Transcranial resection of tumors of the paranasal sinuses and nasal cavity

J. Bob Blacklock, M.D., Randal S. Weber, M.D., Ya-Yen Lee, M.D., and Helmut Goepfert, M.D.

Section of Neurosurgery, and Departments of Head and Neck Surgery and of Diagnostic Imaging, The University of Texas M.D. Anderson Cancer Center, Houston, Texas

Combined cranial and facial procedures for resection of malignancies of the paranasal sinuses and nasal cavity have been used with variable success and complication rates in the last 25 years. A series of nine patients undergoing 10 exclusively transcranial procedures for these tumors is presented, and an effective technique for reconstruction without free tissue transfer is described. The patients in this series suffered no major complications, and all have remained free of disease during the short follow-up period. The technique described in this report offers the advantage of wide exposure, symmetrical approach to the superstructures of the face and orbits, the potential for resection of a large portion of the anterior cranial floor, and substantial reconstruction which is a major factor in avoiding complications.

KEY WORDS ▪ facial neoplasm ▪ transcranial approach ▪ paranasal sinus ▪ nasal cavity

Surgical extirpation of malignant tumors of the paranasal sinuses and nasal cavity has become more aggressive during the last 25 years. Combined cranial and facial approaches have been effective for removing tumors that involve the anterior cranial floor, the ethmoid, maxillary, and sphenoid sinuses, and the nasal cavity. There is controversy, however, regarding the value of combined cranial and facial resection for tumors that clearly invade the anterior cranial fossa, with or without transdural penetration. Although many of these tumors have been resected through a combined cranial and facial procedure, selected cases may be resectable through a bifrontal craniotomy alone without cranial incisions. Experience at the University of Texas M.D. Anderson Cancer Center bears on the choice of approach, clarifying further the role of bifrontal craniotomy alone. That experience is reviewed here.

Summary of Cases

Clinical Material

Between November, 1985, and July, 1988, 47 major skull base resections for malignancies were performed, 22 of which involved the anterior skull base. Of these, eight procedures included orbitectomies, one was aborted when invasion of both optic nerves was found, three were performed with combined coronal and facial incisions, and 10 were carried out by transcranial resection without cranial incision.

Nine patients, ranging in age from 17 to 65 years, underwent transcranial resection of tumors arising in the nasal cavity or paranasal sinuses. Table 1 summarizes the features of each patient. One patient (Case 1) had two tumors of different histologies which were resected at one operation. In Case 3, a frozen section diagnosis of tumor was not possible at surgery; therefore, resection of involved bone of the clivus, left optic canal, and orbit was deferred. Definitive pathological diagnosis of osteosarcoma was made after surgery and a second transcranial operation was performed to complete the resection.

Surgical Procedure and Technique

Following the induction of general anesthesia, a lumbar subarachnoid drain is placed and used intraoperatively for cerebrospinal fluid (CSF) drainage if needed. The CSF drain is left in place postoperatively for 3 to 5 days with the patient positioned supine with 30° of head elevation, calibrated to CSF pressure equal to a fluid column at the top of the head. This keeps CSF pressure relatively low but, more important, allows decompression of pressure waves during Valsalva maneuvers,
Paranasal sinus and nasal cavity tumor surgery

### Summary of nine cases of transcranial tumor resection

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Location</th>
<th>Histology</th>
<th>Chemotherapy</th>
<th>Radiotherapy</th>
<th>Follow-up (mos)</th>
<th>Status</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55, M</td>
<td>E, O, C, S, N, M sella</td>
<td>adenocarcinoma</td>
<td>CR no no no no</td>
<td>27</td>
<td>NED</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>64, M</td>
<td>E, O, C, S, N, F, M</td>
<td>pituitary adenoma</td>
<td>NR no yes† no</td>
<td>27</td>
<td>NED</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>17, F</td>
<td>E, O, C, S, Cl, N, M</td>
<td>neuroendocrine carcinoma</td>
<td>PR yes yes‡ yes‡</td>
<td>22</td>
<td>NED</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>53, M</td>
<td>E, C, S</td>
<td>osteosarcoma</td>
<td>PR yes no no</td>
<td>20</td>
<td>residual</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>55, F</td>
<td>E, S, N</td>
<td>osteosarcoma</td>
<td>PR yes no no</td>
<td>14</td>
<td>NED</td>
<td>delayed CSF leak, resolved</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>49, M</td>
<td>E, C, S, N, M</td>
<td>small-cell carcinoma</td>
<td>PR yes no no yes</td>
<td>7</td>
<td>NED</td>
<td>blepharitis</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>29, F</td>
<td>B, E, O, S, N, M</td>
<td>small-cell carcinoma</td>
<td>PR yes no yes</td>
<td>2</td>
<td>NED</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>17, M</td>
<td>E, N, S, Nph</td>
<td>adenocarcinoma</td>
<td>no yes yes** no</td>
<td>1</td>
<td>NED</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>49, F</td>
<td>E, N, S</td>
<td>chondrosarcoma</td>
<td>no no no no</td>
<td>1</td>
<td>NED</td>
<td>none</td>
<td></td>
</tr>
</tbody>
</table>

