

# Modifications to the orbitozygomatic approach

## Technical note

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✓ The orbitozygomatic craniotomy is one of the workhorse approaches of skull base surgery, providing wide, multidirectional access to the anterior and middle cranial fossae as well as the basilar apex. Complete removal of the orbitozygomatic bar increases the angles of exposure, decreases the working depth of the surgical field, and minimizes brain retraction. In many cases, however, only a portion of the exposure provided by the full orbitozygomatic approach is needed. Tailoring the extent of the bone resection to the specific lesion being treated can help lower approach-related morbidity while maintaining its advantages. The authors describe the technical details of the supraorbital and subtemporal modified orbitozygomatic approaches and discuss the surgical indications for their use.

Modifications to the orbitozygomatic approach are an example of the ongoing adaptation of skull base procedures to general neurosurgical practice.

**KEY WORDS** • skull base surgery • surgical anatomy • orbitozygomatic approach • modified orbitozygomatic approach

SINCE the seminal description of the supraorbital craniotomy by Jane, et al.,<sup>17</sup> the orbitozygomatic craniotomy has evolved considerably.<sup>10,20,35</sup> As described by Pellerin, et al.,<sup>24</sup> and Hakuba, et al.,<sup>13</sup> the orbitozygomatic approach offers full exposure of the anterior and middle cranial fossae, basilar apex region, and upper clivus. The approach has been applied effectively to neoplastic and vascular lesions.<sup>14,16,19–21,23,24,28,30,35</sup> Compared with the traditional pterional/transsylvian approach, the orbitozygomatic approach offers several advantages, including a better operative trajectory with multidirectional access, a shallower surgical field, and less brain retraction through increased bone removal at the skull base. Nevertheless, potential complications are associated with this additional exposure.<sup>18,20,21</sup>

We use a modified orbitozygomatic craniotomy to fit the location and nature of lesions more precisely. Our goal is to minimize the risks associated with skull base exposure without sacrificing the advantages offered by the more extensive orbitozygomatic approach. We use two major modifications of the traditional orbitozygomatic craniotomy, including supraorbital and subtemporal variations. The supraorbital modification combines a pterional craniotomy with a supralateral orbitotomy to access lesions in the anterior and middle cranial fossae. The subtemporal modification unites a pterional craniotomy with mobilization of the zygomatic arch to expose the temporal fossa up to the tentorial edge. In this article we revisit previous surgical solutions and describe step-by-step instructions for the proposed modifications.

*Abbreviation used in this paper:* ACoA = anterior communicating artery.

## Patient Positioning and Scalp Flap Preparation

The patient is placed supine. Depending on the location of the lesion, the patient's head can be rotated 30 to 90° to the side contralateral to the surgical incision. The neck is extended toward the floor until the malar eminence is the highest point in the operative field. This maneuver facilitates retraction of the frontal lobe away from the orbital roof and skull base by gravity. The head is then rigidly fixed in position (Fig. 1). If required for the case, registration for frameless stereotaxy is then performed. Pressure points on the body are padded, and the patient is secured to the table so that the head position can be altered to optimize the surgical view. The angle of the microscope also can be manipulated for multidirectional viewing.

The field for the scalp incision is prepared with a minimal strip-shave behind the hairline. If desired, epinephrine is injected for local anesthesia. The incision is similar to that used for the pterional craniotomy, beginning 1 cm anterior to the tragus at the root of the zygomatic arch. The incision curves forward gently past the midline to where the hairline intersects the contralateral midpupillary line. This scalp flap fully exposes the frontotemporal area, the superior and lateral aspects of the orbit, the malar eminence, and the zygomatic root, thereby avoiding extensive traction on the frontalis branch of the facial nerve. The incision should not extend more than 1 cm below the zygomatic arch to avoid injury to the facial nerve branches.<sup>25</sup> If a contralateral procedure has already been performed or is anticipated, the two incisions may converge at the midline in a Sutar-type manner and be extended across the midline another 2 to 3 cm as necessary. During the scalp incision, the posterior branch of

