The Laryngoscope

Anterior Pedicle Lateral Nasal Wall Flap: A Novel Technique for the Reconstruction of Anterior Skull Base Defects

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Objectives: Expansion of the clinical indications for ablative endoscopic endonasal approaches has behooved us to search for new reconstruction alternatives. We present the anatomic foundations of a novel anterior pedicled lateral wall flap (Hadad-Bassagaisteguy 2 or HB2 flap) for the vascularized reconstruction of anterior skull base defects.

Study Design: Anatomic description. Feasibility study. Technical report

Methods: Using a cadaveric model, we investigated the feasibility of harvesting an anteriorly based mucoperiosteal flap from the lateral nasal wall. We then applied the techniques developed in the anatomical laboratory to reconstruct two patients with defects resulting from the endoscopic endonasal resection of esthesioneuroblastomas and one patient with an extensive meningoencephalocoele of the anterior cranial fossa.

Results: HB2 flaps were harvested and transposed to reconstruct anterior skull base defects in cadaveric specimens, and subsequently, in three patients. The HB2 flap provided adequate coverage in the cadaveric model, as well as clinically in our three patients. Their postoperative healing was uneventful.

Conclusions: The HB2 flap is a feasible alternative for the reconstruction of anterior skull base defects in select patients.

Key Words: Cranial base, sinonasal, facial plastics/reconstructive surgery.

Level of Evidence: 2B.

***Laryngoscope*, 121:1606–1610, 2011**

INTRODUCTION

Technological improvements, better understanding of the endoscopic surgical anatomy, and a rapidly growing surgical experience have lead to the resection of larger and more complex tumors via expanded endonasal approaches (EEA).[1] Reconstruction of the resulting skull base defects, however, has been a major obstacle toward the acceptance and popularization of these approaches.[2] Despite this and other challenges, the indications for EEA continue to develop.[1]

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Editor's Note: This Manuscript was accepted for publication March 15, 2011.

This material has never been published and is not currently under evaluation in any other peer-reviewed publication. This material has not been presented.

The authors have no financial disclosures for this article, and no funding support was required for the completion of this manuscript.

The authors have no conflicts of interest to disclose.

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DOI: 10.1002/lary.21889

It has been demonstrated that the success following the reconstruction of small defects of the skull base is independent of which technique or tissue is used; thus, the use of vascularized tissue in these cases does not appear to be critical.[1,3,4] In contrast, large surgical defects of the skull base have been traditionally repaired using regional vascularized flaps.[5] Vascularized flaps promote faster, more reliable, and complete healing,[1] therefore diminishing the risk of complications associated with a persistent communication of the sinonasal tract and the cranial cavity.[6]

Recent developments, including the nasoseptal, middle, and inferior turbinate pedicled flaps have partially overcome the challenge of obtaining vascularized tissue from areas outside the nasal cavity. However, these flaps are not always available, as the donor site may be compromised by tumor or prior surgery, and occasionally, the size of the defect may require multiple flaps or even a hybrid technique.[1,4] The expansion of surgical indications and the subsequent variability of clinical scenarios have propelled a search for alternative flaps and other methods of reconstruction.

Our manuscript describes a novel pedicled flap based on branches of the facial and anterior ethmoidal arteries, the Hadad-Bassagaisteguy (HB2) flap. We describe its anatomic foundation and demonstrate its feasibility based on cadaveric studies and our early clinical experience. We believe that this flap has the potential to emerge as an alternative to the Hadad-Bassagasteguy nasoseptal flap for the reconstruction of large anterior skull base defects.

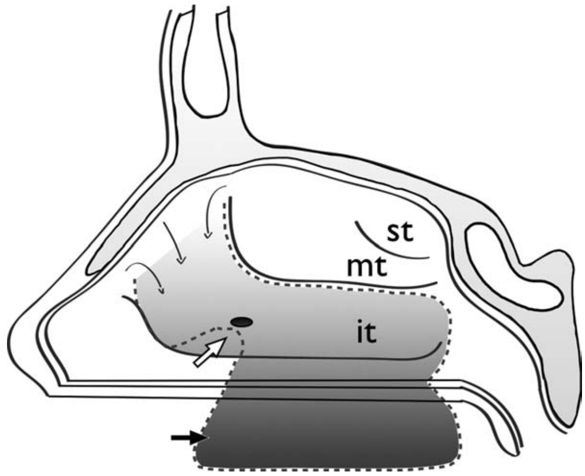

Fig. 1. Artistic representation of the right lateral nasal wall demonstrating the incisions needed to harvest the anterior pedicle lateral nasal wall flap (HB2). IT = inferior turbinate; MT = middle turbinate; ST = superior turbinate. The curved arrows demonstrate the base of the pedicle and flow of the blood supply. The white arrow points to the incision over the head of the middle turbinate and elevation of the mucoperiosteum off its meatal side. The black arrow points toward the extension over the nasal floor.

