Use of titanium mesh for reconstruction of large anterior cranial base defects

Technical note

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Reconstruction of anterior cranial base defects is often necessary following resection of tumors, destructive infectious lesions, or fibrous dysplasias. Damage to the skull base may also occur following traumatic injury to the face or cranium, which at times may be severe enough to warrant surgical reconstruction. A competent frontal fossa floor is important in isolating the intracranial space from the contaminated paranasal sinuses and in preventing prolonged CSF leakage. Although infrequently observed, large skull defects may also result in herniation of cranial contents into the paranasal sinuses, further increasing the risk for cerebral infection.

Various methods of repairing the floor of the frontal fossa have been described. Authors of some reports have indicated that reconstruction using soft tissue alone is adequate in most patients. The pericranial flap is most commonly used for primary repair; use of skin, galeal, and various free muscle flaps has been described in patients who do not have sufficient native tissue. To provide more rigid fixation, some authors have also reported using bone grafts and metallic mesh in conjunction with soft-tissue repair. Because of the higher risk of postoperative infections, however, the application of avascular tissue has not become popular. Furthermore, the low incidence of postoperative brain herniation into air sinuses in patients undergoing frontal fossa surgery has been put forth as another argument against the use of rigid repairs.

Although the use of soft tissue alone may be adequate in preventing the formation of a CSF fistula, a more rigid repair may be advantageous in preventing the development of meningoencephalocele in patients with large cranial base defects and/or longer expected survival. Here we report our experience using titanium mesh in combination with vascularized pericranium to repair large anterior skull base defects. The technique described is simple, reproducible, effective in providing a rigid support, and has not been associated with increased rates of infection.

Clinical Material and Methods

Thirteen patients requiring reconstruction of a large anterior cranial base defect were included in this study. Patient characteristics are detailed in Table 1. Tumor resection was performed in eight patients immediately preceding the reconstructive procedure. Three patients were treated for fibrous dysplasia. Two patients harbored ethmoidal meningoencephaloceles that protruded through large bone defects, resulting in persistent CSF rhinorrhea. A transcranial–transfacial approach was performed in five patients. Anterior skull base reconstruction was performed in an identical manner in all patients by using the method described.
TABLE 1

Summary of patient characteristics

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Diagnosis</th>
<th>Follow Up (mos)</th>
<th>Complication</th>
</tr>
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<tr>
<td>1</td>
<td>21</td>
<td>fibrous dysplasia</td>
<td>39</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>traumatic injury</td>
<td>34</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>43</td>
<td>nasal carcinoma</td>
<td>12</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>olfactory neuroblastoma</td>
<td>34</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>meningoencephalocele</td>
<td>33</td>
<td>none</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>fibrous dysplasia</td>
<td>28</td>
<td>none</td>
</tr>
<tr>
<td>7</td>
<td>63</td>
<td>meningocecele, recurrent</td>
<td>23</td>
<td>CSF leak</td>
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<td>8</td>
<td>36</td>
<td>fibrous dysplasia</td>
<td>21</td>
<td>none</td>
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<tr>
<td>9</td>
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<tr>
<td>13</td>
<td>60</td>
<td>olfactory neuroblastoma</td>
<td>8</td>
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</tr>
</tbody>
</table>

Surgical Technique

A standard bifrontal craniotomy was performed for tumor resection or reconstruction in each patient. Briefly, a bifrontal skin incision was sharply made, leaving the pericranium intact over the frontal bone. While keeping the operative area moist, a subgaleal tissue plane was developed sharply over the pericranium as the scalp was reflected anteriorly. Special effort was made to avoid any damage to the pericranium during this maneuver so as to have an intact graft for the reconstruction. The pericranium was then cut a few centimeters behind the posterior margin of the scalp incision and bilaterally above the superior temporal lines and reflected anteriorly as a vascularized pedicle (Fig. 1 upper left). This flap was then wrapped in moist sponges for later use.

After performing a standard bifrontal craniotomy, the frontal sinuses were exenterated and packed with muscle and Gelfoam. The tumor and the involved dura and bone were resected via a subfrontal approach. Small dural openings were closed primarily by using No. 4-0 braided nylon, and larger defects were left open until final closure.

Reconstruction of the frontal fossa floor was performed by first placing No. 4-0 braided nylon sutures in the posterior edge of the dura over the planum sphenoidale (Fig. 1 upper right). The needles were left attached to the sutures. Usually eight to 10 sutures were needed to ensure coverage of the entire width of the frontal fossa. For patients with extensive involvement of the sphenoid sinus, special attention was given to avoiding injury to the optic nerves during suture placement. The sutures were then passed through the midpoint of the pericranial flap, which was gently pushed over the sinus defect. The sutures were tied, leaving the distal portion of pericranium free (Fig. 1 lower left). A piece of titanium mesh, previously fashioned to cover the cranial base defect, was then secured with screws to the anterior edge of the frontal bone. The pericranium was then reflected posteriorly over the exposed frontal lobes and sutured to the dura (Fig. 1 lower left). The craniotomy was closed in standard fashion, and patients received intravenously administered antibiotic agents for 24 hours postoperatively. Fibrin glue and external CSF drainage were not used in any patient.

