Cranio-orbitozygomatic Approach and Its Orbitopterional Modification: Microsurgical Anatomy and Surgical Technique

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ABSTRACT

OBJECTIVE: The cranio-orbitozygomatic (COZ) approach improves the surgical exposure by providing the shortest possible route to the lesion. We discussed the microsurgical anatomy of the region and described the steps for a safe COZ approach.

METHODS: The COZ approach and its modifications were performed in 21 cases between November 2004 - December 2005 for lesions involving the skull base and brainstem. We analyzed each of the operative procedures retrospectively and discussed the technical difficulties in the light of the microsurgical anatomy of the region.

RESULTS: The two-piece COZ approach provides the removal of a considerable amount of orbital roof and lateral wall and the craniotomy can safely be extended into the superolateral border of the superior orbital fissure. The sequences of the orbital and zygomatic osteotomies can be standardized regardless of the exposure of the inferior orbital fissure, which depends on the distance between its anterolateral edge and the frontozygomatic suture. The orbitopterional modification of the COZ, in which the removal of the zygoma is omitted, can be used when the lesion is located primarily anteriorly and when the subtemporal approach is unnecessary.

CONCLUSIONS: The technical difficulties and complications related to the COZ approach can be minimized by understanding the regional microsurgical anatomy in relation to the orbital and zygomatic osteotomies, all of which should be performed in a rational fashion.

KEY WORDS: approach, microsurgical anatomy, orbitozygomatic, skull base, tumor,

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INTRODUCTION

The cranio-orbitozygomatic (COZ) approach recently became one of the most frequently employed skull base exposures in the neurosurgical armamentarium (1-5, 7-15, 17-25, 28). The approach increases the operative angles and the amount of working space through a full exposure of the anterior and middle cranial fossae (10). The COZ approach also improves the surgical exposure with a multidirectional view by providing the shortest possible route to the lesion. Less brain retraction resulting from the increased bone removal at the skull base is the hallmark of the approach.

The main variations of the approach include the one-piece and the two-piece COZ craniotomies, and an orbitopterional (OPT)

modification that contains removal of the orbital roof, alone (14). The complications related to the COZ approach can only be minimized by understanding the relationship between the orbital and zygomatic osteotomies and the surrounding anatomical structures. Utilizing the work of pioneering authors, we have reviewed the microsurgical anatomy of the region and presented the technique for the two-piece COZ and the OPT approaches in a stepwise manner. Our aim was to describe the most appropriate sequence of the dissections and the skull base cuts of the approach and to delineate the technical difficulties.

MATERIALS AND METHODS

Eleven two-piece COZ and 10 OPT approaches were performed between November 2004 - December 2005 for lesions involving the skull base and brainstem. Each of the approaches were retrospectively analyzed and the technical difficulties were reported accordingly.

