Published online: 2020-07-20

Transcranial Approaches to the Orbit

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J Neurol Surg B 2020;81:450–458.

Abstract

Transcranial approaches to the orbit provide familiar and flexible approaches with wide access to the majority of the orbit, only limited in the inferomedial orbit. A pterional craniotomy is the predominant approach but can be expanded with an orbital or zygomatic osteotomy for even wider access. Minimally invasive approaches, such as the lateral supraorbital or "eyebrow" supraorbital approach, are options for selected pathologies and minimize morbidity related to the approach
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Keywords
- craniotomy
- pterional
- orbitozygomatic
- eyebrow
- supraorbital

Introduction

For neurosurgeons, transcranial approaches to the orbit are often the most familiar approaches and provide wide access to the entire superior and lateral orbit. Transcranial approaches include pterional craniotomy, lateral supraorbital craniotomy,[1] frontotemporal orbitozygomatic approach,[2] bicoronal subfrontal approach, and supraorbital/"eyebrow" approach. This wide range of approaches can be tailored for locations throughout the orbit, from the superomedial orbit to the inferior lateral orbit with no anterior or posterior limitation. Their wide access and flexibility is especially useful for pathologies that extend beyond the orbit, involve large areas of the orbit, or multiple cranial compartments.

Pearls and Tips

- Transcranial approaches provide the widest access to the superior and lateral orbit and can be used for virtually any pathology in the orbit that is superior or lateral to the optic nerve or globe.
- Addition of orbital and zygomatic osteotomies can be customized; they can be used alone or in combination.
- A zygomatic osteotomy adds inferior access, especially if a tumor involves the inferior orbital fissure or extends to the middle fossa or Meckel's cave.
- Orbital dissection of orbital tumors, even when approached via craniotomy, are best performed in conjunction with an oculoplastic surgeon.
- If the goal of orbital surgery is decompression of the orbit, bony reconstruction can usually be avoided.

Pathologies Treated

Virtually any orbital pathology can be treated with a transcranial approach. This includes hemangiomas, venous malformations, decompression for optic nerve sheath meningioma, metastasis, and sphenoorbital meningiomas.[3,4] Craniotomies are especially useful for extensive tumors and those requiring dural or orbital reconstruction, as they provide significant access to the entire orbit and frontotemporal dura. Sinonasal tumors impacting the orbit can also be addressed with a bicoronal approach, even including an anterior craniofacial resection with anything from periorbital margin resection to orbital exenteration as indicated.[5]

Transcranial approaches can be used to biopsy orbital lesions as well but should generally be reserved for when a larger resection is needed. Craniotomy healing could delay treatment for conditions like lymphoma and has the potential to be contaminated by or spread invasive fungal infections.

published online
July 20, 2020

DOI https://doi.org/10.1055/s-0040-1713855.
ISSN 2193-6331.

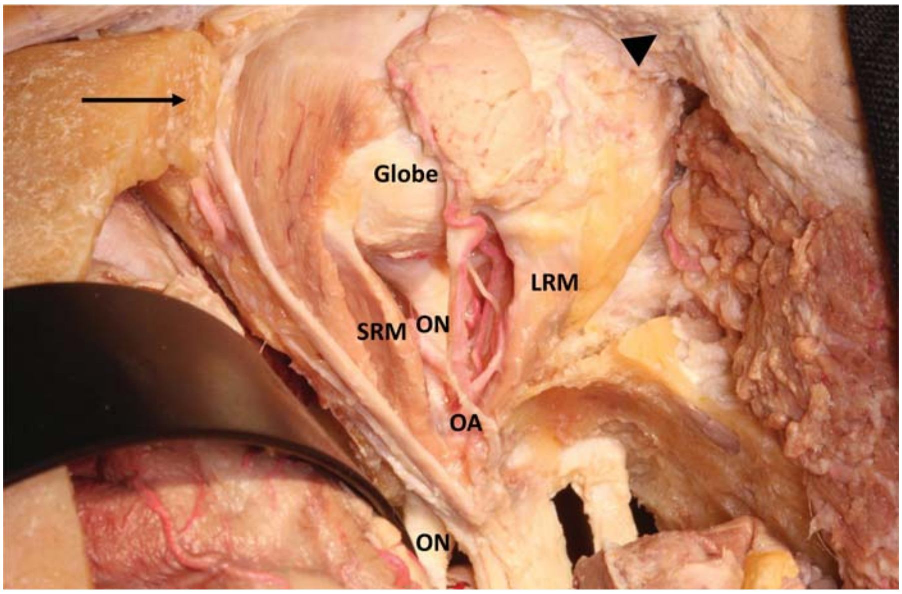

Fig. 1 Cadaveric dissection showing wide access to the superolateral orbit via a frontotemporal orbitozygomatic approach (FTOZ). The arrow points at the medial orbital osteotomy at the level of the supraorbital notch/bundle and the arrowhead is at the inferior orbital osteotomy at the zygoma. LRM, lateral rectus muscle; OA, ophthalmic artery; ON, optic nerve; SRM, superior rectus muscle.

Anatomic Location

More important than histology is lesion location when considering a transcranial approach to the orbit.[6] A standard pterional or frontotemporal craniotomy naturally provides access to the entire anterior superolateral orbit (►**Fig. 1**). Further removal of the sphenoid wing provides access to the superolateral posterior orbit and orbital apex. This craniotomy can also be expanded into a frontotemporal orbitozygomatic (FTOZ) approach. An orbital osteotomy can improve access to the anterior globe and lessen frontal dural retraction. In general, inferior or medial access is limited via craniotomy, but this can be expanded significantly laterally by adding a zygomatic osteotomy which gives access to the middle and infratemporal fossae and therefore the inferolateral orbit and associated anatomy.[7] A bicoronal incision with subfrontal craniotomy can access the medial aspect of the orbit from a superior trajectory and addition of an orbital bar or partial orbitotomy can increase this to cover almost the entire orbit, but not without some added morbidity.

