Chapter 105 – Reconstruction after Skull Base Surgery

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The goals of reconstruction after any oncologic resection are preservation and rehabilitation of function, restoration of cosmesis, and avoidance of morbidity. Any reconstruction after anterior craniofacial resection should strive to separate the cranial cavity from the upper aerodigestive tract, obliterate the dead space, preserve neurovascular and ocular function, and restore cosmesis (Table 105-1). Multiple free tissue grafts, vascularized local flaps, free microvascular flaps, and allografts are available for these purposes (Table 105-2).

Table 105-1 -- GOALS OF RECONSTRUCTION

Separation of cranial cavity from upper aerodigestive tract
Obliteration of dead space
Function neurovascular ocular
Cosmesis

Table 105-2 -- MATERIALS FOR RECONSTRUCTION

Free tissue grafts
Vascularized flaps
Pericranial/galeal
Temporalis muscle
Forehead
Scalp
Facial
Free microvascular flaps
Rectus abdominis
Radial forearm
Latissimus dorsi
Allografts
Plates/mesh
Bone cement

PATIENT SELECTION

Any patient who requires a skull base resection that produces a pathway of communication between the cranial cavity and the upper aerodigestive tract will need some form of reconstruction. Before embarking on reconstruction of the surgical defect, key patient factors must be considered, including underlying medical comorbid conditions such as diabetes mellitus and peripheral vascular disease and, most importantly, the size and site of the defect. It is often the complexity of the resection that dictates the option most suitable for reconstruction. Defects may involve a significant volume of soft tissue and facial or cranial bones, and there may be functional concerns such as resection of walls of the orbit or communication with the oral cavity. An important point to consider with respect to patient selection is what additional treatments may be required. Postoperative radiation therapy is often necessary after oncologic resection of malignant tumors of the skull base. Vascularized tissue is superior to any other source to avoid the complications of radiation therapy.

PREOPERATIVE PLANNING

Estimation of the extent of resection by thorough analysis of the preoperative imaging studies, including computed tomography (CT) and magnetic resonance imaging, is fundamental in planning the reconstruction and obtaining informed consent. In addition, angiography may be necessary to assess for peripheral vascular disease if a free microvascular flap is necessary. Doppler ultrasonography is another technique available to assess flow through vessels that supply the possible regional or free flaps.

It is important to communicate with other team members regarding the types of reconstruction being considered. Frequently, the members of the skull base team who perform the ablation may be different from the ones who perform the reconstruction.

SURGICAL TECHNIQUES

Pericranial Flap/Galeopericranial Flap

The majority of defects after anterior craniofacial resection involve the area of the anterior skull base located between the orbits and extending from the crista galli anteriorly to the planum sphenoidale posteriorly (Fig. 105-1). This area is amenable to reconstruction with a pericranial or galeopericranial flap.[1–3] Both pericranial and galeopericranial flaps are vascular pedicled flaps supplied by the supraorbital and supratrochlear vessels (Fig. 105-2). Thus, sacrifice of the supraorbital and supratrochlear vessels would render the pericranial flap nonviable. Harvesting of the pericranial flap does not impair the blood or sensory supply to the remaining scalp. Both flaps can be designed to reach the clival region or be divided longitudinally to reconstruct two different defects (i.e., anterior skull base and nose or orbit).