RESULTS

Stepwise Description of the Approaches

Position, incision, and dissection of the Temporalis Muscle. The patient is placed supine and the head is rotated between 30 and 60 degrees to the opposite side of the incision depending on the location of the lesion. The head is also extended 10° degrees in relation to the floor, placing the sylvian fissure perpendicular to the surgeon's visual line (Figür 1A).
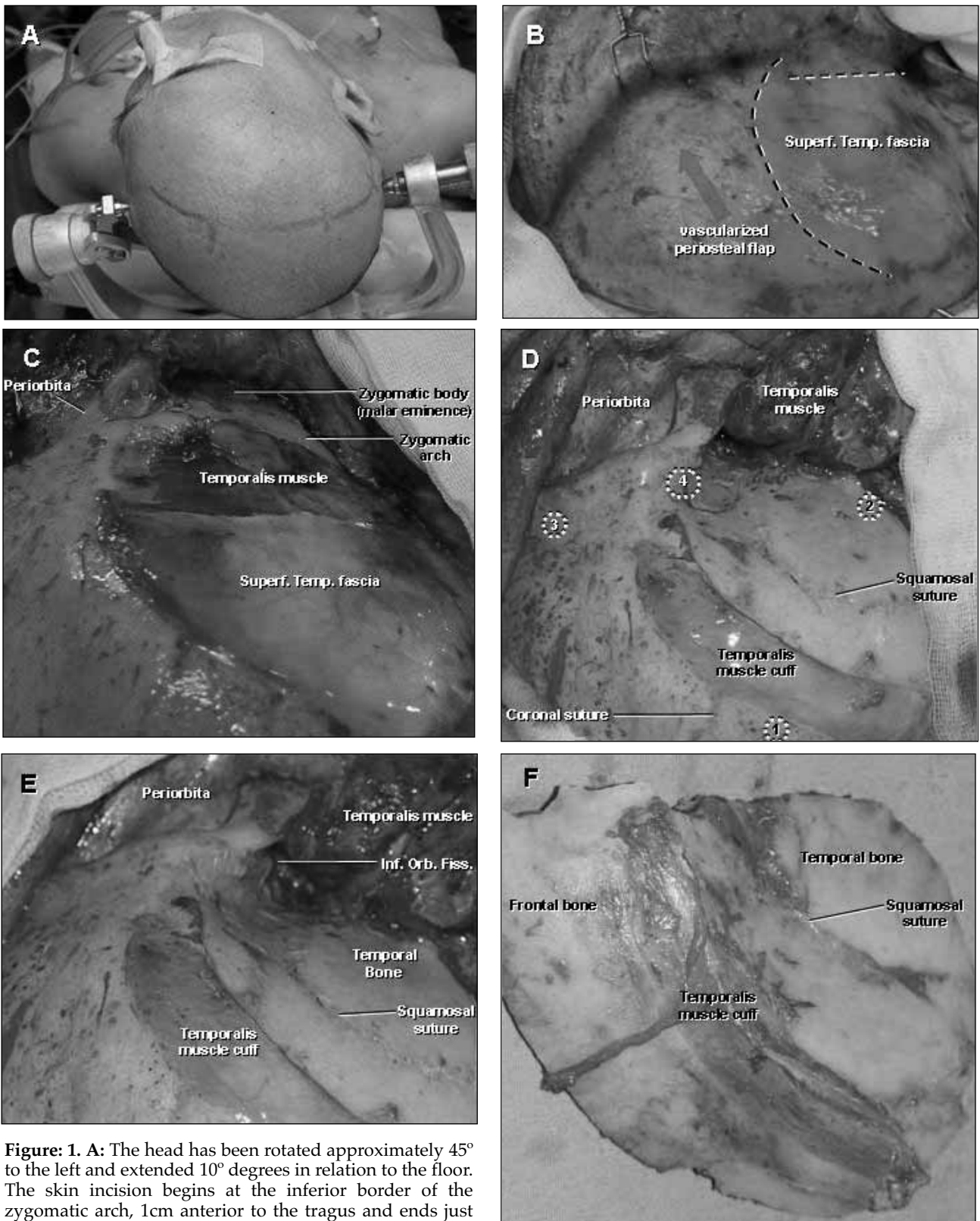
The frontotemporal skin incision begins at the inferior border of the zygomatic arch, 1cm anterior to the tragus, then proceeds posterosuperiorly and curves anteriorly to end just behind the site where the hairline intersects the contralateral midpupillary line (Figür 1A). To preserve the plane of dissection, we prefer the subfascial dissection of the temporalis muscle to minimize the risk of injury to the frontotemporal branches of the facial nerve that innervates the orbicularis oculi, corrugator supercilii and frontalis muscles on the forehead. The incision is confined to the galea and does not penetrate the temporalis fascia. As the flap is elevated, the upper edge of the temporal fat pad lying above the zygoma comes into view. The fat pad overlies the temporal fascia and contains the frontotemporal branches of the facial nerve (Figür 1B). At the upper edge of the fat pad, an incision is made through the superficial and deep layers of the temporalis fascia that extends

into the temporalis muscle. This allows the fat pad and the underlying temporalis fascia to be reflected as a single layer with the scalp flap to protect the branches of the facial nerve (Figür 1C). The superficial fascia of the temporalis muscle attaches to the lateral side of the zygoma and the lateral orbital rim and the deep fascia of the temporalis muscle inserts onto the medial side of the zygoma as well as the lateral orbital rim (27). Staying above the layer of the temporalis muscle allows for the exposure of the supraorbital rim, lateral orbital rim, and the entire zygomatic process (Figür 1C).

The fat pad, a critical anatomical landmark during the subfascial and interfascial dissections of the temporalis muscle, is located above, below and between the two fascial layers which may complicate determining the true location of the frontotemporal branches of the facial nerve. However, the branches of the facial nerve are consistently found within the fat pad that is located above the superficial and deep layers of the temporalis fascia (Figür 1C). The remaining parts of the temporalis fascia is freed from its attachments to the frontal and zygomatic processes of the zygomatic and frontal bones, respectively. In the frontal region, it is necessary to preserve the base of the pericranium and elevate it separately from the scalp flap in order to obtain a vascularized pericranial flap medial to the superior temporal line (Figür 1B).

An alternative way of preserving the frontotemporal branches of the fascial nerve is interfascial dissection (27), in which a fascial incision is carried only through the superficial temporalis fascia. Only the superficial fascia of the temporalis muscle is elevated off the deep fascia and the temporal muscle and reflected forward with the skin flap (Figür 3).

