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# Skull Base Reconstruction following Surgical Treatment of Sinonasal Malignancies

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## Abstract

Skull base defects following resection of anterior cranial fossa and sinonasal tumors are not uncommon. Advances in endoscopic techniques have allowed for entirely endonasal resection and reconstruction of these tumors. This article discusses techniques in the evaluation and management of anterior skull base defects.

**Keywords**
- skull base reconstruction
- anterior cranial base
- sinonasal malignancy
- nasoseptal flap

## Introduction

Skull base reconstruction technique following resection of sinonasal malignancies that involve the anterior cranial base plays a critical role on patient outcomes. Anterior skull base reconstruction involves separating the nasal cavity from the anterior cranial base by means of flaps and grafts, with need for meticulous intraoperative decision-making and postoperative management.

## Principles of Anterior Cranial Base Reconstruction

General principles of skull base reconstruction include (1) separation of intranasal from intracranial contents; (2) identification, characterization, and control of cerebrospinal fluid (CSF) leak to restore central nervous system homeostasis and to prevent ascending sources of infection; and (3) use of grafts and/or flaps, often in a multilayer fashion, to achieve the first two goals, while still achieving the goals of surgery (e.g., oncologic resection).

### Cerebrospinal Fluid Leak

CSF leaks are traditionally categorized as either high- or low-flow. While there is no absolute consensus on the definition of either type of leak, it is generally accepted that in high-flow leaks, the dural defect is in direct communication with a cerebral cistern or ventricle, or at least of considerable size. By size criteria, many sources in the literature utilize $1 \times 1$ cm or greater dural defects to define high-flow leaks.[1]

### Single versus Multilayered Closure

The major goal of reconstruction is to separate the intracranial contents from the nasal cavity. This can be done in a variety of ways, including free grafts and vascularized pedicled flaps in either single-layer or multilayer techniques. The surgeon must be careful to ensure that all mucosa along the edges of the defect has been removed and that the flap, or graft, is oriented with the mucosal surface facing outward to minimize risk of mucocele formation and maximize flap or graft take.

Defects without CSF leaks can be closed with a single-layer autograft with the goal of promoting remucosalization.

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While low-flow leaks can often be reconstructed with single layered closure, a systematic review by Soudry et al demonstrated a decreased risk of postoperative CSF leak in both high- and low-flow leaks with multilayer closure.[2] Additionally, they demonstrated that vascularized pedicled flaps were superior for the repair of high-flow leaks.[2]

## Reconstructive Options

### Inlay or Underlay Grafts

Considerations for determining the type of graft to be used include cost, tissue availability, and donor site morbidity. Examples of nonautologous, synthetic grafts include collagen-based dural replacements, porcine submucosal grafts, or acellular dermis. Autologous tissue grafts include fascia (e.g., temporalis and fascia lata) and fat (e.g., abdomen and earlobe). Abiri et al evaluated the use of autologous or nonautologous grafts on postoperative CSF leak and other outcomes and found that reconstructions utilizing autologous and nonautologous grafts were associated with similar rates of postoperative CSF leak and major complications, including meningitis.[3] Moreover, they found that, in cases with intraoperative CSF leak, nonautologous grafts were associated with reduced postoperative meningitis rates.[3] To date, the evidence overall suggests comparable outcomes for reconstruction between autologous and synthetic grafts when used as part of the underlay.[3,4]

### Free Mucosal Grafts

Free mucosal grafts harvested from the nasal septum, nasal floor, or middle turbinate are excellent for low-flow CSF leaks resulting from small defects, or potentially for larger defects of the anterior cranial fossa. They can be used as part of a single- or multilayer reconstruction (►**Fig. 1**). Many surgeons mark the mucosal surface to ensure that it is not inadvertently placed over the bone that would prevent graft take.

### Intranasal Vascularized Pedicled Flaps

#### Nasoseptal Flap

The nasoseptal flap (NSF) is based off the posterior septal branch of the sphenopalatine artery and can be used for large defects from the anterior to posterior cranial fossa. The flap is classically described as harvesting septal mucosa 1.5 cm inferior to the skull base to preserve olfactory nerve fibers. Several modifications of the flap have been described including extending onto the nasal floor and inferior meatus to enlarge the flap area. Relaxing incisions and progressive dissection into the sphenopalatine foramen and pterygopalatine fossa also allow for greater reach[5–8] (►**Fig. 2**). With these modifications, the flap can cover clival defects. Relative contraindications to the flap include frontal sinus defects, as there may be inadequate reach. The flap has been used in pediatric patients with excellent outcomes and no increased risk of complications.[9]

#### Middle Turbinate Flap

The middle turbinate flap is based off the posterolateral nasal branches of the sphenopalatine artery. Its pedicle location makes it a viable option for sellar and some suprasellar defects if an NSF is not available. However, this flap is technically challenging to elevate and has a limited anterior reach.