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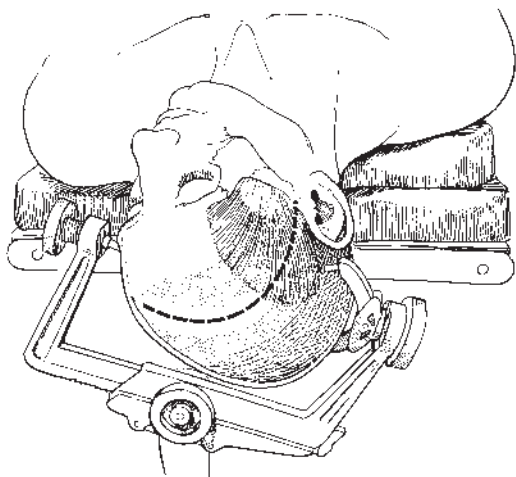


FIG. 1. Drawing showing the positioning of the patient's head and the scalp incision line for the modified orbitozygomatic approach. The incision crosses to the contralateral midpupillary line to gain wide exposure of the ipsilateral frontoorbital region. It also lessens retraction on the frontalis branch of the facial nerve within the scalp flap.

the superficial temporal artery can be preserved if there is any possibility that a microvascular bypass may be needed.

The scalp flap is partially elevated anteriorly from the underlying superficial temporalis fascia with blunt and sharp dissection. A construct of fishhooks and rubber bands suspended from the Leyla bar can facilitate retraction. Scalp elevation separate from the underlying temporalis fascia should be minimized to prevent creation of an anatomical dead space. It is also important to avoid extensive exposure of the subgaleal fat pad in the pterional region because the frontalis branch of the facial nerve travels in this plane. At the point where the fat pad is exposed, a subfascial or myofascial dissection should be performed to preserve the nerve.<sup>5,6,8</sup>

### *Supraorbital Modified Orbitozygomatic Craniotomy*

The frontal periosteum is elevated as a separate layer that is left attached along the brow ridge anteriorly. If a frontal sinus is entered, this vascularized periosteal graft is readily available for repair. For this modification, subfascial dissection of the temporalis fascia is unnecessary. Instead, when the subgaleal fat pad is exposed, the temporalis fascia, muscle, and periosteal flaps are elevated as one layer together with the scalp. This flap extends from the inferior aspect of the scalp incision up to and then parallel to the superior temporal line. A fascial cuff can be created to facilitate later reapproximation of the temporalis muscle layers.<sup>31</sup>

The supraorbital modification requires no exposure of the malar eminence and zygomatic root, so the frontalis branch of the facial nerve is protected. Still, traction injury to the nerve can occur if the scalp flap is retracted too vigorously. As described by Oikawa, et al.,<sup>22</sup> the subperiosteal plane is used to elevate the temporalis muscle from the underlying bone. To prevent atrophy of the temporalis muscle, electrocauterization should be minimized, especially low in the temporal region, which has a rich supply of nerves and blood vessels to the muscle. The muscle also is mobilized at the anatomical keyhole and over the lateral orbit to ex-

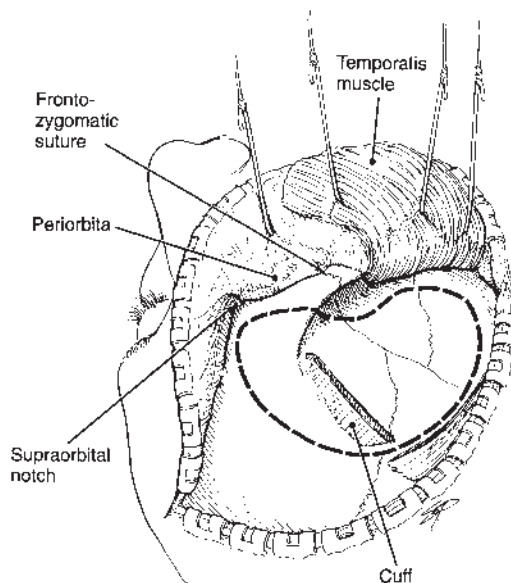


FIG. 2. Drawing showing exposure of the superolateral orbital rim with pertinent landmarks, including the supraorbital notch and frontozygomatic suture as limits for the orbital osteotomy. The pterional craniotomy is performed in the usual manner. A subfascial dissection is not required with the supraorbital modification of the orbitozygomatic osteotomy. Instead, the dissection remains subperiosteal over the lateral orbit until the suture is exposed. The myofascial cuff at the temporalis line is used for later reattachment of those layers.

pose 5 mm lateral to the frontozygomatic suture. Dissection must remain in the subperiosteal plane over the lateral orbit to prevent injury to distal branches of the frontalis nerve. The mobilized myofascial flap is then retracted inferiorly.