During the elevation of the temporalis muscle, a cuff of temporalis fascia is preserved along the superior temporal line which aids in anchoring the temporal muscle at the time of closure (Figür 1D). The temporalis muscle is elevated from the bone caudally-to-rostrally by using periosteal elevators. The temporalis muscle is then reflected inferiorly and posteriorly towards the posterior portion of the zygomatic arch (Figür 1D). This retrograde dissection permits the muscle to be elevated off the bone along its normal anatomical plane minimizing trauma to deep arterial feeders from the deep

Figure: 1. A: The head has been rotated approximately 45° to the left and extended 10° degrees in relation to the floor. The skin incision begins at the inferior border of the zygomatic arch, 1cm anterior to the tragus and ends just behind the site where the hairline intersects the contralateral midpupillary line. **B:** The incision has been confined to the galea and did not penetrate the temporalis fascia. At the upper edge of the fat pad, which contains the frontotemporal branches of the facial nerve, an incision will be performed through the superficial and deep layers of the temporalis fascia that extends into the temporalis

muscle (*straight dashed line*). In the frontal region, an incision along the superior temporal line (*curved dashed line*) will provide a vascularized pericranial flap. **C:** The fat pad and the underlying temporalis fascia has been reflected as a single layer with the scalp flap to protect the branches of the facial nerve. Staying above the layer of the temporalis muscle made it possible for the exposure of the supraorbital rim, lateral orbital rim, and the entire zygomatic process, along with part of the malar eminence. **D:** A cuff of temporalis fascia has been preserved along the superior temporal line which aids in anchoring the temporal muscle at the time of closure. The temporalis muscle has been elevated and then reflected posteroinferiorly towards the posterior portion of the zygomatic arch. The location and the sequence of burr holes for the initial frontotemporal craniotomy on the right side have been shown. **E:** Following the elevation of the temporalis muscle, the inferior orbital fissure, an important anatomical landmark when performing an COZ approach, has been defined along the lateral wall of the orbit. The separation of the periorbita bluntly from the roof of the orbit eventually ends up in the identification of the inferior orbital fissure in most of the cases. **F:** The initial part of the two-piece COZ approach, the frontotemporal craniotomy, has been completed on the right side and the bone flap includes a mucle cuff along the superior temporal line.

temporal artery and may minimize future atrophy of the muscle (16).

Following the elevation of the temporalis muscle, the inferior orbital fissure, an important anatomical landmark when performing an COZ approach, can usually be defined inferiorly along the lateral wall of the orbit (Figür 1E). The inferior orbital fissure lies between the lateral wall and the floor of the orbit and is bordered above by the greater wing of sphenoid, below by the maxilla, and laterally by the zygomatic bone or the zygomaticomaxillary suture. The fissure transmits the infraorbital branches of the maxillary artery and the nerve. However, the most frequently encountered part of the fissure during the COZ approach, the anterolateral part, is always devoid of these anatomical structures. Surprisingly, the anterolateral end of the inferior orbital fissure was hidden below the temporalis muscle under the body of the zygoma in 3 of our cases and the fissure could not be viewed or palpated prior to orbital and zygomatic osteotomies.

The separation of the periorbita bluntly from the roof of the orbit eventually ends up in the identification of the inferior orbital fissure in most of the cases. The periorbital separation is easier when performed in a lateral to medial direction. It begins laterally on the orbital roof near the lacrimal gland and sweeps from the inferior orbital fissure laterally to the lateral edge of the supraorbital notch medially (Figür 1E). The periorbita is continuous with the frontal periosteum and preserving the base of the frontal periosteum during scalp elevation is helpful in defining the periorbital plane and keeping the periorbita intact during its separation from the roof and lateral wall of the orbit.

Two-piece COZ Approach. The two-piece OZ craniotomy combines the pterional craniotomy with a supraorbital osteotomy and removal of a portion of the zygoma. We prefer the two-piece OZ craniotomy as described by Zabramski et al (28). The pterional craniotomy is performed using the footplate attachment (Medtronic Midas Rex Legend EHS, Fort Worth, TX) (Figür 1F). The bone flap is elevated and the remainder of the temporal squama is removed to the level of the floor of the middle fossa with the aid of rongeurs and the high-speed drill. In preparation for the skull base cuts of the two-piece OZ craniotomy, the dura is initially dissected from the frontal bone medially, followed by the sphenoid ridge and, finally, the middle fossa. The sphenoidal ridge is drilled away with a 4 mm round cutting drill until the temporal dura near the junction of the roof and the lateral wall of the orbit is reached (Figür 2A). The temporal dura and recurrent meningeal branch of the ophthalmic artery are identified at the lateral edge of the superior orbital fissure.

