Transpalpebral Orbitofrontal Craniotomy: A Minimally Invasive Approach to Anterior Cranial Vault Lesions

Kofi D. Owusu Boahene, M.D.,^{1,4} Michael Lim, M.D.,^{2,4} Eugene Chu, M.D.,^{1,5} and Alfredo Quinones-Hinojosa, M.D.^{3,4}

ABSTRACT

To describe a minimally invasive approach to anterior cranial vault pathology using a transpalpebral exposure with a miniorbitofrontal craniotomy. Design: Case series. Setting: Tertiary referral hospital with multidisciplinary skull base program. Participants include patients with intra-axial and extra-axial anterior skull base lesions who underwent the transpalpebral minicraniotomy approach. Main Outcome measures: Feasibility of the approach to permit adequate exposure of targeted lesion. We applied this approach in seven patients for the repair of persistent cerebrospinal fluid leaks, pneumocephalus, and the biopsy or resection of midline brain tumors along the anterior cranial base. The approach allowed bimanual instrumentation working with either endoscopic or microscopic visualization for tumor resection and repair of dural and cranial base defects. We measured an average working distance of 4 cm to the sella. The transpalpebral miniorbitofrontal craniotomy approach to the anterior cranial base is quick, adequate, and safe and should be considered as an alternative to extended bifrontal approaches and/or pterional craniotomies for select anterior cranial vault pathology.

KEYWORDS: Eyelid, palpebral, minimally invasive, anterior skull base approach

The development of surgical techniques to access anterior cranial vault lesions have evolved around attempts to safely reach the sella. In 1906, Horsely reported the first successful series of pituitary tumor resection using a large semicircular scalp flap, extensive removal of cranial bone and gradual retraction of the brain.¹ Other pioneering neurosurgeons advanced various aspects of the transcranial approach to the sella by promoting frontal, anterolateral, and fronto-orbital approaches.²⁻⁶ Presently, most anterior cranial vault path-

ologies are approached via a coronal scalp flap and variations of orbitofrontal craniotomy.⁷⁻¹⁰ Although these approaches are well established and provide wide exposure, they involve extensive dissection that include a long scalp incision, mobilization of the facial nerve branches, large bone flap, brain retraction and disruption of olfaction. Recent advances made in stereotactic image guidance and endoscopic sinus surgery have facilitated the evolution of minimally invasive skull base surgery. As with the open approaches, endoscopic skull base and

¹Department of Otolaryngology Head and Neck Surgery, ²Department of Neurosurgery and Oncology, and ³Department of Neurosurgery and Neuroscience, ⁴The Johns Hopkins University School of Medicine, Baltimore, Maryland; ⁵University of California at Irvine, Orange, California.

Address for correspondence and reprint requests: Kofi D. Owusu Boahene, M.D., Department of Otolaryngology Head and Neck Surgery, The Johns Hopkins University School of Medicine, 601 N. Caroline Street, Johns Hopkins Outpatient Center, 6th Floor,

Baltimore, MD 21287 (e-mail: dboahen1@jhmi.edu).

Skull Base 2010;20:237-244. Copyright © 2010 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1 (212) 584-4662.

Received: October 25, 2009. Accepted: January 11, 2009. Published online: March 1, 2010.

DOI: <http://dx.doi.org/10.1055/s-0030-1249247>.

ISSN 1531-5010.

intracranial surgery evolved from techniques developed to reach sella lesions through the sphenoid sinus.¹¹ Currently, the endoscopic transphenoidal approach to the sella has been logically extended to treat a wide range of anterior intracranial lesions.^{12,13} Although endoscopic approaches have the advantage of avoiding external incisions, large bone flaps and brain retraction, they may involve indirect working angles and have limited reconstruction options. In this report, we describe a direct open approach to the anterior cranial vault through a blepharoplasty-type eyelid incision and a miniorbitofrontal craniotomy supplemented with endoscopic illumination. In our limited experience, the outcomes and cosmetic results are excellent and this approach should be considered in the armamentarium of skull base surgeons.

OPERATIVE TECHNIQUE

Patient Positioning and Preparation

All patients selected for this approach undergo a CT and MR imaging with intraoperative stereotactic image guidance protocol. Patients are positioned with a Mayfield head holder (Integra, Plainsboro, NJ) and the stereotactic image guided navigation system is registered for accuracy. Lubricating ophthalmic ointment is applied

to the eye and a cornea shield or temporary tarsorraphy suture is placed to protect the cornea. A lumbar sub-arachnoid drain is placed for CSF release and brain decompression in those patients with deep brain lesions. Mannitol is administered and pCO₂ is lowered as needed for further brain decompression.