Specialties Involved/Recommended

Orbital surgery of any kind requires multidisciplinary collaboration. This is especially true for transcranial approaches. Although extraorbital tumors with orbital compression can be operated by a neurosurgeon alone, aspects, such as reconstruction and perioperative management, benefit from ophthalmology involvement. As soon as the tumor invades periorbita and definitely when the tumor is intraconal, an oculoplastic surgeon should generally be involved. Their knowledge of and comfort with orbital anatomy and its manipulation can allow safer and more complete resection of tumors deep within the orbit itself. If a tumor extends from the sinonasal cavity to involve the orbit or vice versa, involvement of otolaryngology is recommended. In addition, their involvement can be very helpful when performing subfrontal or orbitozygomatic approaches.

Technique

Incision location and size depends somewhat on the extent and location of the tumor but can include anything from a hemicoronal or full bicoronal to an eyebrow incision. Pterional, minipterional, and lateral supraorbital (LSO) approaches all provide similar access via a smaller incision behind the hairline.[8] These do not allow full subfrontal or inferotemporal access as easily but can be modified to allow it. All of these require either sub/interfascial dissection or one piece myofascial flaps to avoid injury to the frontalis branch of the facial nerve. The "eyebrow" incision for a supraorbital craniotomy is placed below the points where the frontalis branches enter the muscle, but can result in transient weakness because of direct injury to the frontalis muscle itself.

All of these craniotomies can utilize a "keyhole" burr hole as one point for starting the craniotomy. This gives access to the lateral orbit, frontal, and temporal dura. The craniotomy is extended as medially and posteriorly as the incision allows or pathology requires.

Superolateral orbital osteotomies can be made via pterional, supraorbital, or hemicoronal incisions.[9] Full orbitozygomatic osteotomies require a curvilinear, or hemi/full bicoronal incision to avoid extending the resulting scar into the forehead.[10] A differential temporalis flap allows the muscle to be reflected inferiorly which provides greater access to the sphenoid wing and lateral orbit. Osteotomies can be made with a reciprocating saw at the supraorbital notch, body of zygoma (connecting to inferior orbital fissure) and root of the zygoma (anterior to the glenoid fossa). These can then be connected with a matchstick burr or osteotome and released from the underlying temporalis

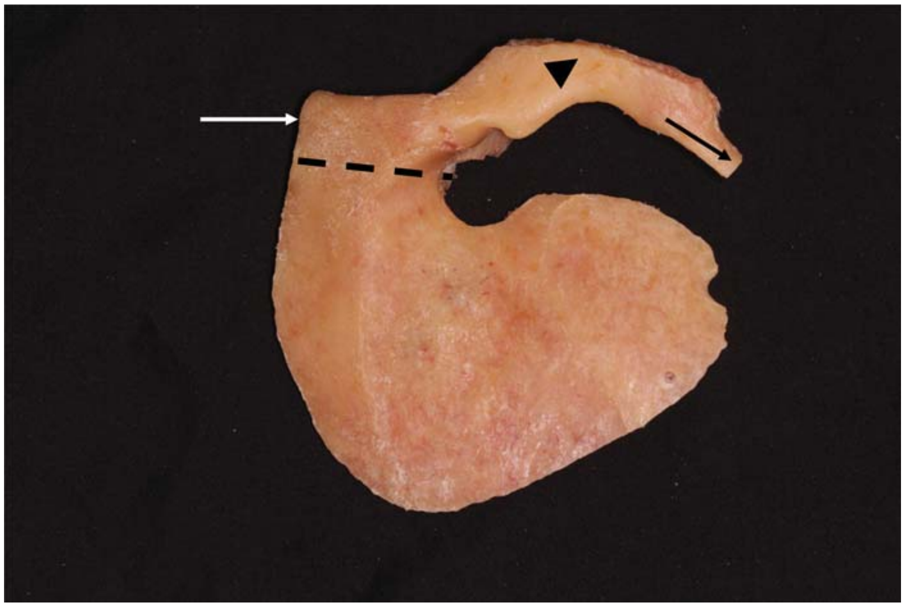

Fig. 2 Cadaveric dissection showing a one-piece FTOZ (frontotemporal orbitozygomatic) craniotomy. A two-piece is generally preferred (dashed line showing the typical craniotomy separation). White arrow, medial orbital osteotomy at the supraorbital notch; arrowhead, "V" osteotomies at the zygoma; black arrow, osteotomy at the root of the zygoma.

and masseter muscle. It can also be done as one piece, removing it simultaneously with the craniotomy (►**Fig. 2**).[11]

The lateral orbit and orbital roof removal is tailored to the orbital exposure needed depending on tumor location. Coagulation and transection of the meningoorbital fold and artery allows access posteriorly all the way to the superior orbital fissure and cavernous sinus. Careful removal of the anterior clinoid process provides optic canal decompression and facilitates cavernous sinus exposure via an interdural (Hakuba's/Dolenc's type) dissection (►**Fig. 3**).

