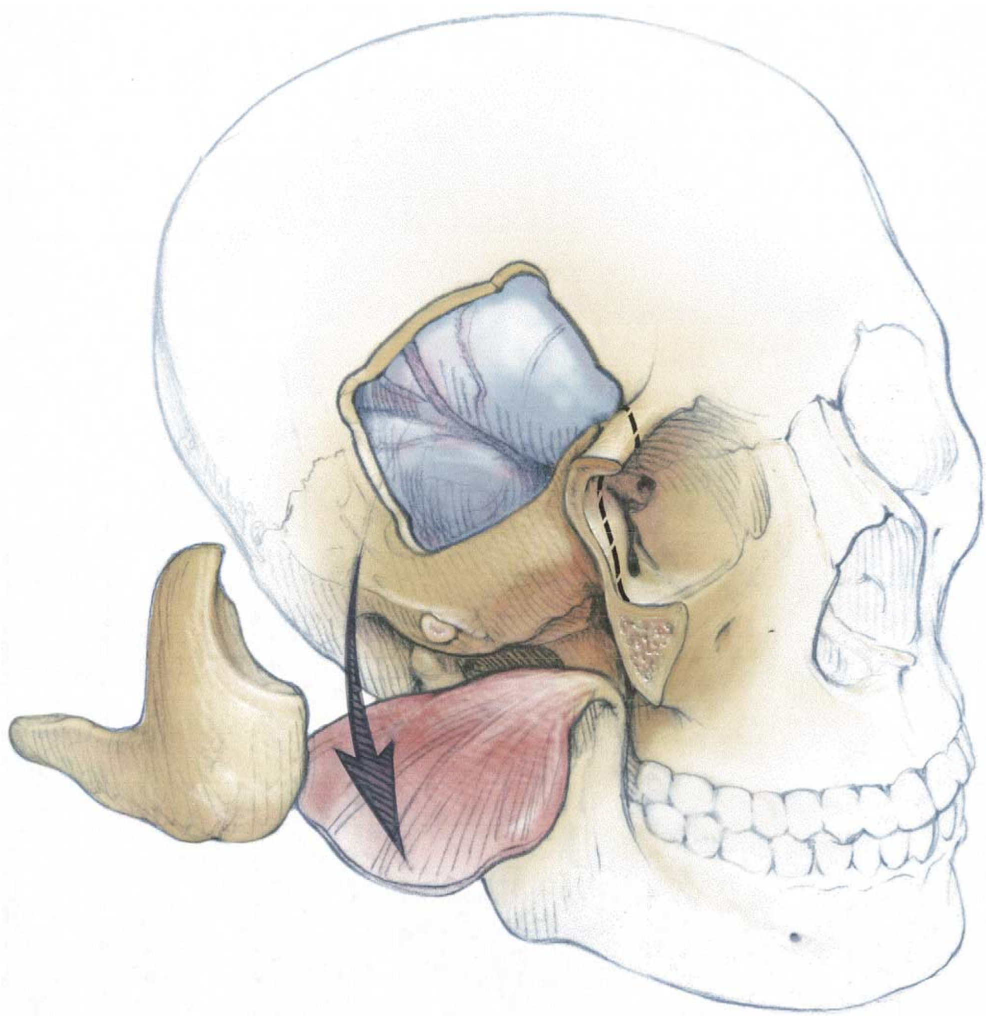

Fig 1. Diagram demonstrating completed frontotemporal craniotomy. Orbitozygomatic segment has been removed and temporalis muscle is being reflected inferiorly. Dashed line within orbit represents area that may be removed to improve access to the orbital apex if this is required.

sinus has been violated during the craniotomy, it is cranialized at this point and the nasofrontal duct is occluded with inversion of the mucosa and a small temporalis muscle graft to obliterate the duct. The area is then covered with a pedicled pericranial flap, effectively sealing the area. The previously adapted miniplates and screws are used to replace the bone segments in position with further placement of miniplates and screws as needed to provide 3-dimensional stabilization. We then adapt 1.5-mm titanium dynamic mesh to the inferior temporal defect and secure this in place with a series of 4-mm-long screws. Bone dust gathered during the osteotomies is used to fill the gaps between the osteotomy sites and to fill the gaps within the titanium mesh. If a temporalis muscle flap has been performed, hydroxyapatite cement is used to complete the temporal cranioplasty to achieve restoration of temporal contour. A layered closure is performed over 2 No. 10 Jackson-Pratt drains.