Eyelid Incision and Orbitofrontal Exposure

The transpalpebral approach to the anterior cranial base starts with an upper eyelid crease incision (Fig. 1A). The planned eyelid incision corresponding with the upper eyelid tarsal crease is outlined preoperatively with the patient sitting upright. The incision extends from the inner canthal region to the lateral canthal area following the natural upper eyelid crease. At least 3 mm of skin is left intact over the medial canthus to prevent webbing. The lateral extension of the incision is planned in a natural wrinkle line. The incision is carried through the skin and orbicularis oculi muscle. The orbital septum deep to the orbicularis oculi muscle is kept intact preventing fat herniation. Dissection is carried over the orbital septum to the superior orbital rim. The arcus marginalis, which is the periosteal attachment along the superior orbital rim is sharply incised and released along the superior and lateral orbital rim. The supraorbital neurovascular bundle is

Figure 1 Surgical steps of the transpalpebral miniorbitofrontal craniotomy approach to the anterior cranial vault. (A) Upper eyelid crease incision for the transpalpebral approach. The incision is outline in the tarsal crease with the patient sitting upright and may extend lateral to the lateral canthus within a natural crease. (B) Wide exposure of the supraorbital bar, frontal bone and temporal fossa. The soft tissue is protected with gauze and retracted. The supraorbital nerves are preserved and may be mobilized within the brow fat for additional exposure. (C) Type 1 minicraniotomy limited to the frontal bone is used to expose the frontal sinus and allows introduction of the endoscope and instruments to address anteriorly located defects that do not require extensive intracranial dissection. (D) Type 2 minicraniotomy is variably designed and performed with the aid of a small burr hole. Using the pediatric craniotome minimizes bone loss. (E) Preplating across the osteotomy sites facilitates an anatomic reconstruction at the end of the case. The image guided navigation system is used to determine the most direct working trajectory to the target lesion and aids in determining the size of the bone flap to be removed. (F) Dural exposure and intracranial dissection is aided by either the operating microscope or endoscope. The dura is opened with a semicircular dural flap. Brain decompression by CSF release or administration of mannitol improves the exposure. (G) Direct dural repair is performed and reinforced with dural substitute grafts. (H) Carefully approximating the eyelid layers ensures an excellent cosmetic outcome.

released from its notch or foramen and protected. If needed, the superior orbital nerve is mobilized free for ~1 cm in the brow allowing further soft tissue retraction. Subperiosteal elevation of the frontalis muscle and forehead skin is widely performed to expose the frontal bone, superior and lateral orbital rim and temporal fossa as needed. The orbital roof is exposed by releasing the periorbital being careful to avoid fat herniation. Soft tissue retractors are placed along the incision to maintain the bony exposure (Fig. 1B).

Minicraniotomy

The craniotomy is variably designed based on the location of the pathology to provide the most direct approach for instrumentation. Using image guidance, the desired working trajectory to the defect or tumor is determined and appropriate craniotomy is outlined. The type of craniotomy performed is tailored to the location of the defect or lesion. For anteriorly located defects or lesions, the craniotomy may be limited to the anterior wall of the frontal sinus and superior orbital ridge without violating the floor of the frontal sinus. We classify this as a type 1 craniotomy (Fig. 1C). Using a combination of diamond burr, Kerrison punches and bone rongeurs, a window is then created through the posterior wall of the frontal sinus to assess the defect and frontal dura. For access to posteriorly located and intracranial pathology, the craniotomy is designed to include parts of the orbital roof and rim to gain direct access to the anterior cranial. We have classified this second type of craniotomy as a type 2 craniotomy (Fig. 1D). For a type 2 craniotomy, a McCarty keyhole is made to gain access to both the anterior cranial fossa and the orbit and a pediatric craniotome is used to complete the craniotomy. With the footplate in the intracranial cavity, a C-shaped cut curving superiorly is created; as the cut nears the supraorbital foramen and the orbital ridge, the handle of the craniotome is angled inferiorly and medially to begin the orbital ridge osteotomy. At this point then, starting once again at the burr hole, the lateral aspect of the osteotomy is done to ultimately create a 1-piece craniotomy/orbital ridge osteotomy. It is important to make sure that the bony opening over the frontal bone is high enough to ensure an adequate working corridor. Preplating across the osteotomy sites before performing the craniotomy facilitates an anatomic reconstruction at the end of the case (Fig. 1E). In most cases the craniotomies are lateral to the frontal sinus but occasionally the frontal sinuses may be violated. In such cases, maintaining the frontal sinus outflow tract preserves postoperative mucociliary drainage. A 2 cm by 2 cm craniotomy is often adequate for the introduction of an endoscope, multiple instruments and microdissection aided by the operating microscope.