#### Lateral Nasal Wall Flap

The lateral nasal wall flap, also referred to as the inferior turbinate flap, can be used for sellar and clival defects (►**Fig. 3**). One of the technical limitations of this flap is that it often retains the memory of the curvature around the inferior turbinate.[10] A technical pearl is to mobilize and transect the nasolacrimal duct sharply to incorporate all of the inferior meatus mucosa, if needed, and prevent postoperative epiphora.

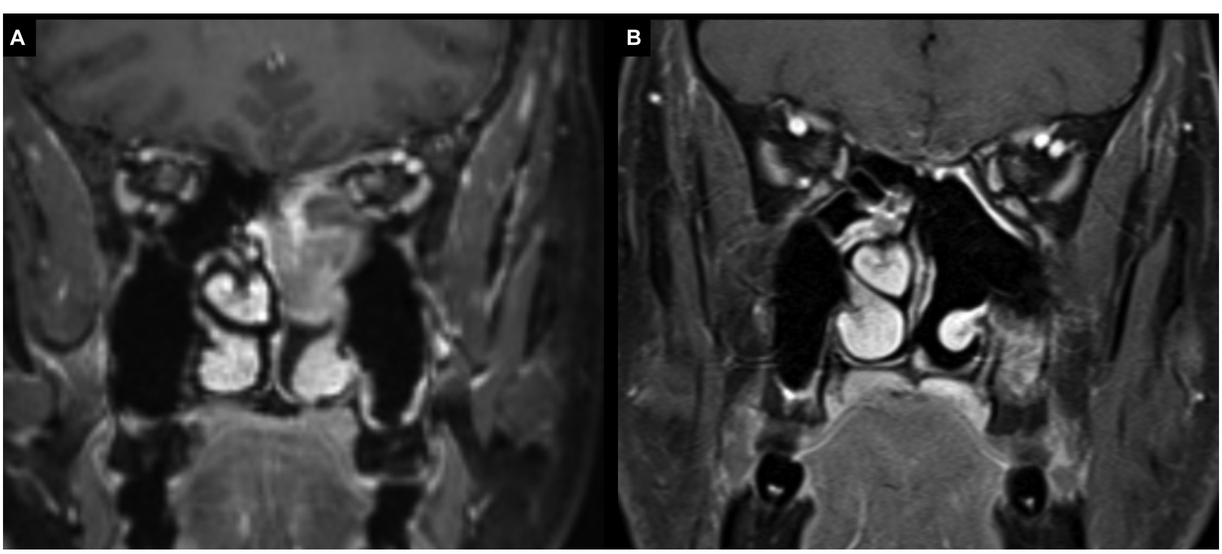


**Fig. 1** Free mucosal graft reconstruction used to reconstruct a unilateral transcribriform defect following resection of a Kadish B esthesioneuroblastoma. Images represent preoperative (A) and 40 months postoperative (B) views with no evidence of recurrent disease.

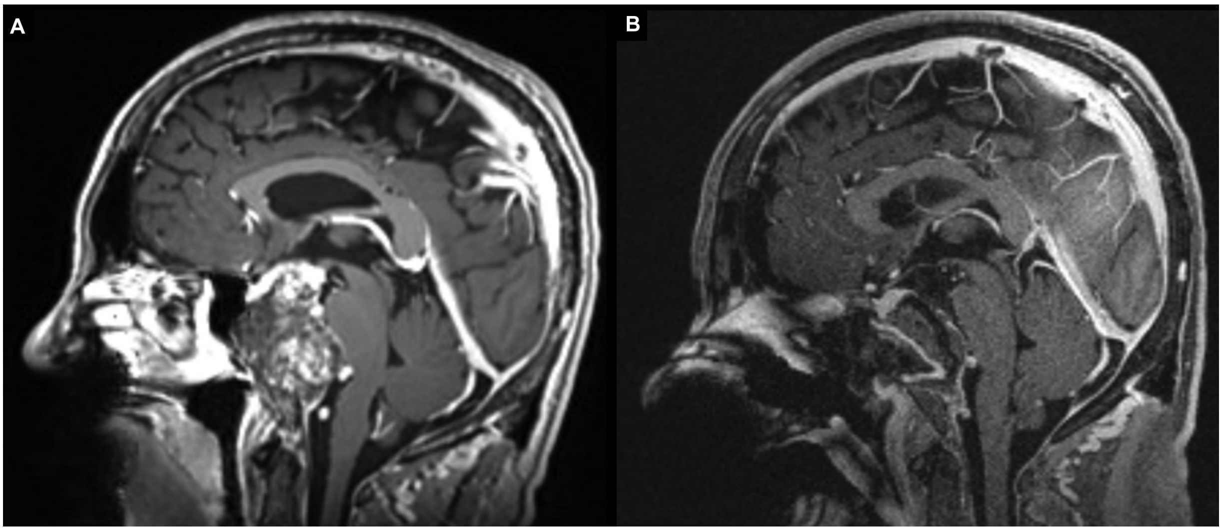


**Fig. 2** Preoperative magnetic resonance imaging (MRI) of clival chordoma (**A**) and immediate postoperative MRI of subsequent posterior cranial fossa defect (**B**) reconstructed using a multilayer technique, including an extended nasoseptal flap.