Reconstruction

Reconstruction following craniotomy for orbital lesions always has to take into account careful cosmetic and functional reconstruction of the orbit. From assuring proper alignment of an orbital osteotomy, to separating the sinonasal cavity, to ensuring proper orbital support and reconstruction; replating of cranial bone flaps has to include a careful plan for the orbit. That said, if orbital decompression is a major goal of surgery, unless there is a major violation of periobita, no

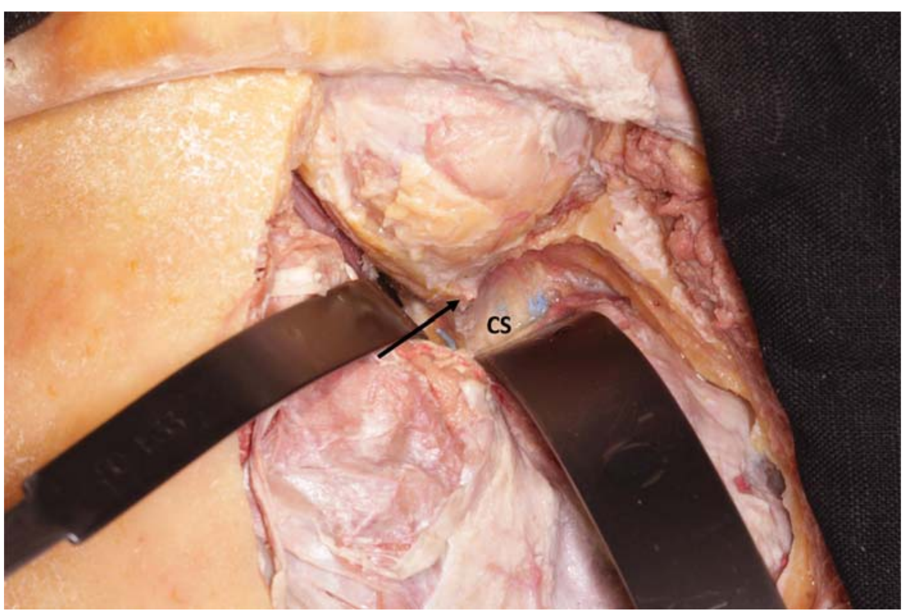

Fig. 3 Cadaveric dissection showing the interdural dissection between the temporal lobe dura and cavernous sinus (CS) dura. This exposure can be achieved after coagulation and division of the meningo-orbital fold/artery (arrow), followed by removal of the anterior clinoid process.

reconstruction of the orbital roof of lateral orbit is typically needed. The orbital rims can be replaced without the orbital walls to preserve cosmesis. Concerns over pulsatile enophthalmos are generally unfounded. In rare cases where this does occur, it is usually short lived with maturation and increased scarring of the surgical site.

If orbital decompression is not a part of surgery and, especially, if the periorbita is opened extensively, then soft tissue reconstruction should be considered. Local tissues, such as temporalis fascia and pericranium, are excellent autografts, easily harvested, and with virtually no morbidity. If there is dural involvement, these tissues can also be used for dural reconstruction and fat grafts can help to separate and support the orbit, as well as dumbbell into any areas that cannot be closed in a watertight fashion (such as the superior orbital fissure or cavernous sinus). Orbital plating can prevent enophthalmos in cases without proptosis where large areas of the orbit are removed. Silicon coated plates can help avoid orbital entrapment or restrictive strabismus from scar but are not always needed.

Temporalis muscle provides an additional vascularized reconstruction in cases where a large defect is left or vascularized separation of a sinus or intracranial space is needed. With orbital exenteration, the entire muscle can be rotated into the orbital apex and provide an excellent local reconstructive option in preparation for future prosthesis.

Intraoperative Neurophysiology

Global neurophysiology is generally a good idea during craniotomy. Modalities, such as somatosensory evoked potentials (SSEPs), are generally used. Electromyography (EMG) can be impractical given the exposure of the muscles involved. Sterile leads can be placed intraoperatively but often have to be wrapped around the muscle itself. Alternatively, simple stimulation with observation of muscle activation can provide a good surrogate.

Complications

Complications of transcranial approaches include intracranial and orbital complications. Dural tack-up sutures can prevent epidural hematoma and careful dural repair ensures lack of meningocele or cerebrospinal fluid (CSF) leak. Posterior orbital exposure and dissection is assisted by proper brain relaxation including rarely CSF diversion. This can prevent complications, such a cerebral contusion or venous infarct, that result from retraction.

Meticulous hemostasis is key especially for intraorbital and intraconal surgery. If a tense retroorbital hematoma occurs, urgent lateral canthotomy is critical to avoid permanent loss of vision. Care to control the ethmoidal arteries during a subfrontal/medial approach is also critical to prevent postoperative hematoma. Finally, proper separation of the sinuses and nasal cavity from the orbital reconstruction and cranial flap/plating is key to avoid acute or delayed infection. Violation of the periorbita, either intentionally or unintentionally, increases the risk of several additional complications. The levator muscle attachment can be injured during superior orbital dissection, either for tumor or for orbitotomy (such as during an FTOZ) and can result in a transient or very rarely permanent ptosis. Open periorbita also dramatically increases the risk of entrapment, especially of the lateral rectus muscle, when replating the orbit and zygoma. Periorbital reconstruction can limit this risk and careful inspection in the orbit immediately after plating is mandatory.

Approach Limitations

Transcranial approaches are extremely versatile as they can be customized to access the majority of the orbit (►**Fig. 1**). However, they have a natural medial and inferomedial anatomic limitation, especially in the posterior orbit. In addition, they can sometimes be unnecessarily expansive exposures which has the potential to increase risk of infection and approach-related morbidities. Finally, these approaches truly are best applied by a fully collaborative, multispecialty team which can sometimes be a limitation depending on institutional investment and availability of all subspecialties.

Case Examples

Case 1

A 33-year-old woman presented with progressive proptosis resulting in mild diplopia, decreased visual acuity and recurrent chemosis. CT shows significant osseous involvement of the orbital roof and lateral orbit with resultant proptosis (►**Fig. 4**). There is also osseous involvement extending back to the temporal squamosal bone and down to the pterygoid base. Associated dural involvement includes nearly all of the anterior temporal dura and a significant portion of the frontal dura (►**Fig. 5**). A radical removal is performed via a frontotemporal orbitozygomatic approach with resection of all involved bone and dura. The orbit is not reconstructed but the removed frontotemporal bone is replaced with a mesh cranioplasty (►**Figs. 6** and **7**).

