Preservation of olfaction in anterior craniofacial approaches

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Through the combined efforts of neurosurgeons, head and neck surgeons, and craniofacial surgeons, the standard transbasal approach to the frontal fossa has been modified to include removal of the orbital roofs, nason, and ethmoid sinuses. This approach has been combined further with facial disassembly procedures to provide extensive midline exposure to the midface and clival region. Extended frontal approaches, however, necessitate removal of the crista galli and sectioning of the olfactory rootlets with the associated risk of anosmia, cerebrospinal fluid (CSF) leak, and the need for complex reconstruction of the frontal floor. To avoid these problems, the authors have modified the technique of handling the cribriform plate to preserve the olfactory unit.

Circumferential osteotomy cuts are made around the cribriform plate to allow an en bloc removal with its attachment to both the dura and underlying mucosa. Opening of the dura is avoided and the cribriform bone is used to reconstruct the floor. Four patients underwent this approach, for treatment of an angiofibroma in three and a fibrosarcoma in one. The mean follow-up period was 7 months. No patients developed a CSF leak, and within 8 weeks olfaction had returned in all patients. There was no other associated morbidity. These data suggest that this modification of the transbasilar approach can alleviate extensive reconstructive procedures and CSF leaks while preserving olfaction.

KEY WORDS - cerebrospinal fluid leak • osteotomy • transbasal approach • olfaction • surgical approach

TECHNICAL advances and a better understanding of the anatomy of the anterior cranium have led to the development of more extensive surgical approaches to the cranial base. Through the combined efforts of neurosurgeons, head and neck surgeons, and craniofacial surgeons, the standard transbasal approach to the frontal fossa has been modified to include removal of the orbital roofs, nason, and ethmoid sinuses. This approach has further been combined with facial disassembly procedures to provide extensive midline exposure to the midface and clival region. Extended frontal approaches, however, necessitate removal of the crista galli and sectioning of the olfactory rootlets with the associated risk of anosmia, cerebrospinal fluid (CSF) leak, and the need for complex reconstruction of the frontal floor.

To avoid these problems, we have modified the technique of handling the cribriform plate to preserve the olfactory unit. The surgical technique and recent experience with the modification are described.

Operative Technique

Craniotomy

A bicornal incision is placed far enough posteriorly to assure adequate galeal and pericranial flap length for reconstruction. The scalp and pericranial flaps are reflected anteriorly (in two separate layers) to the supraorbital rims and nason. The temporalis muscles are reflected laterally leaving a cuff of muscle on the bone flap to facilitate closure. After the supraorbital nerve and vascular bundle are separated from their foramina, the periorbita is stripped circumferentially. A high-speed drill is used to perform the bifrontal craniotomy, which extends anteriorly 15 mm above the orbital ridge and posteriorly along the convexity of the cranium.

Removal of the Frontonasal-Orbital Unit and Isolation of Cribriform Plate

After CSF has been drained via a spinal drain, the frontal dura is dissected from the orbital roofs to the

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Fig. 1. Left: Illustration of the skull anatomy showing the initial circumferential cribiform plate osteotomies. A = anterior osteotomy, B and C = parasagittal osteotomy, and D = posterior osteotomy. Additional lines indicate intended osteotomy cuts for removal of the frontonasal-orbital unit. Right: Illustration demonstrating removal of the frontonasal-orbital unit.

Osteotomies are then performed to remove the frontonasal-orbital unit, thus leaving the cribiform unit exposed (Fig. 1). The orbital fascia is retracted and, looking posteromedial, the dura posterior to the cribiform plate above the planum sphenoidale is elevated. An osteotomy is performed under direct vision posterior to the cribiform plate through the planum sphenoidale (Fig. 2 left). The final cut is made through the ethmoid bone and mucosa. The ethmoid trabeculae are cut individually with scissors in the same plane; care is exerted to assure that a generous cuff of nasal mucosa remains attached inferiorly to the cribiform plate (Fig. 2 right). This maneuver completely separates the cribiform plate from its bony connection, leaving it attached to the base of the frontal dura with the olfactory rootlets.