The periorbita must be freed along the supralateral orbit. Typically, the limits of exposure include the supraorbital notch medially and the frontozygomatic suture laterally. If a more medial orbitotomy is required, the supraorbital nerve can be mobilized from its foraminal notch and retracted with the scalp. The periorbital dissection is best initiated near the lacrimal gland, just medial to the frontozygomatic suture. The periorbita is attached to the bone suture, and once freed at this point, a plane is defined for further dissection. The dissection proceeds in this plane by using a blunt probe such as a Penfield No. 1, sweeping from the inferior orbital fissure laterally to the supraorbital notch medially (Fig. 2). Medially, the trochlear sling insertion must not be disrupted. The depth of dissection is seldom more than 2 to 3 cm. Violation of the periorbita is revealed by the presence of yellow periorbital fat, which can sometimes be confused with the pinkish-tan, laterally located lacrimal gland. Disruption of the periorbita leads to increased periorbital edema and bruising and may increase the risk of enophthalmos. As the periorbita is freed, the scalp flap can be retracted farther to enhance the exposure of the orbital rim.

The supraorbital modified orbitozygomatic craniotomy can be performed using a one- or two-piece method; both have been applied to the full exposure. We have modified our procedure from that described by Zabramski, et al.,<sup>35</sup> by using a two-piece method. The one-piece supraorbital modification to the orbitozygomatic craniotomy is also described.<sup>9</sup>

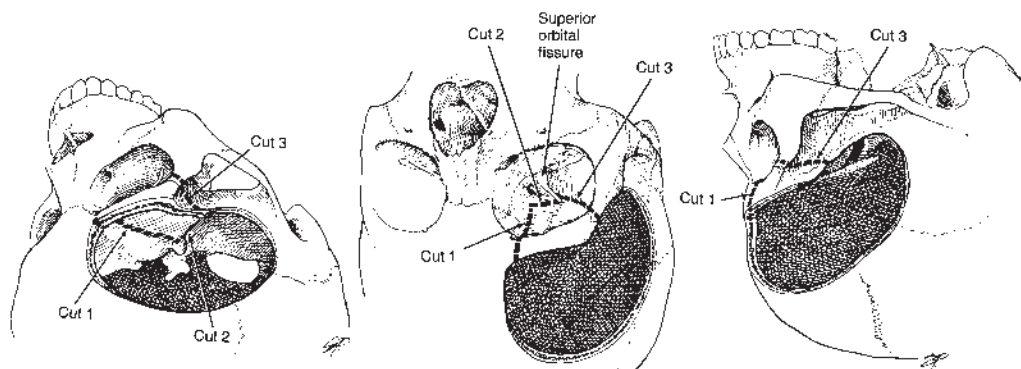


FIG. 3. Three drawings showing the location and angles of the three cuts required to produce the orbital osteotomy. In this example, a two-piece method is illustrated; the pterional craniotomy was performed previously.

### Two-Piece Method

A pterional craniotomy is performed in the usual fashion with a high-speed pneumatic drill. We usually place a small burr hole in the low temporal bone and one in the frontal bone at the pterion. Ideally, the latter burr hole should span the intracranial and orbital compartments, separated by the orbital roof. If necessary to prevent the dura from tearing, more burr holes can be placed along the anticipated edge of the bone flap. The craniotomy is completed using the foot-plate attachment. The size of the pterional craniotomy is tailored to the needed surgical exposure. For lesions in the anterior fossa, the bone flap can be extended anteriorly and medially. When a far frontal bone flap or orbital osteotomy is created, the frontal sinus can be violated. At the end of the procedure, a multilayer repair can be made using a muscle plug, fibrin glue, and a vascularized periosteal flap. For hemostasis, tack-up stitches are placed around the periphery, except over the anterolateral orbit where the dura mater must be freed from the bone to facilitate the orbital osteotomy.

