Orbital Roof Craniotomy Via an Eyebrow Incision: A Simplified Anterior Skull Base Approach

H.-D. Jho

Department of Neurological Surgery, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

Utilizing the conceptual combination of brain protective skull base surgery and minimalism, a conventional frontal craniotomy for tumors in the subfrontal and parasellar regions is modified to an orbital roof craniotomy. Through a 4 to 5 centimeter (cm) long eyebrow incision an orbital roof craniotomy (measuring 2 cm by 3 cm), including the supraorbital arch, is made as a single piece bone flap. The orbital roof is opened up to the supraorbital fissure and to the optic canal by additional removal of the bone in the orbital roof. This will expose the globe and the orbitofrontal duramater. When the dural incision is made at the orbital portion of the dura mater, the orbital contents are retracted by tack-up sutures. The tumor is removed utilizing the orbital space rather than the intracranial space. Brain retractors are not necessary and are not used to execute the tumor resection. This technique has been used in three patients with craniopharyngiomas, seven patients with meningiomas, and one patient with a subfrontal teratoma. Gross total resection was achieved in three patients with craniopharyngiomas and in five patients with subfrontal or parasellar meningiomas. Subtotal resection of the tumor was achieved in two patients with recurrent meningiomas and in the patient with a subfrontal teratoma. The surgeon’s operating space through this exposure was sufficiently ample to achieve the goals of the operation. The direct eyebrow incision provides an additional vital working space with a width of more than 1 cm at the skull base by eliminating the scalp flap which a coronal incision employs. The surgical technique is described with a report of 11 cases.

Key words: Brain tumor – Craniopharyngioma – Craniotomy – Meningioma

Introduction

With an effort to protect the brain in skull base surgery, different skull base surgical techniques have been reported recently for approaching the parasellar area (1–3). The concept in these skull base approaches entails extensive exposure at the base of the skull so that the brain is not damaged by unnecessary retraction. Although these procedures have made contributions to minimizing brain injury, they are more complicated in opening and closure than the conventional subfrontal craniotomy approach. The time spent on the approach itself may be substantial and the complicated exposure may possibly increase the associated morbidity. Despite the extensive exposure made with complex skull base techniques, the surgeon is still often confined to a small surgical space to accomplish tumor removal while minimizing brain injury. This tiny but vital working space is a key and essential area for ample exposure.

The concept of minimalism has been introduced recently to minimize morbidity associated with the surgical procedure itself, to enhance the patient’s quick recovery coupled with improved outcome, and to improve cost effectiveness. With the conceptual combination of brain-protective skull base surgery and risk-reduction minimalism in techniques approaching the subfrontal and parasellar region, the orbital roof craniotomy technique is utilized through a small eyebrow incision. Although it is simply a modified technique rather than an entirely new one, this technique provides direct key-point exposure to permit surgeons to reach neoplasms or vascular lesions in the subfrontal or parasellar regions eliminating unnecessary portions of the exposure process and usage of brain retractors.

Clinical Material and Methods

Patient population

From July of 1994 to February of 1996, 11 patients were treated with this technique. Seven were men and four women. Median age was 48 years (range 30 to 78 years). Three patients had craniopharyngiomas. One of the three had a recurrent craniopharyngioma with three previous craniotomies. All three presented with a visual disorder and panhypopituitarism. The patient with a recurrent craniopharyngioma had diabetes insipidus preoperatively. Seven patients had meningiomas. One patient had an olfactory groove meningioma; two, planum sphenoidale; two, tuberculum sellar; one, anterior clinoid; and one, sellar. Two of the seven meningiomas were recurrent. The clinical presentation of the meningiomas was a visual disorder in four patients and personality changes and headaches in three patients. One of the patients with headaches and a visual disorder had a teratoma at the subfrontal region extending to the posterior fossa (Table 1).