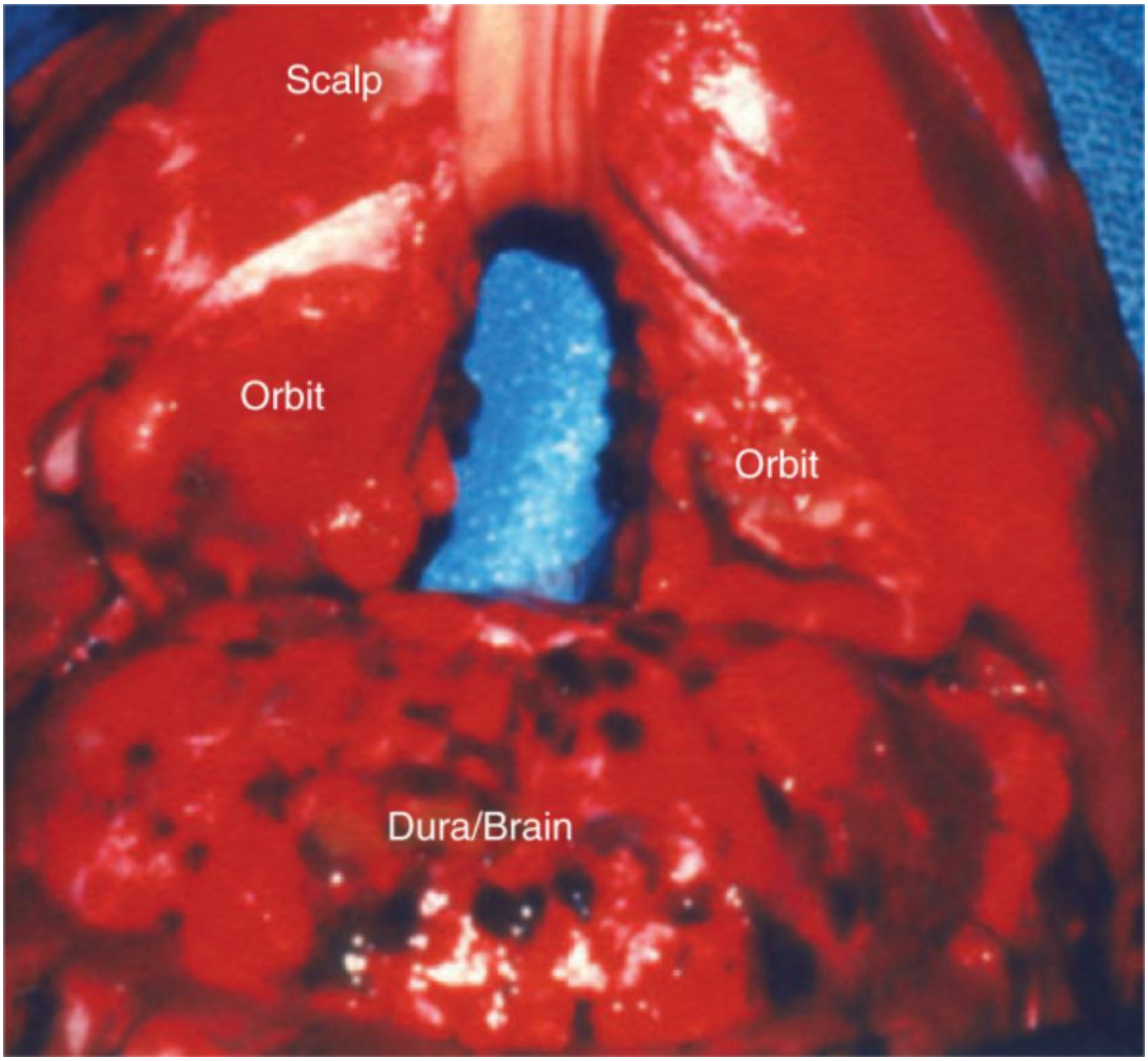

Figure 105-1 Intraoperative photograph demonstrating the defect after anterior craniofacial resection.

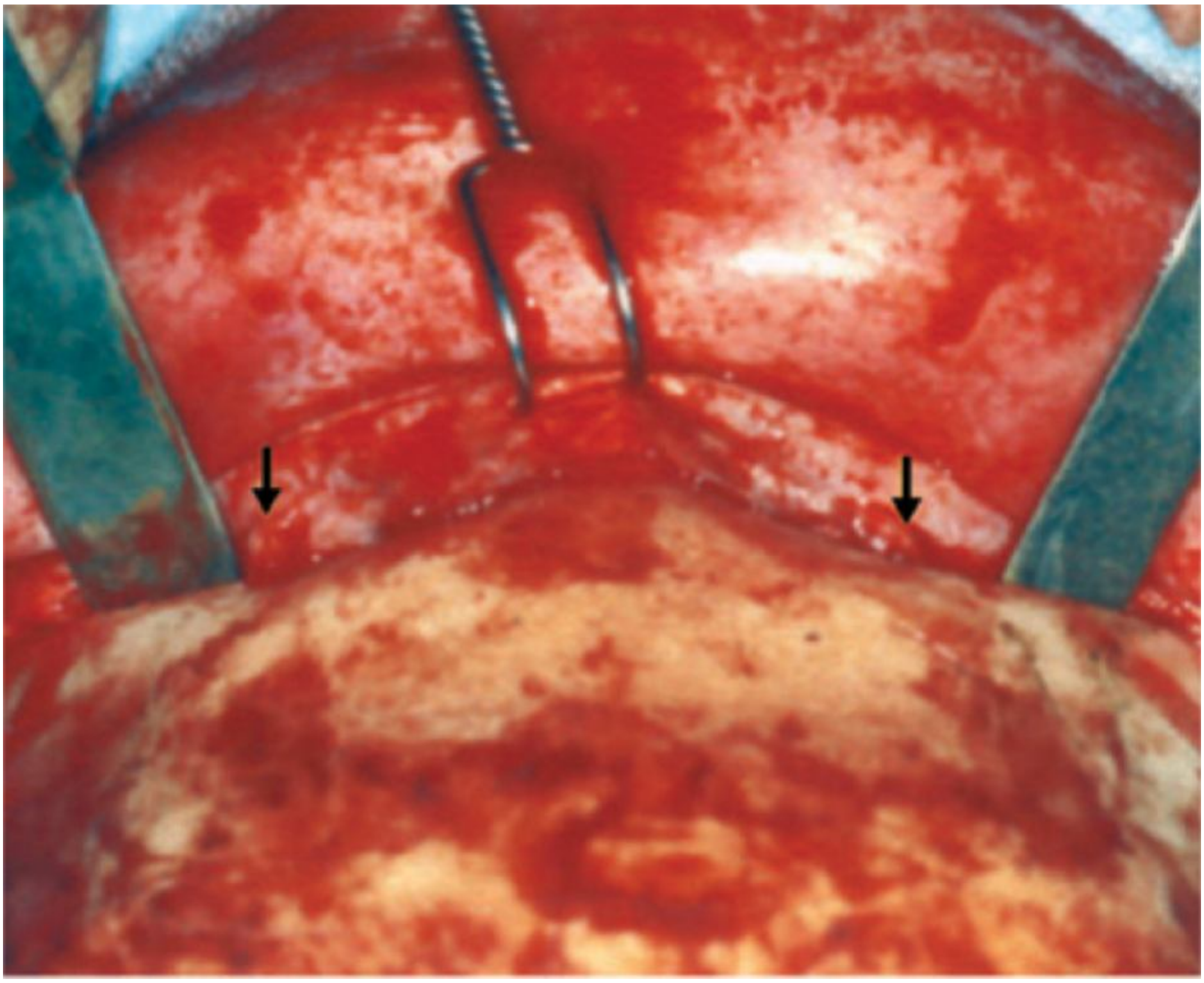

Figure 105-2 The vascular supply of both pericranial and galeopericranial flaps includes the supratrochlear and supraorbital vessels *(arrows)*.

