The supraorbital eyebrow approach in children: clinical outcomes, cosmetic results, and complications

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OBJECT The supraorbital eyebrow approach utilizes an eyebrow skin incision to fashion a supraorbital craniotomy for exposure of the subfrontal corridor. This provides anterolateral access to surgical lesions in the anterior cranial fossa, parasellar regions, brainstem, and medial temporal lobe. With use of the endoscope, further areas can be accessed. This approach has been applied effectively in adults, but questions remain about its use in children—specifically with regard to adequate working space, effectiveness for achieving the desired results, cosmesis, and complications.

METHODS The authors conducted a retrospective review of more than 450 cases involving patients of all ages who had undergone a supraorbital eyebrow approach performed by the senior author (C.T.) from 1995 to 2013. Only cases involving patients younger than 18 years with a minimum follow-up of 6 weeks were included in this study. All inpatient and outpatient records were retrospectively reviewed and clinical/operative outcomes, cosmetic results, and complications were recorded. In the present article, the authors briefly describe the surgical approach and highlight any differences in applying it in children.

RESULTS Fifty-four pediatric patients who had undergone a supraorbital eyebrow approach met inclusion criteria. The pathological conditions consisted mostly of tumors or other resectable lesions. In a total of 51 resectable lesions, 44 surgeries resulted in a gross-total (100%) resection and 7 cases resulted in subtotal (50%–99%) resection. The endoscope assisted and expanded visualization or provided access to areas not reached by standard microscopic visualization in all cases. Cosmetic outcomes were excellent. In all cases, the incisional scar was barely visible at 6 weeks. In 3 cases a minor bone defect was observed on the forehead. Given the small size of the frontal sinus in children, no frontal sinus breaches occurred. Additionally, no CSF leak or wound infection was identified.

CONCLUSIONS The supraorbital eyebrow approach is extremely effective in achieving desired results in properly selected cases in patients of all pediatric age ranges, from infants to teenagers. There is sufficient working space for the endoscope and all instruments, allowing for endoscopic assistance and bimanual surgical technique. Cosmetic results are excellent, and complications related to the approach are minimal.

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KEY WORDS supraorbital craniotomy; keyhole; minimally invasive surgery; eyebrow; neuroendoscopy; craniopharyngioma; complications; cosmesis; technique
oscopy, which enhances or expands visualization and access to the sella/pituitary fossa, region under the ipsilateral optic nerve/carotid artery, contralateral segments of the circle of Willis, anterior third ventricle, anterior interhemispheric fissure, upper third of the clivus, interpeduncular cistern, medial aspect of the ipsilateral middle cranial fossa and temporal lobe, and anterior olfactory groove.

The supraorbital eyebrow approach has been described in the literature and has been used to treat unruptured aneurysms and various tumors in adults, such as meningiomas, pituitary adenomas, and intra-axial orbitofrontal masses, with good clinical outcomes. However, questions remain regarding its appropriateness in children due to several issues, which include feasibility of the approach, adequacy of the working space, effectiveness for achieving the desired results, cosmesis, and risk of complications. Therefore, we retrospectively examined all pediatric cases in which the senior author (C.T.) performed a supraorbital eyebrow craniotomy and evaluated clinical/outcome outcomes, cosmetic results, and complications.

**Methods**

**Patients**

A retrospective review identified more than 450 patients of all ages who had undergone a supraorbital eyebrow approach performed by the senior author (C.T.) from 1995 to 2013. Only patients younger than 18 years with at least 6 weeks' follow-up were included. A total of 54 patients met the age criterion and had immediate postoperative clinical follow-up, with postoperative imaging studies having been performed in 52 of these cases. Patients were diverse in ethnicity and came from the following countries: Australia, China, Peru, Cuba, Egypt, Vietnam, US, Indonesia, Germany, and Singapore. For all nonlocal patients, follow-up clinical examinations were conducted by neurosurgical colleagues who reported the results to the senior author; brain imaging studies were sent to the senior author. Otherwise, patients reported routinely to our clinic for follow-up, and imaging was performed at our hospital or the studies were brought in for review.

Postoperative cosmetic follow-up greater than 6 weeks was recorded in 42 of the 54 patients. Only physical examination by the senior author and postoperative photographs of the eyebrow and forehead of the patient were used in reporting the cosmetic outcome.