Operative technique

The operation is performed under general anesthesia with endotracheal intubation. The patient’s head is positioned in the midline upright position with a head pin fixation sys-
Table 1 Summary of cases

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Type of tumor</th>
<th>Preoperative symptoms</th>
<th>Results</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>F</td>
<td>Teratoma</td>
<td>Headache, Visual disorder</td>
<td>Subtotal resection</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>M</td>
<td>Craniopharyngeoma</td>
<td>Visual disorder, Panhypopituitarism</td>
<td>Symptoms improved</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
<td>M</td>
<td>Craniopharyngeoma</td>
<td>Visual disorder, Panhypopituitarism</td>
<td>Total resection</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>59</td>
<td>M</td>
<td>Craniopharyngeoma</td>
<td>Visual disorder, Panhypopituitarism</td>
<td>Vision improved</td>
<td>Diabetes</td>
</tr>
<tr>
<td>5</td>
<td>69</td>
<td>M</td>
<td>Olfactory groove meningioma</td>
<td>Headache, Personality change</td>
<td>Vision improved</td>
<td>Diabetes</td>
</tr>
<tr>
<td>6</td>
<td>61</td>
<td>M</td>
<td>Tuberculum sellar meningioma</td>
<td>Visual disorder</td>
<td>Total resection</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>43</td>
<td>M</td>
<td>Planum sphenoidale meningioma</td>
<td>Headache, Personality change</td>
<td>Symptoms improved</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>78</td>
<td>F</td>
<td>Recurrent tuberculum sellar meningioma</td>
<td>Visual disorder</td>
<td>Subtotal resection</td>
<td>Visual loss</td>
</tr>
<tr>
<td>9</td>
<td>48</td>
<td>F</td>
<td>Planum sphenoidale meningioma</td>
<td>Headache, Personality change</td>
<td>Total resection</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>36</td>
<td>M</td>
<td>Anterior clinoid meningioma</td>
<td>Visual disorder</td>
<td>Symptoms improved</td>
<td>None</td>
</tr>
<tr>
<td>11</td>
<td>46</td>
<td>F</td>
<td>Recurrent sellar meningioma</td>
<td>Visual disorder</td>
<td>Vision</td>
<td>Worsened in other eye</td>
</tr>
</tbody>
</table>

The eyebrow skin incision is made at 1 or 2 millimeters (mm) above the eyebrow and about 4 to 5 cm in length. One third of the skin incision is located medially to the supraorbital notch and two thirds, laterally to it. The first wrinkle on a patient's forehead is used when they have noticeable forehead wrinkles. It is usually located about 1 cm above the eyebrow. The supraorbital nerve is divided along the skin incision line. Although the supraorbital nerve is not reanastomosed at the time of closure, reanastomosis of the nerve may enhance the recovery of forehead sensation. The periosteum is dissected exposing the supraorbital arch and frontal bone. The periorgita is dissected from the roof of the orbit. The supraorbital arch is exposed in an area about 3 cm in width by 2 cm in height. The supraorbital notch is located at the medial one third point of the exposed bone.

Drill bit without the dura-protective guard, the supraorbital arch is divided from the intracranial cavity to the orbit. The periorgita is protected with a narrow blade ribbon retractor. When the frontal bone is too thick to be cut with a pediatric bit, an adult bit is used. The orbital roof is fractured medially and laterally along the longitudinal axis of the orbital roof. Once the medial and the lateral portions of the orbital bone have been fractured, the orbital roof is fractured by lifting the bone flap toward the globe. A single piece bone flap including the supraorbital arch and the orbital roof is then removed (Fig. 1a). The orbital roof in the bone flap may be fractured at the middle of the orbital roof or near the optic canal depending on the thickness of the bone. The remaining orbital roof is removed with a small rongeur up to the optic canal and to the superior orbital fissure. The bone fragments from the orbital roof are kept as intact as possible for later replacement. Half of the surgical field is occupied by the globe and the other half by the orbitofrontal dura mater (Fig. 1b). The orbitofrontal dura mater is opened in curvilinear fashion exposing the orbitofrontal cortex. Dural tack-up sutures are made to retract the globe as much as possible which will create a working space under the orbitofrontal cortex. A piece of latex glove with a cotton pledge is placed at the exposed brain to apply gentle counter-pressure comparable to the intracranial pressure.

Under the operating microscope, the prechiasmatic or Sylvian cistern is approached and cerebrospinal fluid (CSF) is drained. Once the CSF has been drained, the brain will fall
away from the base of the skull with gravity providing a 1 to 2 cm wide natural working space. This will facilitate tumor removal or provide an approach to vascular lesions. Brain retractors are not required to remove tumor located near the optic system, the pituitary stalk, the lamina terminalis, the basilar artery, or the main arteries of the anterior circulation. This technique will also provide excellent exposure to the orbital cavity. Brain retractors were not used at any time in any of our cases.