Case 2

A 54-year-old woman presents with eye swelling, headache, and positive blood cultures. MRI reveals a right orbital and epidural abscess associated with frontal sinusitis (►**Fig. 8**). To avoid craniotomy, an eyebrow incision is used to access the orbit, drain the abscess, and remove the orbital roof to access the epidural abscess with no replacement of bone. A drain is left behind and tunneled out of the lateral aspect of the eyebrow incision (►**Fig. 9**). The frontal sinus infection is treated in the same setting with endoscopic endonasal sinus surgery. After 1 month of antibiotic treatment for invasive pneumococcus, her imaging and symptoms resolved completely (►**Fig. 10**). She declined HIV or other autoimmune testing.

Case 3

A 72-year-old woman with a history of breast cancer and now cutaneous squamous cell carcinoma treated with chemotherapy and radiation presents with progression in the orbit with vision loss and severe ophthalmic division

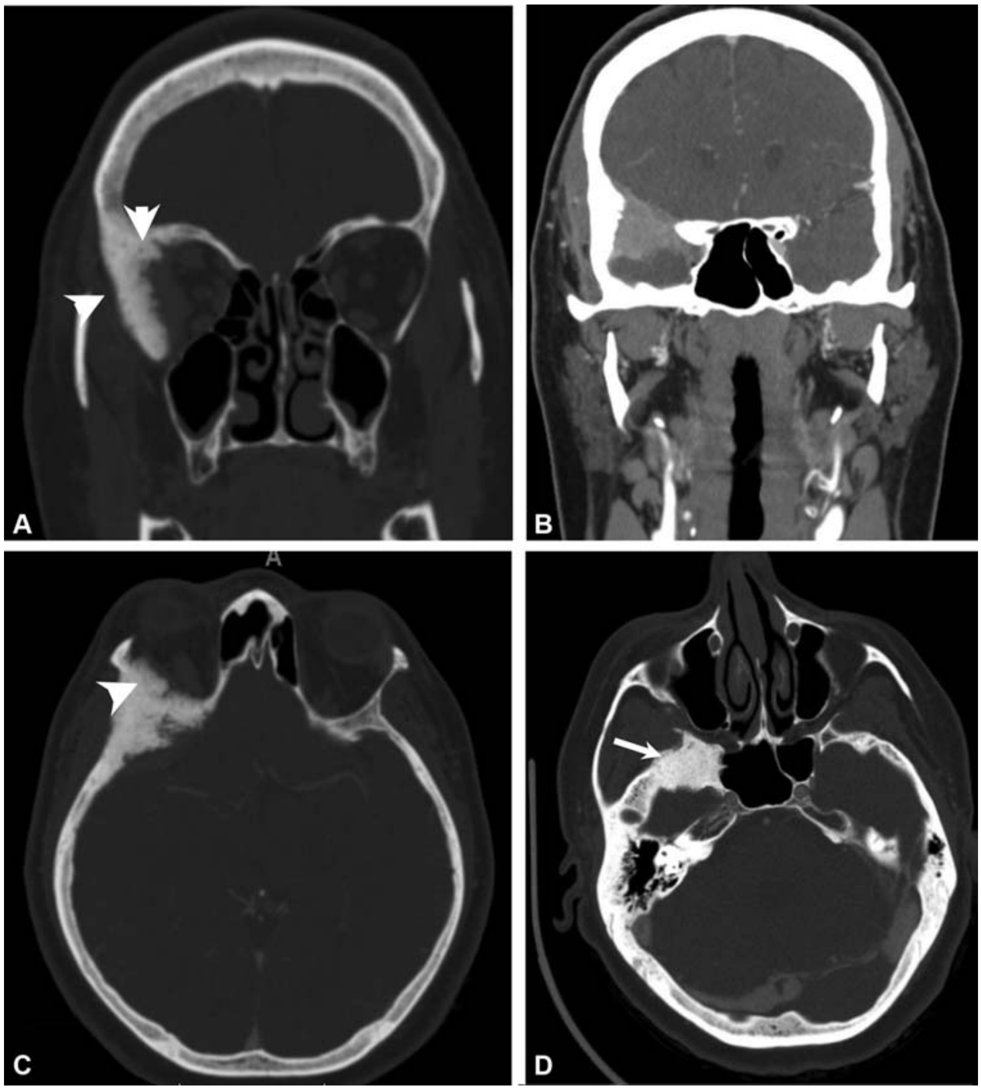

Fig. 4 Preoperative coronal (**A, B**) and axial (**C, D**) CT showing significant osseous involvement by a spheno-orbital meningioma, including the orbital roof and lateral orbit (arrowheads), but extending to the temporal squamosal bone and even the pterygoid base (arrow). CT, computed tomography.