All inpatient and outpatient records were retrospectively reviewed, and the following clinical outcomes were recorded: patient age, sex, histopathological diagnosis, location of pathology, use of endoscope, and extent of tumor resection: gross-total resection (100%), subtotal resection (50%–99%), and partial resection (<50%). The following cosmetic results were recorded: eyebrow alopecia, frontal palsy, supraorbital hypoesthesia, and any forehead depression or indentation and titanium plate migration. The following complications were recorded: frontal sinus breach, CSF leak, wound infection, visual impairment, anosmia, diabetes insipidus, and any other major neurological complication or deficit.

**Surgical Technique**

The approach has been described in detail in the literature and is briefly described here, and any differences in children are highlighted (Fig. 1A–L). The child's head is placed in a 3-point rigid head-holder or placed on a padded headrest, gently translated anteriorly, extended, and rotated to the contralateral side. The ipsilateral eye is lubricated and closed with a temporary nylon tarsorrhaphy suture (Fig. 1C and D). Use of image-based frameless stereotactic guidance determines the position of the frontal sinus and ensures an optimal trajectory to the lesion of interest. It is prudent to avoid the frontal sinus. However, in children, the frontal sinus is often small and therefore generally not encountered. This is a positive aspect that makes the approach and craniotomy in children more standard and uniform than in adults.

A skin incision is made within the superior aspect of the eyebrow, extending from the supraorbital notch medially (to avoid the supraorbital nerve) to the lateral aspect of the eyebrow (Fig. 1C). We prefer to place the incision within the eyebrow, as it is more cosmetically pleasing when the scar is hidden within the eyebrow without loss of hair. The subgaleal layer is undermined, the skin is retracted superiorly with fish hooks, and a U-shaped pericranial flap is reflected inferiorly (Fig. 1E and F). Laterally, the superior portion of the temporalis muscle is dissected to allow placement of a bur hole below the superior temporal line in the keyhole region. A craniotomy is fashioned, and the protuberances of the orbital roof are drilled flat, as is the inner table of the inferior ledge of the craniotomy (Fig. 1E and F). The dura is then opened in a U-shaped fashion. The subfrontal corridor is dissected under microscopic visualization. With dissection of arachnoid adhesions and CSF egress, the frontal lobe falls away, an important aspect in the typically full brain of a child. Patience is required to prevent frontal lobe retraction and allow CSF egress. The pathology is identified and treated using the appropriate lesion-specific microsurgical techniques (Fig. 1G and H). Neuroendoscopy with a 30° endoscope may be used to augment visualization of the sella, interpeduncular cistern, interhemispheric cistern, contralateral circle of Willis, basal frontal lobe, and middle cranial fossa, if necessary (Fig. 2A–I). As in endonasal skull base surgery, where the long shaft of the endoscope is stabilized against sinonasal structures, in the supraorbital approach, the shaft can be stabilized by the superior or inferior bone edge of the craniotomy. In all cases, we use the endoscope to assist in visualization, and in operations undertaken for tumor resection, we use the endoscope to inspect for completeness of resection. This is often imperative in children. With the supraorbital approach, we never resect lesions through the endoscope's working channel. The endoscope is always used in an assistive manner.

After the lesion of interest has been addressed, the dura is closed in a watertight fashion and sutured to the lower rim of the craniotomy as an epidural tack-up (Fig. 1I). The bone is replaced with low-profile titanium plates (Fig. 1I). Care is taken to minimize the gap between the skull and bone flap at the more cosmetically noticeable superior margin. The pericranium, frontalis muscle, and galea are closed in layers. The skin of the eyebrow is reapprroximated with a subcuticular nylon suture without knots (Fig. 1J).
Proper placement of this final skin suture is essential in obtaining a cosmetically acceptable result.