When the tumor has been removed, the dura mater is closed with 4-0 nonabsorbable sutures. The small pieces of bone taken from the roof of the orbit are laid between the dura mater and the globe. The bone flap is repositioned with titanium micro-plates and screws. If the frontal sinus is exposed at the edge of the craniotomy, it is simply reaproximated with intimate approximation of the inner table of the frontal sinus. The mucosa and the ostium of the frontal sinus are kept intact as much as possible. When the dura is not closed in watertight fashion, a periosteal occlusive graft is placed to obliterate the frontal sinus. The peristeum is closed with 3-0 absorbable sutures. The supraorbital nerve was not reanastomosed in this series but can be reattached with 8-0 nylon sutures. The skin is closed in subcuticular fashion. The skin closure is further reinforced with Steri-strips®. One Band-aid® dressing is applied.

When a patient refuses the eyebrow incision, a unilateral coronal incision is made from 1 cm anterior to the tragus to the forehead behind the hair line. The supraorbital nerve remains intact with a unilateral coronal incision. The remainder of this procedure resembles the procedure incorporating the eyebrow incision. The coronal scalp flap will hinder the about one centimeter wide operating space at the frontal base. The cases in which a coronal incision was utilized are not included in this series.

Illustration of cases

Case 1: This 34-year-old woman was referred to the University of Pittsburgh Medical Center (UPMC) with complaints of headache and blurred vision for one year. Her neurological examination was normal besides papilledema. Magnetic resonance (MR) imaging of the brain showed a large subfrontal tumor extending to the premesencephalic cistern (Fig. 2a). A right-sided orbital roof craniotomy was performed via a 4 cm long incision just above the eyebrow in January of 1995 (Fig. 2c). Gross total resection was achieved except for tiny pieces of capsular membrane attached to the pituitary stalk, right optic nerve, and perforating arteries of the basilar artery. Histologic diagnosis was teratoma. She was moved to a regular room after she recovered from anesthesia. She ambulated on the day of her operation. She was discharged home on the third postoperative day. An MR scan of the brain taken two days postoperatively demonstrated good resection of the tumor (Fig. 2b). Her headaches resolved and her blurred vision improved postoperatively.

Case 2: This 59-year-old man was referred to UPMC with panhypopituitarism and a visual field defect. An MR scan of the brain demonstrated a suprasellar tumor suggestive of a craniopharyngioma (Fig. 3a). He underwent a right-sided orbital roof craniotomy via a 4 cm long incision along the first crease of his forehead for total resection of the tumor in August of 1995 (Fig. 3c). His postoperative course was benign except for diabetes insipidus. He was discharged home on the third postoperative day. A postoperative MR scan of the brain demonstrated total resection of the tumor (Fig. 3b). His visual fields improved with some residual defect.

Case 3: This 48-year-old woman was referred to UPMC with a six-month history of personality changes, loss of smell, and headache. Neurological examination was normal except for the loss of smell. An MR scan of the head showed a subfrontal enhancing mass measuring 4 cm in diameter with severe bifrontal edema, suggestive of a planum sphenoideale meningioma (Fig. 4a). She underwent a right-sided orbital roof craniotomy via a 4 cm long skin incision along her first forehead wrinkle which was about 1 cm above the eyebrow (Fig. 4c). Gross total resection of the tumor was

* Steri Strip® from 3M, St Paul, MN 55144-1000.
** Band-aid® from Johnson & Johnson Medical, Inc. Arlington, Texas 76004-3130.
Fig. 2  Sagittal views of the MR scans in case 1 show a tumor extending from the anterior frontal base to the premesencephalic cistern (a) and good resection of the tumor 2 days postoperatively (b). A line for the surgical incision 1 or 2 mm above the eyebrow is drawn about 4 cm in length (c). The picture at the right upper corner depicts a surgical scar six weeks postoperatively. The surgical scar is often not noticeable three to six months postoperatively.

