Eyebrow incision for combined orbital osteotomy and supraorbital minicraniotomy: application to aneurysms of the anterior circulation

Technical note

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A modification of the supraorbital keyhole approach, the eyebrow incision–minisupraorbital craniotomy with orbital osteotomy, is described. Unique to this approach is a one-piece supraorbital craniotomy, measuring 2.5 × 3.5 cm, that incorporates the orbital rim and roof and the frontal process of the zygomatic bone through an eyebrow incision. The orbital osteotomy facilitates view of the anterior and middle cranial fossa through the operating microscope, as well as the maneuverability of instruments through a small craniotomy. A pericranial flap is elevated with its base at the orbit and used for closure of the frontal sinus, if necessary. The approach was used successfully in elective surgery of 10 aneurysms of the anterior circulation. The mean aneurysm size was 5.9 mm, with a range of 4 to 10 mm. Advantages of this approach include minimal disruption and exposure of normal brain tissue, reduced frontal lobe retraction, and an excellent postoperative cosmetic result. The approach is performed quickly by virtue of a limited skin incision with minimal temporalis muscle dissection and a small bone flap. The neuroendoscope, although helpful at times, is not essential and no special instruments or intraoperative image guidance is required. Relative contraindications include the presence of a large frontal sinus, severe brain edema, and recent subarachnoid hemorrhage. In addition, this approach has not been used for the treatment of giant intracranial aneurysms.

Key Words • aneurysm • orbital osteotomy • minicraniotomy • eyebrow incision • keyhole approach

Recently, minimally invasive approaches for access to the anterior cranial fossa and the sellar and parasellar regions have been described.1,4,7–9,10 Because they involve techniques in which there are minimal exposure and disruption of normal anatomy, potential advantages of these approaches include reduced operative morbidity, expeditious patient recovery, and cost effectiveness in case management. Successful management of supratentorial aneurysms by a keyhole supraorbital craniotomy has recently been reported.5,10 The small craniotomy used in these approaches often requires the use of special intraoperative instrumentation, including the neuroendoscope,5,10 intraoperative imaging, and a robotic guidance system.9 We describe a modification of the supraorbital keyhole approach, in which we combine an orbital osteotomy with a supraorbital minicraniotomy to facilitate both view and access to the anterior and middle cranial fossa in a minimally invasive fashion. Our preliminary experience with this approach in the management of aneurysms of the anterior circulation is presented.

Abbreviations used in this paper: CSF = cerebrospinal fluid; MCA = middle cerebral artery.

Clinical Material and Methods

Between January 1996 and November 2000, the senior author (W.G.) used a supraorbital craniotomy with an eyebrow incision10 in the management of 40 cases of various intracranial lesions (Table 1). Of these, nine patients (eight women and one man) with 10 aneurysms of the anterior circulation were treated by a combination of orbital osteotomy and supraorbital minicraniotomy. Table 2 lists the patients’ demographic data, location and size of the aneurysms, duration of follow-up review, and complications. The average age of the patients was 56.2 years (range 44–68 years). Aneurysm sizes were obtained during angiography. Postoperative eyebrow movement was graded using a scale of 0 to 4 in which 0 indicates no movement; 1, flicker or trace movement; 2, asymmetrical movement; 3, symmetrical passive movement; and 4, symmetrical movement against resistance. The average follow-up period was 7.9 months (range 3–14 months).

Operative Technique

The patient is positioned in a supine position. The head is elevated above the level of the heart and turned between
Eyebrow incision–supraorbital minicraniotomy for aneurysms

10° and 60° to the contralateral side of the intended incision. The extent of head rotation depends on the location of the lesion; it is increased for anterior lesions and decreased for more posterior or ipsilateral lesions. Approach to an MCA aneurysm requires a head rotation of not more than 10° to 20°. The head is slightly extended 10° to 15° (with the malar eminence the most superior point) and fixed in a Mayfield headholder (Mayfield, Ohio Medical Instrument Co., Inc., Cincinnati, OH) attached to the operating table.

