– MANAGEMENT OF COMPLICATIONS OF ENDOSCOPIC SINUS SURGERY

Chapter 18 – Complications of Endoscopic Sinus Surgery: CSF Leak

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A cerebrospinal fluid (CSF) leak involves a communication between the arachnoid space and the sinonasal tract; this implies the trespassing of the mucoperiosteum, the cranial bone, dura mater, and the arachnoid (Fig. 18-1). The etiology of CSF leaks can be divided into post-traumatic and spontaneous. Post-traumatic CSF leaks are by far the most common and these include postaccidental injuries such as closed-head injuries with and without skull base fractures and surgery.[1–3] Of interest for the otolaryngologist are those CSF leaks produced during endoscopic sinus surgery. Although the incidence of CSF leaks after endoscopic sinus surgery is less than 1% due to the high volume of surgeries, this still remains one of the most common causes.[4–21]

Immediate identification and repair of a CSF leak avoids development of life-threatening complications.[1,2] Intraoperatively, the surgeon may identify a source of clear fluid and/or the pulsating dura or brain. Postoperatively, patients with CSF leaks present with symptoms such as clear nasal discharge associated with headache or complications such as pneumocephalus, meningitis, or brain abscess. A highly reliable way of corroborating a CSF leak is the use of a β2 transferrin test. β2 transferrin is a protein that exists in CSF, in perilymph, and in ocular humors. This protein can be detected using electrophoretic techniques, and its presence corroborates a CSF leak. The test is highly specific and highly sensitive and only a minimal volume is necessary to detect the protein. Detection of β trace protein has been reported recently and seems to be a better test than the β2 transferrin. It has the same advantages of the β2 transferrin test but it can be performed faster and is less costly. Patients with renal disease, however, may present with elevation of the beta trace protein level and patients with meningitis may have a lower level, leading to a false-positive or false-negative result, respectively. Direct endoscopic visualization may identify the site of a CSF leak and in these cases the corroboration by β2 transferrin or β trace is unnecessary. The use of intrathecal fluorescein may be used as an alternative. Despite known side effects, fluorescein is safe when injected in the intrathecal space at a low concentration (less than 5%) and low volume (5 mL). In our practice, however, we rarely use fluorescein because the logistics of performing a lumbar puncture in the otolaryngology office precludes its use. In addition, there is a medicolegal concern due to the warning on the fluorescein label, which states that it is not for intrathecal use. Nonetheless, the European and American literature supports its use when indicated and corroborates its usefulness.

Imaging is useful to identify the presence of a skull base defect and to stage its site and size. A high-resolution computed tomography (CT) scan using both coronal and axial views with a bone algorithm is the preferred technique for the initial evaluation. The skull base defect is better visualized when the area is scanned at an angle perpendicular to the defect. In other words, defects at the ethmoid roof are better seen in the coronal CT scan, whereas defects of the posterior wall of the frontal sinus are better shown in the axial CT scan. In our practice, patients with a negative CT scan undergo a CT cisternography. This involves the intrathecal injection of contrast at the same time of a high-resolution CT scan. If this test fails to identify a skull base defect, 10 mL of normal saline solution is injected into the intrathecal space to increase the CSF pressure, and, therefore, to increase the sensitivity of the test by inducing an active leak. Although some advocate an MR cisternography, our experience with this technique has yielded mixed results. We recommend magnetic resonance imaging (MRI) when the patient presents with a meningoencephalocele to better assess the contents of the sac and in those patients who present with brain injury. It is important to understand the nature of the contents within a meningocele or meningoencephalocele, in that we have encountered critical vascular structures within the sac. This has an important therapeutic implication because, most of the time, this sac is transected and discarded, and not reduced back into the intracranial space.

Once the skull base defect has been adequately staged, the patient can be taken to the operating room for repair. Multiple techniques have been reported for the repair of a CSF leak. In 1952, Hirsch described the first endonasal repair of CSF leak using a septal flap.[22] Subsequently, Montgomery described his experience using septal flaps through an external nasal approach to treat CSF leak.[23] In 1976, McCabe reported his experience with the use of osteomucoperiosteal flaps from the septum or middle turbinate through an external ethmoidectomy approach.[24] In 1989, a publication of McCabe's updated experience reported a 100% closure rate with a follow-up of 1.6 to 22 years.[25] The use of these and other local flaps to treat CSF leaks via an endoscopic approach was subsequently reported.[13,26]

In 1985, Calcaterra[27] described the use of free muscle or fascia grafts to treat CSF leaks using an external ethmoidectomy approach, and in 1989 Papay and colleagues[28] described an endoscopic technique. Multiple publications followed, reporting the use of free grafts and/or local flaps for the repair of CSF leak. Recently, a vascularized nasoseptal flap has been devised to reconstruct skull base defects of various etiologies and early follow-up data reveal a remarkable improvement in controlling large CSF leaks, such as those associated with expanded endonasal approaches to the skull base.[29]

The most predominant factors influencing the choice of which technique and material are used during the endoscopic endonasal closure of CSF leaks are the availability of the biologic material and the experience and familiarity of the operating surgeon with various techniques. Most techniques yield similar results in experienced hands, as confirmed by a meta-analysis of the literature by Hegazy and colleagues.[1] After analyzing all reports in the English literature comprising a series of endoscopic repairs of more than five patients, this study found no significant differences in outcome, regardless of which surgical technique or which homologous material was used for the repair.