A reciprocating saw is used to make the skull base cuts

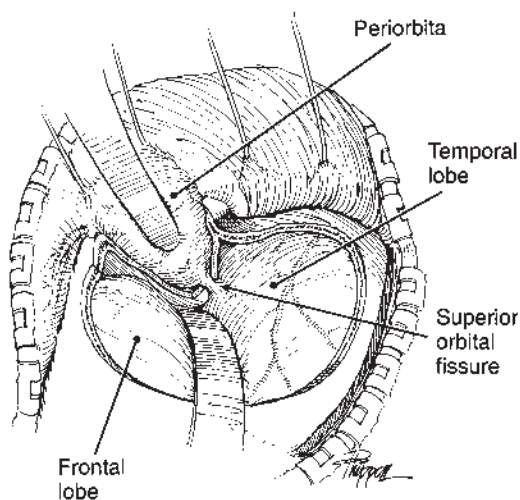


FIG. 4. Drawing showing exposure of the superior orbital fissure and periorbita after removal of the bone flap from the pterional craniotomy and orbital osteotomy. Sometimes, the small "napkin-ring" of bone around the fissure must be removed with rongeurs rather than with the osteotome.

(Fig. 3). In preparation for these cuts, the dura must be dissected from the floor of the frontal fossa, the sphenoidal ridge, and the anterior temporal fossa. The orbital contents, dura, and brain must be protected when the orbital osteotomies are made. Malleable retractors are useful in the orbits and cranial vault. Alternatively, Telfa strips can be placed between the periorbita and orbital roof. The rapidly vibrating saw must not contact the brain or dura because traumatic injury is possible even if the dura is not violated.

Three cuts will remove a wedge-shaped piece of bone that composes the supralateral orbit. The first osteotomy begins over the orbital rim at the medial edge of the pterional craniotomy, usually just lateral to the supraorbital notch. It extends perpendicularly from the orbital rim back over the orbital roof approximately 3 cm. A second cut proceeds from the most posterior aspect of the first cut, perpendicularly toward the superior orbital fissure. Sufficient retraction of the frontal lobe to allow the reciprocating saw to reach the superior orbital fissure safely may not be possible. In such cases, the residual bone can be removed with rongeurs once the orbitotomy is completed. The last cut extends perpendicularly from the orbital rim, just lateral to the frontozygomatic suture, and toward the superior orbital fissure. This last cut should involve only the lateral orbit; it should not place the brain at risk. If the bone fails to mobilize, a hand-held osteotome can be used with a mallet to complete any of the cuts. Alternatively, the high-speed drill can be used to remove any remaining islands of bone. The bone is then removed after remaining soft tissue attachments have been freed.

Depending on the extent of the supralateral orbitotomy, additional bone may have to be resected. Removing the roof and lateral wall of the orbit back to the superior orbital fissure is critical to take advantage of the low trajectory offered by the orbitozygomatic approach (Fig. 4). If necessary, this resection is best accomplished with rongeurs or a high-speed drill. Likewise, bone remaining along the medial aspect of the orbital roof can be resected after the bone freed by the osteotomy has been removed. Including as much of the superior and lateral orbital walls as possible with the initial orbitotomy, however, is preferred and should help prevent enophthalmos even if the periorbita is violated.<sup>35</sup>

The dura is opened with an inferiorly based flap. Tack-up stitches are placed along the edges of the dural flap. Additional dural sutures are placed more deeply over the medial

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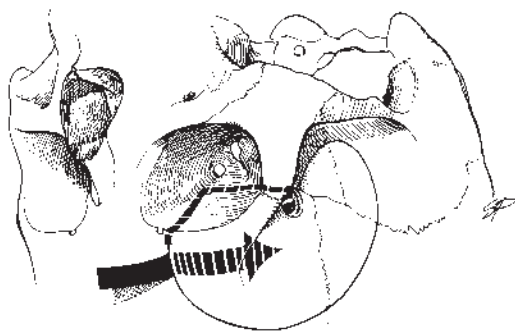


FIG. 5. Drawing showing the craniotomy and orbital cuts required for the one-piece method. Ideally, a burr hole should be placed near the anatomical keyhole to span the intracranial and orbital compartments. The bone flap must be raised medially to laterally (arrow) to avoid driving the orbital roof into the frontal lobe.

surface of the flap gently to retract the periorbital contents inferiorly and laterally. This last maneuver can provide as much as an additional centimeter of skull base exposure, especially if the periorbita has been violated. Maintaining an intact dura over the orbital roof greatly facilitates the approach.