Fig. 3  Coronal views of the MR scans in case 4 reveal a round enhancing suprasellar mass suggestive of a craniopharyngioma (a), and complete resection of the tumor 6 weeks postoperatively (b). Band-aid dressing is applied postoperatively. The surgical incisional line is visible along the first forehead wrinkle at 1 cm above the right sided eyebrow six weeks postoperatively (c).
Orbital Roof Craniotomy Via an Eyebrow Incision: A Simplified Anterior Skull Base Approach

Fig. 4 Axial view of the MR scan in case 9 shows a subfrontal tumor measuring 4 cm in diameter with substantial surrounding brain edema suggestive of a planum sphenoidale meningioma (a). The sagittal view of the MR scan reveals complete resection of the tumor six weeks postoperatively (b). A Band-aid® dressing is placed postoperatively. The surgical incisional line is still noticeable along the first wrinkle crease 1 cm above the eyebrow six weeks postoperatively (c).

achieved without incident. Despite the extensive bifrontal edema displayed on the MR scan, a brain retractor was not required. The postoperative course was benign and she was discharged home on her third postoperative day. A postoperative MR scan taken 6 weeks postoperatively demonstrated total resection of the tumor and resolution of the bifrontal cerebral edema (Fig. 4b). Her clinical symptoms resolved.

Results

Working space

The working space provided by the 2 × 3 cm craniotomy was sufficiently large for a surgeon to handle two two-blade surgical instruments simultaneously. To facilitate handling in the limited space the surgical instruments have to be slender with their blades parallel. Removal of the orbital roof had to be carried out near the optic nerve and superior orbital fissure to eliminate the usage of brain retractors. The pieces of latex glove and cottonoids placed on the surface of the brain sacrifice a few millimeters of operating space. Using thinner material for brain protection may help to minimize the narrowing of this vital working space.

Surgical outcome

In the patient with a teratoma, most of the tumor was resected except for tiny pieces of thin tumor capsule attached to the pituitary stalk, the right optic nerve, and brainstem perforating arteries. Her headache and visual disorder improved postoperatively. Gross total resection of the tumor was achieved in the three patients with craniopharyngiomas. All three experienced improvement of their visual disorder and continued to have panhypopituitarism. Gross total resection of the tumor was achieved in five patients with meningiomas. All five patients resolved their symptoms postoperatively. Subtotal resection of the tumor was achieved in two patients with recurrent meningiomas which were extended into the cavernous sinus. One of the two recurrent meningiomas was treated with stereotactic gamma knife surgery for residual tumor in the cavernous sinus. Her preoperative visual disorder improved in one eye but deteriorated in the other eye which was functionally blind preoperatively. The other patient with a recurrent meningioma was not treated for the residual tumor because
of her advanced age. Her preoperative visual disorder which was blindness in one eye and a severe visual field defect in the other deteriorated to functional blindness.

Complications

All patients experienced postoperative sensory numbness along the supraorbital nerve distribution. The area of numbness lessened with time. None of the patients developed pain syndromes or painful neuromas. None of the patients developed frontalis paralysis. Periorbital ecchymosis and swelling occurred postoperatively and had subsided gradually over one or two weeks. Application of a cold pack around the eye lessened the degree of postoperative periorbital swelling. Skin incisions were noticeable at the six week follow-up visit but unnoticeable at three to six months. Deterioration of vision occurred in the two patients with recurrent meningiomas which had encased the optic nerves. Two patients with craniopharyngiomas developed diabetes insipidus postoperatively in addition to their preoperative panhypopituitarism (one patient with a recurrent craniopharyngioma had diabetes insipidus preoperatively). None of the patients showed clinical or MR imaging evidence of brain injury related to the surgical approach.

Discussion

Despite the meticulous preparation for brain reduction, retraction induced brain injury occurs more often than desired in the surgery of lesions located at the base of the skull (4). In an attempt to protect the brain in addition to the conventional measures of brain reduction, a more basal approach to the lesion had been applied as a surgical tactic for brain protection (1-3). This extensive skull base approach requires radical dissection in the soft tissue and bone, which may consume more of the surgeon's time and energy by being asserted to the surgical exposure itself. Despite the extensive exposure made with the conventional craniotomy and additional skull base approaches, the surgeon's final operating space is still often very limited confining the surgeon to a small keypoint working area.