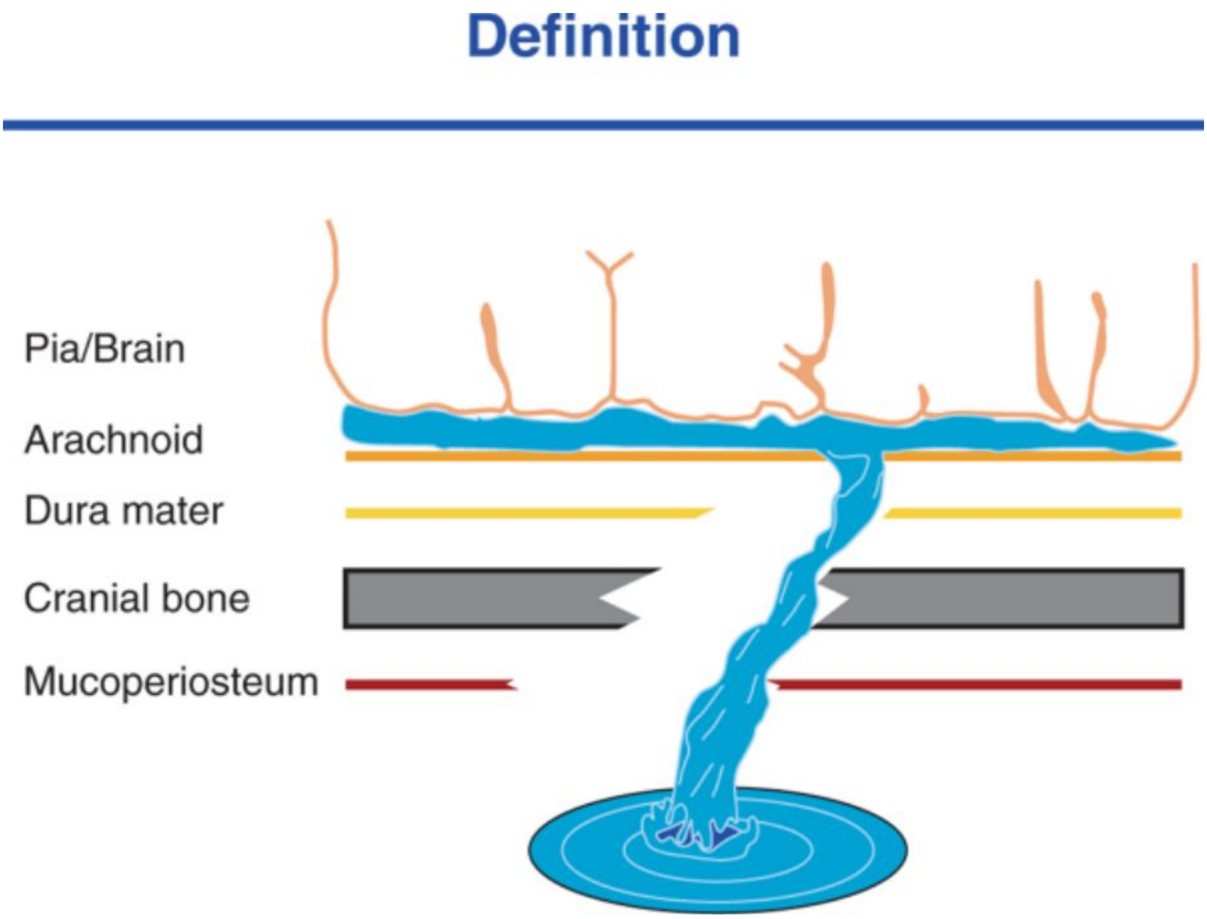

Figure 18-1 Schematic representation of a CSF leak to the sinonasal tract.

PATIENT SELECTION

The diagnosis and management of a CSF leak involves three critical steps: distinguishing a CSF leak from other sources of rhinorrhea, locating the leak, and ruling out high intracranial pressure secondary to altered CSF dynamics.

A clinical diagnosis of a CSF leak is based on a history of clear, watery nasal drainage, usually unilateral, and commonly associated with headache. Increased rhinorrhea when the patient leans over, tilts the head forward, or performs a Valsalva maneuver further suggests the presence of a CSF leak. A life-threatening complication arising from the CSF leak, such as pneumocephalus, brain abscess, or ascending bacterial meningitis may be the initial presentation.

Conditions such as vasomotor rhinitis and sympathetic denervation can cause profuse rhinorrhea that may be confused with a CSF leak. Nasal irrigations during endoscopic sinus surgery or used for nasal hygiene postoperatively may accumulate in the paranasal sinuses and later present as postoperative rhinorrhea. Thus biochemical testing is indicated to confirm the true nature of the nasal drainage. CSF is high in glucose and low in protein. However, normal nasal discharge has been shown to be falsely positive for glucose in 45% to 75% of cases.[30] β2 transferrin is a protein found in CSF, aqueous humor, and perilymph, but not in blood or nasal secretions; therefore β2 transferrin is a reliable chemical marker of CSF leakage.[31–35] As previously mentioned, β-trace protein seems to be superior to β2 transferrin as a chemical marker for a CSF leak.[36]

PREOPERATIVE PLANNING

When CSF leak develops after sinus surgery, the endoscopic surgeon typically has an impression as to the possible site of injury to the cranial base (i.e., site of the CSF leak).

Therefore a thorough endoscopic office examination of the nasal cavity may corroborate the site of the leakage. Fistulas with low-pressure leaks are difficult to identify, especially in the presence of postoperative tissue edema and blood clots.

Intrathecal injection of contrast materials and radioactive tracers has been advocated to confirm a CSF leak and to identify the site of origin. Intrathecal fluorescein may be used to aid in the diagnosis and localization of the CSF leak. During this test, 0.5 mL of fluorescein, of a concentration not greater than 5%, is diluted with 10 mL of CSF, obtained through a lumbar puncture, and is then injected intrathecally. Fluorescein is neurotoxic and a low concentration–low volume injection is mandatory to avoid the neurologic complications associated with higher concentrations. After intrathecal injection of the fluorescein solution, the CSF leak may be visualized using the nasal endoscope.[31–35,37] Under a Wood lamp (i.e., black light), fluorescein appears as bright yellow-green; nonetheless, the yellowish color of fluorescein may be identified without the need for special lighting.

Logistics of performing a lumbar puncture in an outpatient setting and medicolegal considerations (fluorescein drug package insert includes an advisory warning against intrathecal use) have discouraged us from its use. Intrathecal injections, in any case, are rarely critical to the identification of the CSF leak caused by endoscopic sinus surgery.

Others have advocated the intrathecal injection of air, which can “bubble” out at the fistula site, thus aiding in its identification.[37] Air, however, is an irritant to the brain and may induce seizures. Normal saline solution may be injected into the intrathecal space to increase the pressure within the subarachnoid space and thus aid in the identification of the leak.

