The Supraorbital Keyhole Approach via an Eyebrow Incision for Resection of Tumors around the Sella and the Anterior Skull Base

Abstract

Objective: This study evaluates the technique, indications, advantages and limitations of the minimal invasive supraorbital keyhole approach via an eyebrow skin incision for resection of tumors around the sella and the anterior skull base.

Methods and Results: In 9 patients (5 males, 4 females) different tumors (6 meningoas, 1 craniopharyngioma, 1 Rathke’s cleft cyst and 1 hypophyisitis) with a maximum diameter of 30 millimeters were resected via a small eyebrow incision and a supraorbital keyhole craniotomy. Details of the operative procedure include the use of a high-speed drill, a microsaw, bayonet-shaped instruments, careful microsurgical dissection, the use of a neuroendoscope and miniplats for closure. In all patients complete tumor removal was achieved. Mean duration of surgery was 01 h 51 min and mean hospital stay was 8.9 days. There were no significant postoperative complications. Clinical examination and MR imaging after a mean follow-up of 313 days revealed no tumor recurrence and a very satisfying overall functional and cosmetic result in all patients.

Conclusion: The eyebrow incision supraorbital keyhole approach proved to be safe, effective and time-sparing. The authors recommend this approach for resection of small tumors around the sella and the anterior skull base in selected cases as a valuable alternative to standard skull base approaches.

Key words
Keyhole approach · eyebrow incision · anterior skull base · skull base surgery · endoscopy-assisted surgery

Introduction

Advances in neuroimaging and recent developments such as neuronavigation, neuroendoscopy and interventional neuroradiology have encouraged neurosurgeons to develop or modify surgical procedures in order to minimize exposure and dissection of normal anatomy. Such minimally invasive procedures have the potential to reduce operative morbidity, to facilitate patient recovery, to speed up the surgical procedure and thus improve cost-effectiveness in case management. The supraorbital keyhole approach is a minimally invasive procedure to access lesion of the anterior cranial fossa [1–3]. Recently, several authors have reported their experience using this approach to treat aneurysms of the anterior circulation [4–9]. This report critically analyzes the authors’ experience with a supraorbital keyhole approach via a small skin incision within the eyebrow (Fig. 1) in the management of tumorous lesions around the sellar region and the anterior skull base.

Patients and Methods

Nine unselected consecutive patients, 5 females and 4 males, with tumorous lesions around the sellar region and the anterior skull base were treated between January 2000 and December 2002 using a supraorbital keyhole approach with an eyebrow incision. Mean age of the patients was 47.6 years (range 36.2 to 65.7 years). There were 6 meningoas, 1 craniopharyngioma, 1 Rathke’s cleft cyst and 1 patient with a suprasellar enhancing mass, which was histologically classified as hypophysisis. Maximum diameter of the lesions did not exceed 30 millimeters. A
summary of the patients’ clinical characteristics is presented in Table 1. At follow-up all patients underwent a complete neurological examination including functional testing of facial and frontal nerves performed by a member of the clinical staff other than the surgeon. The cosmetic result was judged by visual inspection. Enhanced MR imaging was performed in all cases to look for residual or recurrent tumor.

**Surgical technique**

The patient was placed in a supine position with the head sharply fixed in a 3-pin device and elevated above the level of the heart. Depending on the location of the lesion the head was turned between 15 and 45 degrees to the opposite side to achieve a straight line of vision. An about 40 mm skin incision was carried out within the eyebrow starting lateral to the supraorbital foramen and the course of the frontal nerve and extending laterally to the frontal process of the zygomatic bone. A limited dissection of the temporalis muscle was carried out to expose parts of the frontal process of the zygomatic bone. Then a burr hole was placed just behind and above the frontosphenoid suture. The dura was dissected free using a Gigli-saw guide. The orbital roof was then identified and, if necessary, the burr hole was extended to the level of the orbital roof. All bony material including bone dust was carefully collected to cover the burr hole at the end of surgery. A frontal osteotomy of about 25 × 35 mm flush with the orbital roof was then carried out by means of a high speed craniotome equipped with a footplate. A microsaw was also used for this purpose in some cases. Thus, the osteotomy consisted of a small frontal craniotomy which includes parts of the orbital rim. An important point is to have the cutline of the bone flush with the floor of the orbital roof in order to minimize retraction of the frontal lobe. Then a linear dura incision was performed. In general, intradural surgery was similar to standard microsurgery via a subfrontal route. Fine bayonet-shaped microsurgical tools for suction, dissection, cutting and coagulation are recommended. A neuroendoscope was used in some cases because of its capability to provide a close-up wide angled view (Fig. 2). After resection of the tumor a careful watertight closure of the dura was performed. Dural closure was facilitated by dissecting the dura free from the surrounding bone and the orbital roof. The replaced bony segment was fixed by means of a titanium miniplate and the burr hole was closed with bone dust or a bone chip (Fig. 1) and covered by the reinserted temporalis muscle. Finally a non-absorbable monofil 4–0 suture was used for wound closure and a simple adhesive tape dressing was applied. If the frontal sinus was opened the mucosa of the sinus