### *One-Piece Method*

The one-piece method combines the pterional craniotomy with the orbitotomy into one bone flap in a manner similar to the supraorbital craniotomy described by Delashaw, et al.<sup>9</sup> Preparation is similar to that described earlier. The pterional craniotomy is created with the high-speed pneumatic drill and footplate attachment. In this method, however, the drilling stops at the orbital rim just lateral to the supraorbital notch, and again at the pterion from below. An island of bone remains between the supralateral orbital rim and the pterional bone flap. Because the intracranial compartment has not yet been opened, the orbitotomy cuts must proceed from the orbital rim and be made within the orbit.

Two major cuts are made with the reciprocating saw. The first extends through the orbital rim just lateral to the supraorbital notch and connects to the pterional craniotomy. The reciprocating saw must not be allowed to cut past the orbital roof into the brain. It is seldom necessary to extend the cut very far posteriorly over the frontal floor. Instead, an osteotome and mallet can be used to fracture the bone. Twisting of the seated osteotome extends a fracture laterally toward the superior orbital fissure. The second cut proceeds over the orbital rim, just lateral to the frontozygomatic suture, back toward the burr hole at the anatomical keyhole. The entire cut should be made over the lateral orbital wall and should remain extracranial. Again, the osteotome can be used to extend fractures along the osteotomy lines to connect the cuts, especially at the pterion. Ultimately, this technique relies on blind fracture of the orbital roof.

Once all bone connections have been severed and the one-piece flap moves freely on the dura, it can be mobilized (Fig. 5). The flap must be elevated from the dura, proceeding medially to laterally. If the bone flap is elevated posteriorly to anteriorly, the mobilized orbital roof can be driven into the inferior frontal lobe. If mobilization of the bone flap is difficult, we recommend conversion to a two-piece procedure by using the high-speed drill with footplate attach-

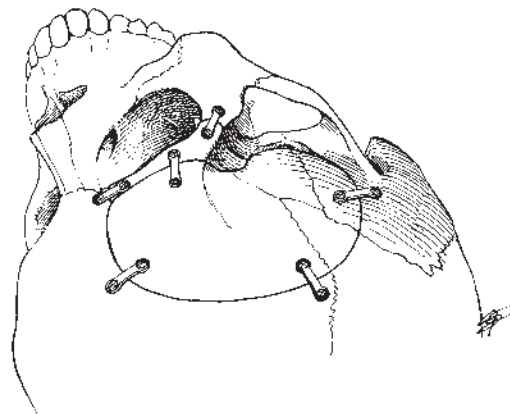


FIG. 6. Drawing showing replacement of the bone removed during orbital osteotomy and pterional craniotomy; miniplates and screws are used to reattach it.

ment to cut behind the orbital rim, between the burr holes. Additional bone often must be removed around the superior orbital fissure, as described earlier. The one-piece method is less predictable in terms of osteotomy placement and preservation of the orbital wall and roof.

We do not advocate using the one-piece method for patients with tumors of the sphenoid ridge, for elderly patients in whom the dura is very adherent to the bone, or for patients in whom thickened orbital roofs and walls are observed on preoperative studies. In infants and very young children, the malleable bone may break along suture lines rather than where intended.

### *Surgical Closure*

When the procedure is completed, the dura is closed in a watertight manner and any violations of the frontal sinus are repaired. The bone is replaced and fastened with miniplates and screws. We prefer low-profile instrumentation, especially over the orbital rim. Two miniplates secure the bone removed by osteotomy at its medial and lateral edges over the orbital rim. To prevent the construct from twisting, an additional plate can be used to affix the midorbital rim to the pterional bone flap once it has been replaced with plates and screws (Fig. 6). Care must be taken to align all bone flaps anatomically to obtain the best cosmetic results. Orbital reconstruction is seldom required because the orbital roof and lateral wall are replaced with the bone removed at osteotomy. The myofascial temporalis flap is reapproximated, with special attention given to the keyhole region where atrophy of the temporalis muscle can be most disfiguring. The scalp is closed in multiple layers.

### *Subtemporal Modified Orbitozygomatic Craniotomy*

The subtemporal modification to the orbitozygomatic craniotomy involves many of the methods of preparation and exposure that have been described for the supraorbital modification. Notably different are the need for a subfascial dissection of the temporalis fascia and omission of the periorbital dissection with orbital rim exposure. The following description refers to the section detailing the supraorbital modification when similar steps are required.