Management of the Cranial Vault Pathology

Illumination and magnification of the surgical cavity is achieved with either a rigid endoscope or operating microscope. Defects of the posterior frontal sinus wall, associated dural defects and cerebrospinal fluid leak can be directly accessed through the posterior frontal sinus wall and repaired. Through the frontal sinuses, intersinus septae may be taken down with a rongeur for more exposure. The endoscope provides a wide view of the surgical corridor. For more posterior lesions, dural elevation can be safely performed from the crista galli to the planum sphenoidale. For unilateral pathology, olfaction may be preserved by limiting dural dissection only to the involved side. For intraaxial lesions, an inferiorly based dural flap is created in a semicircular fashion (Fig. 1F). Decompressing the brain by withdrawing CSF through a lumbar drain, early administration of mannitol, and adjustment of pCO₂ improves exposure and dissection performed to the targeted pathology. The exposure is often adequate for bimanual microdissection with the aid of the operating microscope or endoscope.

Reconstruction of Postsurgical Defect

Reconstruction of the post surgical defect involves three phases: dural repair, bony reconstruction, and cosmetic closure of the eyelid incision. Dural reconstruction is performed by direct suturing, with dural replacement grafts, fascia lata grafts, or pedicled pericranial flaps. When feasible, primary dural suturing is performed (Fig. 1G). The dural repair is reinforced with fibrin glue or DuraSeal[®] (Confluent Surgical, Waltham, MA). When needed, a pedicled pericranial flap can be harvested by retrograde dissection off the elevated scalp flap. The dissection is facilitated by the use of a 30 rigid endoscope for further visualization. Once all dural defects have been repaired, the bone flap is replaced and fixated with a low profile miniplates. The eyelid incision is closed by approximating the orbicularis oculi muscle and skin as separate layers (Fig. 1H).

POSTOPERATIVE CARE

To minimize periorbital swelling, the patients head is inclined at 30. Artificial eye tears are liberally applied. The eyelid incision is cleaned daily and ophthalmic antibiotic ointment applied. Ice packs are applied at intervals for 2 days to minimize swelling and bruising.

RESULTS

We reviewed a series of seven consecutive patients who had anterior cranial lesions or defects approached through a transpalpebral orbitofrontal craniotomy approach (Table 1). The eyelid incision was adequate in all cases for soft tissue elevation from the temporal fossa to

Table 1 Patient Demographics, Diagnosis, and Outcomes

Patient	Location of Defect/Tumor	Diagnosis	Extent and Type of Craniotomy	Status of Olfaction	Outcome and Complications
42F	Left frontal lobe dura, posterior lateral wall of frontal sinus wall	CSF leak	Frontal bone 1 cm × 1 cm Type 1	Preserved	CSF leak repaired with excellent aesthetic outcome
19M	Frontal dura defect Posterior frontal sinus wall	CSF leak, pneumocephalus	Frontal bone 1 cm × 1 cm Type 1	Unchanged	CSF leak and pneumocephalus resolved
58F	Planum sphenoidale	Meningioma	Orbitofrontal 3 cm × 2 cm Type 2	Preserved	Complete tumor resection
49F	Suprasellar	Meningioma CSF leak	Orbitofrontal 3 cm × 2 cm Type 2	Preserved	Complete tumor resection, CSF leak resolved
37F	Suprasellar attached to optic chiasm	Langerhans cell histiocytosis	Orbitofrontal 3.5 cm × 3 cm Type 2	Preserved	Diagnostic biopsy, vision stable, chemotherapy initiated
50M	Sella	Pituitary adenoma	Orbitofrontal 3 cm × 3 cm Type 2	Preserved	Complete tumor resection
47F	Olfactory groove	Meningioma	Orbitofrontal 2 cm × 2 cm Type 2	Unilaterally preserved	Complete tumor resection

CSF, cerebrospinal fluid.