Scintigraphy with indium (In-111) has been advocated for the identification of a CSF leak. Radiotracing is a very sensitive test, but it is associated with a high false-positive rate[31] and has a poor resolution that precludes establishing the specific point of leakage. In general, we do not advocate scintigraphy. In our practice, the presence of the CSF leak is validated with β2 transferrin electrophoresis. CT, MRI, CT cisternography, and/or endoscopy are used to identify the site of origin.

Imaging is critical to locate the site of the leak and estimate its size. High-resolution CT (HRCT) is our preferred initial imaging study to aid in the identification of the site of injury and its extent. HRCT with contrast also provides information about the possibility of intracranial complications, such as hematoma or brain contusion, that occur in the setting of acute trauma (iatrogenic or accidental). HRCT with views taken at a perpendicular plane from the suspected site of injury better evaluates the integrity of the bony wall in question. Coronal CT views are best to evaluate defects of the cribriform plate, fovea ethmoidalis, or planum sphenoidale, whereas axial views are superior to evaluate the posterior wall of the frontal or sphenoid sinuses. We use MRI to ascertain the contents of meningocele or meningoencephalocele.

HRCT, however, may not identify small areas of surgical trauma or linear nondisplaced fractures. In this case, HRCT can be used in conjunction with intrathecal contrast to identify the leak. CT cisternography has been documented to be both sensitive and reliable. Water-soluble nonionic contrast materials with less toxicity, headache, nausea, and arachnoiditis have replaced metrizamide. Identification of the leak using contrast studies, however, requires the presence of an active leak. Intermittent leaks that are temporarily sealed by swelling, inflammation, or brain herniation may yield a false-negative result. Intrathecal injection of saline solution to increase the CSF pressure, “a saline challenge,” enhances the sensitivity of the test.

Others have suggested MR cisternography to complement the information offered by an HRCT without the need for intrathecal contrast.[38] In our experience however, this technique has yielded inconsistent results.

SURGICAL TECHNIQUE

Ethmoid Sinus Roof and Cribriform Plate

If a CSF leak is suspected during endoscopic sinus surgery, all overlying mucosa should be reflected away from the defect to closely examine the area and to determine the extent of injury. Exposure of the entire defect is essential. In fact, exposure of the defect may be a more important factor determining the success of the repair than size or site.[39–41] It should be emphasized that for the graft to take, the defect should be prepared and there should be a denuded area that facilitates contact of the graft with the skull base.

An inlay or onlay free tissue graft may be used to patch the site of injury (Fig. 18-2 through 18-4). Fascia lata, temporalis muscle, abdominal fat, septal or middle turbinate mucosa or composite grafts, periosteum, and perichondrium are suitable grafting tissues. When possible, the dura is elevated around the edges of the defect using a small elevator and the graft is inserted between the dura and the bone of the skull base, that is, an epidural inlay graft (see Fig. 18-2). Alternatively, the dura may be separated from the brain and the inlay graft may be placed in the subdural space (see Fig. 18-3). When an inlay graft is not possible due to technical difficulties or because the leak involves a linear fracture that does not expose the dural defect, or because dissection of the dura may risk neurovascular structures, the graft is placed as an onlay over the defect, outside the cranial cavity (see Fig. 18-4). Free muscle or fat grafts can also be used as a dumbbell or "bath plug" graft (Fig. 18-5).[42] Fibrin glue, platelet rich serum, or other biologic glue may be used to increase the adhesiveness of the muscle or fascia graft.

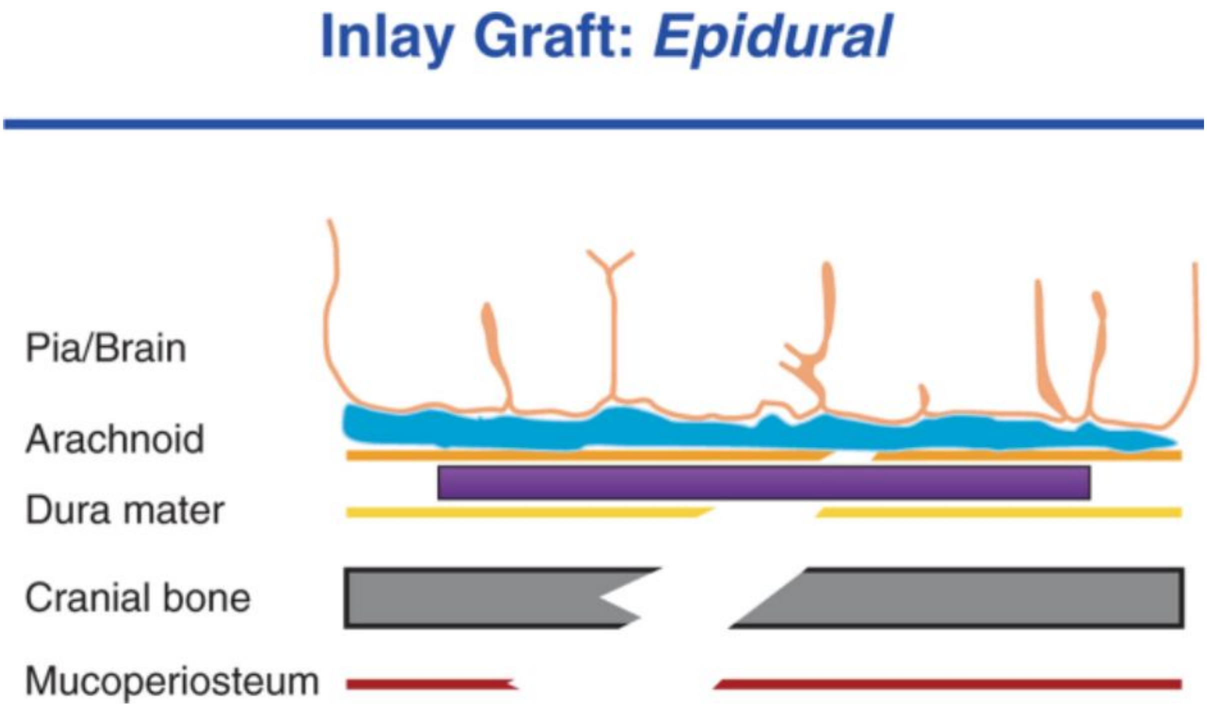

Figure 18-2 Schematic representation of an inlay epidural free graft.