The skull base cuts of the two-piece OZ craniotomy begins medially along the orbital roof and the previously freed periorbita should be protected with retractors during the sequence of these cuts. The first osteotomy divides the superior orbital rim and the roof. The cut begins along the orbital roof just lateral to the supraorbital notch and is angled toward the superolateral edge of the superior orbital fissure (Figür 2B). The next cut frees the lateral orbital wall by connecting the posterolateral end of the initial osteotomy and the anterolateral part of the inferior orbital fissure, which can usually be visualized or palpated with a spatula (Figür 2B). In those cases where the inferior orbital fissure can not be visualized, this cut extends beneath the junction of the frontal and temporal processes of the zygomatic bone about one centimeter.
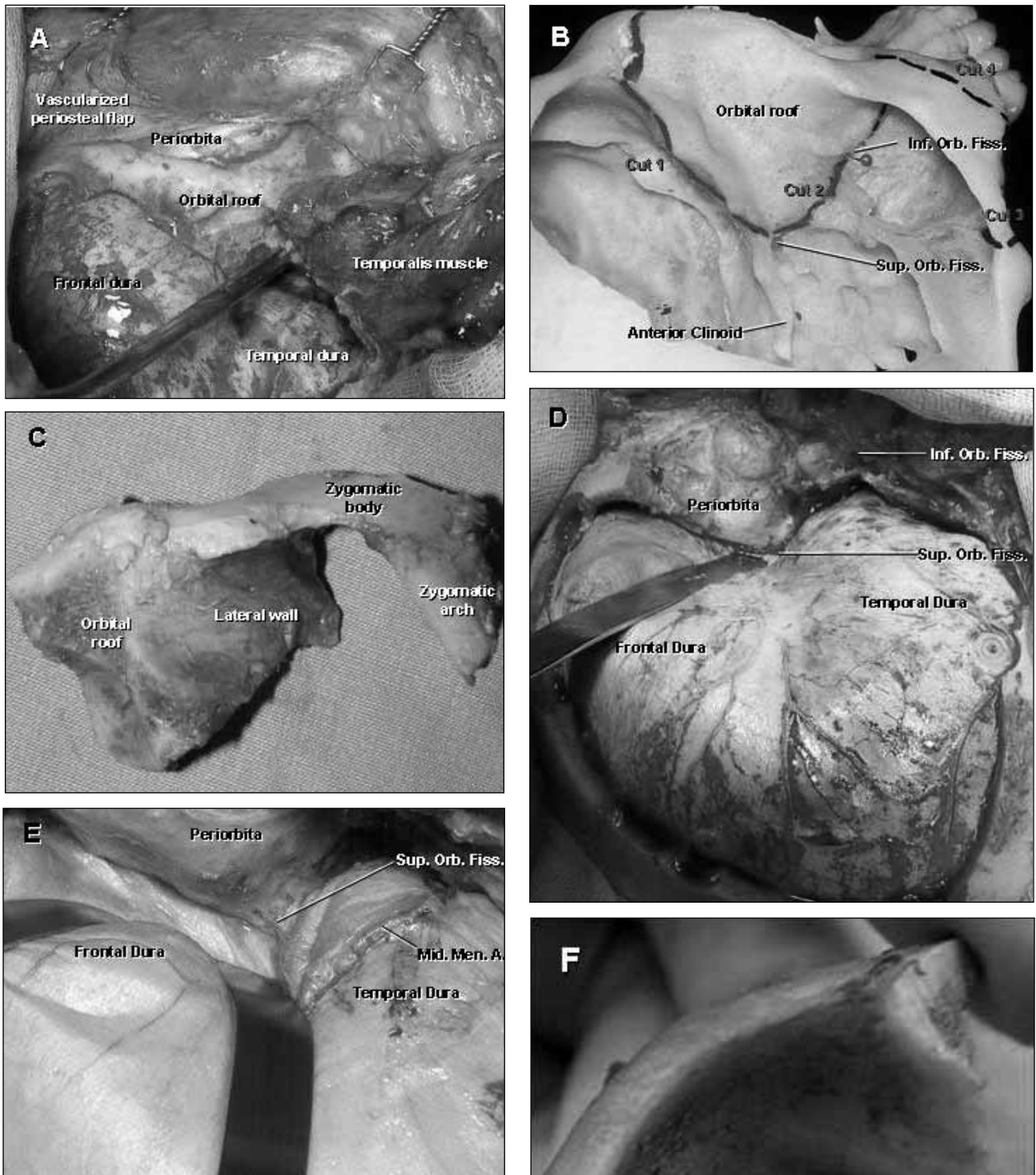
Figure 2A: The frontotemporal craniotomy has been completed on the right side. **B:** Four skull base cuts of the two-piece OZ craniotomy have been shown on a skull, following a right frontotemporal craniotomy. The first osteotomy divides the superior orbital rim and the roof (*cut 1*). The next cut frees the lateral orbital wall by connecting the posterolateral end of the initial osteotomy and the anterolateral part of the inferior orbital fissure (*cut 2*). The third cut is made across the anterior root of