Recently, minimalism in skull base surgery using a "keyhole" surgical technique has been introduced into the neurosurgical community (5). This small limited exposure requires less time in opening and closure than the more extensive skull base techniques. Recovery from the surgery may be fast and it may be cost effective. Although the principle of "keyhole" surgery is risk reduction, small and limited exposure does not necessarily reduce the risk of surgery. A surgeon may then have to be almost acrobatic in the performance of his technique through this limited exposure which may then actually increase the risks of the operation.

With the conceptual combination of skull base surgery aiming at protection of the brain and minimalism, the conventional subfrontal approach has been modified to provide a surgeon with exposure of only a necessary keypoint working area. An extensive frontal craniotomy exposes the frontal brain through which a surgeon is not able to advance in order to gain access to lesions without damaging the frontal lobe. This exposure to the frontal brain is a part of unnecessary exposure in extensive skull base surgery. If a surgeon truly tries to avoid damaging the brain by physical force; the keypoint working space in the subfrontal approach should be the area that combines the naturally existing potential space created by the drainage of CSF and the orbital cavity.

A coronal skin incision itself will sacrifice this vital 1 cm wide intrinsic working space. An extensive bicoronal incision from tragus to tragus is required in order to peel the scalp flap down to the frontal suture to maximize the exposure through a coronal incision. A skin incision just above the eyebrow will maximize exposure to this keypoint working area by eliminating a hindering scalp flap, and will provide the advantages of minimalism by avoiding a long skin incision and surrounding dissection.

The orbital roof craniotomy technique is a modification rather than an innovation. Frazier (6) in 1913 described a successful operation performing a combination of an osteoplastic frontal craniotomy and an orbital roof resection to approach a pituitary tumor. The surgical incision was made along the eyebrow, midline forehead, and forehead behind the hairline with the skin flap attached to the temporal side. With burr holes, a frontal craniotomy was made using an osteoplastic technique. The supraorbital arch, including a part of the orbital roof, was resected as a second piece of the bone flap. The rest of the orbital roof was removed to obtain access to the pituitary tumor.

Jane et al. (7) in 1982 modified this two piece bone flap method to a one piece bone flap technique through a coronal skin incision naming it "the supraorbital approach". Others reported similar techniques with modifications (8-12). The bone flap was removed through an eyebrow incision in this report is similar to the orbital roof flap taken as the second piece by Frazier. The supraorbital approach reported by Jane et al. still exposes a substantial portion of the frontal intracranial cavity as the brain swells. The technique reported here is one that incorporates a dimensionally smaller frontal bone flap, and a more extensive resection of the orbital roof up to the optic canal and the superior orbital fissure. The surgeon's main operative space is the orbital cavity rather than the intracranial cavity. Therefore, the technique described here is designated as an orbital roof craniotomy instead of a supraorbital approach. Although this technique is described here using a direct eyebrow incision, it can be done through a coronal incision if a patient desires not to have a visible scar on the forehead. Although the line of the incision above the eyebrow was still visible in patients at their six week follow-up, it was not noticeable six months postoperatively. Our skin incisions have not been made in the middle of the eyebrow to avoid hair loss.

This technique is not a "keyhole" technique, but rather a minimal, necessary, and adequate exposure to locate the intrinsic keypoint operating space. The working space, which measures 2 x 3 cm, is adequate for a surgeon to utilize two-blade surgical instruments under direct microscopic visualization. No special measures such as hyperven-
Orbital Roof Craniotomy Via an Eyebrow Incision: A Simplified Anterior Skull Base Approach


• ENDOSCOPE ASSISTED •
• MICRONEUROSURGERY •

ENDOSCOPE ASSISTED MICRONEUROSURGERY •
CONGRESS
June 10-12, 1998, Sheraton, Airport Frankfurt, Germany

ENDOSCOPE ASSISTED MICRONEUROSURGERY •
CONGRESS
June 10-12, 1998, Sheraton, Airport Frankfurt, Germany

ENDOSCOPE ASSISTED MICRONEUROSURGERY •
CONGRESS
June 10-12, 1998, Sheraton, Airport Frankfurt, Germany

Acknowledgement

The author wishes to thank Arthur P. Nestler, B.S.N., for his review of this manuscript.

References


Corresponding Author

Hae-Dong Jho, M.D., Ph.D.
Department of Neurological Surgery
Presbyterian University Hospital
Suite B-400, 200 Lothrop Street
Pittsburgh
Pennsylvania 15213
USA