The pericranium comprises the periosteum and the areolar tissue that separates the periosteum fromthe galea. Both tissue layers are raised as a single unit with a combination of sharp and blunt dissection extending from the bicoronal incision to the supraorbital neurovascular bundles. Additional length could be gained by planning harvesting of the flap distal to the bicoronal incision. We prefer to harvest the pericranial flap at the end of surgery (Fig. 105-3) to prevent desiccation and avoid inadvertent injury to the flap during the extirpative part of the operation. The flap is inserted under the supraorbital and craniotomy bone grafts to cover the anterior skull base defect (Fig. 105-4). Compression of the flap by the supraorbital bone graft should be avoided.

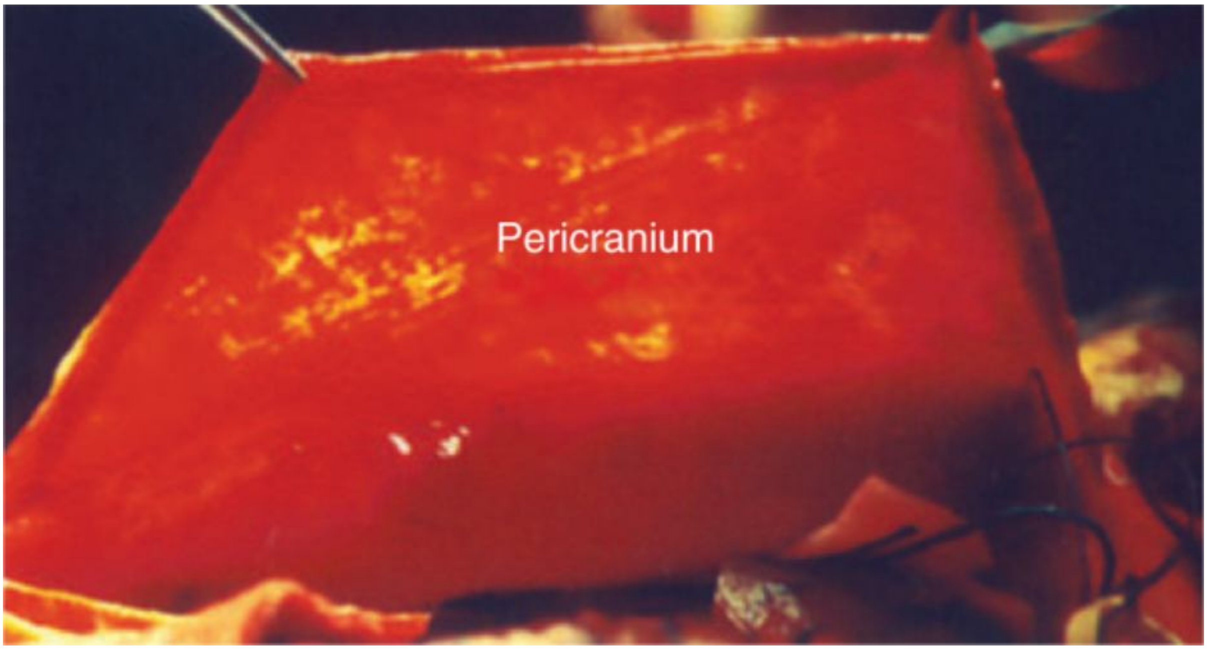

Figure 105-3 Intraoperative photograph demonstrating a pericranial flap.

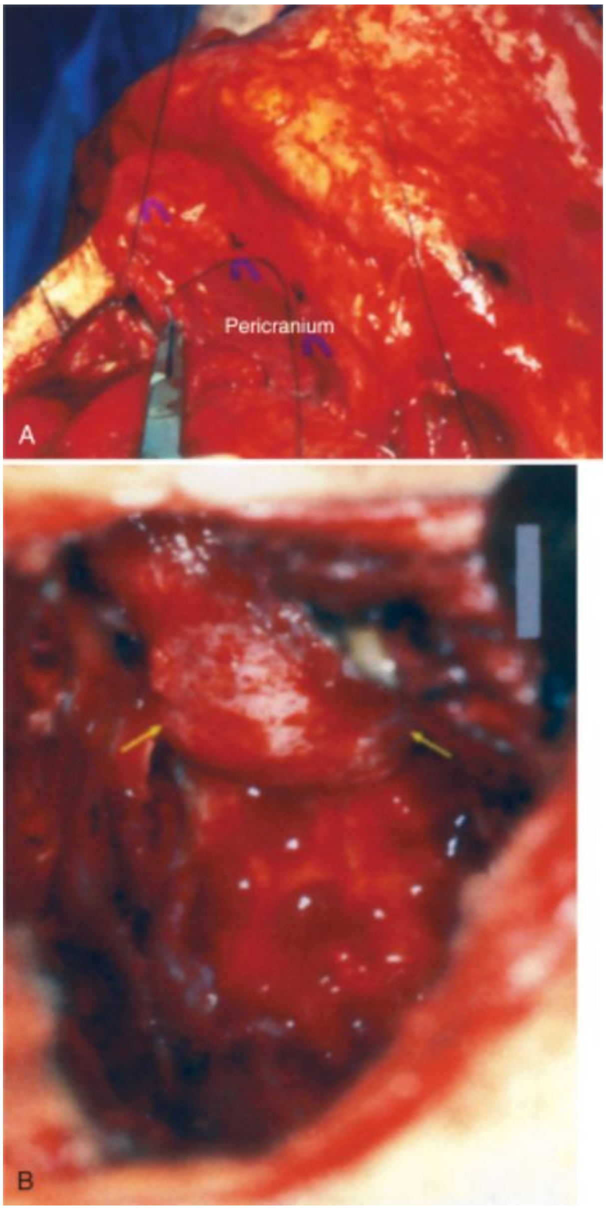

Figure 105-4 **A**, Intraoperative photograph of a pericranial flap inset between the dura and skull base. **B**, Pericranial flap seen from the nasal side (*arrows*).