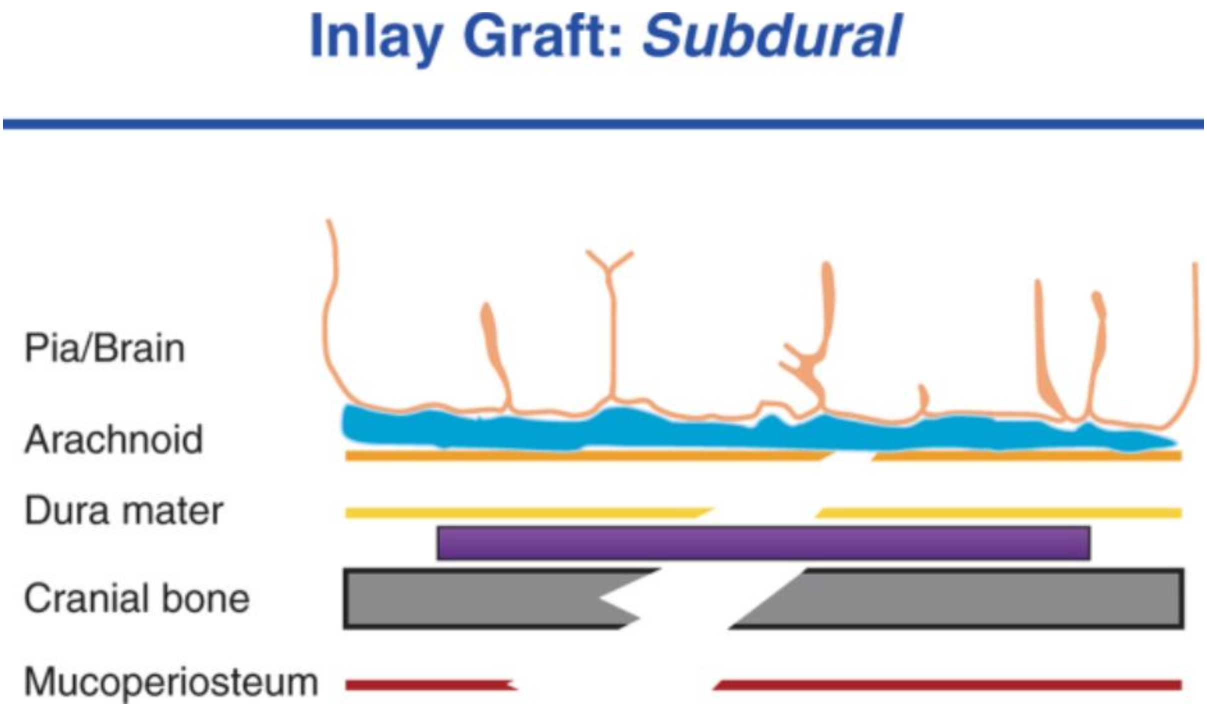

Figure 18-3 Schematic representation of an inlay subdural free graft.

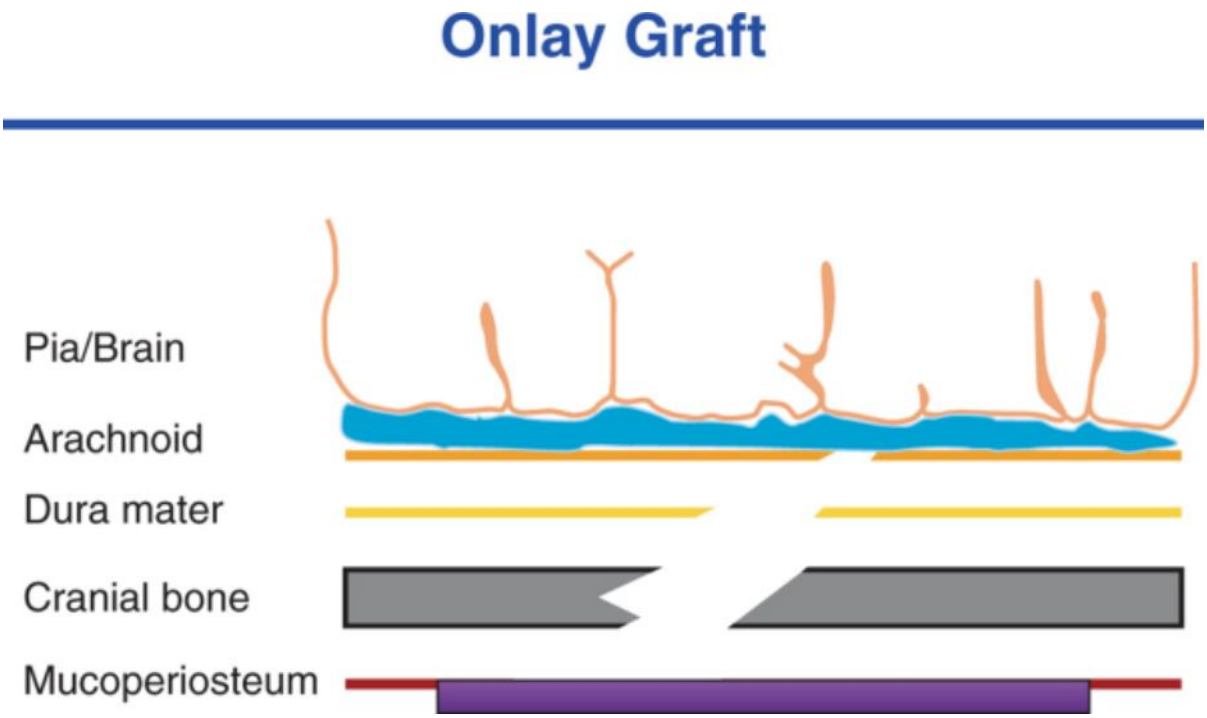

Figure 18-4 Schematic representation of an onlay free graft.