zygomatic process of the temporal bone (*cut 3*). The fourth cut is made across the zygomatic body (*cut 4*) and the osteotomy meets the cut along the lateral orbital wall (*Cut 2*) at the anterolateral margin of the inferior orbital fissure. **C:** The second bone flap of the two-piece COZ approach has been removed, which includes the zygomatic arch, the orbital roof, the superior and the lateral orbital rims. **D:** The two-piece COZ approach has been completed on the right side and the superolateral edge of the superior

orbital fissure has been exposed. **E:** The two-piece COZ approach has been performed on the right side in a cadaveric dissection. The recurrent meningeal branch of the ophthalmic artery, which courses along the temporal dura near the junction of the roof and the lateral wall of the orbit, often delimits the superolateral edge of the superior orbital fissure. **F:** The bone flap has been elevated through an orbitopterional approach and includes the orbital roof and the superior and lateral orbital rims.

The third cut, the easiest cut of the approach, is made across the anterior root of zygomatic process of the temporal bone, just anterior to the articular tubercle of the zygoma (Figure 2B). The process is divided obliquely, in an attempt for providing a more stable base for fixation. The fourth and final cut is the most difficult cut of the two-piece COZ approach, since it is often not possible to see the medial extension of this cut. The cut is made across the zygomatic body and is also in close relation with the anterolateral part of the inferior orbital fissure (Figure 2B). This cut is made 1 cm below the junction of the frontal and temporal processes of the zygomatic bone, above the malar eminence. The osteotomy across the zygomatic body meets the cut along the lateral orbital wall (Cut 2) at the anterolateral margin of the inferior orbital fissure (Figure 2B).

The second flap of the two-piece COZ approach can be removed following the completion of these four consecutive cuts (Figür 2C). The remaining soft tissue attachments, including the deep temporalis fascia and temporalis muscle that attaches beneath the zygomatic body should be freed in order to elevate the bone flap, which includes the zygomatic arch, the orbital roof, the superior and the lateral orbital rims and exposes the frontal and temporal dura and the periorbita (Figure 2D and 2E).

Orbitopterional Modification. The third and fourth cuts of the two-piece COZ approach are not performed in this modification, and the second cut is tailored along the lateral wall of the orbit instead. Following the pterional craniotomy, the first osteotomy across the medial orbital rim towards the superior orbital fissure is exactly the same as in two-piece COZ approach. The second cut, the final cut of the OPT approach, proceeds anterosuperiorly from the most posterior aspect of the first cut vertically towards the superior orbital rim and extends to a

point just lateral to the frontozygomatic fissure. The elevated bone flap in the OPT approach includes the orbital roof and the superior and lateral orbital rims (Figure 2F).

Additional bone can be resected to reach the superolateral edge of the superior orbital fissure using a high speed drill or rongeurs (Figür 2E). The recurrent meningeal branch of the ophthalmic artery, which courses along the temporal dura near the junction of the roof and the lateral wall of the orbit, often delimits the superolateral edge of the superior orbital fissure.

The closure includes the reconstruction of the orbitozygomatic bone flap, followed by the pterional bone flap (Figure 3G and H). In order to obtain good cosmetic results at the region of the pterion, the temporalis muscle is sutured to the muscle cuff that is left within the center of the pterional bone flap.

DISCUSSION

The one-piece and the two-piece COZ craniotomies are one of the most commonly adopted skull base approaches in neurosurgical practice (1-5, 7-15, 17-24, 28). We have described the advantages and disadvantages of the one- and two-piece COZ approaches in a previous study (24). During the last decade, several authors demonstrated the enlarged operative exposures and specified the increased operative angles obtained through the COZ approaches (10, 18, 20). The results of these reports propagated the proposal of more than one modification for the standard COZ approach (4, 5, 14, 18, 19, 22, 24, 28).

During the elevation of the scalp flap, a subfascial or an interfascial dissection along the temporalis fascia should be performed to preserve the frontotemporal branches of the facial nerve. We prefer the subfascial dissection of the temporalis muscle to preserve the frontotemporal branches and

only two patients in this series experienced temporary paresis of the frontal muscle. There were no episodes of frontal muscle paresis in the last 17 cases. Caudal to rostral and postero-anterior subperiosteal elevation of temporalis muscle and avoidance of monopolar cauterization helps minimize the muscle atrophy (16). During the subperiosteal dissection of the temporalis muscle, the surgeon should be careful when approaching the region just posterior to the anterolateral edge of the inferior orbital fissure, since the muscle at this region receives its supply from the deep temporal arteries that originate from the maxillary artery. The deep temporal nerves that arise from the mandibular division of the trigeminal nerve and innervate the temporalis muscle, are also susceptible to injury at this region.