Results
Clinical/Operative Outcomes
A total of 54 children (35 boys and 19 girls) met the inclusion criteria (Table 1). The average age of patients at the time of surgery was 9.6 years (range 1.5–16 years). The pathology consisted of craniopharyngiomas (39 cases), gliomas (6 cases), dermoids (2 cases), hypothalamic hamartomas (2 cases), a neurenteric cyst (1 case), trauma (1 case), a pituitary macroadenoma (1 case), cavernoma (1 case), and a primitive neuroectodermal tumor (PNET; 1 case). Lesions occurred in the following locations: suprasellar region (41 cases), optic pathway/hypothalamus (7 cases), cerebral peduncle (3 cases), parasellar region (1 case), orbit (1 case), and preopticine cistern (1 case). In all cases, surgery was performed with endoscopic assistance. In a total of 51 cases involving resectable lesions, 44 surgeries resulted in a gross-total resection and 7 cases resulted in subtotal resection. No recurrences have been identified to date. In a depressed skull fracture after trauma, a supraorbital eyebrow approach allowed elevation of the fracture, cranioplasty, and excellent cosmesis and skin closure. In no case was there a need to convert to a larger craniotomy or a new skin incision and different approach. Blood loss was minimal in all cases.

The approach provided access to the lesion in all cases without brain retraction (Fig. 3A–F). Brain retractors were not used in any case. The endoscope was used to assist and expand visualization or provide access to areas not reached by standard microscopic visualization in all cases (Fig. 2E and F). Within the small keyhole craniotomy, the lens shaft of the endoscope was stabilized by being placed against the bone edge. The endoscope was held by an assistant to allow for bimanual surgical technique or held by the senior surgeon for visual inspection (Fig. 2E and F). There were no endoscope-associated complications.

Cosmetic Results
In general, cosmesis was excellent (Table 2, Fig. 2I, Fig.
Eyebrow craniotomy in children

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4A–G). Eyebrow alopecia and supraorbital hypoesthesia were not observed. Only 5 cases of frontalis palsy were identified. Forehead depression was not seen at 6-week follow-up in any case, but 2 years postoperatively 3 cases were identified; the depression was minor in appearance and less than 5 mm in depth from the skin surface in each of the 3 patients. In all cases, the incisional scar was barely visible 6 weeks postoperatively. In no case has a child complained about postoperative jaw or temple pain or pain with mastication.

Complications

There were few complications (Table 2). The frontal sinus is small in children, and no frontal sinus breach occurred. No CSF leak or wound infection was identified. Visual impairment occurred in 3 cases; 2 of the patients who experienced visual impairment had craniopharyngiomas and the other had a cavernoma. Loss of smell was identified in only 1 child. Diabetes insipidus occurred in 85% of the patients with craniopharyngioma. Other complications included a complete third cranial nerve palsy after resection of a neurenteric cyst, panhypopituitarism after craniopharyngioma resection, and permanent hemiplegia after resection of a Grade III astrocytoma of the cerebral peduncle.

Discussion

Evolution of the Supraorbital Eyebrow Approach

Approaches to the anterior cranial fossa, medial temporal lobe, suprasellar and parasellar regions, and brainstem have evolved significantly over the last 3 decades with the goal of minimal brain retraction and optimal visualization. The supraorbital approach has been modified consid-
erably to achieve this—initially by Jane et al. and subsequently by Delashaw et al. and Al Mefty and Fox. With advancements in neuroanesthesia and the advent of endoscope-assisted microneurosurgery, the keyhole concept developed, whereby only the necessary brain and surgical corridors that need exposure are exposed. Although the craniotomy is smaller, the access is the same. With proper tissue handling and surgical techniques, an eyebrow skin incision can be used to perform a supraorbital craniotomy, and thus tissue trauma can be limited and surgical time decreased. Concerns have been raised, however, regarding the use of this approach in pediatric cases. Here we reviewed all pediatric supraorbital eyebrow approaches performed by the senior author (C.T.) in cases that met inclusion criteria and found the approach highly effective in children in regard to multiple outcome measures.

Working Space, Brain Retraction, and Use of the Endoscope

Some have questioned using the supraorbital keyhole approach in children for various reasons, including insufficient working space. This concern is minimized by employing proper positioning and surgical techniques, an eyebrow skin incision can be used to perform a supraorbital craniotomy, and thus tissue trauma can be limited and surgical time decreased. Concerns have been raised, however, regarding the use of this approach in pediatric cases. Here we reviewed all pediatric supraorbital eyebrow approaches performed by the senior author (C.T.) in cases that met inclusion criteria and found the approach highly effective in children in regard to multiple outcome measures.