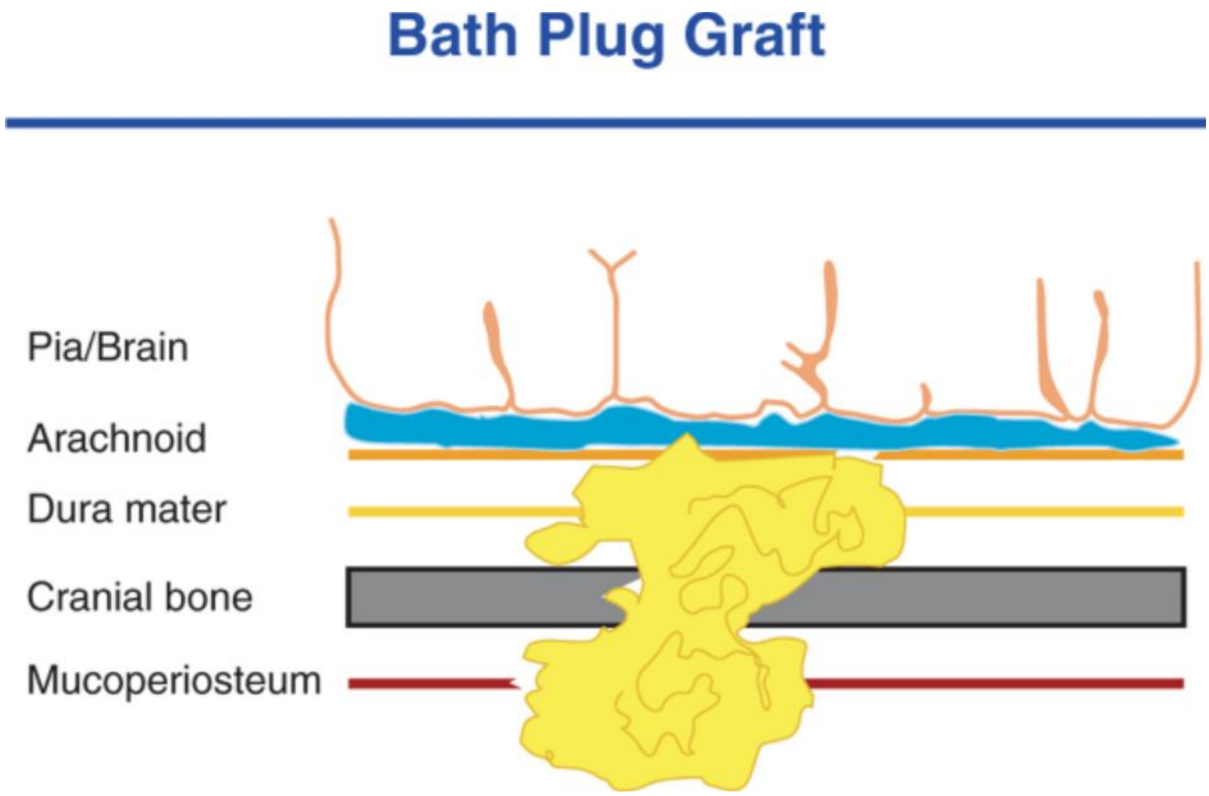

Figure 18-5 Schematic representation of a “bath plug” free graft.

The graft is supported in place with layers of Gelfoam/Gelfilm (Upjohn Co., Kalamazoo, MI), followed by a sponge packing or bacitracin-impregnated gauze. Gelfoam and/or Gelfilm prevent adherence of the packing to the graft, thus preventing accidental avulsion of the graft when the packing is removed 3 to 7 days after the surgery.

Alternatively, a vascularized tissue flap may be designed and harvested transnasally using mucoperichondrium from the middle turbinate or septum. Recently we have been using the Hadad-Bassagasteguy flap, which consists of a septal mucoperichondrial/mucoperiosteal flap based on the posterior septal artery (Figs. 18-6 through 18-8).[43,44] The entire mucoperichondrium/mucoperiosteum may be harvested on one side to cover very large defects of the skull base. Another vascularized pedicle flap using the mucoperiosteum of the inferior turbinate has been described also.[45]