For this modification the frontalis branch of the facial nerve must be protected. After the scalp flap has been par-

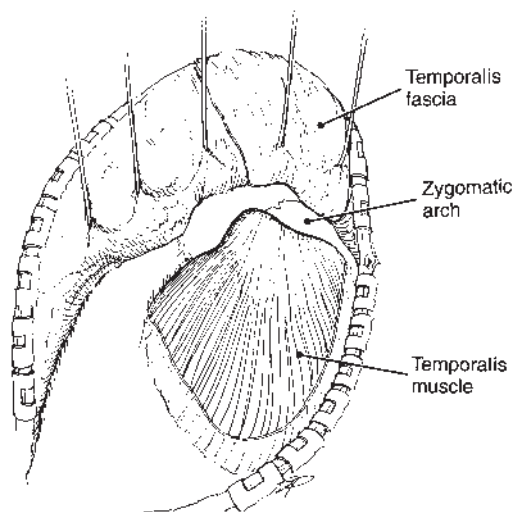


FIG. 7. Drawing showing elevation of the temporalis fascia from the underlying muscle as a separate layer. This helps to protect the frontal branch of the facial nerve, which runs in the fat pad between the scalp and fascia. Exposure from the root of the zygoma to the maxillary eminence is sufficient to mobilize the zygoma.

tially mobilized, a subfascial technique is used.<sup>35</sup> We do not use the interfascial dissection described by Yaşargil, et al.,<sup>34</sup> because it may not protect the nerve as effectively as a subfascial technique.<sup>5,6,8</sup> The temporalis fascia is cut along the inferior scalp incision and the cut is continued 1 cm under the superior temporal line to create a fascial cuff for later approximation. Alternatively, the fascia can be incised in a semicircular arc just above the subgaleal fat pad. The fascia is elevated from the underlying temporalis muscle toward the zygomatic arch and malar eminence by using blunt and sharp dissection. At the fascia–bone interface, the temporalis fascia fuses with the periosteum. The dissection proceeds over the zygomatic arch and malar eminence in the subperiosteal plane (Fig. 7). The exposure then proceeds anteriorly to the maxillary eminence. The mobilized fascia is then retracted while the temporalis muscle is elevated, as described earlier.

#### *Craniotomy With Zygomatic Osteotomy*

This modification is performed in two pieces. The pterional craniotomy is performed. In the low temporal region, special care is taken to include as much bone as possible with the bone flap. The purpose of this modification is to enhance subtemporal exposure to the middle fossa and tentorial edge. Consequently, temporal bone must be removed with rongeurs or the high-speed drill until the exposure is flat with the floor of the middle fossa. Even after this bone resection, the temporalis muscle lying over the zygomatic arch precludes a low trajectory to the temporal fossa. The zygomatic osteotomy addresses this problem.

With the temporalis muscle released from retraction, the zygomatic arch is exposed. Two cuts are made with the reciprocating saw (Fig. 8). The first cut is beveled through the root of the zygoma. This oblique osteotomy lessens the prominence of the zygomatic root while directing the cut away from the glenoid fossa and mandibular joint; painful mastication can result if these structures are violated. The cut also provides a wide and stable base for fixation. The

second cut extends through the zygomatic arch just anterior to the zygomaticotemporal suture at the malar eminence. This osteotomy parallels the angle of the superior zygomatic arch. There is no need to dissect the bone from the underlying muscles. Preservation of the tendinous insertions of the masseter muscle is preferred to help speed recovery of normal mastication. The bone arch and temporalis muscle can be retracted together through the resulting gap to obtain a lower trajectory and shallower depth of field to the temporal region.

#### *Surgical Closure*

After the dura is closed and the pterional bone flap is replaced, the zygomatic arch must be secured to the skull base. We use low-profile miniplates and screws to secure the bone to the skull base. The zygomaticotemporal suture is easily fractured while manipulating the bone removed during the osteotomy. If this happens, an additional plate may be required. Care also must be exerted when securing the arch at the zygomatic root. If the screw is too long, it may penetrate the mandibular joint; a 4-mm-long screw is usually sufficient.

The temporalis muscle and fascia are closed in successive, separate layers. The fascia covers the reconstruction of the zygomatic arch while the muscle lies beneath it. The scalp is closed in multiple layers. No further reconstruction should be needed to achieve excellent cosmesis.