Temporalis Muscle Flap

Defects of the anterolateral and infratemporal skull base, as well as defects of the orbit, oral cavity, oropharynx, and nasopharynx, may be reconstructed with a temporalis muscle flap.[4–6] This muscle flap may be divided vertically to reconstruct two separate defects (i.e., subtemporal skull base and orbit), or most commonly, the anterior half of the muscle is used for reconstruction and the posterior half is transposed anteriorly to fill the anterior temporal fossa. In our practice, the temporalis muscle flap is most commonly used to provide soft tissue cover for the bone grafts or titanium mesh used for reconstruction of the orbital walls, to reconstruct the infratemporal fossa or skull base, or to obliterate the orbital cavity after exenteration. A temporalis muscle flap may be used as an adjunct to a pericranial flap when resection of the skull base has been extended laterally (Fig. 105-5).

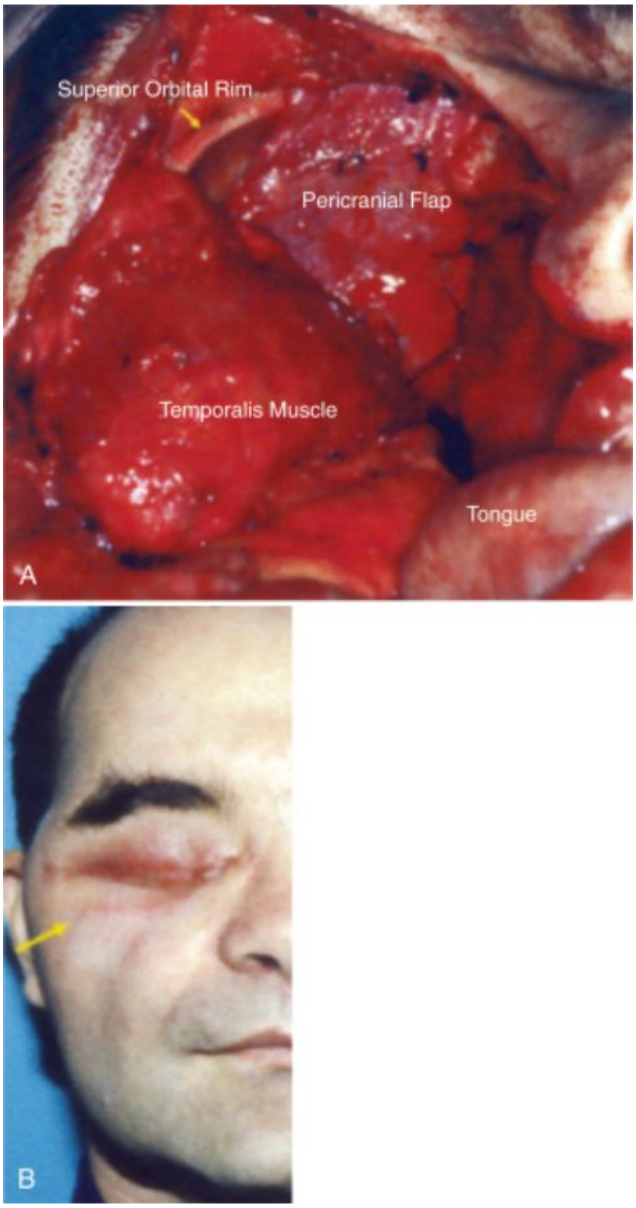

Figure 105-5 **A**, Intraoperative photograph of reconstruction of the skull base and orbit with the temporalis muscle. **B**, Postoperative appearance.

The temporalis muscle flap is harvested by dissecting the temporalis muscle from the temporal fossa with a combination of electrocautery and blunt dissection. Its insertion to the zygoma (superficial and deep layersof the deep temporal fascia) should be transected to gain adequate mobilization. To protect the frontal branches of the facial nerve, the superficial layer of the deep temporal fascia is incised along an imaginary line that extends from the superior orbital rim to the root of the zygoma. The plane of dissection proceeds deep to this fascial layer, which corresponds to a subperiosteal plane over the zygomatic arch and malar process. Its reach or arc of rotation may be increased by dividing the insertion of the temporalis muscle to the coronoid process of the mandible.

The muscle is then rotated and sutured into place. If the posterior half was not used, it is transposed anteriorly and sutured to the lateral orbital rim and to a curvilinear plate screwed at the level of the temporal line. The temporalis muscle flap is supplied by the deep temporal artery, a terminal branch of the internal maxillary artery. Dissection of the flap in its medial aspect or oncologic resection or preoperative embolization of the muscular branches of the internal maxillary artery will render the flap nonviable.

Temporoparietal Fascia Flap

The temporoparietal (superficial temporal fascia) fascia flap is supple and offers an extended reach that allows it to be used for reconstruction of anterior, lateral, and posterior skull base defects, as well as maxillofacial defects. [7–13] It can be harvested bilaterally as two separate flaps or as a bipedicle flap, which may provide enough tissue to reconstruct the entire anterior skull base.

The temporoparietal fascia flap includes the superficial temporal fascia and galea, which is supplied by the superficial temporal artery. Its vascular supply encompasses an area that extends from the ipsilateral temporal artery to the midline and covers up to 15 cm in width (Fig. 105-6). It is critical to plan harvesting of this flap in advance. To preserve its integrity and blood supply, the flap should be harvested at the time of the bicoronal incision. Because a customary hemicoronal or bicoronal incision would divide the flap and sacrifice its blood supply, anterior harvesting of the flap should be limited to the hairline since the frontal branch of the facial nerve may be injured if the dissection is extended anterior to this point. To harvest the temporoparietal fascia, the coronal incision is extended to but not through the galea, and the flap is then harvested by sharp dissection. The dissection is somewhat cumbersome and tedious because of the rich blood supply of the scalp. Hemostasis is achieved with bipolar cautery.