the mid forehead. Minicraniotomies 1 to 3 cm was performed. All lesions were adequately exposed for direct access and bimanual dissection either under endoscopic illumination and or microsurgical dissection with the operating microscope. Two patients with anteriorly located defects had type 1 craniotomies. In these two patients, posterior frontal sinus wall and frontal dural defects were exposed with smaller craniotomies 1 cm by 1 cm and endoscopic illumination. Five patients underwent type 2 craniotomies for lesions along the anterior cranial base (Table 1). In two patients, we measured the distance from the eyelid exposure to the sella as 4 cm using the stereotatic navigation system (Fig. 2A and B). With the brain decompressed, the optic chiasm and sella was reached with either endoscopy or microscopic illumination. There were no CSF leaks or bone flap loss. In all patients, olfaction was preserved. The cosmetic outcome of the eyelid approach was satisfactory in all cases (Figs. 3 and 4). There were no long-term periorbital complications.

Illustrative Cases

PATIENT 1

A 42-year-old female underwent orbitotemporal craniotomy for clipping of an aneurysm through a bicoronal incision. She developed postoperative CSF rhinorrhea and massive forehead swelling. On CT scan, the frontal sinus was opacified and a defect of the frontal dura along the anterior cranial vault was identified as the site of CSF leak (Fig. 3A). An extremely lateral frontal sinus wall defect was also noted. A transpalpebral minicraniotomy approach was used to expose the cranial and dural defect. A limited type 1 minicraniotomy 1 cm by 1 cm limited to the anterior wall of the frontal sinus was performed. Excellent endoscopic visualization of the dural defect was achieved (Fig. 3B). Direct access allowed bimanual instrumentation and repair of the defect using fascia lata graft and fibrin sealant. The frontal sinus outflow tract was left undisturbed. The CSF leak was successfully repaired and the eyelid healed with excellent cosmetic and functional results (Fig. 3C and D).

PATIENT 2

A 58 years old female presented with a meningioma in the region of the planum sphenoidale (Fig. 4A and B) and worsening visual field examination. A transpalpebral approach with a type 2 3 × 2 cm mini-orbitofrontal craniotomy including the anterior and posterior walls of the lateral frontal sinus was performed. A small burr hole in the temporal fossa allowed dural elevation. The meningioma was accessed and completely removed with the aid of the operating microscope. Dural repair was performed with a pericranial flap. She was discharged home within 48 hours of her surgery. Her

Figure 2 Exposure following the transpalpebral approach with orbitofrontal craniotomy. (A) A 3×2 cm orbitofrontal craniotomy was performed through an upper eyelid crease incision. (B) The sella is measured at 4 cm along a direct dissection trajectory.

postoperative course was uncomplicated and at her 6 month follow-up visit, eyelid cosmesis and function were excellent (Fig. 4C and D).

PATIENT 3

A 34-year-old female presented with memory loss, panhypopituitarism, and diabetes insipidus. Pre-operative MRI showed an enlarging suprasellar mass

adherent to the optic chiasm (Fig. 5A). A transpalpebral approach was performed to expose the lesion for biopsy. Endoscopic illumination of the optic chiasm allowed biopsy of the lesion through the lamina terminalis (Fig. 5B). The lesion was diagnosed as histiocytosis X. She tolerated the procedure well with no eyelid complications. Treatment for the histiocytosis X was initiated.

Figure 3 A 42-year-old female who developed CSF leak following a craniotomy for an aneurysm repair. (A) Computed tomography showing a bony defect in the extreme posterior lateral wall of the frontal sinus (blue arrow). (B) Through a transpalpebral approach, a minifrontal craniotomy was performed and the defect exposed endoscopically (open arrow showing defect and site of CSF leak). (C, D) Aesthetic appearance of eyelid following the transpalpebral approach (left with eye open, right with eye closed).

Figure 4 Computed tomography of the head in a 58-year-old female who presented with progressive visual field loss showing a meningioma in the planum sphenoidale region (A, B). Postoperative photographs taken 3 months following the transpalpebral approach with orbitofrontal craniotomy (C, D).

DISCUSSION

We have described a direct approach to anterior cranial vault lesions through an upper eyelid incision. The transpalpebral minicraniotomy approach is minimally disruptive, quick to perform and allows excellent exposure and direct access for bimanual instrumentation.