Results

One patient in our series with a malignant nasal carcinoma died of progressive metastatic disease 12 months following tumor resection. All other patients were available for follow-up review. At a mean follow-up time of 22 months (range 8–39 months), no adverse reaction related to the use of titanium mesh was observed. None of the patients developed meningitis. Shortly after discharge two patients developed CSF leakage, manifested as rhinorrhea. These patients had extensive tumor involvement of dura overlying the sphenoid sinus and optic canals, which prevented adequate suturing of the pericranium flap. Both patients responded well to a 4-day course of temporary lumbar CSF drainage. These rates of postoperative CSF leakage (15%) and infection (0%) are similar to those reported by other investigators who have used pericranial flaps for surgical repair. Furthermore, encephalocele formation was not encountered in any of our patients.

Illustrative Case

This 55-year-old man presented with a 2-month history of headache, sinusitis, and purulent nasal discharge. Craniofacial computerized tomography and MR imaging revealed a large ethmoidal and maxillary sinus mass invading the orbital apex and the anterior and middle cranial fossa dura (Fig. 2). A transnasal endoscopic biopsy specimen of the mass revealed poorly differentiated carcinoma. The patient underwent transcranial–transfacial resection of the mass including orbital exenteration. Tumor resection resulted in a large defect involving the orbital roof and the ethmoidal and sphenoidal sinuses. Because of tumor involvement, the dura overlying the planum sphenoidale and optic canals was resected, thus preventing a watertight suturing of the deep portions of the pericranium. One week postoperatively, the patient developed CSF rhinorrhea, which responded to temporary lumbar CSF drainage. After treatment with external-beam radiation, the patient has remained free from further complications as of his 9-month follow-up examination.

Discussion

Use of titanium mesh and vascularized pericranium provides a simple method for reconstruction of large anterior cranial base defects. Application of this technique in 13 patients with a variety of destructive lesions did not result in any postoperative infections and was associated with a relatively low rate of CSF leakage.

Although the use of vascularized pericranium in reconstruction of frontal skull base defects is popular, the utility of rigid materials in such repairs is disputed. This is based on a relatively good patient outcome with exclusive use of pericranium and a higher risk of postoperative infection with the use of avascular tissue. Nevertheless, for patients with extensive skull defects and/or longer survival who may be at higher risk for development of postoperative meningoencephalocele, a more rigid repair may be necessary. Although the use of vascularized bone has been advocated by some authors, harvesting and fashioning split-thickness skull fragments to fit larger defects may be time-consuming and difficult. In our series, by placing a...
Skull base repair with titanium mesh

**Fig. 1.** *Upper Left:* Artist’s illustration (anterior view) of a typical bifrontal craniotomy showing a large dura and cranial base defect prior to reconstruction. The pericranial flap is cut behind the scalp incision and is folded anteriorly. *Upper Right:* Leaving the needles attached, several nylon sutures are placed deep into the dural and sinus openings. The sutures are individually passed through the midpoint of the pericranial flap, which is folded and gently pushed over the skull defect as the sutures are tied. *Lower Left:* The free end of the vascularized pericranial flap is folded over the dural defect and sutured to the frontal lobe dura. A prefashioned titanium mesh is placed over the pericranium and attached with screws to the frontal bone. *Lower Right:* Removal of retractors allows the brain to rest on the reconstructed floor.
titanium mesh between two layers of vascularized peri-
cranium, we were able to minimize the risk of infection,
while allowing for rigid reconstruction of the cranial base.

The risk of postoperative CSF leak observed in this series was similar to that reported by other investigators. Without the use of fibrin glue or lumbar CSF drainage, the two-layer pericranium was effective in preventing CSF leakage even in patients in whom large dural defects were not closed separately. We believe that meticulous suturing of the pericranial flap to the deep frontal dura is a key step in preventing CSF leakage when using this technique. In the two patients who developed postoperative CSF fistulas, there was extensive destruction of the dura (up to the optic canals) by tumor, making graft suturing impossible. Such patients may benefit from temporary postoperative CSF diversion.

We have described a simple, reproducible, and effective technique for repair of large anterior cranial base defects. As emphasized by others, application of vascularized pericranium was essential for prevention of postoperative CSF leakage and cerebral infection. However, long-term follow-up review and comparison with other techniques described in the literature are needed to judge the efficacy of titanium mesh in preventing the development of meningoencephalocele in these patients.

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References


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