RESULTS

Between 1997 and 2002, 17 patients underwent the extended orbitozygomatic approach at our institution for a variety of neoplasms with involvement of the cavernous sinus and optic chiasm (8 meningiomas, 3 schwannomas, 2 hemangiomas, and 4 recurrent pituitary neoplasms with optic chiasm involvement). Access to the neoplasm was excellent in each case. Proximal control of the

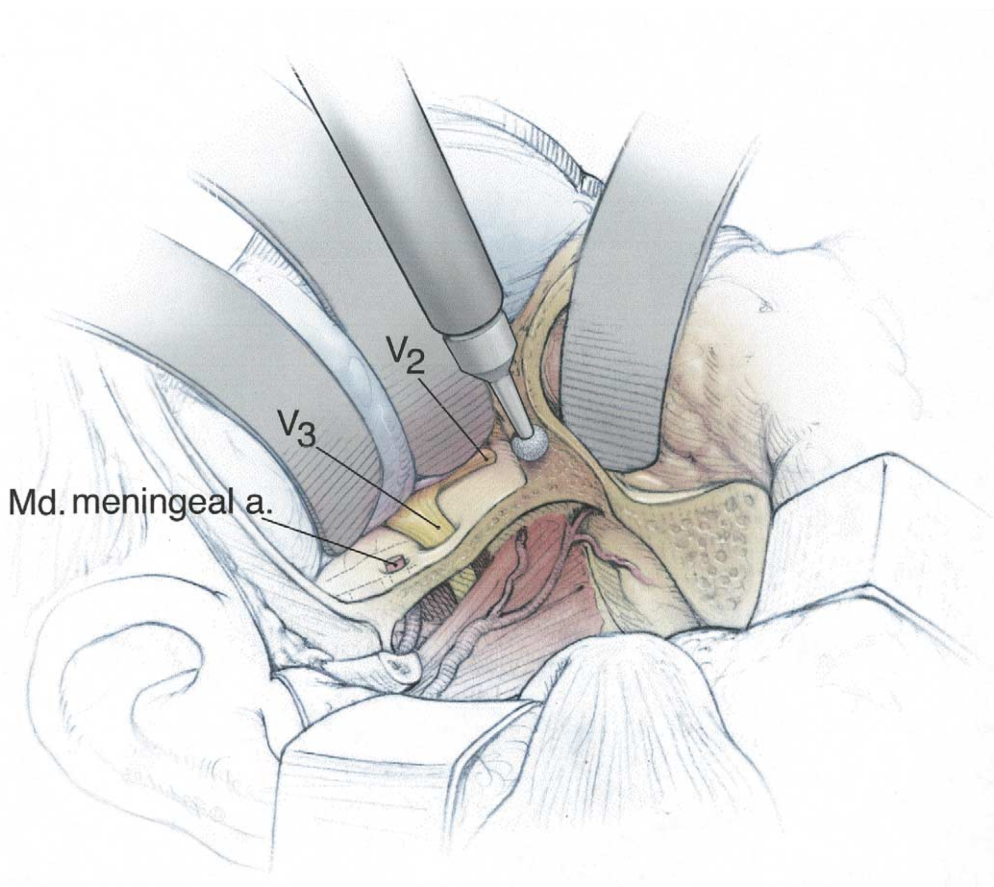

Fig 2. Diagram demonstrating removal of the bone inferior to the craniotomy site and along the floor of the middle cranial fossa to the level of foramen ovale and middle meningeal artery. This artery is slightly anterior to the carotid canal and serves as a safe landmark. *V2*, Second division of trigeminal nerve; *V3*, third division of trigeminal nerve; *md meningeal a.*, middle meningeal artery.