With the endoscope as an adjunct, wide visualization of lateral and midline lesions in the anterior cranial fossa is possible. With the miniorbitofrontal craniotomy, the working corridor runs long the skull base. As a result, intradural lesions may be accessed without the need for extensive and prolonged frontal lobe retraction. While

Figure 5 (A) Computed tomography showing a perichiasmatic histiocytosis biopsied through the transpalpebral approach. (B) Endoscopic view of the optic chiasm (arrow).

lesions located extremely anterior and lateral along the anterior skull base may be challenging to access via a transnasal endoscopic approach, they can be readily reached through this eyelid approach. Olfactory sensation can be preserved because of the angle of approach and the limited frontal lobe retraction. Placing the incision in a natural eyelid crease results in a well camouflaged scar and excellent cosmesis.

Traditional approaches to anterior cranial vault defects include variations of orbitofrontal, orbitozygomatic, unilateral subfrontal, supraorbital, and extended bifrontal craniotomies.⁷⁻¹⁰ These established approaches are each suited for particular lesions with regard to location, size, malignancy, and goal of the surgery. However, they require extended scalp incisions, removal of large bone flaps and brain retraction to obtain a sufficiently large operative field. This extensive dissection may result in scalp alopecia, forehead dysesthesia, brow ptosis, anosmia, frontal lobe edema, and related neurologic sequelae.

Increasingly, midline anterior cranial defects and tumors are being managed by transnasal endoscopic techniques. The transnasal endoscopic approach avoids the external incisions seen in open approaches. The transnasal endoscopic approach is ideal for pituitary tumors because a natural surgical corridor through the sphenoid sinus already exists. For larger tumors and more anteriorly located lesions, the transnasal endoscopic approach may become limited by inadequate visualization, indirect and difficult working angles, difficulties with managing extensive skull base defects that result from the approach and associated CSF leaks. As a result, operating time and hospital stays may be prolonged.

The approach described here combines the desirable aspects of the traditional open approach and endoscopic skull base surgery in a minimally invasive manner. The eyelid incision is used in cosmetic blepharoplasty and is well hidden. The dissection plane in the eyelid preserves all the functional eyelid structures thus minimizing postoperative complications. Approaching the anterior cranial fossa from above preserves the bony skull base floor which supports subsequent dural repairs and minimizes the chance of recurrent CSF leaks. In addition, direct water tight dural repair by suturing is possible and can also be reinforced with pedicled pericranial flaps. While bimanual instrumentation working under the microscope is possible, using the endoscope as an adjunct further improves the surgical range and visualization.

We have tailored the type and extent of craniotomy to the location of the targeted defect or lesion. For anterior dural defects and lesions involving the posterior frontal sinus wall and frontal lobe dura, a type 1 craniotomy limited to the frontal bone and supraorbital bar is adequate. Endoscopic illumination through the

type 1 craniotomy provides a wide view and working access to instrumentation. The type 2 minifronto-orbital craniotomy allows more extended access and is used for posteriorly located lesions. Including the anterior two thirds of the orbital roof in the craniotomy allows a more direct trajectory to deeply located tumors without the need for extensive frontal lobe retraction. Using stereotactic navigation systems, we are able to select the most direct working angle and corridor to the target lesion. This information helps in the design of the craniotomy. We have applied this approach to defects or lesions located along the posterior wall of the frontal sinus, optic chiasm and sella. We believe this approach can be adapted for pathology involving the posterior wall of the frontal sinuses, frontal lobe and dura, orbital apex and olfactory groove. With the midline exposure, this approach can be extended to approach low lying interhemispheric aneurysm of the anterior cerebral or anterior communicating arteries. This approach is also desirable in revision cases where dissecting through previous scalp flaps, scar, bone flaps or cranial mesh can be avoided.

Several authors have described their experience with the supraorbital craniotomy approach through variations of forehead and eyebrow incisions.¹⁴⁻¹⁷ Andaluz et al described an approach to the anterior cranial fossa through an eyelid incision.¹⁸ These reports have clearly demonstrated the feasibility of accessing lesions not only in the sellar/parasellar region, but also the anterior cranial fossa and interpeduncular cistern through minicraniotomies.