The dura along the remaining orbital roofs and planum sphenoidale can be elevated along the entire frontal floor to the level of the anterior clinoid processes and optic foramina. Consequently, the entire contents of the frontal fossa could be elevated generously, providing ample access to the area of interest.

Although removal of the lateral orbit in the nasofrontal unit facilitates tumor exposure and performance of the osteotomy posterior to the cribiform plate, this step is not essential. For centrally situated tumors, a more limited lateral exposure can be used. Additional osteotomies, such as the LeFort I, can be performed as necessary. Tumors are removed in the usual fashion.

Reconstruction

Reconstruction begins with the rigid fixation of the frontonasal-orbital unit to the maxillary bone using miniplate systems. The plates are preadapted before the osteotomies are performed to ensure perfect realignment during reconstruction. The upper lateral cartilages are reattached and the medial canthal ligaments are repaired by transnasal wiring. The cribiform plate complex is returned to the medial aspect of the fossa floor and affixed with interosseous wires (Fig. 3). The preserved pericranium is placed on the floor; the osteotomies around the cribiform plate to seal the connection between the ethmoidal sinus and the cranium. The calvarial bone flap is replaced with a plate, and the temporalis muscle is attached to the fascial cuff on the bone. The galea and skin are closed. Since the cribiform plate is replaced, no additional bone is required to repair the floor.

Illustrative Case

This 16-year-old boy (Case 1) sought treatment after two episodes of epistaxis that caused hypotension and loss of consciousness. A magnetic resonance (MR) image revealed a large mass extending from the nasopharynx into the anterior cranial base, cavernous sinus, and clivus (Fig. 4 left). The mass was identified as an angiofibroma. The tumor was embolized to facilitate resection. A combination of a frontonasal-orbital and transmaxillary (LeFort I) osteotomy was performed. The superior, paracavernous, and posterior extensions of the tumor were removed through a cranial approach.
### TABLE I
Clinical summary of four patients treated with the modified anterior craniofacial approach

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Type of Tumor</th>
<th>Presentation</th>
<th>Operative Procedure</th>
<th>CSF Leak*</th>
<th>Complications</th>
<th>Time to Return of Olfaction Postop</th>
<th>Follow-Up Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16, M</td>
<td>angiofibroma</td>
<td>life-threatening epistaxis</td>
<td>transfrontal naso-orbital approach, cribiform plate osteotomy. LeFort I osteotomy</td>
<td>no</td>
<td>none</td>
<td>2 wks</td>
<td>6 mos</td>
</tr>
<tr>
<td>2</td>
<td>14, M</td>
<td>angiofibroma</td>
<td>rhinorrhea, epistaxis, rt exophthalmos</td>
<td>transfrontal naso-orbital approach, cribiform plate osteotomy. LeFort I osteotomy</td>
<td>no</td>
<td>none</td>
<td>4 wks</td>
<td>5 mos</td>
</tr>
<tr>
<td>3</td>
<td>16, M</td>
<td>angiofibroma</td>
<td>anosmia, airway obstruction</td>
<td>transfrontal naso-orbital approach, cribiform plate osteotomy</td>
<td>no</td>
<td>none</td>
<td>8 wks</td>
<td>10 mos</td>
</tr>
<tr>
<td>4</td>
<td>43, F</td>
<td>fibrosarcoma</td>
<td>epistaxis, airway obstruction</td>
<td>transfrontal naso-orbital approach, cribiform plate osteotomy. LeFort I osteotomy</td>
<td>no</td>
<td>none</td>
<td>3 wks</td>
<td>7 mos</td>
</tr>
</tbody>
</table>

*CSF = cerebrospinal fluid.

(Fig. 5). The remaining anterior portion of the tumor was resected through the LeFort I exposure. Postoperatively, the patient had no signs of CSF leaks, and within 2 weeks he could distinguish the smell of coffee, perfume, tobacco, and orange juice. His postoperative MR image showed complete tumor resection and the olfactory plate in its normal location (Fig. 4 center and right).