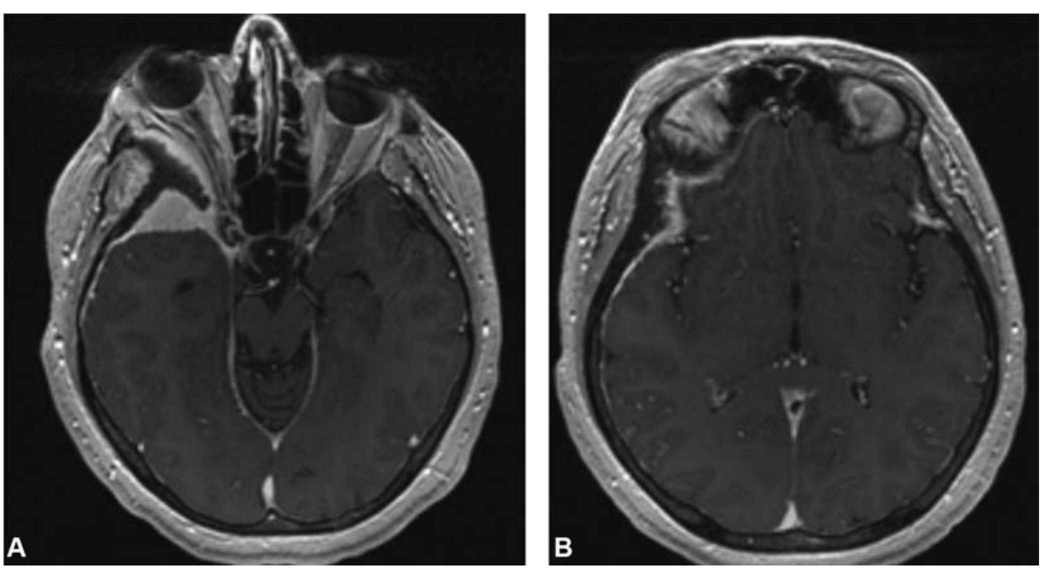

Fig. 5 (**A, B**) Preoperative MRI showing dural thickening and frank tumor involvement of the anterior and lateral temporal dura, as well as a portion of the frontal and subfrontal dura in addition to lateral orbital periosteum. MRI, magnetic resonance imaging.

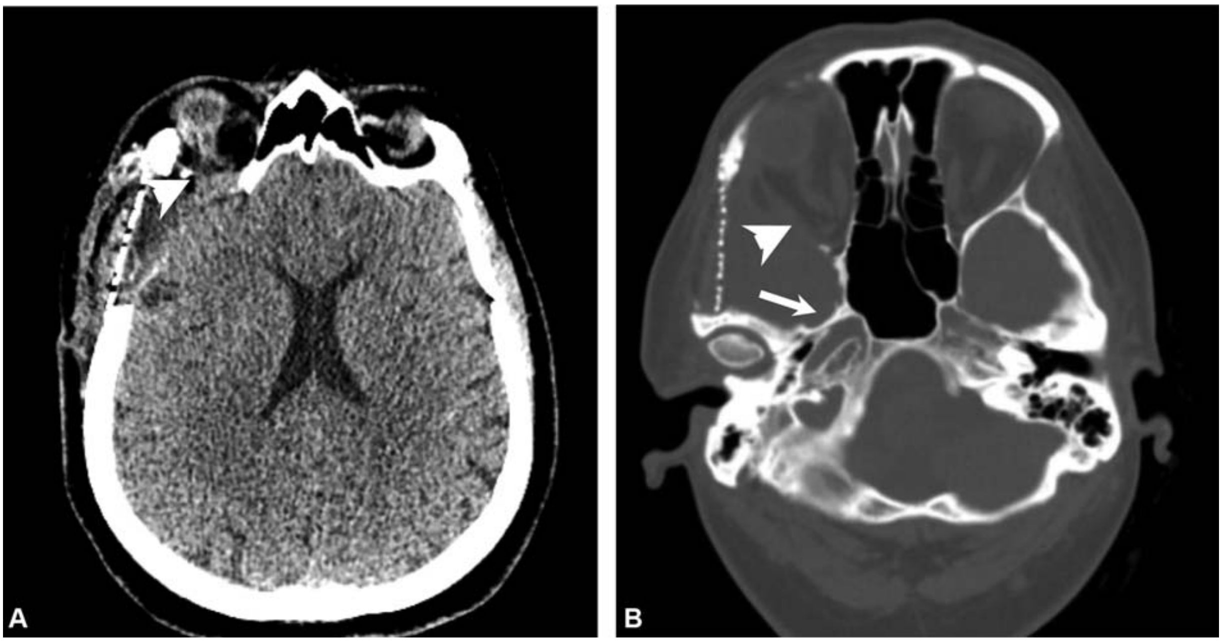

Fig. 6 (A, B) Postoperative CT showing complete resection of all involved bone and dura with mesh was utilized for the cranioplasty. Note that no reconstruction was performed in the lateral orbital wall, aligning with the surgical goal of decompressing the orbit. This included all the bony lateral orbit posterior to the orbital rim (arrowhead) and the involved pterygoid bone (arrow). CT, computed tomography.