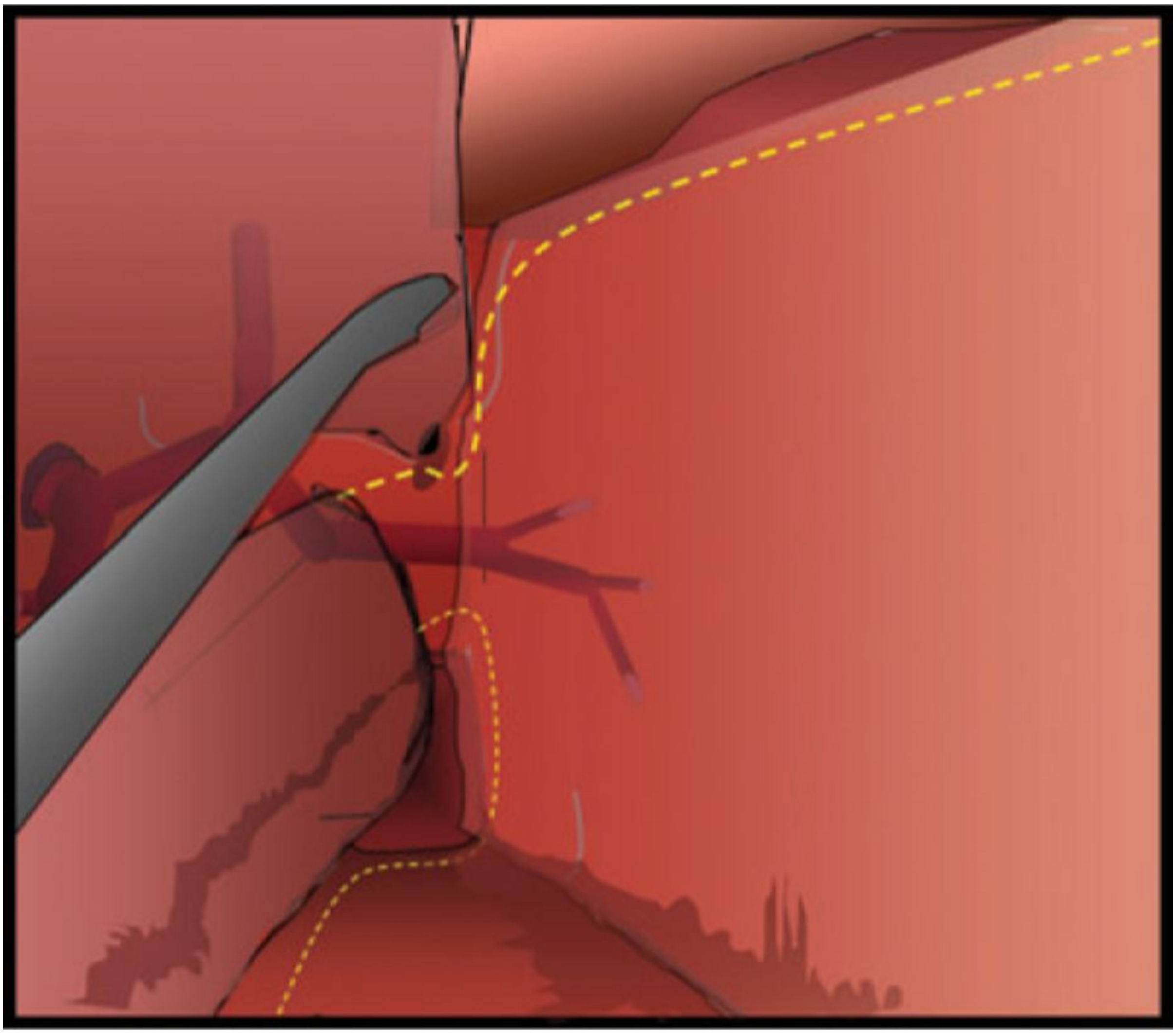

Figure 18-6 Schematic representation of the incisions for a pedicled nasoseptal flap. The superior incision is placed 1 to 2 cm below the level of the olfactory sulcus. The inferior incision is placed at the level of the maxillary crest or at the floor of the nose. An anterior vertical incision joins the two parallel horizontal incisions. Posteriorly the superior incision extends to cross the rostrum of the sphenoid sinus at the level of its natural ostium. The inferior incision extends following the posterior free edge of the septum and crosses the posterior choana to reach the lateral wall of the nose.

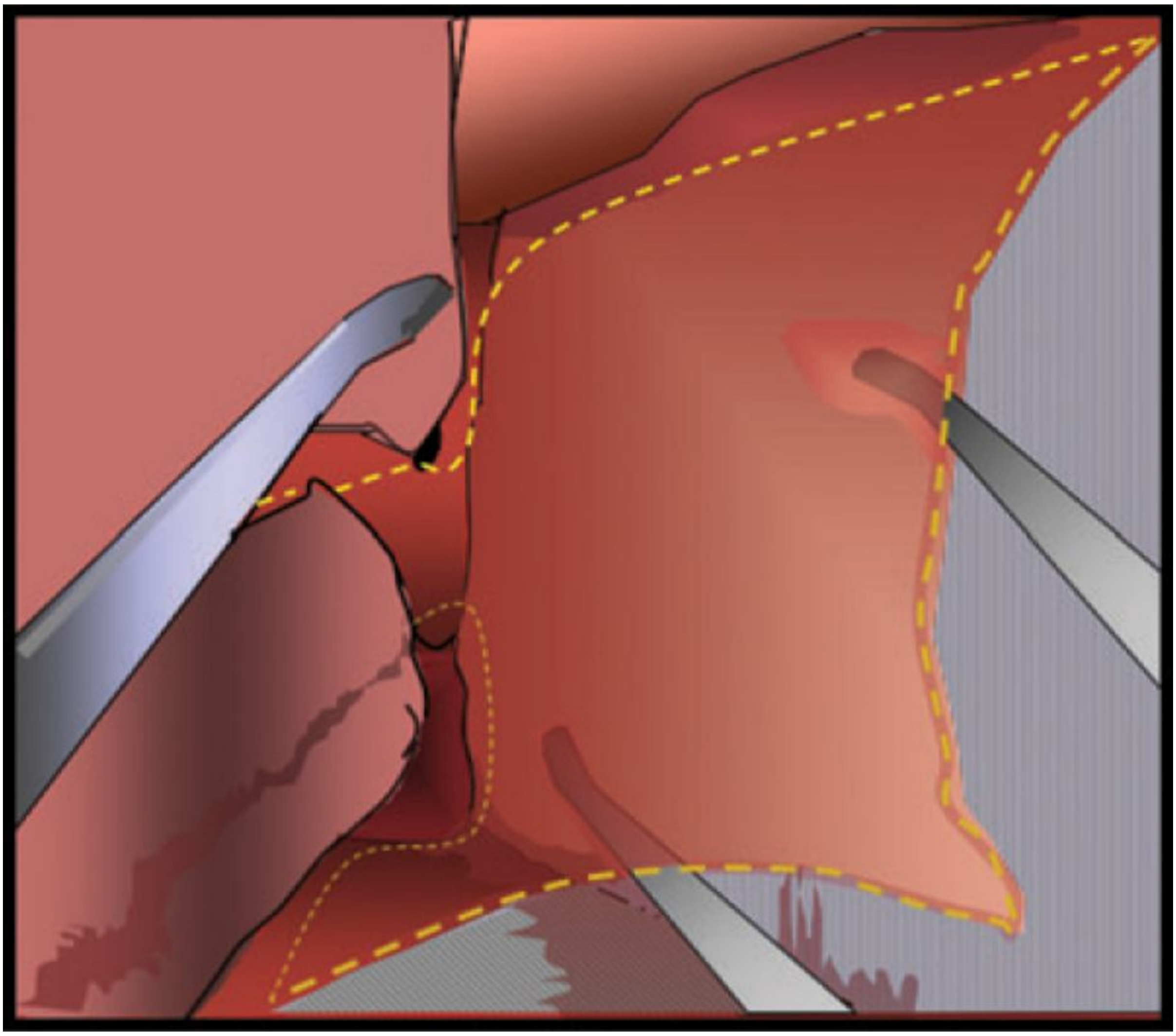

Figure 18-7 Schematic representation of elevation of the nasoseptal flap following a subperichondrial/subperiosteal plane.

