Split-calvaria osteoplastic rotational flap for anterior fossa floor repair after tumor excision

Technical note

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A split-calvaria osteoplastic rotational flap to repair the anterior fossa floor after tumor excision was devised and tested clinically. At surgery, the flap is outlined between the glabella and the vertex. After the pericranium between the glabella and the flap’s anterior pole is elevated to form its pedicle, a full-thickness craniotomy is performed to expose the diploic aspect of the bone graft donor site (when the graft is relatively wide, bifrontal craniotomies may be advantageous). The diploic space is split in situ, taking care to protect the pedicle and its attachments to the osseous segment. Linear osteotomies in the outer table are created to mobilize the flap. With the flap rotated frontally, the craniotomy is completed. After tumor extirpation, the margins of the osseous segment of the flap are shaped to conform to the defect of the anterior fossa floor. Transverse osteotomies are performed so that the graft’s convex curve conforms to that of the anterior fossa floor. The flap is then rotated into position.

Follow-up evaluation in two patients at 22 and 30 months demonstrated bone integrity of the anterior fossa floor with graft preservation. Transient postoperative cerebrospinal fluid (CSF) rhinorrhea, which occurred in Case 1, was avoided in Case 2 by placing the osseous segment of the graft coplanar with the bone floor of the fossa. Neither patient had late meningitis or CSF rhinorrhea.

The split-calvaria osteoplastic rotational flap may represent an advance toward the ideal reconstruction of the anterior cranial fossa floor.

KEY WORDS · pericranial rotational flap · reconstructive surgery · skull · anterior fossa · bone graft · operative technique

Resection of the floor of the anterior fossa has been used to achieve radical excision of tumors arising in this vicinity. Such growths include meningioma,1 esthesioneuroblastoma,2 orbital tumors,3 and paranasal tumors.4.5.6 At the completion of such resections, an osseous defect in the floor of the anterior fossa establishes a communication between the intracranial and the nasal compartments.

Much effort has been expended in designing repairs for defects of this type.7 Firtell and Grissius8 have listed characteristics of an ideal cranioplasty, to which we would add an adequate seal separating the cranial and nasal compartments, prevention of meningoencephalocele formation, and protection of intracranial contents from injury during subsequent intranasal procedures. Soft-tissue flaps that have been used include pericranium,2 galea and frontalis,8 temporalis muscle,7 or free-tissue transfer.8 Although straightforward to implement, soft-tissue flaps lack the rigidity that an ideal reconstruction should possess. To overcome this limitation, surgeons have augmented these flaps with free bone grafts (split rib or calvaria)9 or metallic mesh.10 There are drawbacks to both methods. Free bone grafts are subject to osteomyelitis and resorption;10 metallic mesh, being a foreign body, is subject to bacterial colonization and soft-tissue erosion.

We have developed an alternative rigid reconstruction: the split-calvaria osteoplastic rotational flap (Fig. 1). We describe the surgical procedure and present two cases with long-term follow-up evaluation.

Operative Technique

The method involves an elaboration of the classic pericranial flap7 based along the supraorbital ridge. As we shall indicate, the classic procedure is augmented by
Split-calvaria osteoplastic rotational flap repairs

Fig. 1. Drawing to illustrate the split-calvaria osteoplastic rotational flap described here.

Fig. 2. Plan of the bone flap. a = distance from the glabella over the anterior margin of the bifrontal craniotomy to the anterior margin of the extirpation defect (6 to 7 cm, on average); b = the longitudinal extent of the extirpation defect (4 cm, on average); c = the margin of the pericranium which will overlap the dura of the planum sphenoidale (1 cm, on average).

Fig. 3. Illustration showing the diploë overlying the superior sagittal sinus exposed via a parasagittal craniotomy (either unilateral or bilateral).

an island of outer table which remains adherent to the pericranial flap. After the flap has been raised, the shape of the osseous segment can be modified so that the bone conforms to the extirpation defect.

Mapping the Pericranial Pedicle

On the basis of preoperative computerized tomography (CT) scans and magnetic resonance (MR) images, the surgeon estimates the dimensions of the extirpation defect. Prior to draping the patient, a tape with radiopaque markers is placed on the sagittal midline from the glabella to the vertex. With the ruler in place, a radiograph in the lateral plane permits measurement of the distance from the glabella, over the rostral margin of the planned craniotomy, to the margins of the pro-

posed extirpation (Fig. 2). The graft pedicle should be long enough to allow the graft to be tension-free after final placement. A margin of 1 to 2 cm of pericranium beyond the posterior pole of the osseous segment should be included to allow it to overlap the dura of the planum sphenoidale.

Raising the Composite Flap

The site of attachment between the pericranial pedicle and the osseous component of the flap must be protected assiduously during dissection. To accomplish this, a four-step method was developed to permit splitting the diploë in situ.

1. After the graft has been outlined, the pedicle is created by elevating the pericranium between the glabella and the anterior pole of the osseous segment; during this step, care is taken to protect attachments between the pericranial and subjacent osseous segments of the composite graft.

2. A full-thickness craniotomy is then performed on one or both sides of the osseous segment, thereby exposing the calvarial cross section of the graft. Wide donor sites are readily harvested with bilateral exposure of the diploë; narrower donor sites can be safely harvested with one-sided exposure. The superior sagittal sinus, now vulnerable, is mobilized and protected (Fig. 3).