* E = ethmoid sinus(es); O = orbit(s); C = cribiform plate; S = sphenoid sinus; N = nasal cavity septum; M = maxillary sinus(es); Nph = nasopharynx; B = brain; Cl = clivus; NR = no response; PR = partial response; CR = complete radiographic response; NED = no evidence of disease; CSF = cerebrospinal fluid.
† Radiation 14 years before for treatment of a pituitary adenoma following transcranial surgery. Tumor was recurrent and resected simultaneously with the sinus tumor.
‡ Prior to referral to our institution.
§ Cesium implant in sphenoid sinus was used postoperatively due to the presence of tumor in the posterior sphenoid sinus mucosa.
|| This patient committed suicide 7 months after surgery. He had a long history of depressive disorder.
** This patient was treated at 9 years of age for squamous-cell carcinoma of the nasopharynx.

A very healthy layer of connective tissue is universally available between the galea and the temporalis muscle fascia; it is contiguous with the pericranium anteriorly and superiorly. This pericranial flap is raised from the skull using a wet sponge on the thumb to roll the tissue free from the bone down to the supraorbital nerves and arteries, taking care to preserve these structures. The scalp and pericranial flaps are folded forward and held with a wet sponge to avoid any penetrating retraction into the pericranial layer. The temporalis fascia is incised down to the bone at the anterior aspect of the muscle to expose the skull in the surgical “keyhole.” Burr holes are then placed at this site, just above the orbital roof and, to provide access into the most anterolateral aspects of the frontal fossa, just above the lateral extent of the lesser wing of the sphenoid bone.

Two additional burr holes are placed at the hairline on either side of the sagittal sinus and a free bone flap is cut with a craniotome. Figure 1 illustrates the approach. This inferior cut is normally made 1 cm above the superior orbital rims through the frontal sinuses. An epidural dissection along the floor of the frontal fossa is carried out anteriorly and on either side of the midline to isolate the cribiform plate and any tumor protruding into the anterior cranial fossa. If there is gross tumor involving the dura then a large segment of dura is resected in a circumferential fashion. The resected dura is left attached to the underlying bone or tumor.

If there is tumor involving the basifrontal lobe, that segment of brain is removed with bipolar cautery and suction and tissue from the surgical margins in the

---

J. Neurosurg. / Volume 71 / July, 1989

11
FIG. 1. Diagram showing the initial approach to the paranasal sinuses. The pericranial flap is raised from a point posterior to the skin incision and extends the full width of the bicoronal incision. The lateral aspects of this flap include the connective tissue overlying the temporalis fascia to create a continuous flap. The craniotomy is broad, being the width of the entire frontal bone. This flap provides a broad view of the anterior skull base, making resection of the paranasal sinuses feasible and allowing for a broad-based reconstruction which completely sequesters the free bone flap from the sinus and nasal structures.

The lateral margins of resection encompass the ethmoid labyrinth and lateral wall of the nose, as indicated in Fig. 2, which illustrates the plane of this cut. The anterior bone cut is made either just behind the frontal sinus or through the frontal sinus and frontal nasal ducts and extended down into the nasal septum with large septal scissors. The posterior bone cut is made through the planum sphenoidale, behind the posterior extent of the tumor. The posterior cut is carried inferiorly through the sphenoid sinus and out through the floor to the nasopharyngeal cavity. Figure 3 indicates the planes of these cuts.

Reconstruction of the anterior cranial fossa and sequestration of the free bone flap from the sinus structures is of critical importance in avoiding infections. The value of the far lateral burr holes behind the frontotemporal line becomes apparent when the pericranial flap is placed across the floor of the anterior fossa. This lateral access allows us to easily extend the pericranial flap to the limbus sellae. The initial line of sutures is placed through a row of small holes drilled in
Paranasal sinus and nasal cavity tumor surgery

FIG. 3. The sites of the anterior and posterior bone cuts are dictated by the location of the tumor. The anterior cut may be through the frontonasal ducts if necessary. The posterior cut always begins in the planum sphenoidale and may be extended through the base of the sphenoid sinus and into the nasopharynx.

The bone of the cut edge of the planum sphenoidale. These bone sutures are then placed through the edge of the pericranial flap and marked with hemostats. The second row of sutures is located just anterior to this by placing sutures through the dura in a position posterior to the cadaveric patch and anterior to the cut edge of the planum sphenoidale. This area of dura is sometimes quite small. These interrupted sutures are carried laterally to a point where running sutures are feasible on each side.