#### **Discussion**

Skull base procedures have revolutionized neurosurgery. An essential tenet of skull base surgery is that improved operative exposure and reduced brain retraction can be achieved through increased bone resection. Nevertheless, the increased exposure provided by these approaches comes at the expense of a greater risk of cosmetic deformity and other complications.<sup>18,20,21,35</sup> Tailoring the extent of bone removal to the exact exposure needed for a particular lesion can help reduce these risks while maintaining the advantages of the skull base approach. The modifications to the orbitozygomatic approach described here are an example of adapting skull base procedures to general neurosurgery practice.

The first stages in the development of the orbitozygomatic approach can be traced to a method for a supraorbital craniotomy presented by Jane, et al.<sup>17</sup> Subsequent additions by other authors modified the approach to its current form.<sup>1,3,10,13,20,24,35</sup> Al-Mefty<sup>1</sup> combined a pterional craniotomy and superolateral orbitotomy in a one-piece procedure. Pellerin, et al.,<sup>24</sup> described an orbitofrontal craniotomy with extensive removal of the lateral orbit, malar eminence, and malar arch in patients with sphenoid wing meningiomas. The resective nature of the procedure combined with the destructive effects of the tumor necessitated reconstruction of the orbit, temporal roof, pterion, and frontomalar bone. The orbitozygomatic–infratemporal approach reported by Hakuba, et al.,<sup>13</sup> provided similar exposure but preserved much of the skull base with the three required bone flaps. Delashaw, et al.,<sup>10</sup> modified this approach, describing a one-piece craniotomy that includes the orbital roof and separate removal of the zygomatic arch. Alaywan and Sindou<sup>3</sup> and McDermott, et al.,<sup>20</sup> described a pterional craniotomy combined with an

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orbitozygomatic osteotomy. We perform the full orbitozygomatic craniotomy as described by Zabramski, et al.<sup>35</sup> This method combines subfascial dissection with a unique series of orbital cuts that provide the widest possible exposure while minimizing bone loss and the subsequent risks of cosmetic deformity.

The efficacy of the approach for particular lesions has been examined in numerous studies. The original descriptions of the approach were mostly applied to skull base tumors, especially those involving the sphenoid wing and orbit.<sup>10,13,17,19,20,24</sup> The orbitozygomatic approach has also been used to treat aneurysms, particularly those involving the ACoA complex and basilar apex.<sup>13,14,16,21,23,28,30</sup>

The increased skull base exposure offered by the full orbitozygomatic approach has been quantified in several cadaveric studies.<sup>3,12,15,27</sup> Honeybul, et al.,<sup>15</sup> found that the surgical window increased as much as 300% for basilar apex targets. They also quantified a shallower depth of field of 2 to 3 cm. Alaywan and Sindou<sup>3</sup> noted improved surgical field angles. Schwartz, et al.,<sup>27</sup> described significant improvements in surgical exposure with the orbital osteotomy; zygomatic arch removal had a more variable effect. Gonzalez, et al.,<sup>12</sup> found that both the angle of attack and the working area were significantly increased with the orbitozygomatic approach compared with the pterional.

The supraorbital modification is best applied to lesions of the anterior fossa, middle fossa, and proximal sella. In this respect, the modification preserves the improved, lower skull base trajectory and shallow depth of field to these lesions. Brain retraction is also minimized because more working space is available when the orbital roof and lateral wall are removed. The same modification also improves access to the sphenoid wing and middle fossa compared with a simple frontal orbitotomy.<sup>29</sup> The subtemporal exposure offered by the full orbitozygomatic craniotomy is seldom needed for lesions in these locations.

An excellent example of the benefits of this modification is found with ACoA aneurysms. Extensive opening of the sylvian fissure is often required to allow complete relaxation and retraction of the frontal lobe to obtain full visualization of the ACoA complex. Removal of the orbital roof allows a subfrontal approach to the area with minimal opening of the proximal sylvian fissure and opticocarotid cisterns. With this modified approach, the use of brain retractors can often be avoided and resection of the gyrus rectus can be minimized.

We have also used the supraorbital modification to treat sellar lesions, including internal carotid artery segment aneurysms and sellar tumors. Access to the posterior fossa and basilar region usually requires the full orbitozygomatic approach. In these instances the sylvian fissure must be opened widely to mobilize the temporal lobe and to reveal the caroticoophthalmic window to the basilar apex. Likewise, lesions along the tentorial edge require temporal lobe mobilization and are best exposed with a full orbitozygomatic approach or a subtemporal modification.