In the two piece OZ, the fronto-temporal bone flap is elevated as the initial step and the orbitozygomatic osteotomy is performed separately, as a second step. The orbital roof and lateral wall are removed under direct vision, which allows for a more consistent and complete orbitotomy compared to the one-piece OZ (24). We believe that the two-piece COZ approach is safe and easy to perform if the above mentioned sequence of orbital and zygomatic cuts are made in a proper manner. The knowledge of the microsurgical anatomy of the region is mandatory when performing the skull base osteotomies.

An important anatomical landmark in COZ approach is the inferior orbital fissure, into which some of the skull base osteotomies extend. The inferior orbital fissure needs to be identified before performing these cuts in most of the cases. In a previous report, Shimizu and Tanrıöver divided the inferior orbital fissure into three parts (22). The first portion, the anterolateral part of the fissure, communicates below with the temporal fossa and contains the temporalis muscle. The middle portion opens into the infratemporal fossa, which contains the pterygoid muscles and venous plexus, and the maxillary artery and mandibular nerve and their branches. The posteromedial part opens into the pterygopalatine fossa, which contains the maxillary nerve, branches of the maxillary artery and nerve, and the pterygopalatine ganglion. The anterolateral part of the fissure into which two cuts of the two-

piece OZ craniotomy extend contains the orbital smooth muscle and is covered externally on the temporal fossa side by the temporalis muscle and may transmit a small branch of the maxillary artery.

None of the previous reports specifically mention the percentage of visualization of the inferior orbital fissure during COZ approaches. In our series, we could not visualize or palpate the inferior orbital fissure in 3 cases. In these cases, the anterolateral edge of the fissure was located more than a cm below the junction of the frontal and temporal processes of the zygomatic bone. This finding did not change the sequence of the skull base cuts of the approach. We were able to perform the cuts safely and the COZ approach was completed in a similar fashion in all of six cases.

Inadvertent exposure of the frontal sinus during COZ approaches may result in undesired complications, such as cerebrospinal fluid (CSF) leaks. In this series, the frontal sinus was exposed in 4 cases and we used the same closure technique in each case. This technique includes the removal of the mucosa, followed by plugging a piece of muscle with a fibrin glue and finally turning a vascularized periosteal flap to close the passage of the sinus. We did not encounter a CSF leak or meningitis in our small group of patients.

Contrary to the some other previous reports, we do not extend the initial two cuts of the two-piece COZ approach into the superolateral edge of the superior orbital fissure. Alternatively, we prefer to remove the remaining part of the orbit (less than 5 mm) with a small rongeur under direct vision.

The COZ approach must be tailored in relation to the location of the pathology. If the pathology is primarily located along the middle fossa, including the floor and more medially towards the tentorial edge, the infratemporal region, and the interpeduncular and prepontine cisterns, we usually use the full two-piece COZ approach. The removal of the zygomatic arch in these cases, enables the bulky temporal muscle to be reflected posteroinferiorly to decrease retraction over the temporal lobe.