ICA was gained in each case from where it was followed into the cavernous sinus with the outlined technique. There was a single death in this series, which was thought to be unrelated to the procedure. The patient developed perioperative hypotension resulting in a contralateral brain cerebrovascular accident in the postoperative period. Otherwise, all patients recovered uneventfully from the procedure and were discharged to home within 11 days of the procedure with no adverse procedure-related outcomes. There was no evidence of cerebrospinal fluid leak, meningitis, or brain abscess in any of our patient population. Gross tumor clearance was achieved in each case.

Three patients with meningiomas and 1 with recurrent pituitary adenoma had received gamma knife or other radiation treatment in the past before surgery. In this subgroup, 1 patient with meningioma (she had had both gamma knife and external beam radiotherapy in the past) was noted to have early recurrent disease at the contralateral (to operated side) cavernous sinus 3 years postoperatively. All of the others in the group who had received gamma knife treatment before surgical resection of recurrent tumor remain free of disease.

Of the 13 patients who had not had radiation treatment in the past, gross tumor clearance was achieved in each case. One patient with meningioma developed recurrent disease at the level of the orbital apex dura, which was completely cleared with a subsequent operation (same approach). One patient with schwannoma did receive gamma knife treatment postoperatively as this had represented his third recurrence. Both of these patients now remain free of gross disease as based on radiographic follow-up.