The subtemporal modification arose from the need to obtain greater exposure of the subtemporal middle fossa. Numerous authors have addressed this problem.<sup>2,4,7,11,26,32</sup> Removal of temporal bone until it is flat with the middle fossa floor provides excellent lateral visualization. Gaining exposure to the cavernous sinus or tentorial edge requires upward retraction of the temporal lobe. Intradurally, this re-

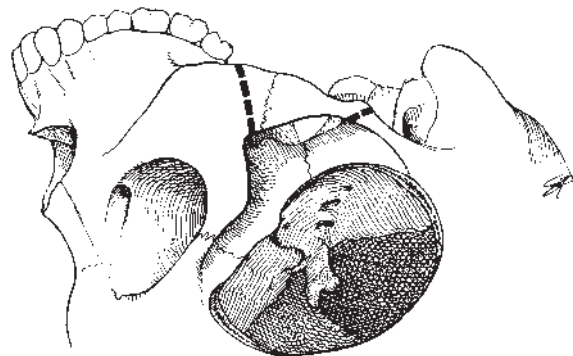


FIG. 8. Drawing showing the cuts through the root of the zygoma and at the posterior aspect of the maxillary eminence, which allow the zygoma to be mobilized and retracted through the opening, along with the temporalis muscle. The pterional craniotomy is performed as a separate step.

traction is limited by brain turgor, risk of retraction injury, and the possibility of damage to the vein of Labbé. A lower trajectory for the surgical approach is prevented by the prominence of the temporalis muscle draped over the zygomatic arch. This problem is addressed by performing zygomatic osteotomies and displacing the zygomatic arch with the attached muscle inferiorly to allow a lower angle of attack that parallels the floor of the middle fossa. Preservation of the masseter muscle attachments along the medial surface of the zygomatic arch maintains the blood supply to the arch and helps speed recovery of normal mastication. This modification is most usefully applied to lesions of the anterior temporal fossa, up to the tentorial edge. Cavernous sinus lesions might also be included; however, if access to the intracranial internal carotid artery is needed, we recommend the full orbitozygomatic approach. Lesions that extend from the middle fossa into the sellar region also tend to require the full approach. The subtemporal modification, although less often used, can provide critical exposure in select lesions of the temporal fossa.

The modifications to the orbitozygomatic approach described here are an amalgamation of the best aspects of previously described procedures tailored to fit specific needs. For example, Yaşargil, et al.,<sup>33</sup> first used a separate orbital osteotomy with a frontal craniotomy to access ACoA aneurysms. Our supraorbital osteotomy is very similar to those reported by Al-Mefty<sup>1</sup> and Delashaw, et al.,<sup>9</sup> except that we prefer to use a two-piece method that relies on a full pterional craniotomy with separate orbital osteotomies to remove the orbital roof, rather than attempting to fracture the roof of the orbit in situ.

Various forms of the subtemporal modification have also been described previously.<sup>2,4,7,11,26,32</sup> Our modification most closely resembles that described by Fujitsu and Kuwabara.<sup>11</sup> They, however, included no formal discussion of preserving the frontal branch of the facial nerve, nor was a myofascial cuff prepared for reattachment of the temporalis muscle and fascia. We also use a less extensive pterional-type rather than a bicoronal incision. Al-Mefty and Anand<sup>2</sup> performed a zygomectomy to expose and transect the coronoid process so that the temporalis muscle could be reflected upward. This method risks unnecessary exposure of the facial nerve and temporomandibular joint. Uttley, et al.,<sup>32</sup> also used a more extensive zygomectomy that incorporated the

malar eminence and part of the lateral orbit. Our method emphasizes a pterional craniotomy with enhanced subtemporal exposure by improved temporalis muscle retraction through the zygomectomy. Naturally, preservation of the frontalis branch of the facial nerve is essential for a good cosmetic outcome.

### Conclusions

The orbitozygomatic approach is a workhorse skull base approach for accessing the anterior and middle cranial fossae as well as the deep sellar and basilar apex regions. By increasing the extent of bone removal from the skull base, the approach offers an improved, multiangle trajectory, a shallower depth of field, and decreased brain retraction. The extensive exposure is not always warranted for specific lesions, which, nevertheless, benefit from certain aspects of the approach. The supraorbital and subtemporal osteotomies maximize exposure while minimizing the extent of bone resection. These benefits may lower approach-related morbidity, although no series have been analyzed.

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