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![Fig. 1](image-url)

*Fig. 1* Case No. 1: This 54-year-old female patient suffered from unilateral visual loss caused by a meningioma around the right anterior clinoid. MR imaging (A: sagittal plane; B: coronal plane) demonstrates an enhancing mass. C–F: Details of the operative procedure. C: The patient is positioned prone with the head slightly extended, 15 degree turned left and fixed in the 3-pin device. D: Close-up view of the draped operative field with the eyebrow incision line marked. E: Bony segments of the supraorbital osteotomy. F: Closure of the osteotomy by means a titanium miniplate.
Table 1  Clinical characteristics of the patients and results of follow-up

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (years), Sex</th>
<th>Diagnosis</th>
<th>Presenting symptoms</th>
<th>Duration of surgery (hh:mm)</th>
<th>Hospital stay (days)</th>
<th>Comments</th>
<th>Follow-up (days)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, L.P.</td>
<td>54, f</td>
<td>meningioma</td>
<td>visual loss</td>
<td>01:42</td>
<td>7</td>
<td>endoscopy assisted</td>
<td>668</td>
<td>improved vision, no tumor</td>
</tr>
<tr>
<td>2, Y. S.</td>
<td>39, m</td>
<td>meningioma</td>
<td>visual loss</td>
<td>01:30</td>
<td>9</td>
<td>lumbar CSF drain</td>
<td>551</td>
<td>normal vision, no tumor</td>
</tr>
<tr>
<td>3, M.K.</td>
<td>36, f</td>
<td>Rathke’s cleft cysts</td>
<td>hormonal dysfunction, headache</td>
<td>01:51</td>
<td>9</td>
<td>none</td>
<td>400</td>
<td>mild headache, no tumor</td>
</tr>
<tr>
<td>4, G.S.</td>
<td>41, f</td>
<td>meningioma</td>
<td>headache</td>
<td>02:00</td>
<td>12</td>
<td>endoscopy assisted</td>
<td>365</td>
<td>no tumor</td>
</tr>
<tr>
<td>5, A.S.</td>
<td>38, f</td>
<td>hypophysisis</td>
<td>diabetes insipidus</td>
<td>03:06</td>
<td>9</td>
<td>endoscopy assisted</td>
<td>319</td>
<td>no tumor</td>
</tr>
<tr>
<td>6, W.L.</td>
<td>54, m</td>
<td>meningioma</td>
<td>visual loss, headache</td>
<td>02:31</td>
<td>8</td>
<td>none</td>
<td>218</td>
<td>normal vision, no tumor</td>
</tr>
<tr>
<td>7, H.S.</td>
<td>65, m</td>
<td>craniopharyngioma</td>
<td>visual loss</td>
<td>01:37</td>
<td>8</td>
<td>none</td>
<td>137</td>
<td>improved vision, minimal facial weakness, no tumor</td>
</tr>
<tr>
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<td>meningioma</td>
<td>visual loss</td>
<td>01:40</td>
<td>10</td>
<td>endoscopy assisted</td>
<td>113</td>
<td>improved vision, no tumor</td>
</tr>
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<td>9, A. S.</td>
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<td>meningioma</td>
<td>headache</td>
<td>00:44</td>
<td>8</td>
<td>lumbar CSF drain</td>
<td>43</td>
<td>mild local hypesthesia, no tumor</td>
</tr>
</tbody>
</table>

was pushed back and the sinus was covered with a flap of temporalis fascia. This material was acquired from the region of the lateral skin incision. The covering of the sinus was held in place by the reinserted and fixed bone flap. In both of our patients with opened frontal sinus a lumbar drain was placed immediately after surgery.

Results

Complete removal of the tumor was achieved in all cases. Mean duration of surgery from skin incision to wound closure was 1 h 51 min with a range of 44 min to 3 h 6 min. Mean length of hospital stay after surgery was 8.9 days (range 7 to 12 days).

Transient periorbital swelling and decreased supraorbital sensation was frequently encountered in the early postoperative period but resolved within days or weeks. The postoperative course was otherwise uneventful in all cases. We observed no new neurological deficits and no infections or disturbances of wound healing. In the two patients with opening of the frontal sinus during osteotomy the lumbar CSF drain was left in place for 5 and 7 days, respectively. No CSF leak occurred.