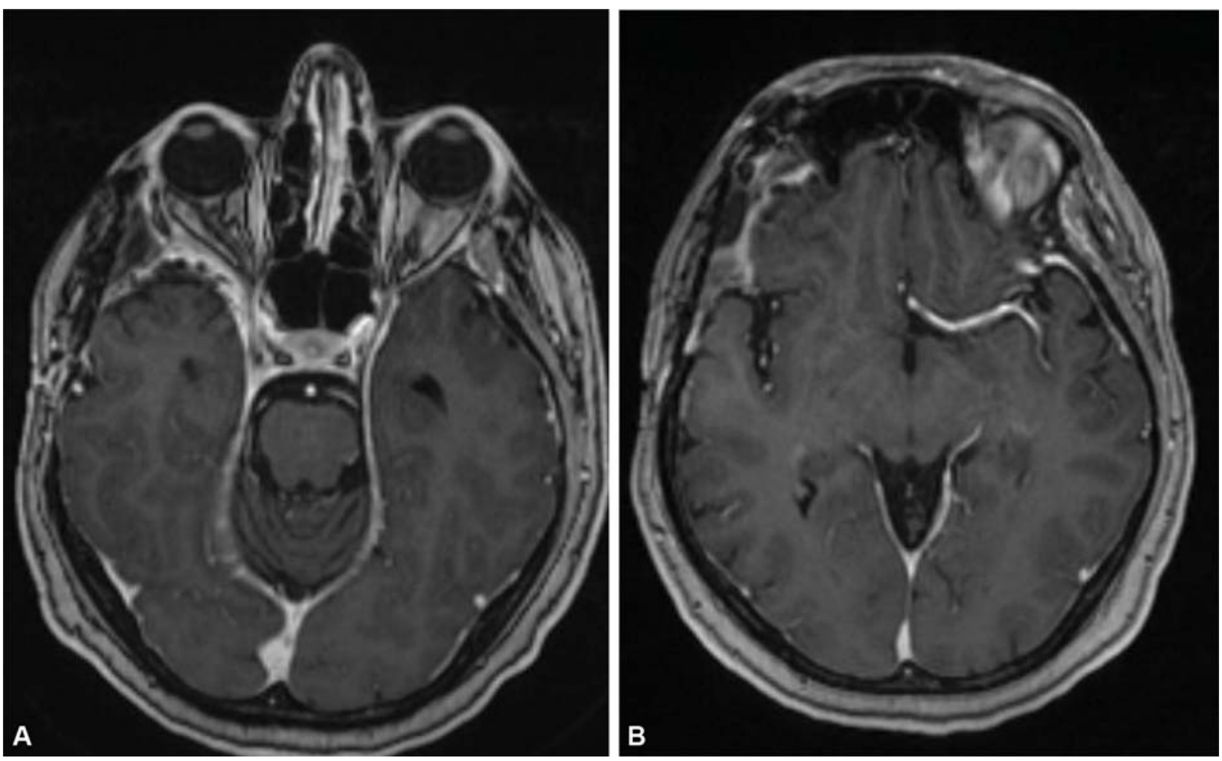

Fig. 7 (A, B) Axial MRI post contrast after FTOZ resection of sphenoorbital meningioma shows complete resection of all dural and orbital tumor with complete reduction of the proptosis. Only residual scar can be seen at the site of the duraplasty. FTOZ, frontotemporal orbitozygomatic.

trigeminal neuropathy (►**Fig. 11**). Orbital exenteration is recommended and performed in conjunction with a hemicoronal incision behind the hairline. The orbit was resected back to the orbital apex and superior orbital fissure, coagulating the ophthalmic artery, and transecting the optic nerve (►**Fig. 12**). The nerve sheath was secured with a suture to prevent CSF egress into the cavity. The entire lateral orbit, sphenoid wing, and orbital roof adjacent to the tumor was resected, exposing frontal and temporal dura. The temporalis muscle was dissected free from the sphenoid wing and rotated into the orbit through the lateral orbital and sphenoid wing defect. This provided coverage of the exposed

Fig. 8 Preoperative coronal, post contrast MRI showing orbital and epidural abscess (arrows), presumed to be extending from the frontal sinus.

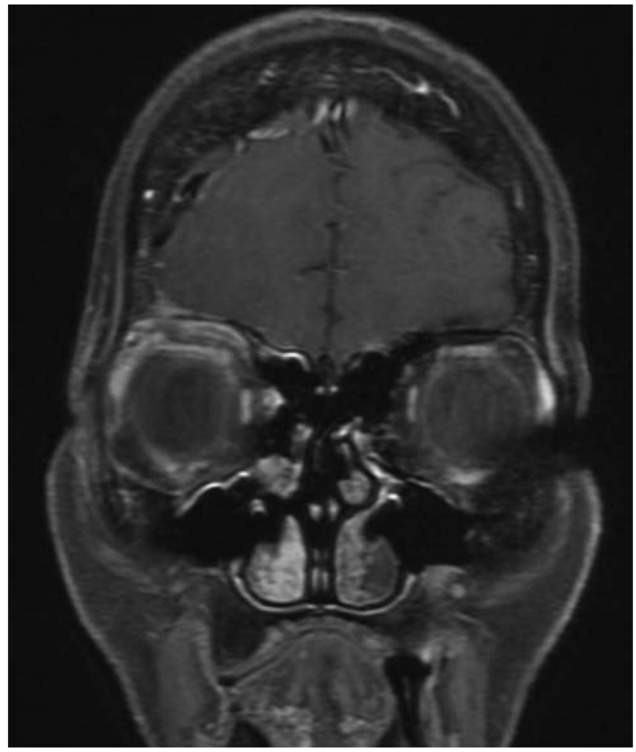

Fig. 10 Postoperative coronal, post contrast MRI showing complete resolution of the abscesses in both the orbit and epidural spaces. MRI, magnetic resonance imaging.