The skin incision is placed in the superior edge of the eyebrow, starting from the midpupillary line and extending laterally to just behind the frontal process of the zygomatic bone (Fig. 1 left). Subcutaneous dissection is performed to expose the pericranium over the frontal bone and the temporalis fascia. Limited subcutaneous dissection is performed in the region of the supraorbital foramen to avoid injury to the supraorbital nerve and artery; however, superficial extension of the skin incision medial to the supraorbital foramen improves the exposure. The corrugator supercilii muscle is gently pushed downward during this dissection. The temporalis fascia is incised a few millimeters before its insertion at the anterior temporal line, leaving a small fascial cuff for reattachment during closure. The keyhole is exposed by subperiosteal dissection of the temporalis muscle. Aggressive dissection of this muscle is avoided to prevent injury to the frontalis branch of the facial nerve and also to avoid postoperative muscle atrophy. The skin flap is retracted using silk sutures.

A pericranial flap is created with its base at the orbital rim, thereby maintaining its continuity with the periorbita, which is stripped from the roof of the orbit (Fig. 1 left). A larger pericranium can be obtained by undermining the subgaleal flap superiorly and medially. The pericranial flap is kept moist until time of closure. The subcutaneous tissue is reapproximated using absorbable suture material.

A Burr hole is placed a few millimeters above the frontotemporal suture. The frontozygomatic process is disconnected using a craniotome. The craniotome (with its footplate attachment) is used to turn a bone flap that originates from the Burr hole site, incorporates the supraorbital bone, and ends just lateral to the supraorbital foramen. An assistant retracts the skin flap to maximize the area of bone cutting. The roof and lateral wall of the orbit are fractured with the aid of an osteotome, while protecting the orbital contents with a spatula. The one-piece bone flap (measuring approximately 2.5 × 3.5 cm) includes the frontal bone, the orbital rim and roof, and the frontal process of the zygomatic arch (Fig. 1 center and right). If the frontal sinus has been entered, it is exenterated by stripping and cauterizing its mucosa. It is then packed with fat, muscle, and liquid hydroxyapatite. The dura mater is opened in a semicircular fashion, with its base at the orbit. At completion of the intracranial procedure, a water-tight dural closure is obtained using silk sutures. The pericranial flap is reflected over any exposed frontal sinus. The bone flap is then secured in place with fixation plates. The subcutaneous tissue is reaproximated using absorbable suture material.

**Results**

Successful ligation of all aneurysms was confirmed with the aid of either intraoperative (Cases 1, 4, 6, 7, and 9) or postoperative (Cases 2, 3, 5, and 8) cerebral angiography (Fig. 2a and b). Aneurysm sizes varied between 4 and 10 mm (mean 5.9 mm). No intraoperative complications were encountered. Surgical exposure was adequate for brain dissection and clip application in all patients. The frontal sinus was entered in three patients (Cases 1, 3, and 6) and was exenterated and closed with pericranium as described earlier. Decreased supraorbital sensation was present in all patients during the immediate postoperative period. Supraorbital sensation improved significantly, returning to normal in all cases within 3 months. Decreased mobility of the eyebrow was observed during the immediate postoperative period in all patients. Full eyebrow mobility (Grade 4) returned in all patients by the 3-month follow-up evaluation, except for the patient in Case 2, in whom recovery occurred 6 months postoperatively (Fig. 3). In one patient (Case 1), periorbital edema lasted for 1 month. A second patient (Case 6), who had a history of diabetes mellitus,
required secondary closure of a nonhealing wound dehiscence at the 6-month follow-up examination; there was no clinical evidence of infection. Three months later (approximately 9 months after the original surgery), this patient exhibited complete wound healing and return of normal sensation and eyebrow movement. In one patient (Case 7), occlusion of the right femoral artery occurred during the immediate postoperative period; this was related to groin access for intraoperative cerebral angiography. This patient underwent successful embolectomy and revascularization of the lower extremity. Postoperative CSF and eyebrow alopecia were not observed in our series.

Discussion

Perneczky and colleagues\textsuperscript{1,6,10} have advocated the keyhole concept in neurosurgery and have used the supraorbital minicraniotomy extensively for a variety of lesions. Recently, others have reported experience with this approach in the management of tumors and aneurysms of the anterior cranial fossa and the sellar and parasellar regions.\textsuperscript{4,5,7}

Fundamental to the keyhole concept is minimization of the craniotomy for optimal intracranial exposure without compromising safety and efficacy in patient treatment. The craniotomy created in the supraorbital keyhole approach consists of either a simple, laterally placed, small supraorbital bone flap,\textsuperscript{1,5,10} with medial extension beyond the supraorbital foramen,\textsuperscript{7} or a one-piece supraorbital bone flap that includes the orbital rim and roof.\textsuperscript{4} To increase the field of view through the microscope and to facilitate the use of microinstrumentation, Perneczky, et al.,\textsuperscript{6} have suggested drilling of the inner table of the superior edge of the craniotomy opening. Recently, Shanno and associates\textsuperscript{9} reported their experience using a technique similar to the one described here in the management of tumors in the anterior cranial fossa, orbit, and sellar and parasellar regions. Their approach was not used in the management of intracranial aneurysms. Furthermore, their approach was routinely performed with the aid of intraoperative image guidance and a robot-mounted operating microscope. Although these intraoperative adjuncts may be helpful, we have not found them necessary. We found that gaining experience with this approach in the laboratory was very helpful.