Table 1. Demographic and clinical characteristics of 54 cases in which supraorbital eyebrow approaches were used in children

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value*</th>
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<tbody>
<tr>
<td>Age (yrs)</td>
<td>Mean 9.6</td>
</tr>
<tr>
<td></td>
<td>Range 1.5–16</td>
</tr>
<tr>
<td>Male sex</td>
<td>35 (65)</td>
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<tr>
<td>Diagnosis</td>
<td>Craniopharyngioma 39 (72)</td>
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<td></td>
<td>Glioma 6 (11)</td>
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<tr>
<td></td>
<td>Dermoid 2 (4)</td>
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<tr>
<td></td>
<td>Hypothalamic hamartoma 2 (4)</td>
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<tr>
<td></td>
<td>Neurenteric cyst 1 (2)</td>
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<td></td>
<td>Trauma, compound skull fracture 1 (2)</td>
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<td></td>
<td>Pituitary macroadenoma, acromegaly 1 (2)</td>
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<tr>
<td></td>
<td>Cavernoma 1 (2)</td>
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<tr>
<td></td>
<td>PNET 1 (2)</td>
</tr>
<tr>
<td>Location</td>
<td>Suprasellar 41 (76)</td>
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<tr>
<td></td>
<td>Optic pathway/hypothalamus 7 (13)</td>
</tr>
<tr>
<td></td>
<td>Cerebral peduncle 3 (6)</td>
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<tr>
<td></td>
<td>Parasellar 1 (2)</td>
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<td></td>
<td>Orbit 1 (2)</td>
</tr>
<tr>
<td></td>
<td>Preoptine cistern 1 (2)</td>
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<tr>
<td>Surgery performed with endoscopic assistance</td>
<td>54 (100)</td>
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</tbody>
</table>

* Values represent numbers of cases (%) unless otherwise indicated.

FIG. 3. Representative pre- and postoperative T1-weighted Gd-enhanced MR images obtained in patients who underwent resection of large craniopharyngiomas via a supraorbital eyebrow approach. Gross-total resection was achieved in all 3 of the cases shown here, demonstrating that this approach can provide adequate working space and visualization for complete resection of these lesions. A and B: Preoperative (A) and postoperative (B) sagittal MR images obtained in a 10-year-old boy. C and D: Preoperative (C) and postoperative (D) coronal MR images obtained in a 12-year-old girl. E and F: Preoperative (E) and postoperative (F) sagittal MR images obtained in an 8-year-old boy.
of the supraorbital approach beyond the view of the operating microscope.

**Appropriately Selected Cases and Effectiveness of the Approach**

It is important to consider each case on an individual basis, as the imaging characteristics of each pathology and individual anatomical variation strongly influence whether a lesion is treatable via a particular approach. Even then, the optimal approach is debatable and may depend on the surgeon’s familiarity with the possible approaches. However, the surgeon must understand the anatomical limitations of each approach. As seen with our pediatric case series, gross-total resection was achieved in 84% of resectable lesions, of which a large majority were craniopharyngiomas, and no recurrences have been noted to date. Although these results are better than published series, they do correspond with results of craniopharyngioma management previously reported by the senior author. A possible explanation is the benefit of endoscope-assisted surgery in detecting “hidden” remnants and consequently allowing for more comprehensive and complete resections. In no case did the supraorbital eyebrow approach limit the ability to achieve gross-total resection, and this is a testament to using the approach in properly selected cases.

**Cosmesis**

Some have expressed concern over the cosmetic outcome achieved with an eyebrow skin incision, especially in children. Placing the incision at the superior aspect of the eyebrow hides the incision within the brow line, and with proper tissue handling and closure, the incision line