For lesions primarily located anteriorly towards the anterior wall of the third ventricle and extending upwards along the anterior communicating artery complex, the OPT modification is adequate. Only
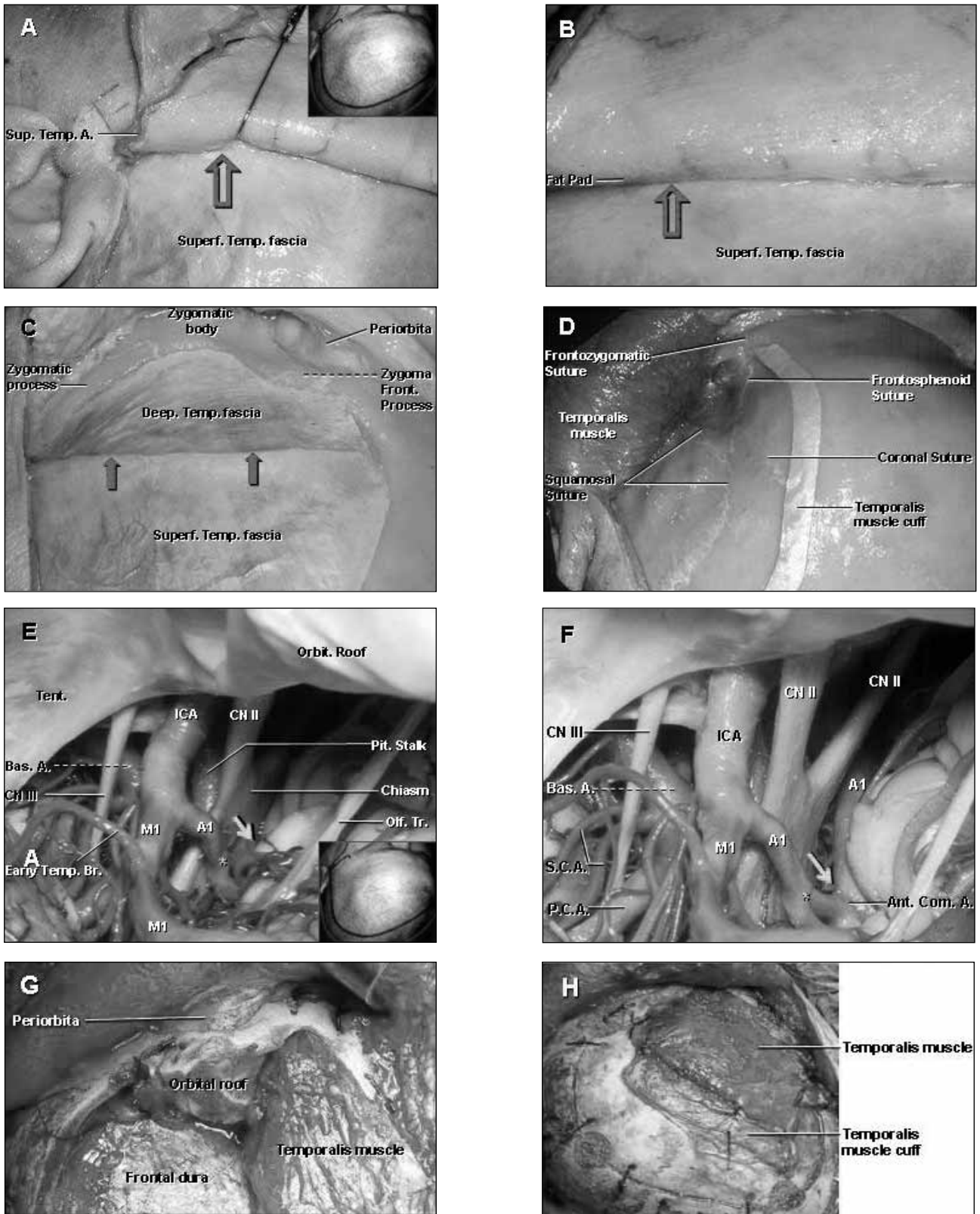
Figure 3: A-D; Stepwise interfascial dissection of Yaşargil on the left side of a cadaveric head to preserve the frontotemporal branches of the facial nerve. **A:** The frontotemporal branches of the facial nerve are consistently found within the fat pad that is located above the superficial and deep layers of the temporalis fascia. The upper edge of the fat pad above the superficial temporalis fascia has been identified (*arrow*). **B:** Enlarged

view of the same dissection. **C:** An incision (*red arrows*) has been performed just above the fat pad and the fascial incision has been carried only through the superficial temporalis fascia, exposing the zygomatic process, body and the lateral and superior orbital rims. **D:** The temporalis muscle has been elevated posteroinferiorly and the inferior orbital fissure has been exposed. **E and F:** Comparison of a pterional intradural exposure with a two-piece COZ approach. **E:** Right pterional craniotomy and an extensive drilling of the sphenoid ridge have been performed on a cadaveric head. The dura and the sylvian fissure has been opened. The anterior communicating artery complex can not be sufficiently visualized in this

dissection. **F:** The remaining part of the orbit has been removed in the same cadaveric head, providing a dissection until the superior orbital fissure. Notice the amount of light provided to the surgical view. The anterior communicating artery complex (*green arrow*) can be exposed with a two-piece COZ approach. **G and H:** Reconstruction of the craniotomy at the end of the procedure. **G:** The closure of the two-piece COZ includes the initial reconstruction of the orbitozygomatic bone flap above the temporalis muscle. **H:** The pterional bone flap has been reconstructed as a second step. In order to obtain good cosmetic results at the region of the pterion, the temporalis muscle is sutured to the muscle cuff that is left within the center of the pterional bone flap.

removing the roof and the lateral walls of the orbit just lateral to the frontozygomatic suture and leaving the zygomatic arch intact would give a satisfactory operative exposure for lesions involving these areas.

The COZ gives an opportunity to access a wide range of pathologies involving the skull base and the hidden areas under the brain. The complexity of the approach can only be simplified by understanding the deductive sequence of orbital and zygomatic osteotomies in addition to knowledge of the microsurgical anatomy of the region.