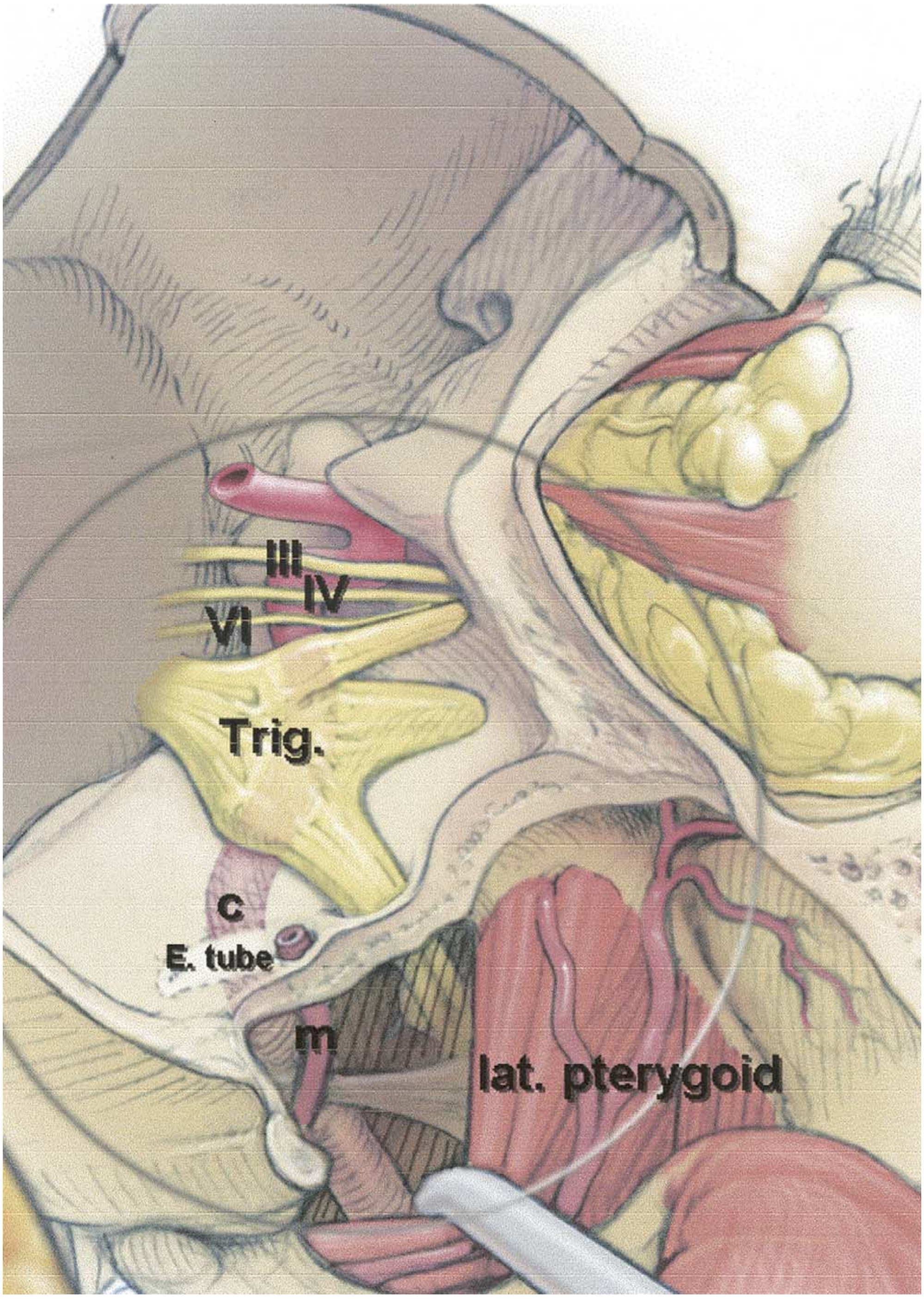

Fig 3. Exposure achieved with the extended orbitozygomatic approach. Note wide and shallow access to the cavernous sinus and parasellar areas. *III*, Oculomotor nerve; *IV*, trochlear nerve; *VI*, abducens nerve; *Trig.*, trigeminal nerve; *c*, carotid artery; *E. tube*, Eustachian tube; *m*, middle meningeal artery; *lat.pterygoid*, lateral pterygoid muscle.

A single patient who had 3 resections of a recurrent pituitary adenoma before an extended orbitozygomatic approach underwent gross clearance of disease but recurrence developed at 18 months postoperatively, which was treated with further surgery (subcranial approach) and gamma knife treatment. Subsequent follow-up at 1 year failed to reveal the presence of any recurrent or persistent disease.