The pericranial flap is sutured to the dura all the way out to the lateral burr holes, and then the pericranium is sutured to the fascia temporalis at the burr holes. The pericranium is progressively sewn to the fascia temporalis until the attachment with the scalp is reached. Closure in this fashion effectively sequesters the bone flap and cadaveric dural patch from facial structures. At this point the nasal cavity and obliterated sinuses are packed transnasally, while direct visualization and palpation of the pericranial flap are still possible. Figure 4 illustrates the posterior and lateral extent of the reconstructive flap.

The craniotomy is then closed. The mucosa of the frontal sinus in the inferior portion of the free bone flap is drilled away and the flap is fixed into position with stainless steel wire. The bone flap is not sutured inferiorly since to do so would penetrate the pericranial flap. When these fixation sutures are tightened a slot is created through which the pericranial flap passes to create a new floor for the anterior cranial fossa. Figure 5 illustrates this. The scalp is then closed in layers and

FIG. 4. Superior view of the pericranial flap extending to the posterior cut edge of the planum sphenoidale. The value of this reconstructive flap is apparent when the posterior extent is sutured to the cut edge of bone and then brought out widely to a point of the lateral burr holes. The edge of the flap is sutured to the dura posteriorly along the lesser wings of the sphenoid. This provides a broad-based vascularized support and sequesters the bone flap away from the paranasal sinuses and nasal cavity.

FIG. 5. Diagram showing a lateral view of the closure of the craniotomy. The broad-based pericranial flap tucks into the burr holes at each side of the craniotomy and easily fits in the slot inferiorly beneath the free bone flap. This avoids compromise of the blood supply and allows broad-based support for the anterior cranial fossa.
compressive bandages are applied to the head. The patient is observed in the surgical intensive care unit and then transferred to a regular care ward. Bed rest is maintained until the spinal drain is removed 3 to 5 days postoperatively.

Surgical Results and Complications

There were no deaths or major complications among the nine patients. One patient (Case 3) developed delayed CSF rhinorrhea 1 month after the second operation; it resolved with 4 days of lumbar CSF drainage. A rent in the dura occurred during the clivectomy of her second operation and was repaired; this was the most likely source of the leak. This site was well behind the limits of the usual anterior cranial floor resection and well behind the pericranial reconstruction. One patient (Case 6) developed blepharitis after discharge and was readmitted for intravenous antibiotics, which resulted in rapid resolution; this patient is one of two with postsurgical infections in our current series of 47 patients with craniofacial and skull base resections who received the three-drug regimen described. There has been no recurrent disease among the nine patients in the short follow-up period (range 1 to 27 months). Three are still on maintenance therapy (Cases 3, 7, and 8). The current status of each patient and follow-up duration are indicated in Table 1. Preoperative and postoperative radiographic images of illustrative cases are presented in Fig. 6.

Discussion

Since craniofacial resection was initially reported in 1953,1 a number of series have supported the thesis that resection of tumors of the paranasal sinuses is frequently best effected by a combined transcranial and transfacial approach.1,4,7,8 However, a great deal of attention has been turned to the technical issues associated with these approaches, as neurological injury, CSF fistulas, and infections have been major problems.1,3,6 Complications of craniofacial resection are primarily related to the cranium and its contents; the consequences of untoward outcomes after resection of the frontal floor can be devastating. Exposure of the subarachnoid and epidural spaces to the nasal cavity and paranasal sinuses creates an obvious source of direct contamination of a sterile space. Because of these factors, reconstruction of the frontal floor to create a viable barrier between the contaminated and noncontaminated compartments must be accomplished; it is necessary to hold CSF in and to keep infection out to succeed with a craniofacial procedure. The initial contamination of the sterile spaces by the surgery itself must be dealt with by using broad-spectrum antibiotics with known efficacy against all potential infecting organisms in the particular hospital. In the longer term the anatomic reconstruction is relied upon to provide sustained protection from infection.