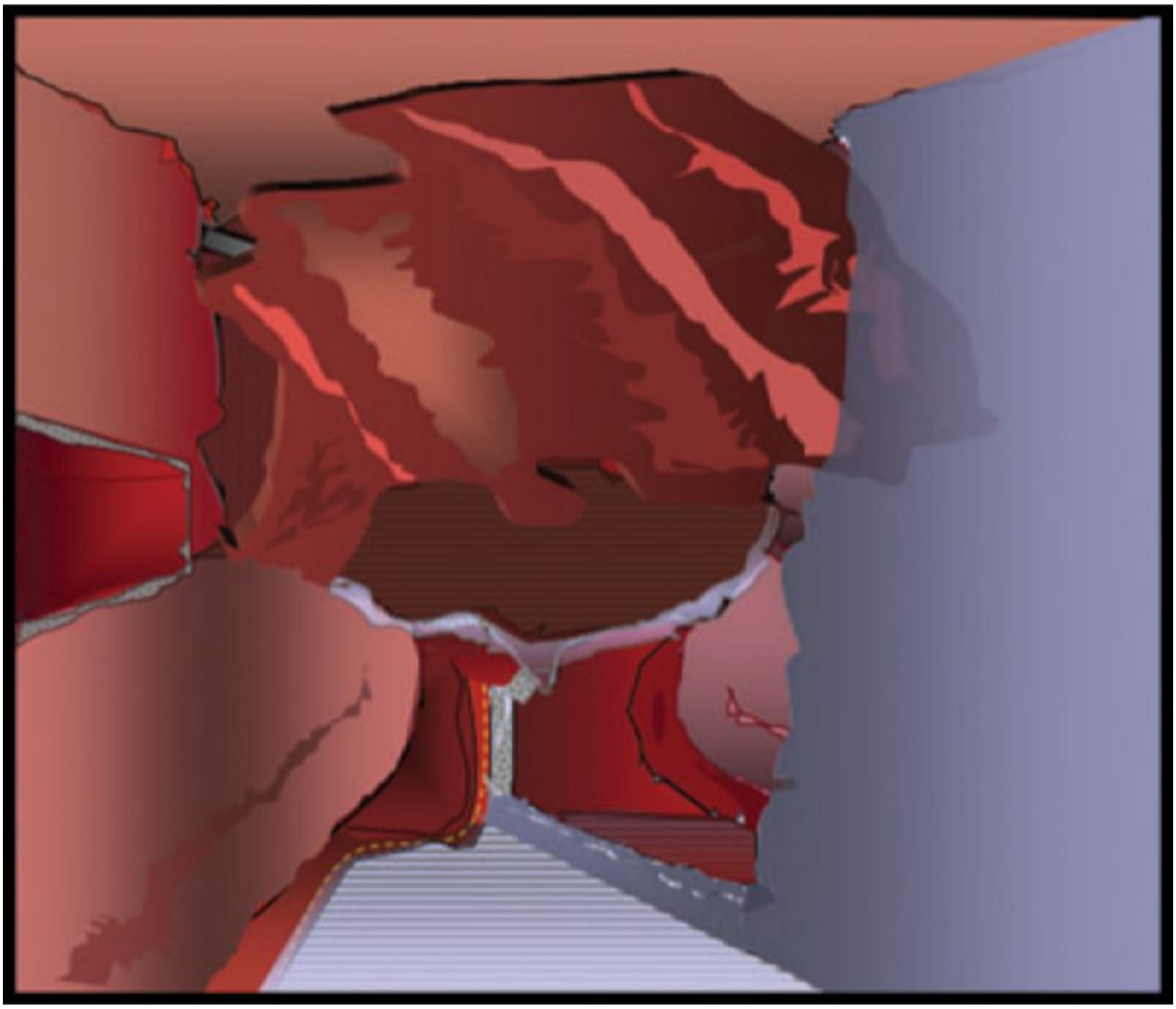

Figure 18-8 Schematic representation of reconstruction of the skull base mobilizing a pedicled nasoseptal flap.

Sphenoid Sinus

CSF leaks involving the sphenoid sinus are amenable to a repair that includes obliteration of the sinus. The sphenoid sinus can be approached transseptally, transethmoidally, or through a direct endoscopic approach such as the one described for pituitary surgery.[46] After proper identification of surgical landmarks (e.g., the carotid canal, optic nerve canal, and optic carotid recesses) and establishing the extent of the defect identifying the leak, the sinus mucosa is thoroughly removed. Onlay or inlay free tissue grafts are placed and the sinus is then obliterated with abdominal free fat (Fig. 18-9). Anteriorly, the exposed fat is covered with a layer of Surgicel followed by Gelfilm, and the nose is packed with ½-inch nasal strip that has been impregnated with antibiotic ointment.