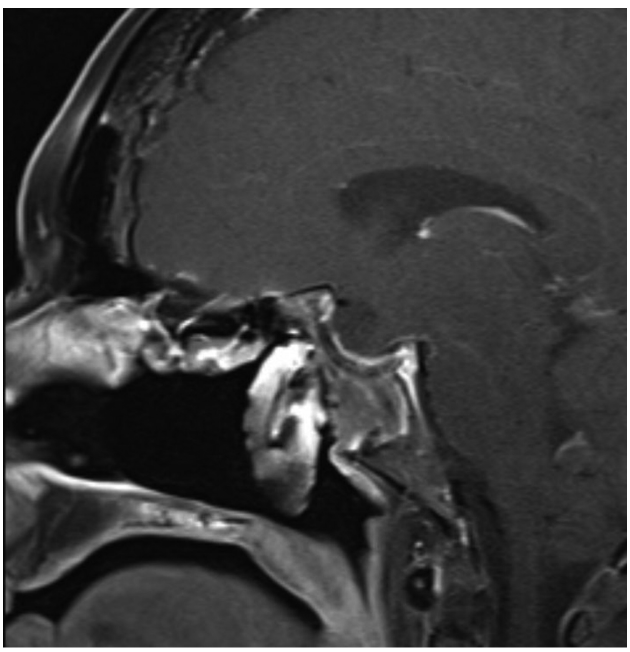

**Fig. 3** Long-term surveillance magnetic resonance imaging demonstrating enhancing lateral nasal wall flap for closure of a suprasellar and sellar defect.

### Extranasal Vascularized Pedicled Flaps

If there are no options for reconstruction within the nasal cavity, as is possible for recurrent operations or radiated cases, extranasal pedicled flaps provide alternative sources of robust tissue.

#### Pericranial Flap

The pericranial flap is an excellent choice for large defects. While the harvest has traditionally been done via open approach, recent advances allow for endoscopic harvest and inset.[11] The flap may be tunneled into the nose from the scalp through a small osteotomy at the bony glabella or anterior table of the frontal sinus. The entirety of the anterior skull base can be reconstructed with this flap. The flap can also extend to the posterior cranial fossa; however, the surgeon should be mindful of potential frontal outflow tract obstruction and flap failure due to compression of the pedicle.

#### Temporoparietal Fascia Flap

The temporoparietal fascia flap has excellent reach to the posterior cranial fossa. However, given its distance from the defect and significant tunneling required, the flap has limited use over the anterior skull base.[12]

### Free Flaps

Free flaps have also been described for large, refractory defects, or for osteoradionecrosis of the skull base.[13] These are often done in conjunction with a microvascular surgeon via a team approach.

## Postoperative Care

There are innumerable postoperative protocols following skull base reconstruction with little evidence or consensus surrounding them.[14] It is important to analyze one's own protocols and update them periodically. Three topics in postoperative care will be discussed below.

### Dural Sealant

Dural sealants are frequently used following endoscopic skull base reconstruction. They have the ability to add a layer over the reconstruction that holds the repair in place and potentially withstands shifts in intracranial pressure.[14] While they are commonly used, comparable reconstructive outcomes have been suggested with and without dural sealant use.[15] Cumulative experience supports the need for a robust multilayered closure where an intraoperative CSF leak is encountered and, while tissue sealants may be appropriate adjunct in these cases, further research is needed to understand the absolute indications and benefits.

### Lumbar Drain

Lumbar drains are intended to divert flow away from the skull base repair and thereby promote healing. There are several studies, including a large meta-analysis of 11,826 patients, that suggest no difference in lumbar drain use at preventing CSF leaks.[16] However, critics of these studies will cite selection bias to use drains in higher risk cases. A randomized controlled trial by Zwagerman et al demonstrated that patients with large dural defects and high-flow leaks had lower rates of postoperative CSF leak when a lumbar drain was utilized.[1] As such, lumbar drains can be considered for high-flow leaks associated with large dural defects, though they may not be necessary for other defects. It is important to remember that lumbar drains are not without morbidity, though generally they are very well tolerated.[17]

### Nasal Packing

Nasal packing is commonly used following skull base surgery for a myriad of reasons including buttressing the reconstruction, assisting with hemostasis, and preventing scarring. There are wide practices in nasal packing use, type, and duration, all of which depend on the experience and preferences of the surgical team. While nasal packing has been associated with decreased quality of life in the immediate postoperative period, the correlation between nasal packing and postoperative CSF leak is limited, heterogenous, and needs to be further investigated.[14]

## Conclusion

Skull base reconstruction is a highly critical part of any surgery involving sinonasal malignancy with intracranial extension or skull base involvement. Current reconstruction techniques allow for consistently low rates of postoperative CSF leaks.[18,19] Important principles include the use of multilayered closure, consideration of flaps and grafts based on the defect, consideration of post-operative protocols prior to surgery, and not compromising the goals of oncologic resection to accommodate subsequent reconstruction.

**Conflict of Interest**
None declared.

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