A number of techniques have been described for reconstruction of the frontal floor after the tumor is removed from the skull base, each having advantages and disadvantages. The craniotomy described here provides a broad view of the frontal floor from each side, ease of performing the craniotomy and, most important, broad access for placing a substantial pericranial flap across the frontal floor back to the planum sphenoidale. Applying the pericranial flap to the dura at a point posterior to the repair or patch of the dura provides a compartment in which the free bone flap can be placed in order to remain anatomically sequestered from the nasal cavity and paranasal sinuses. This

Fig. 6. Computerized tomography (CT) scans of Case 3. A: Preoperative coronal CT image at the level of the posterior orbits. B: Postoperative appearance 20 months after placement of the flap with the pericranial flap providing support between the orbits. The bone density between the orbits is the beginning of calcification in this pericranial/dural interface. C: Preoperative CT scan showing the same tumor posteriorly. At the level of the pterygoid plates the left cavernous sinus is visible but the right cavernous sinus is attenuated. The pituitary is seen superior to the tumor mass. D: The postoperative appearance at the same level as C. Some ossification has occurred.
Paranasal sinus and nasal cavity tumor surgery
craniotomy flap also offers the surgeon a very impressive view of the superstructures of the face after the
frontal floor has been resected. Complete ethmoidectomy can be performed easily and symmetrically, as
access to both orbits and protection of the optic nerves are easily accomplished. This surgical access is also quite
satisfactory for removing the structures associated with the nasal fossa all the way to the floor of the nasal
cavity. Although a facial incision provides a more dramatic view through the face, it does not increase access to
the paranasal sinuses.

In all cases we remained prepared to perform a facial incision if needed to complete the surgery. Skin grafts
were not placed on the underside of the pericranial flap, as mucosalization progresses very quickly on this
healthy, vascularized membrane. The pericranial flap we use is exclusively pericranium, and a careful dissec-
tion will result in a thick, viable layer of tissue; dissecting the galea from the scalp is unnecessary. We believe
that it is of critical importance to use a reconstructive flap that completely sequesters the frontal bone flap
away from the nasal contents, as we have described. This can only be accomplished by a flap that extends
from one temporalis muscle to the other. Dural patches have been made with cadaveric human dura rather than
autologous tissue such as fascia lata. Our experience as well as that of others with cadaveric dura in this situa-
tion has led us to believe that it is superior to fascia lata since it is immediately watertight and well incorporated;
we have not encountered any infections. It is important that the pericranial layer completely cover this nonvi-
able membrane, thus avoiding its exposure to the nasal cavity.

Resection en bloc of tumors in the superstructures of the face is, at best, a theoretical issue because of the
anatomy of the paranasal sinuses and nasal cavity. A true en bloc removal of an invasive tumor is almost
never possible. We have made every attempt to deliver the tumor in a single specimen and have occasionally
succeeded in this effort. We do not believe that a facial incision enhances the surgeon’s ability to accomplish
en bloc resection of paranasal sinus tumors, since success is dictated by the anatomy of the tumor rather
than the surgical approach.

This small group of patients demonstrates that exclusively transcranial resection of tumors of the paranasal
sinuses and nasal cavity is a viable option and is frequently the preferred route. The technique of recon-
struction of the frontal floor and sequestration of the bone flap has proved to be effective; we believe it to be
a superior technique for avoiding infection. Comparison of the long-term results of this procedure with those
of other techniques remains to be done.

Addendum

Since this manuscript was submitted, four additional transcranial resections have been performed without
complication, and two tumors have recurred. One of the latter patients (Case 7), who had bilateral frank
tumor invasion of the brain, suffered a recurrence with diffuse leptomeningeal tumor at 11 months and died
within 2 weeks. In the other patient (Case 8), the tumor, which was enclosed with a positive margin in the na-
sopharynx, recurred at 3 months with adenocarcinoma in the anterior nasal floor where the surgical margins
had previously been negative.

References

1. Chessman AD, Lund VJ, Howard DJ: Craniofacial resec-
tion of tumors of the nasal cavity and paranasal sinuses.
Head Neck Surg 8:429-435, 1986
tions of intracranial facial resection for tumors of the
sinuses: a therapeutic challenge. Am J Surg 150:
406-413, 1985
bined intracranial facial approach to the paranasal
5. Smith RR, Klopp CT, Williams JM: Surgical treatment
of cancer of the frontal sinus and adjacent areas. Cancer
7:991-994, 1954
6. Sundaresan N, Shah JP: Craniofacial resection for ante-
rior skull base tumors. Head Neck Surg 10:219-224,
1988
7. Terz JJ, Young HF, Lawrence W Jr: Combined craniofa-
cial resection for locally advanced carcinoma of the head
and neck. I. Tumors of the skin and soft tissue. Am J
Surg 140:613-617, 1980
8. Terz JJ, Young HF, Lawrence W Jr: Combined craniofa-
cial resection for locally advanced carcinoma of the head
and neck. II. Carcinoma of the paranasal sinuses. Am J
Surg 140:618-624, 1980

Manuscript received September 30, 1988.
Address for Dr. Blacklock: Department of Neurosurgery,
Baylor College of Medicine, 6560 Fannin, Suite 900, Houston,
Texas.
Address reprint requests to: Helmuth Goepfert, M.D.,
Department of Head and Neck Surgery, University of Texas
M.D. Anderson Cancer Center, 1515 Holcombe Boulevard,
Houston, Texas 77030.