### Summary of Cases

**Patient Population**
Between January and June 1992, four patients underwent an extended facial or transfacial approach with preservation of the cribiform plate for removal of large tumors (Table 1). The tumors (angiofibroma in three and fibrosarcoma in one) were primarily located in the nasopharynx, anterior cranial, and clivus requiring both a transfacial and an intracranial approach. Each patient’s presentation, operative treatment, and outcome (specifically, the return of olfaction and CSF leakage) were evaluated prospectively. The mean follow-up period was 7 months.

**Surgical Outcome**
There were no complications or deaths related to the procedure. The mean hospital stay was 6 days. None of the patients developed a postoperative CSF leak or infection, and lumbar drains were removed within 2 or 3 days after surgery. Two patients had transient diplopia which resolved within 1 week.

Postoperatively, when patients related that olfaction had returned, each was tested while blinded with four odors: coffee, perfume, tobacco, and orange juice. During the 1st week, none had discernible olfaction, but three patients (Cases 1, 2, and 4) were able to correctly identify all four odors within 4 weeks. These three patients also noticed an associated return to taste, although no formal testing was performed. The remaining patient (Case 3) had anosmia until 8 weeks postoperatively, when he was able to identify three of the four odors. At 10 months, his olfaction was unchanged and he was able to taste a limited number of foods. This examination, however, showed a significant improvement over the anosmia which he suffered on initial presentation.

**Discussion**
Extending the exposure of the skull base by facial disassembly to improve the surgical access and visualization of skull-base tumors has been the trend in skull-base surgery. The first transbasilar approaches introduced by Frazier and Derome, et al., were limited to exposure of the frontal fossa floor. This technique has undergone many modifications and combinations. Craniofacial surgeons have incorporated both facial and anterior cranial approaches to visualize not only the anterior fossa but the middle fossa (cavernous sinus) and posterior fossa (clivus) as well. Although great efforts have been exerted to return the external bony features to normal, little has been done to preserve olfaction in these patients. It has become accepted that these extended approaches cause bilateral olfactory denervation when the dura is lifted from the cribiform plate or when the cribiform plate and ethmoid sinuses are resected. Although most patients tolerate such a loss, it is a permanent deficit that can limit their occupation and their enjoyment of life.

The same maneuver of detaching the olfactory bulb routinely leaves permanent dural defects, often causing a CSF leak that requires extended hospitalization for closure. Finally, removal of the cribiform plate is usually piecemeal and therefore requires complex reconstructive techniques, including bone grafts. The technique described here addresses all three problems. By removing the cribiform plate unit with nerve, dura, and mucosa intact, olfaction can be spared as these four cases demonstrate. Because the dura remains intact, the risk of CSF leakage is low. During closure, the olfactory complex is returned to its normal anatomical plane and...
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Fig. 3. Intraoperative photograph (left) and illustration (right) looking into the frontal fossa after the frontonasal-orbital unit has been replaced. The cribriform unit is returned to its normal position where it will be surrounded by pericranium.

Fig. 4. Magnetic resonance (MR) T₁-weighted images in Case 1. Left: Sagittal MR image demonstrating the location of the angiofibroma and its extension inferiorly in the nasopharynx and superiorly up to the skull base. Center and Right: Sagittal (center) and coronal (right) enhanced MR images demonstrating the extent of tumor removal. The cribriform plate complex has been returned to its normal position (black arrow). The enhanced sphenoid sinus mucosa is indicated by the arrowhead and the remaining nasal turbinate by the white arrow.

Fig. 5. Intraoperative photograph (left) and illustration (right) showing the frontal fossa from a superior view. The frontonasal-orbital unit has been removed, and the cribriform plate-olfactory complex is behind the retractor. The tumor and mucosa are beneath the suction tip and the right orbit is beneath the retractor.
requires no further reconstruction. The underlying mucosa regenerates rapidly, resuming continuity with the normal nasal mucosa. Our cases suggest that the time to return of olfaction is variable (up to 8 weeks) and likely reflects the duration of the preoperative loss of olfaction from the underlying tumor.

In conclusion, olfaction can be preserved, CSF leakage can be prevented, and complex floor reconstruction can be avoided when this technique of maintaining the normal olfactory-cristiform anatomy is used in anterior craniofacial approaches.

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References


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