All patients had clinical and radiological follow-up with MR imaging. Mean time of follow-up was 313 days (range 43 to 668 days). There was no patient with clinical or radiological evidence of residual or recurrent tumor. One patient presented mild local hypaesthesia at the forehead adjacent to the eyebrow skin incision and another patient showed slight weakness of the frontal branch of the facial nerve (Table 1). Considering the surgical wound, the osteotomy site and the state of the temporalis muscle the overall cosmetic result was very satisfying in all cases. An example is given in Fig. 3.

Discussion

The eyebrow incision supraorbital keyhole approach is essentially a modification of the standard well-known subfrontal approach [10–14] with miniaturization of both the skin incision and the craniotomy. Thus, with some practice the approach is relatively time-sparing compared to standard skull base approaches. The use of a high-speed drill and a microsaw is helpful. A microsaw is advantageous over a craniotome because of its finer cutlines. However, its use requires a careful and complete protection of the dura. The most important difference of this approach compared to a standard microsurgical approach is that the working angle for the surgical tools is more restricted. Handling of the surgical tools through the small keyhole requires some modification of the technique because the surgeon has to work bimanually along a straight axis. The use of a neuroendoscope in addition to the operating microscope is helpful in some cases. It allows early visualization of structures which are hidden behind the tumor (Fig. 2). Furthermore, a bright illumination of the operative field is gained and more details become visible, if a rigid lensscope is used. A very comprehensive description of this technique including numerous details of technical refinements is given by Perneckzy and co-workers [15]. The exposure of dura may be extended by including parts of the orbital roof into the osteotomy, as suggested by other authors [2]. However, we feel that this extension is of limited value, if the initial osteotomy is carried out through the orbital rim and is really flush with the floor of the orbital roof. For closure the use of miniplates and screws is highly advisable because it facilitates an exact and stable fixation of the osteotomized bone (Fig. 1), which is important with regard to the cosmetic result. In both of our patients with opening of the frontal sinus we inserted a lumbar CSF drain prophylactically to prevent a CSF fistula, although we actually do
not believe that this is indispensable, if a watertight dural closure is performed.

A limited skin incision within the eyebrow, preservation of the frontal nerve and careful closure of the dura and the osteotomy site are essential to achieve a favorable cosmetic and functional result. If a more extensive skin incision and a larger craniotomy appear to be necessary it is in our opinion advisable to use a standard bicoronal skin incision and a standard frontal craniotomy, which will result in a more acceptable cosmetic result than an inappropriate enlargement of the eyebrow incision. Thus, an important consideration when applying this approach is the selection of appropriate cases. While it is possible to remove a lesion which is larger than the approach itself by applying the principal of piecemeal tumor removal like in other skull base surgeries, we did not use this keyhole approach for tumors with extensive infiltration of dura and bone. We believe that a wide standard skull base approach is indispensable when extensive drilling of bone and reconstruction of bone and dura is anticipated. Consequently, this approach is reserved for smaller lesion without or with only limited involvement of the dura. These were particularly circumscribed suprasellar lesions and lesions around the sella, the clinoid process, the sphenoid ridge, the planum sphenoidale and orbital roof.

Fig. 2 Case No. 6: Enhanced MR images (A axial plane; B coronal plane) of a 54-year-old man showing a meningioma around the clinoid process compressing the right optic nerve. C–F Intraoperative photographs. C The initial view with the operating microscope demonstrates the tumor covering and compressing the right optic nerve. D The neuroendoscope allows a more close-up and detailed visualization of the relationship between tumor and optic nerve. E View with the operating microscope after tumor resection demonstrating the decompression of the optic nerve. D Endoscopic inspection after tumor resection allows a more wide angled view of the surgical field. (*) right optic nerve, (T) tumor, (H) pituitary stalk.
A further important point to keep in mind is that, although miniaturization of the approach reduces trauma to soft tissue and bone, this does not necessarily include less trauma to brain or less risks of neurological damage. Thus, a careful microsurgical technique of dissection and handling of neural tissue is crucial for the functional result just like in other skull base approaches.

Advantages of the supraorbital approach via an eyebrow incision are the sparing of surgical time by virtue of the small skin incision and craniotomy, which becomes obvious after the surgeon has completed his learning curve. Furthermore, this minimally invasive approach is advantageous over conventional approaches by a more rapid postoperative recovery of the patient and a very satisfying cosmetic result. Once the surgeon has become familiar with this approach these advantages are in our experience actually self-evident.

In summary this approach is a nice extension of the surgical repertoire and an alternative to the conventional subfrontal or pterional approach in carefully selected cases.

References

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