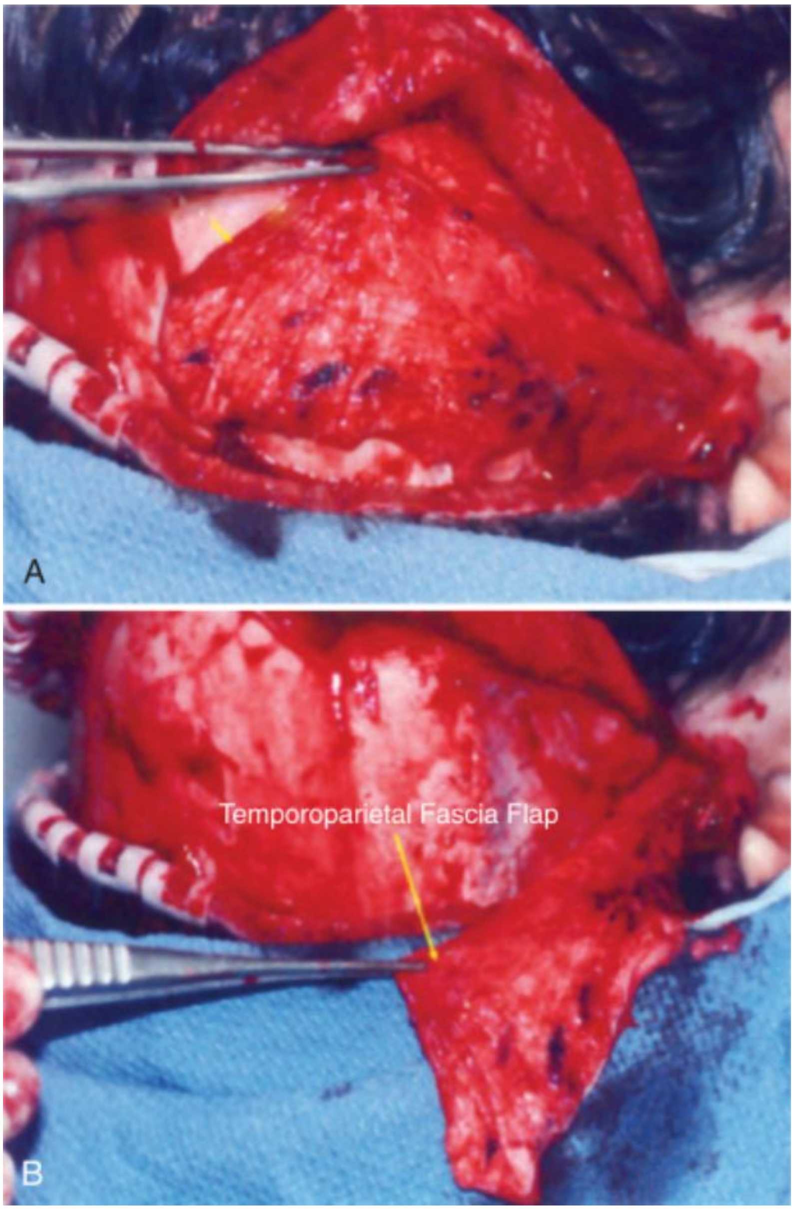

Figure 105-6 **A**, Intraoperative photograph demonstrating dissection of a temporoparietal fascia flap. **B**, Temporoparietal fascia flap.

Microvascular Free Flaps

Microvascular free flaps lengthen the time of surgery and increase its cost and morbidity, so these flaps are recommended only in certain situations, such as the need to reconstruct a defect left by an extended resection that includes all the soft tissues from the skin to the brain, to support the brain, after extended maxillectomies that produce defects that will not retain a prosthesis, or when local or regional flaps are not available.[3,11,12,14–17] Contraindications to the use of free flaps include severe peripheral vascular disease, lack of availability of adequate host vessels, medical instability, and the need for vasopressors. Commonly used microvascular free flaps include the radial forearm flap, the rectus abdominis flap, and the latissimus dorsi flap (Fig. 105-7). A thorough discussion of these flaps is included in Chapter 81.

Figure 105-7 **A**, Extensive anterior and lateral skull base and intraoral defect. **B**, Postoperative photograph demonstrating a nasocutaneous fistula and retraction of the left oral commissure. A latissimus dorsi (LD) free microvascular flap has a tendency to sag because of its bulk and weight.

Reconstruction of the Craniofacial Skeleton

Wires, stitches, titanium alloy plates, or mesh may be used to fix free bone grafts such as the craniotomy bone, the supraorbital block, and other parts of the maxillofacial skeleton[18–21] (Fig. 105-8). We prefer the use of plates or mesh because they yield stable fixation and a more predictable long-term result. Titanium plates and mesh osseointegrate very well; in addition, they produce minimal imaging artifact and radiation scattering. Titanium mesh can also be used to replace parts of the bony framework that had to be resected, such as frontal bone, orbital bone, or anterior maxilla (Fig. 105-9). We cover the mesh with acellular dermis to prevent subsequent indentation of the skin over the mesh pattern.