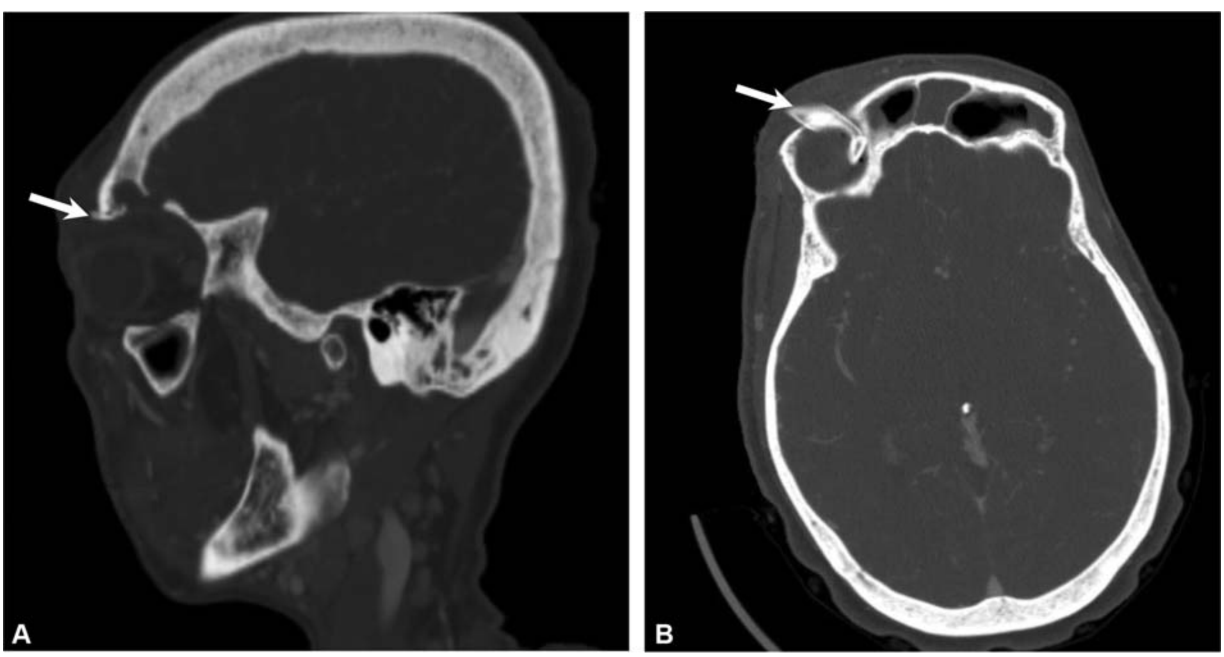

Fig. 9 Postoperative sagittal (A) and axial (B) CT following eyebrow approach for partial orbital roof and minor inferior rim removal to access the orbital and epidural abscesses via the orbital roof. A simple rubber Penrose drain (arrow) is tunneled out of the lateral aspect of the incision. CT, computed tomography.

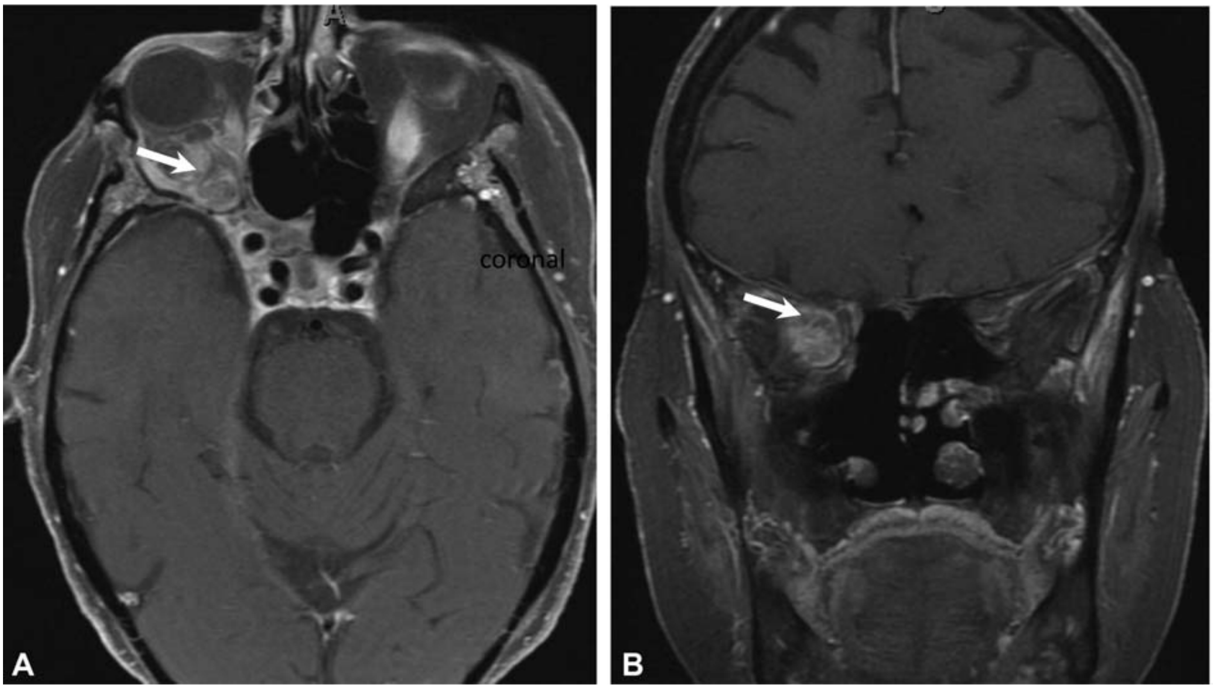

Fig. 11 Preoperative axial (**A**) and coronal (**B**) post contrast T1-weighted MRI images showing a recurrent squamous cell carcinoma involving the superomedial orbit (arrow) and extending to the orbital apex. MRI, magnetic resonance imaging.

frontal and temporal dura, orbital apex, and provided support for a future implant (►**Fig. 13**). The patient had complete relief of her pain and had radiosurgery for the cavernous sinus margin. She did not have local recurrence but died 3 years later from systemic progression.

Conclusion

Transcranial approaches to the orbit provide wide and flexible access to the entire superior and lateral orbit. They can be customized to minimize impact (supraorbital craniotomy) or