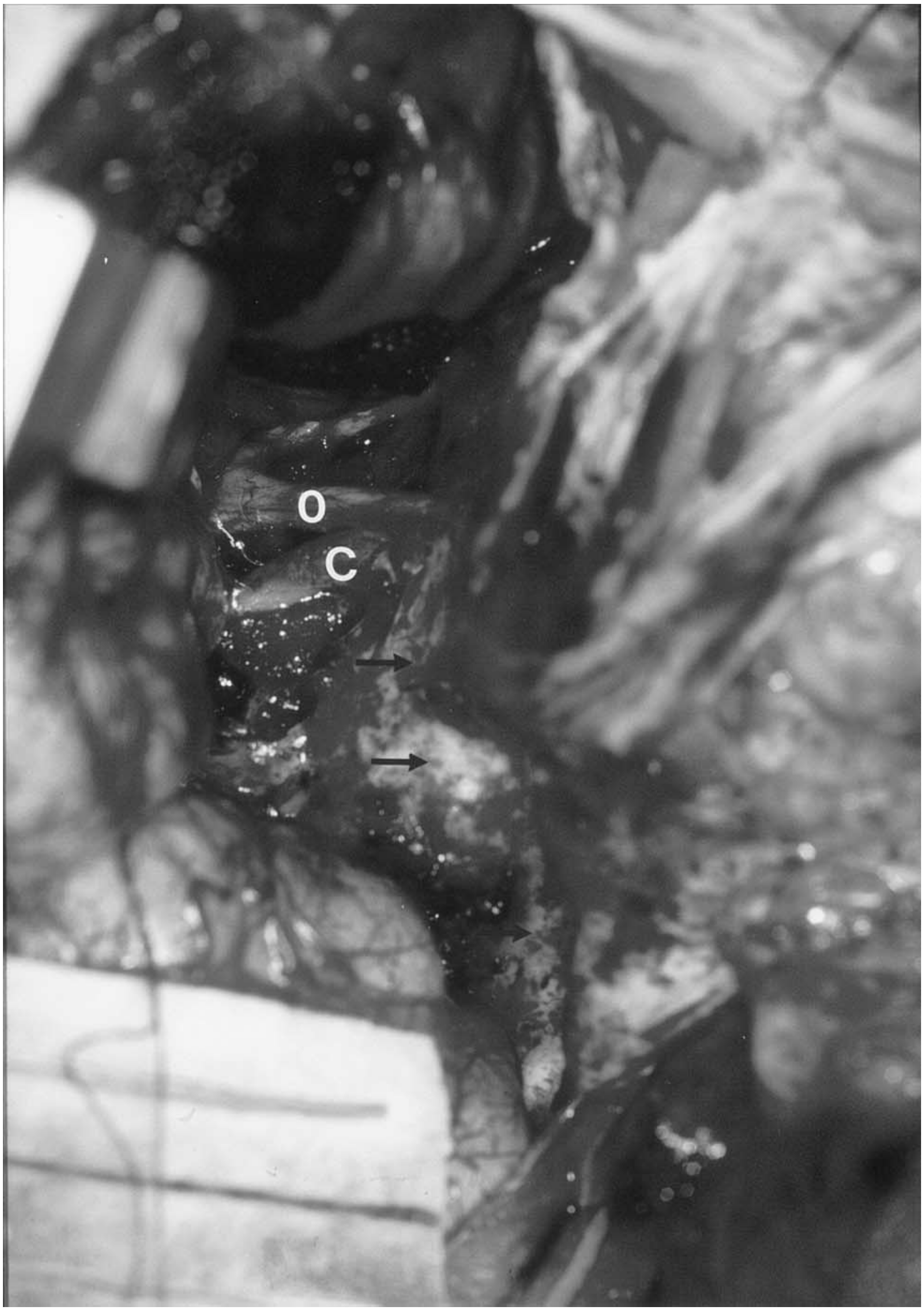

Fig 4. Carotid artery has been traced into cavernous sinus, safely removing tumor en route. Arrows track the course of the carotid artery. *O*, Optic nerve; *c*, carotid artery.

None of our patient series have died of disease.

DISCUSSION

The orbitozygomatic approach is indicated for large lesions in the suprasellar, parasellar, and retrosellar areas, as well as for lesions extending into the cavernous sinus and the orbit. It is also suitable for primary lesions of the cavernous sinus and tumors of the interpeduncular fossa and upper clivus.[13] The approach has evolved over the past century into a useful and popular approach for the skull base surgeon. The modern approach was developed primarily through the works of Jane,[5] Pellerin,[10] Hakuba,[7] and Al-Mefty.[13] Its evolution and multiple modifications have been inspired by the desire for increased exposure, decreased brain retraction, and improved postoperative cosmesis and function. By removing the superior and lateral orbital rims and the zygomatic bone combined with a frontotemporal craniotomy and mobilization of the temporalis muscle inferiorly, this approach allows excellent exposure of the anterior and middle cranial fossa, the area of the upper third of the clivus and posterior fossa. However, by extending the technique to include the most inferior portion of the temporal bone up to the carotid canal, a further increase in exposure can be safely obtained. It facilitates tumor removal by further broadening access while continuing to minimize brain retraction. In addition, it allows for mobilization of the proximal ICA if this is required.

CONCLUSIONS

The orbitozygomatic approach provides wide-angle exposure for removal of lesions involving the cavernous sinus, the sellar region, the interpeduncular fossa, and the upper clivus. By identifying the spine of the sphenoid and then farther extending the approach to include the most inferior portion of the temporal bone up to the carotid canal, we have been able to further facilitate exposure of this region. The improved access with minimal complications supports the inclusion of the extended orbitozygomatic approach in the armamentarium of the skull base surgeon.

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