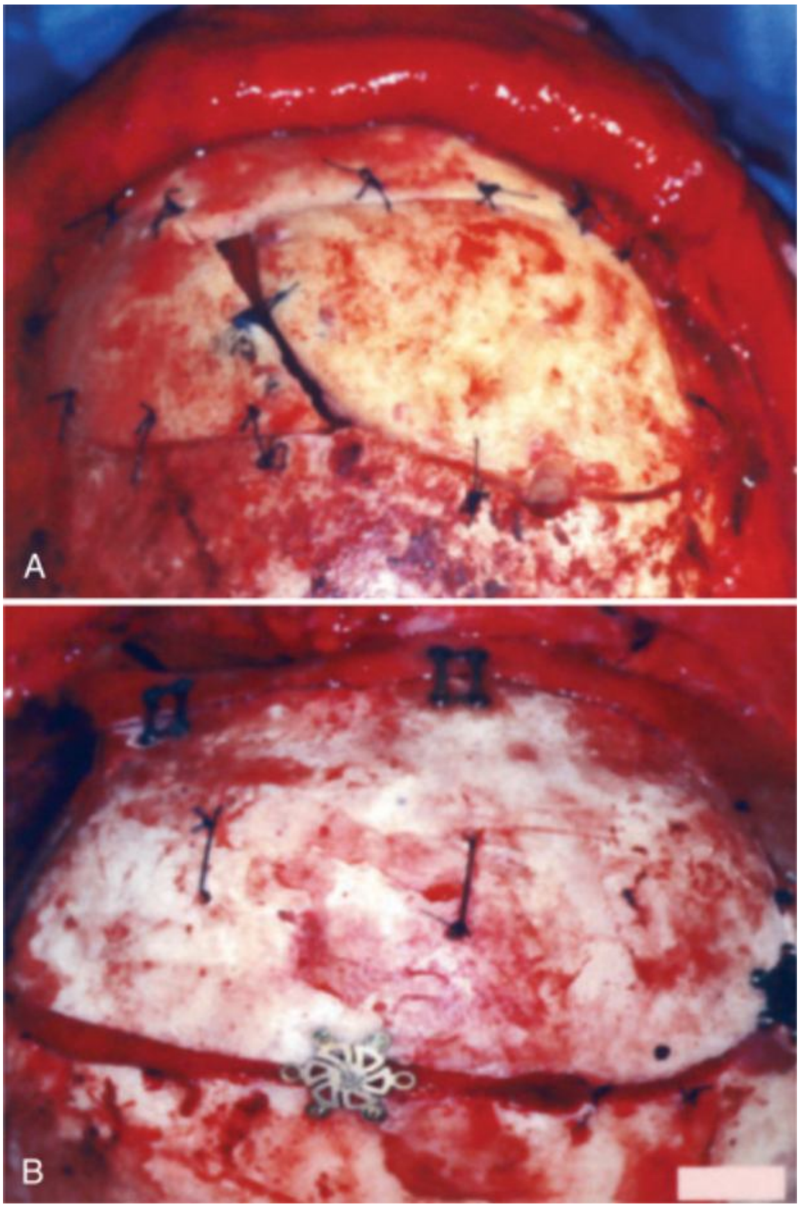

Figure 105-8 **A**, Fixation of bone grafts with sutures. **B**, Fixation of bone grafts with titanium plates.

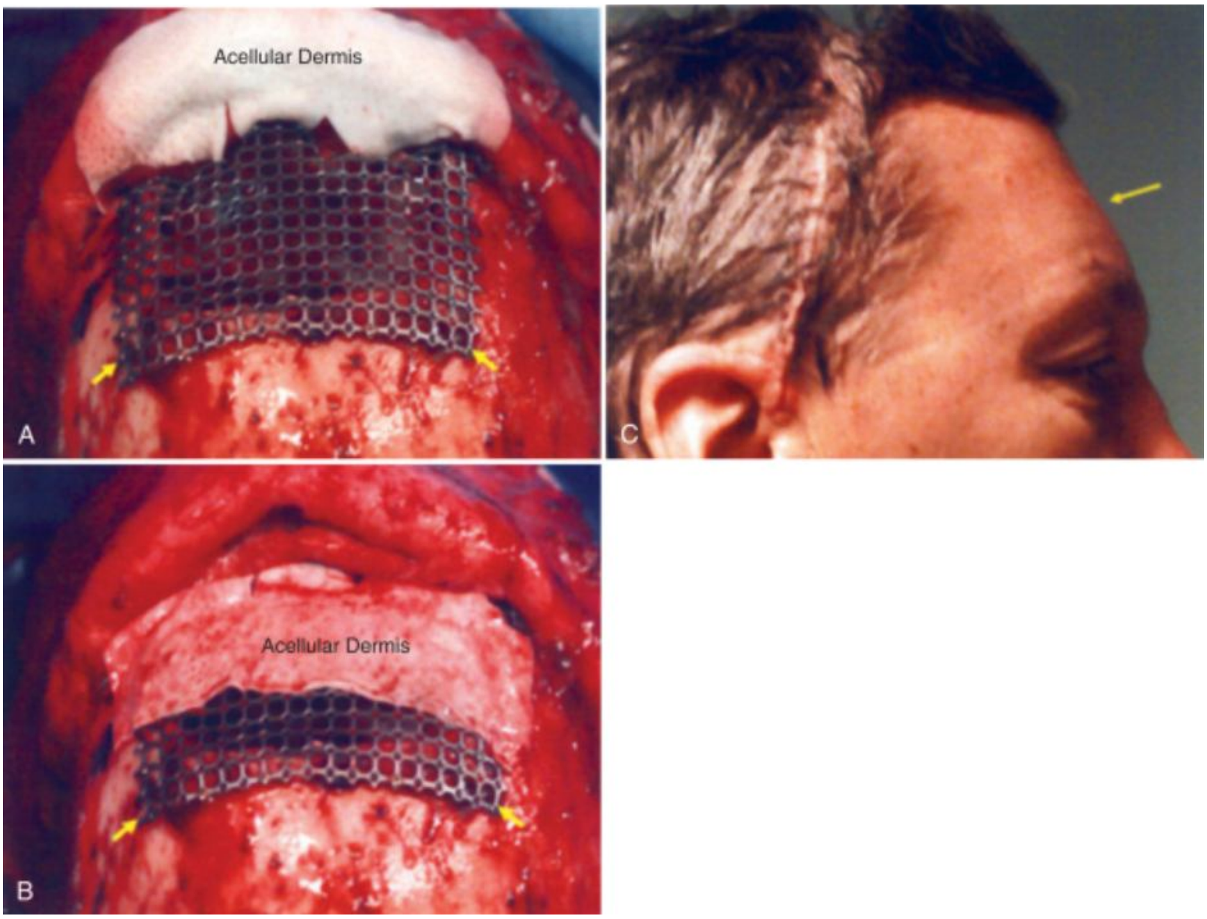

Figure 105-9 **A**, Intraoperative photograph. The frontal and glabellar area is reconstructed with titanium mesh *(arrows)*. **B**, Acellular dermis is layered over the titanium mesh (*arrows*). **C**, Postoperative appearance of frontal contour (*arrow*).