Compared with the suprabrow minicraniotomy approach, the transpalpebral route uses incisions placed in a natural eyelid crease, eliminates the risk of injuring facial nerve branches to the brow elevators, preserves sensory innervation of the forehead and allows removal of the orbital ridge and frontal bone as a single bone flap. The ability to remove the orbital ridge is particularly desirable as it adds the improved exposure described and quantified by Schwartz et al in their cadaveric studies.¹⁹ Following the eyelid exposure and miniorbitofrontal craniotomy, the distance from the bony limits of the exposure to the sella was ~4 cm in our experience. Proper head positioning, wide soft tissue undermining, selection of a direct working trajectory and craniotomy aided by surgical navigation and ample brain decompression maximizes the exposure in this minimally invasive approach.

One relative limitation of the transpalpebral minicraniotomy is the need to traverse the frontal sinus in some patients and the attendant risk of increasing frontal sinusitis and mucocle formation. To minimize this risk, a mucosal sparing technique is important especially in the region of the frontal sinus outflow tract. None of the patients in this series developed frontal sinusitis or mucocle but a longer-term follow up is needed.

Other potential complications include superficial skin abrasion along the brow from retractors. These are preventable by cushioning the soft tissue retractors with moist gauze. When superficial abrasions occur, they should be kept clean and well moisturized with ointments to allow excellent reepithelialization.

The transpalpebral minicraniotomy approach is a safe, direct and minimally disruptive approach to the anterior cranial vault and should be considered as an alternative to more extensive craniofacial approaches for select pathology of the anterior cranial vault.

REFERENCES

1. Horsely V. Remarks on the surgery of the central nervous system. *BMJ* 1890;2:1286–1292
2. Krause F. *Hirnehirurgie*. Deutsche Lin 1905;8:953–1042
3. Dandy W. A new hypophysis operation. *Bull Johns Hopkins Hosp* 1918;29:154–155
4. Frazier CH. An approach to the hypophysis through the anterior cranial fossa. *Ann Surg* 1913;57:145–150
5. Heuer GJ. The surgical approach and the treatment of tumors and other lesions about the optic chiasm. *Surg Gynecol Obstet* 1931;53:489–518
6. Cushing H. *The pituitary body and its disorders: clinical states reduced by disorders of the hypophysis cerebri*. Philadelphia, PA: JB Lippincott; 1912
7. Janecka IP, Sekhar LN. Anterior and anterolateral craniofacial resection. In: Sekhar LN, Janecka IP, eds. *Surgery of Cranial Base Tumors*. New York, NY: Raven Press; 1993: 147–156
8. Al-Mefty O. Supraorbital-pterional approach to skull base lesions. *Neurosurgery* 1987;21:474–477
9. Raveh J, Laedrach K, Speiser M, et al. The subcranial approach for fronto-orbital and anteroposterior skull-base tumors. *Arch Otolaryngol Head Neck Surg* 1993;119: 385–393
10. Zabramski JM, Kiriş T, Sankhla SK, Cabiol J, Spetzler RF. Orbitozygomatic craniotomy. Technical note. *J Neurosurg* 1998;89:336–341
11. Jankowski R, Auque J, Simon C, Marchal JC, Hepner H, Wayoff M. Endoscopic pituitary tumor surgery. *Laryngoscope* 1992;102:198–202
12. Jho HD, Ha HG. Endoscopic endonasal skull base surgery: part 1—The midline anterior fossa skull base. *Minim Invasive Neurosurg* 2004;47:1–8
13. Har-El G, Casiano RR. Endoscopic management of anterior skull base tumors. *Otolaryngol Clin North Am* 2005;38:133–144, ix
14. Delashaw JB Jr, Tedeschi H, Rhoton AL. Modified supra-orbital craniotomy: technical note. *Neurosurgery* 1992;30: 954–956
15. Fernandes YB, Maitrot D, Kehrli P. Supraorbital minicraniotomy. *Skull Base Surg* 1997;7:65–68
16. Jallo GI, Bognár L. Eyebrow surgery: the supraciliary craniotomy: technical note. *Neurosurgery* 2006;59(Suppl 1): E157–E158; discussion E157–E158
17. Ramos-Zúñiga R. The trans-supraorbital approach. *Minim Invasive Neurosurg* 1999;42:133–136
18. Andaluz N, Romano A, Reddy LV, Zuccarello M. Eyelid approach to the anterior cranial base. *J Neurosurg* 2008;109: 341–346
19. Schwartz MS, Anderson GJ, Horgan MA, Kellogg JX, McMenomey SO, Delashaw JB Jr. Quantification of increased exposure resulting from orbital rim and orbitozygomatic osteotomy via the frontotemporal transsylvian approach. *J Neurosurg* 1999;91:1020–1026