The technique reported here is a combination of a supraorbital minicraniotomy and a small orbital osteotomy. The one-piece craniotomy parallels that described by Delashaw, et al.\textsuperscript{2} It includes the frontal bone, the orbital rim and roof, and the frontal process of the zygomatic bone. It differs from their approach in that the craniotomy has a much smaller flap, measuring $2.5 \times 3.5$ cm at maximum, and it is obtained via an eyebrow incision.

In a recent study in which the additional exposure afforded by orbital rim removal and orbitozygomatic osteotomy during frontotemporal craniotomy was quantitated, the orbital rim osteotomy consistently provided a statistically significant gain in exposure.\textsuperscript{8} Orbitozygomatic osteotomy provided a less consistent gain in exposure when the posterior clinoid, edge of the tentorium, and basilar tip apex were evaluated. In our experience, orbital rim osteotomy provides a direct view of the anterior cranial fossa and the sellar and suprasellar regions. Minimal frontal lobe retraction is required and maneuverability of instruments is not inhibited. In addition, by removing the frontal process of the zygomatic bone, structures of the middle fossa are well appreciated. A low basal approach is afforded to the circle of Willis, and dissection of the sylvian fissure and the MCA can be performed easily. The keyhole burr hole in the temporal bone may be expanded backward a few millimeters, if additional exposure of the middle fossa is desired.
Transient loss of supraorbital sensation frequently occurs and is attributed to traction on the supraorbital nerve. Unlike other approaches, an attempt is made to preserve the supraorbital nerve when using the current approach. Prolonged paresis of the eyebrow and elevation may be due to interruption of the insertion of the frontalis muscle on the eyebrow itself. This deficit appears to recover with postoperative healing. As is the case with the standard pterional approach to aneurysms of the anterior circulation, atrophy of the anterior temporalis muscle can occur and may cause a small indentation in the temporal region. Nevertheless, the potential for this complication is reduced by virtue of the limited dissection of the temporalis muscle. The course of the frontalis branch of the facial nerve is well inferior and lateral to the skin incision, where it is less likely to sustain injury. Alopecia of the eyebrow was not observed in this series. Postoperative cosmetic results were quite acceptable and, in most patients, were excellent. The use of the single burr hole obviates the potential for a postoperative defect associated with a second frontal burr hole.

A large frontal sinus is a relative contraindication to this approach. The frontal sinus was entered and exenterated in three patients. Due to the small size of the current series, any correlation between intraoperative entry into the frontal sinus and the risk of postoperative infection or CSF leak would be premature at this time. The pericranial flap is very important for providing tissue to overlay the frontal sinus during closure. The flap can also be used to repair dural defects. We have not used the current approach in the treatment of patients presenting with acute subarachnoid hemorrhage. Brain swelling, bloody CSF, and the increased risk of cerebrovascular rupture make this approach less optimal. In addition, this approach was not used for the treatment of giant intracranial aneurysms.

Conclusions

A modification of the supraorbital keyhole approach through an eyebrow incision is described. By including an orbital osteotomy, a broad view of the anterior and middle cranial fossa can be obtained. Routine use of the endoscope or special instrumentation was not required. The current technique can be used to approach aneurysms of the anterior circulation, including those of the MCA. A watertight dural closure and meticulous wound closure, particularly of the brow skin incision, are important to attain a good cosmetic result. In our experience, the exposure is equal to and, in some cases, better than pterional exposure for treating aneurysms of the anterior circulation. The main advantage of this technique is the low basal approach to the circle of Willis. The superiority of this technique over standard craniotomy or orbitozygomatic craniotomy has yet to be determined. Further applications of this approach are being evaluated.

Acknowledgment

We thank Paul H. Dressel for preparation of the illustrations.

References


Contents of this paper were distributed by a poster presentation at the 2001 Annual Meeting of the American Association of Neurological Surgeons, Toronto, Ontario, Canada.
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