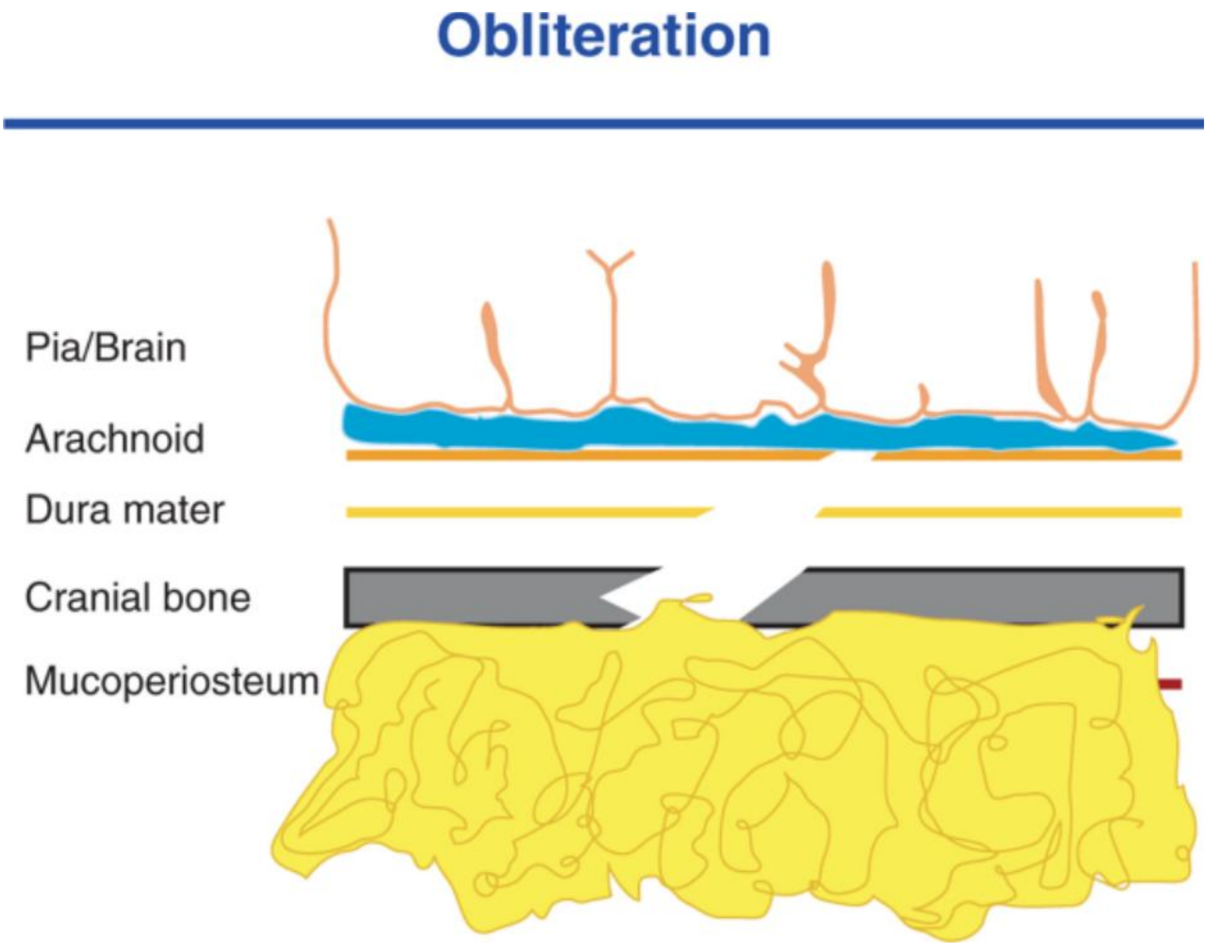

Figure 18-9 Schematic representation of fat obliteration.

An intraoperative CSF leak arising from the sella turcica during pituitary surgery most often can be repaired by obliterating the sella with free fat and reconstructing the floor of the sella with a free bone or cartilage graft harvested during the endoscopic approach.[41] Thus it does not require postoperative packing or the removal of the entire mucoperiosteum of the sinus.

The previously described Hadad flap has been very effective to repair these defects.

Risk of accidental injury to adjacent neurovascular structures is a critical consideration when dealing with defects at the lateral wall of the sphenoid sinus. Adequate visualization of this area is mandatory.

Frontal Sinus

CSF leaks involving the nasofrontal recess often require an extended sinusotomy to adequately expose and repair the defect while preserving the drainage pathway. The Draf III approach,[47] which involves medial widening of the frontal recesses and removal of the superior nasal septum and inferior frontal sinus septum, provides an adequate exposure of leaks around the frontonasal recess, thus allowing an endoscopic repair.

POSTOPERATIVE MANAGEMENT

General Principles

As previously mentioned, the general principles of managing a CSF leak include adjunctive measures that may facilitate healing of the repair, including avoidance of activities that raise the intracranial pressure, such as straining, leaning forward, or lifting objects greater than 15 lb. Other measures include bed rest, stool softeners, 30- to 45-degree elevation of the head of bed, sneezing with an open mouth, and absolute avoidance of nose blowing. “Deep extubation” is used to prevent straining and coughing, and positive pressure mask ventilation is contraindicated.

The use of prophylactic antibiotics for the prevention of meningitis in patients with CSF leaks is controversial. The routine use of antibiotics for traumatic CSF leaks is not of proven efficacy and are thought too select for resistant bacteria. However, the use of antibiotics when the patient has an active sinus infection is warranted. We do, however, favor the use of perioperative prophylactic antibiotics during the repair of the CSF leak. Antibiotics are continued until nasal packing is removed.

A postoperative CT scan without contrast within the first 24 hours after surgery is important to rule out evidence of intracranial bleeding, parenchymal injury, or tension pneumocephalus. We favor a routine CT scan of the brain, even in the absence of any neurologic deficit.

In our practice we work in conjunction with a neurosurgical team during the repairs. Although we do not consider it necessary in all cases, neurosurgical consultation provides an important perspective on intraoperative and postoperative management, especially on the need for a CSF drain or a shunt. A lumbar drain is helpful to control intracranial pressure with a designated amount of CSF removed daily based on CSF production, but it is only used for those patients suspected of having high-pressure hydrocephalus; thus we do not advocate its routine use for CSF leaks produced by endoscopic sinus surgery. Overdrainage should be avoided, because this creates a negative intracranial pressure (i.e., suction effect) that may result in pneumocephalus and promote bacterial contamination of the CSF with resultant meningitis.

Nasal irrigations with nasal saline solution and gentle débridement of crusting are started 1 week postoperatively.

PEARLS

- Early repair of a CSF leak prevents life-threatening complications.
- CSF leaks resulting as a complication of endoscopic sinus surgery are not likely to heal with conservative management and thus require surgical repair.
- Endoscopic repair is the preferred approach.
- β2 transferrin and β trace protein are reliable markers for a CSF leak.
- A high-resolution CT is the preferred imaging technique to localize and stage defects that are suspected postoperatively.

PITFALLS

- Common causes for a failed repair of a CSF leak repair are inadequate exposure or inadequate postoperative management.
- Inappropriate concentration of intrathecal fluorescein administration can lead to neurologic sequelae.
- Positive pressure ventilation should be avoided in the immediate postoperative period to prevent pneumocephalus.