Reconstruction of the Orbit

Reconstruction of the orbital walls is recommended when more than a third of the circumference of the orbit is sacrificed (i.e., more than the lamina papyracea) or when the periorbita had to be removed with the adjacent bony wall.[18–21] This latter defect produces significant enophthalmos and may also lead to hypo-ophthalmia in the case of resection of the orbital floor.

The orbital walls are better reconstructed with rigid materials that resist contraction and provide an immediate and predictable outcome. This can be achieved with bone grafts, titanium mesh, porous polyethylene, or other alloplastic material. We generally use titanium mesh because of its availability and ease of conforming to the orbital walls (Fig. 105-10). Another consideration when choosing the reconstructive material is that these patients usually require postoperative radiation therapy, which raises the possibility of osteoradionecrosis of bone grafts. Titanium mesh, however, needs to be covered with an acellular dermis graft over the orbital side or the soft tissues of the orbit will “grow” into the mesh holes and lead to tethering of the extraocular muscles and severe contraction of the lower eyelid (i.e., ectropion). The medial canthus is repositioned with a titanium plate that is screwed to the remaining nasal bones (Fig. 105-10). The lateral canthus should also be repositioned and sutured to the lateral orbital rim to avoid lower eyelid ectropion.

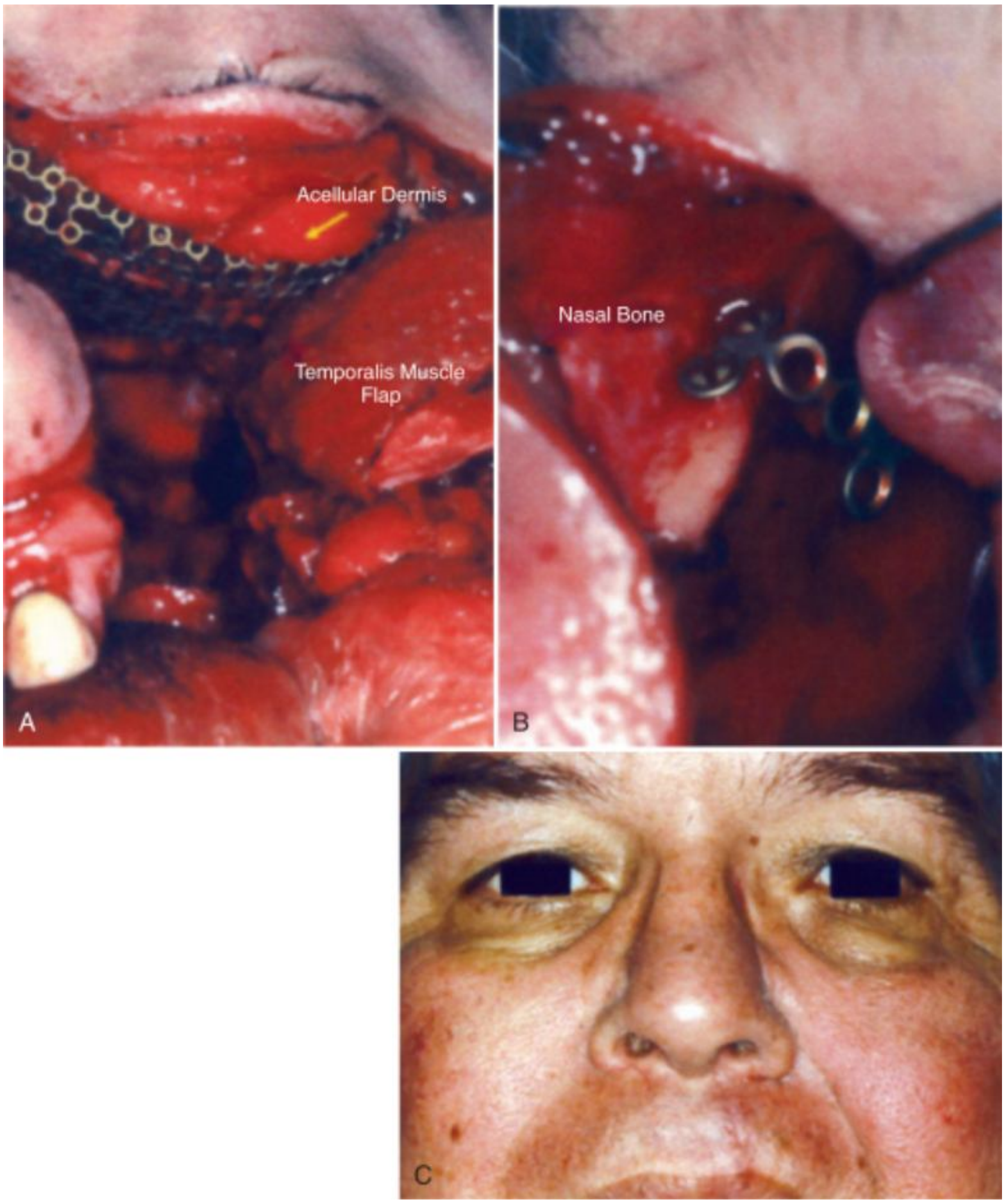

Figure 105-10 **A**, Intraoperative view of a titanium mesh plate used for reconstruction of the orbital floor. A temporalis muscle flap will cover the mesh on its inferior area. The soft tissues of the orbit are separated from the mesh with acellular dermis to avoid ingrowth of the tissues and a frozen globe. **B**, Intraoperative view of a titanium plate used for medial canthopexy. **C**, Postoperative photograph demonstrating less lagophthalmos and enophthalmos than with traditional techniques.