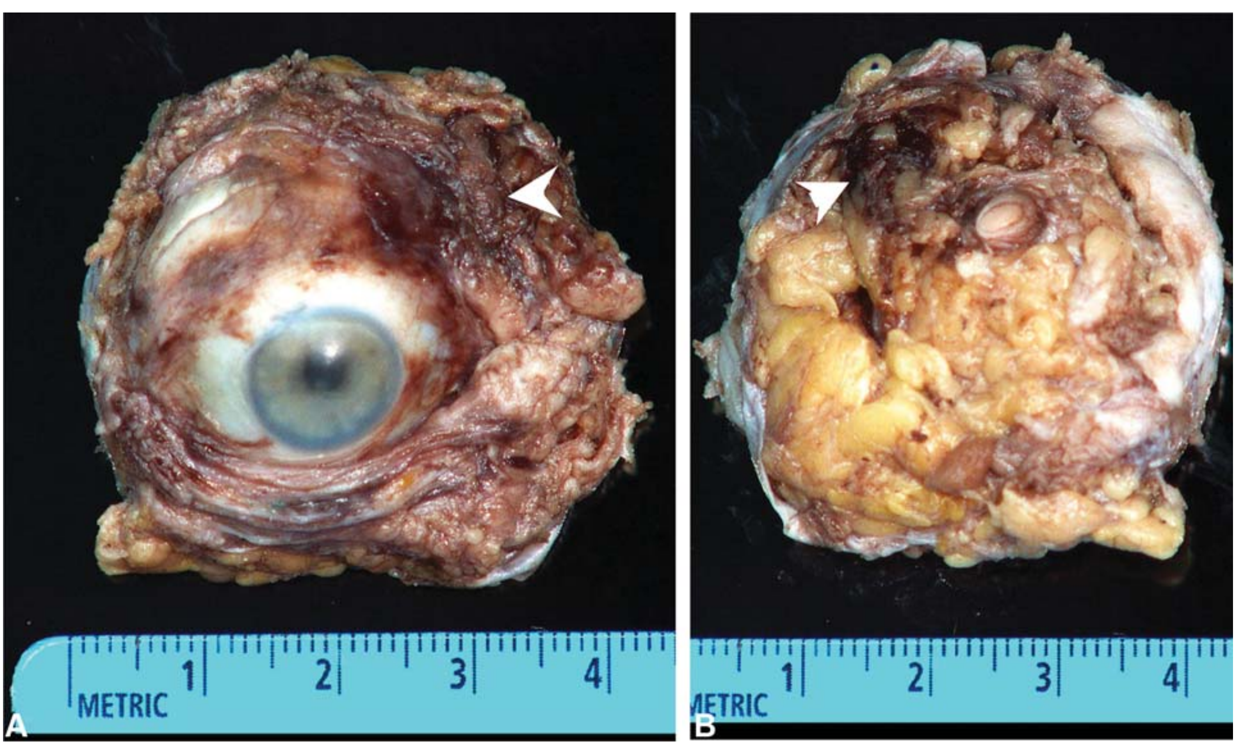

Fig. 12 Gross pathology specimen ((**A**) anterior view, (**B**) posterior) of the orbit along with muscle attachments and tumor (arrowhead). Further margins were taken including the orbital apex, sphenoid wing, and orbital roof.

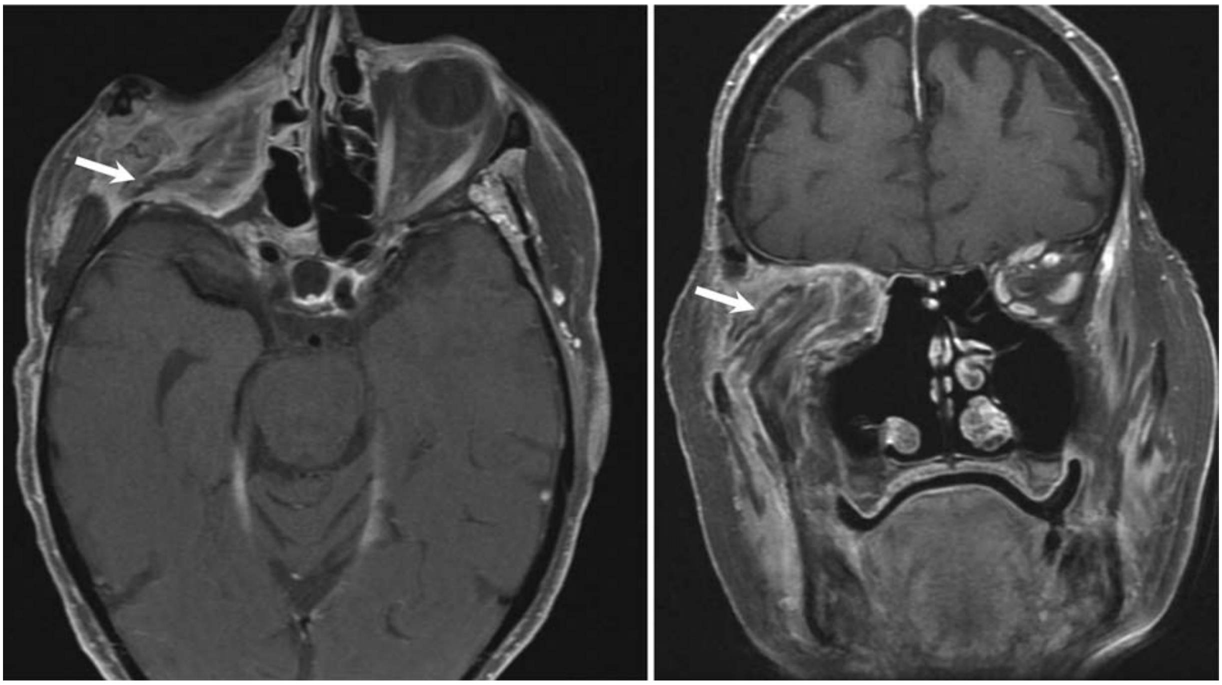

Fig. 13 Postoperative axial (**A**) and coronal (**B**) post contrast T1-weighted MRI images showing complete removal of the tumor with a temporalis muscle rotational flap (arrow) covering the dura and orbital apex and filling the orbital defect. A positive margin at the superior orbital fissure was treated with radiosurgery. MRI, magnetic resonance imaging.

variants applied to widen access (orbitozygomatic osteotomies). Orbital reconstruction is rarely needed for compressive pathologies but care must be taken to separate the orbital structures from any cranial reconstruction to prevent entrapment. These approaches are familiar to neurosurgeons but are generally best applied with an ocular surgeon for intraorbital pathologies.

Source of Funding
None.

Conflict of Interest
P.A.G. is a consultant with ownership interest in SPIWay, LLC, and a consultant for Stryker Corporation.

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