3. With the diploë accessible from either or both sides, osteotomies, either motorized or conventional, are used to split the diploë space.

4. Finally, while the pericranial pedicle is protected, linear osteotomies in the outer table are created to mobilize the osseous segment. The attachment site is now vulnerable, and special care must be taken to protect it. The composite graft is rotated frontally and guarded against injury. With the composite flap fully mobilized, the craniotomy is completed.

Placement of Flap

After extirpation of the tumor, a sterile paper template is fashioned to transfer the outline of the anterior
fossa floor defect to the osseous segment of the composite graft. Care is taken to protect the site of attachment of the pericranium to the bone while the margins of the osseous segment are shaped with a high-speed burr to conform to the template. Further transverse osteotomies can be introduced so that the convexity of the graft conforms to the convexity of the anterior fossa floor. The composite flap is then rotated into position with the osseous element placed coplanar with the osseous floor of the anterior fossa. At the planum sphenoidale the posterior extension of the pericranial segment overlaps the dura intracranially (Fig. 4). A few 4-0 absorbable sutures are placed to tack the pericranium to the dura posteriorly and laterally.

A drain is left in the subdural space and connected to a sealed bag with no suction applied. All calvarial segments are then fixed together with miniplate or wire fixation techniques to create a multi-element reconstruction. Care is taken to avoid compressing the pericranial pedicle as it passes over the anterior margin of the craniotomy. The segment of inner table underlaying the outer table graft site is elevated to the plane of the outer table in order to avoid a palpable outer table defect postoperatively.

Case Reports

Case 1

This 52-year-old woman presented with headache and changes in mental status. Computerized tomography and MR imaging demonstrated an olfactory groove meningioma with invasion of the nasal roof. The patient underwent bifrontal craniotomy and resection of the meningioma. A split-calvaria osteoplastic flap was rotated into position. The osseous segment was scored into six subsegments to allow it to conform to the olfactory groove and ethmoid roof (Fig. 5A and B). The osseous segments were not reduced to the plane of the anterior fossa floor.

The patient did well clinically and returned to her prior activities. She developed cerebrospinal fluid (CSF) rhinorrhea in the immediate postoperative period, which responded promptly to lumbar drainage and did not recur. At 22 months, CT scans demonstrated preservation of the bone graft with restitution of bony integrity of the anterior fossa floor (Figs. 5C and D, and 6). She had no late onset of meningitis or CSF rhinorrhea.

Case 2

This 60-year-old woman presented with severe head-
Subsequent to surgery, the patient did well and returned to her previous activities. She had no CSF leak or late onset of meningitis. At 30 months, CT scans demonstrated bony integrity of the anterior fossa floor (Figs. 7D and 8).

Discussion

In a sterile field, free bone grafts can be expected to re-establish a random capillary supply with adjacent granulation tissue. Some bone resorption (25% to 40%) is likely to occur. A nonsterile field presents obstacles to the long-term integrity of free bone grafts. The utility of temporalis-based composite flaps has been demonstrated for reconstruction of lateral craniofacial bone defects. Casanova, et al., demonstrated the microvascular relationships between periosteum and the outer table of the calvaria, and Psillakis, et al., showed the clinical use of such flaps when based laterally on the temporalis fascia. Demonstration by CT of robust bone grafts 1 year after surgery in both of our cases supports our hypothesis that an osteoplastic flap can meet the challenges of the nonsterile environment.

In Case 1 the osseous segment was simply laid upon the anterior fossa floor. The pericranial segment was thus prevented from achieving tight apposition to the dura of the floor. This arrangement may have been responsible for the CSF rhinorrhea that occurred in the immediate postoperative period in this patient. The leak responded immediately to lumbar drainage, and the patient remained well through the follow-up period. As a result of this experience, in Case 2 we took care to...
place the osseous segment coplanar with the anterior fossa floor in order to optimize the apposition of pericranium to dura. In future cases, fibrin glue may augment the repair. Such details of technique will, we believe, minimize the chance of early CSF leak.

The ability to shape the margins and the contour of the osseous segment allows the surgeon to tailor the graft to each patient. The precise patterns of the osteotomies performed on the osseous segment will vary from case to case. With appropriate alterations in the donor site and the arc of rotation of the pedicle, it may be possible to use the split-calvaria osteoplastic rotational flap for reconstruction of craniofacial defects in other locations.

Conclusions

We have demonstrated the technical feasibility of creating a composite flap consisting of frontal pericranium and the subjacent outer table. A method was developed to permit splitting the diploë in situ while protecting the pedicle and its attachment to the osseous segment. Flaps of this type can be rotated into position on the floor of the anterior fossa. Long-term follow-up evaluation in two cases strongly suggests that the osseous segments of such flaps retain their biological and structural integrity. The split-calvaria osteoplastic rotational flap may represent an advance toward the ideal reconstruction of the anterior cranial fossa.

Acknowledgments

The technique of craniofacial resection used in the patients reported is derived from the surgical teachings of Leonard I. Malis, M.D., and Ved P. Sachdev, M.D., at Mt. Sinai Hospital, New York, New York.

References


Manuscript received March 8, 1993.
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