POSTOPERATIVE CARE

Postoperatively, the patient is transferred to an intensive care unit for continuous cardiovascular and neurologic monitoring. Postoperative anemia, hypovolemia,and electrolyte imbalances are corrected when present.

A CT scan of the brain is performed on the first or second postoperative day to identify intracranial complications such as cerebral contusion, edema or hemorrhage, fluid collections, or pneumocephalus.

The scalp drains are kept on bulb suction only. High-pressure suction can produce rapid shifting of the brain or brain stem (or both), with life-threatening effects. Drains are removed when the drainage is less than 30 mL/day. If the dura was opened or resected during the ablation, the drain puncture site should be closed with an encircling stitch on removal of the drain to prevent infection.

COMPLICATIONS[22–25]

Scalp Wound

Necrosis of the scalp is rare and most often the result of poorly designed incisions or prolonged use of hemostatic clamps. The latter may result in areas of ischemia, particularly around the auricle, that can make the tissue susceptible to secondary infection. Scalp necrosis may also be the result of previous irradiation, which when combined with harvesting of the galeopericranial flap, may render the scalp ischemic.

Postoperative intracranial infection usually results from inadequate separation between the cranial cavity or grafts and the sinonasal tract, from a large dead space, or from noncompliance and blowing the nose in the immediate postoperative period. Partial necrosis of the scalp flap may lead to a wound infection, as well as contamination of the grafts. Restoration of the separation between the cranial cavity and the sinonasal tract, débridement (removal of the free bone grafts), and prolonged antibiotic therapy (45 days, guided by culture and sensitivity testing) are the recommended treatment.

Postoperative Sinonasal Bleeding

Significant postoperative nasal bleeding most commonly arises from a branch of the internal maxillary or anterior ethmoidal artery and is amenable to endoscopic control. Angiography with embolization is reserved for patients in whom the bleeding site is not readily apparent, such as those who underwent reconstruction with a microvascular free flap. Intracranial postoperative bleeding or bleeding from the vascular anastomosis of a free microvascular flap requires surgical intervention.

Cerebrospinal Fluid Leak

In a patient with postoperative rhinorrhea, testing of the fluid for β_2-transferrin is prudent to confirm a cerebrospinal fluid (CSF) leak. Accumulation of irrigation fluid in the sinonasal tract, with subsequent drainage, can mimic a CSF leak in the immediate postoperative period.

A postoperative CSF leak is managed conservatively with bed rest, stool softeners, and a lumbar drain (50 mL every 6 to 8 hours). Persistence of the leak beyond 3 to 5 days, unabated by conservative measures, indicates the need for surgical repair. Surgical exploration, however, may be indicated as initial therapy if loss of the reconstructive flap or dehiscence of the dural repair is suspected.

Tension Pneumocephalus

Trapped intracranial air can act as a space-occupying lesion that compresses the brain parenchyma and gives rise to lethargy, disorientation, slow mentation, or hemiparesis. A CT scan without contrast enhancement confirms the diagnosis and may be used to guide aspiration of the air with a needle placed through a burr hole or osteotomy gap. Recurrent tension pneumocephalus is usually associated with loss of the pericranial flap or may be due to nose blowing by a noncompliant patient despite instructions otherwise. Recurrent pneumocephalus requires bypassing the sinonasal tract airway with a tracheostomy or endotracheal tube or surgical closure of any cranionasal communication, or both.

Limitation of Extraocular Muscle Movement

Some degree of postoperative diplopia is present in most patients and is caused by dissection of the trochlea, postoperative edema, or removal of the orbital walls. It is usually self-limited and typically lasts less than 4 weeks. Reconstructive grafts may entrap the medial, lateral, or inferior rectus muscles and result in restriction of range of motion and permanent diplopia. Intraorbital dissection, such as that required when the periorbita is resected, or surgery on the cavernous sinus may injure the motor innervation of these muscles. A forced duction test helps differentiate between muscle entrapment and loss of muscle innervation.

Enophthalmos

Enophthalmos is caused by expansion of the volume of the orbital cavity as a result of resection of the orbital walls and is more pronounced when the periorbita is resected. It is best to prevent this complication by reconstructing the orbital walls with autogenous bone or titanium mesh (i.e., rigid reconstruction).

PEARLS

- Vascularized tissue is preferred over nonvascularized tissue such as free tissue grafts.
- Local and locoregional flaps are associated with less morbidity, less operative time, and less cost than microvascular free flaps are.
- Microvascular free flaps provide better coverage or support (or both) for defects that include the skin or lateral skull base.
- Trauma to the skull base tends to produce multiple defects.
- High ventricular pressure should be suspected in patients with recurrent CSF leaks.

PITFALLS

- Patients who undergo preoperative radiation or chemoradiation therapy are at a higher risk for devascularization of the scalp from harvesting of a pericranial or galeopericranial flap.
- Patients who have undergone radiation therapy are at higher risk for delayed healing or nonhealing of the defect.
- No reconstruction provides immediate protection against high CSF pressure.
- Patients who have skull base defects are at higher risk for meningitis, even after reconstruction.
- Oncologic resection may destroy the blood supply to local or regional flaps.