REFERENCES

1. Al-Mefty O. Supraorbital-pterional approach to skull base lesions. Neurosurgery 1987;21:474-7

2. Al-Mefty O, Anand VK. Zygomatic approach to skull-base lesions. J Neurosurg 1990;73:668-673

3. Al-Mefty O. Operative atlas of Meningiomas. Lippincott, Williams, and Wilkins, 1998

4. Andaluz N, van Loveren HR, Keller JT, Zuccarello M. Anatomic and clinical study of the orbitopterional approach to anterior communicating artery aneurysms. Neurosurgery 2003;52:1140-9

5. Aziz KMA, Froelich SC, Cohen PL, et al. The one-piece orbitozygomatic approach: the MacCarty burr hole and the inferior orbital fissure as keys to technique and application. Acta Neurochir (Wien) 2002;144:15-24

6. Coscarella E, Vishteh G, Spetzler RF, et al. Subfascial and submuscular methods of temporal muscle dissection and their relationship to the frontal branch of the fascial nerve. J Neurosurg 2000;92:877-80

7. Delashaw JB Jr, Tedeschi H, Rhoton AL Jr: Modified supraorbital craniotomy: technical note. Neurosurgery 1992;30:954-6

8. Frazier CH. An approach to the hypophysis through the anterior cranial fossa. Ann Surg 1913;57:145-52

9. Fujitsu K, Kuwabara T. Orbitocraniobasal approach for anterior communicating artery aneurysms. Neurosurgery 1986;18:367-9

10. Gonzalez LF, Crawford NR, Horgan MA, et al. Working area and angle of attack in three cranial base approaches: pterional, orbitozygomatic, and maxillary extension of the orbitozygomatic approach. Neurosurgery 2002;50:550-7

11. Hakuba A, Liu S, Nishinura S. The orbitozygomatic infratemporal fossa approach: a new surgical technique. Surg Neurol 1986;26:271-6

12. Ikeda K, Yamashita J, Hashimoto M, Futami K. Orbitozygomatic temporopolar approach for a high basilar tip aneurysm associated with a short intracranial internal carotid artery: a new surgical approach. Neurosurgery 1991;28:105-10

13. Ane JA, Park TS, Pobereskin LH, et al. The supraorbital approach: technical note. Neurosurgery 1982;11:537-42

14. Lemole GM Jr, Henn JS, Zabramski JM, et al. Modifications to the orbitozygomatic approach. J Neurosurg 2003;99:924-30

15. MacCarty CS, Brown DN. Orbital tumors in children. Clin Neurosurg 1964; 11:76-88

16. Oikawa S, Mizuno M, Muraoka S, et al. Retrograde dissection of the temporalis muscle preventing muscle atrophy for pterional craniotomy. Technical note. J Neurosurg 1996; 84:297-9

17. Pellerin P, Lesoin F, Dhellemmes P, et al. Usefulness of orbitofrontomalar approach associated with bone reconstruction for frontotemporosphenoid meningiomas. Neurosurgery 1984;15:715-8

18. Pontius AT, Ducic Y. Extended orbitozygomatic approach to the skull base to improve access to the cavernous sinus and optic chiasm. Otolaryngol Head Neck Surg 2004;130:519-25

19. Rhoton AL Jr: The cavernous sinus, the cavernous venous plexus, and the carotid collar. Neurosurgery (suppl) 2002;51:375-410

20. Schwartz MS, Anderson GJ, Horgan MA, et al. Quantification of increased exposure resulting from orbital rim and orbitozygomatic osteotomy via the frontotemporal transsylvian approach. J Neurosurg 1999;91:1020-6

21. Ekhar LN, Kalia KK, Yonas H, et al. Cranial base approaches to intracranial aneurysms in the subarachnoid space. Neurosurgery 1994;35:472-83

22. Shimizu S, Tanriover N, Rhoton AL Jr., et al. The MacCarty keyhole and inferior orbital fissure in orbitozygomatic craniotomy Neurosurgery 2005;57:ONS-152-9

23. Smith RR, Al-Mefty O, Middleton TH. An orbito-cranial approach to complex aneurysms of the anterior circulation. Neurosurgery 1989;24:385-91

24. Tanriover N, Ulm AJ, Rhoton AL Jr, Kawashima M, Yoshioka N, Lewis S. One-piece vs. two-piece orbitozygomatic craniotomy: quantitative and qualitative considerations. Neurosurgery 2006;58:ONS-229-37

25. Yaşargil MG, Fox JL, Ray MW. The operative approach to aneurysms of the anterior communicating artery. Adv Tech Stand Neurosurg 1975;2:113-170

26. Yaşargil MG: Microneurosurgery. Stuttgart: Georg Thieme Verlag, Vol 1, 1984

27. Yaşargil MG, Reichman MV, Kubik S. Preservation of the frontotemporal branch of the facial nerve using the interfascial temporalis flap for pterional craniotomy. Technical article. J Neurosurg 1987;67:463-6

28. Zabramski JM, Kiris T, Sankhla SK, et al. Orbitozygomatic craniotomy. Technical note. J Neurosurg 1998;89:336-41