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value*</th>
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<tbody>
<tr>
<td>Follow-up (yrs)</td>
<td>Mean 8.9</td>
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<td></td>
<td>Range 0.5–16</td>
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<tr>
<td>Extent of tumor resection (n = 51)</td>
<td>Gross-total 44 (86)</td>
</tr>
<tr>
<td></td>
<td>Subtotal 7 (14)</td>
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<tr>
<td></td>
<td>Partial 0 (0)</td>
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<tr>
<td>Cosmesis (n = 42)</td>
<td>Eyebrow alopecia 0 (0)</td>
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<tr>
<td></td>
<td>Frontalis palsy 5 (12)</td>
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<tr>
<td></td>
<td>Supraorbital hypesthesia 0 (0)</td>
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<td></td>
<td>Forehead depression</td>
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<td></td>
<td>6-wk follow-up 0 (0)</td>
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<td></td>
<td>6-mo follow-up 1 (2)</td>
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<td></td>
<td>2-yr follow-up 3 (7)</td>
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<td></td>
<td>Titanium plate migration 0 (0)</td>
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<tr>
<td>Complications (n = 54)</td>
<td>Frontal sinus breach 0 (0)</td>
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<tr>
<td></td>
<td>CSF leak 0 (0)</td>
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<tr>
<td></td>
<td>Wound infection 0 (0)</td>
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<tr>
<td></td>
<td>Visual impairment 3 (6)</td>
</tr>
<tr>
<td></td>
<td>Anosmia 1 (2)</td>
</tr>
<tr>
<td></td>
<td>Diabetes insipidus</td>
</tr>
<tr>
<td>Craniopharyngioma (n = 39)</td>
<td>33 (85)</td>
</tr>
<tr>
<td>Hypothalamic hamartoma (n = 2)</td>
<td>2 (100)†</td>
</tr>
<tr>
<td>Pituitary adenoma (n = 1)</td>
<td>1 (100)†</td>
</tr>
<tr>
<td>Other</td>
<td>3 (6)</td>
</tr>
</tbody>
</table>

* Values represent numbers of cases (%) unless otherwise indicated.
† These 3 cases resulted in transient diabetes insipidus.

**FIG. 4.** Postoperative eyebrow photographs demonstrating typical cosmetic outcome. A–F: Photographs of eyebrow skin incisions in children of various ethnicities at least 6 weeks after surgery demonstrating no loss of hair and an undetectable scar. G: Can you tell which side the approach was performed on in this patient? This photograph was taken after a right supraorbital eyebrow approach. The patient has an undetectable scar and normal frontalis function. Figure is available in color online only.
and scar are practically undetectable 6 weeks postoperatively. This was observed with a variety of skin types, given the ethnic diversity of the children in our series. Others, who have had patients with thin light-colored eyebrows, express concern over the eyebrow incision. Even in cases involving children with very thin eyebrows, we have not had complaints from patients or their families. Others have used a skin incision above the eyebrow to avoid the hair loss potentially associated with an incision in the eyebrow itself. We do not feel this is as cosmetically pleasing and use an incision within the superior aspect of the brow. As seen in our results, we have not observed loss of hair with this incision (Table 2, Fig. 4). In the growing pediatric calvaria, any interference with the dynamic nature of the sutures might cause long-term growth problems and subsequent cosmetic deformity. However, no bone defect over the pterion, abnormal bone growth, or migration of the titanium plates was observed. However, a minor bone defect on the forehead where the craniotomy cut was made was observed in 3 cases. Because the supraorbital approach utilizes a small incision and involves minimal temporalis dissection, scalp pain, temporalis atrophy, and difficulty with mastication were rarely observed. Important in adults, this may be even more of an advantage in the very young.

Complications

Other concerns have included risk of frontal sinus violation, CSF leak, and risk of infection and meningitis. Even in our adult series, we avoid the frontal sinus, and infection is almost nonexistent. In children, the frontal sinus is generally small, and we did not encounter it in any case in our series (Table 2).

Limitations

As with all retrospective studies, there is an inherent bias compared with prospective studies. There was incomplete follow-up of cosmetic outcome, as only 78% of the patients had direct observation and recorded findings.

Conclusions

We demonstrated in the largest series to date that the supraorbital eyebrow approach could be successfully used in properly selected cases in patients of all pediatric ages with excellent cosmesis and minimal complications.

References


Author Contributions
Conception and design: all authors. Acquisition of data: Dlouhy, Teo. Analysis and interpretation of data: Dlouhy, Teo. Drafting the article: Dlouhy. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Dlouhy. Administrative/technical/material support: Dlouhy, Teo. Study supervision: Teo.

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