MATERIALS AND METHODS

Two fresh and three preserved cadaveric specimens were used for the anatomic dissections,which were originally performed at the Medical School of Rosario (Province of Santa Fe, Argentina) and reproduced at the Minimally Invasive Neurosurgery Center (MINC) anatomy labs at the University of Pittsburgh Medical Center (approved by the Committee for Oversight of Research Involving the Dead). All specimens were prepared using a standardized protocol including vascular silicone injections, colored red for the arterial system and blue for the venous system.[7] We investigated the feasibility of harvesting and transposing the anteriorly based HB2 flap for reconstruction of ventral skull base defects (see description of the technique below).

The anatomic principles and technical nuances learned in the dissection laboratory were applied clinically for the reconstruction of three patients requiring transcribiform EEAs at the Instituto de Diagnostico y Cirugia: Cabeza y Cuello, Nariz y Senos Faciales, Base Anterior de Craneo (Rosario, Argentina), and the John Wayne Cancer Institute (Santa Monica, CA). Two patients presented esthesioneuroblastomas (ENB) that were deemed amenable to an endoscopic endonasal resection, but their extension precluded the use of the Hadad-Bassagasteguy nasoseptal flap. A third patient presented an extensive meningoencephalocole involving the fovea ethmoidalis and cribiform plate. Under institutional review board exemption, the clinical data of these patients was reviewed restrospectively.

Surgical Technique (Figs. 1–5)

Incisions may be made with a monopolar electrocautery using an extended, insulated, needle tip (Valley Lab, Boulder, CO), or an extended Colorado tip (Stryker Corporation, Kalamazoo, MI). Alternatively, the mucoperiosteum can be incised with a contact laser, Cottle elevator or any other sharp instrument of preference. The flap's pedicle is aligned vertically and extends from the roof of the nasal cavity, just anterior to the middle turbinate, to the head of the inferior turbinate (Figs. 1 and 2A and B). Its posterior incision follows the lacrimal bone (i.e., ungis), anterior to the uncinate process. The pedicle's anterior incision follows the caudal edge of the nasal bones and the anterior border of the ascending maxillary process (piriform aperture), thus extending from the most caudal aspect of the nasal bones to the upper aspect of the inferior turbinate. The anterior border of the ascending process of the maxilla is easily palpated as it interfaces with soft tissue.

The pedicle's posterior incision joins a sagitally oriented incision that extends over the superior aspect of the inferior turbinate, just inferior to the uncinate process. Posterior to the uncinate process, the incision can migrate superiorly to incorporate the fontanelle of the maxillary sinus. Alternatively, an ipsilateral maxillary antrostomy can be opened to facilitate the priorly described incision. Resection of the middle turbinate is not critical, but it greatly facilitates the incisions and harvesting process. At the most posterior aspect of this incision, the sphenopalatine foramen and its corresponding arteries will be encountered. Control of the sphenopalatine artery requires clipping or cauterization of its anterior and inferior branches, which respectively supply the maxillary sinus fontanelle and the inferior turbinate. As previously stated, part of the fontanelle can be incorporated into the flap, thus increasing the flap width. As this incision reaches the posterior extent of the inferior turbinate it intersects a perpendicular incision that travels medially to cross the floor of the nose and reach the septum (Fig. 1). The pedicle's anterior incision continues anterior to the head of the inferior turbinate and then intersects another perpendicular incision that also crosses the floor of the nose to reach the septum (Figs.1 and 2C). The two horizontal incisions at the floor of the nose are joined by another incision that follows the maxillary crest at the junction of the floor of the nose and nasal septum (Fig. 2D). This incision incorporates the mucoperiosteum of the nasal floor into the flap. This component can be tailored according to the size of the defect, either decreasing the surface area of the nasal floor harvesting (a more lateral incision) or including the most inferior aspect of the nasal septum mucoperiosteum (incision is placed higher on the nasal septum).

A separate vertical incision over the head of the inferior turbinate is extended laterally to intersect the pedicle's anterior incision (Fig. 2E). This latter incision is critical to allow the elevation of the mucoperiosteal lining of the nasal and meatal sides of the inferior turbinate. The flap is elevated subperiosteally with a Cottle or other periosteal elevator, and the dissection is continued along the medial aspect (bone) of the inferior turbinate (Fig. 2F). The opening of the lacrimal duct is spared by curving the anterior horizontal incision around it or by performing an elliptical incision around the opening. Once the incisions around the nasolacrimal duct are completed the mucosa is elevated medially.

It is useful to "greenstick" fracture the inferior turbinate medially, so that it remains at 90° of the lateral nasal wall. This facilitates the visualization and elevation of mucoperiosteum from its meatal aspect. The remaining mucosa of the lateral aspect of the inferior turbinate and the inferior meatus is elevated (Fig. 3A and B), and the residual turbinate bone is removed with rongeurs or through-cutting instruments. The mucoperiosteum of the lateral aspect of the inferior turbinate (meatal side) is elevated until it joins the lateral wall at the level of the opening of the nasolacrimal duct. The flap (mucoperiosteum) is then elevated posteriorly towards the palatine bone (Fig. 3A–C). Last, the nasal floor mucosa is elevated and the flap is freed posteriorly (Fig. 3C).

Of notice, the original orientation of the HB2 (lateral nasal wal) lies in the sagittal plane, whereas the defect is oriented axially; therefore, the placement of the HB2 flap over the defect required some rotation of the flap pedicle (less than 90°),

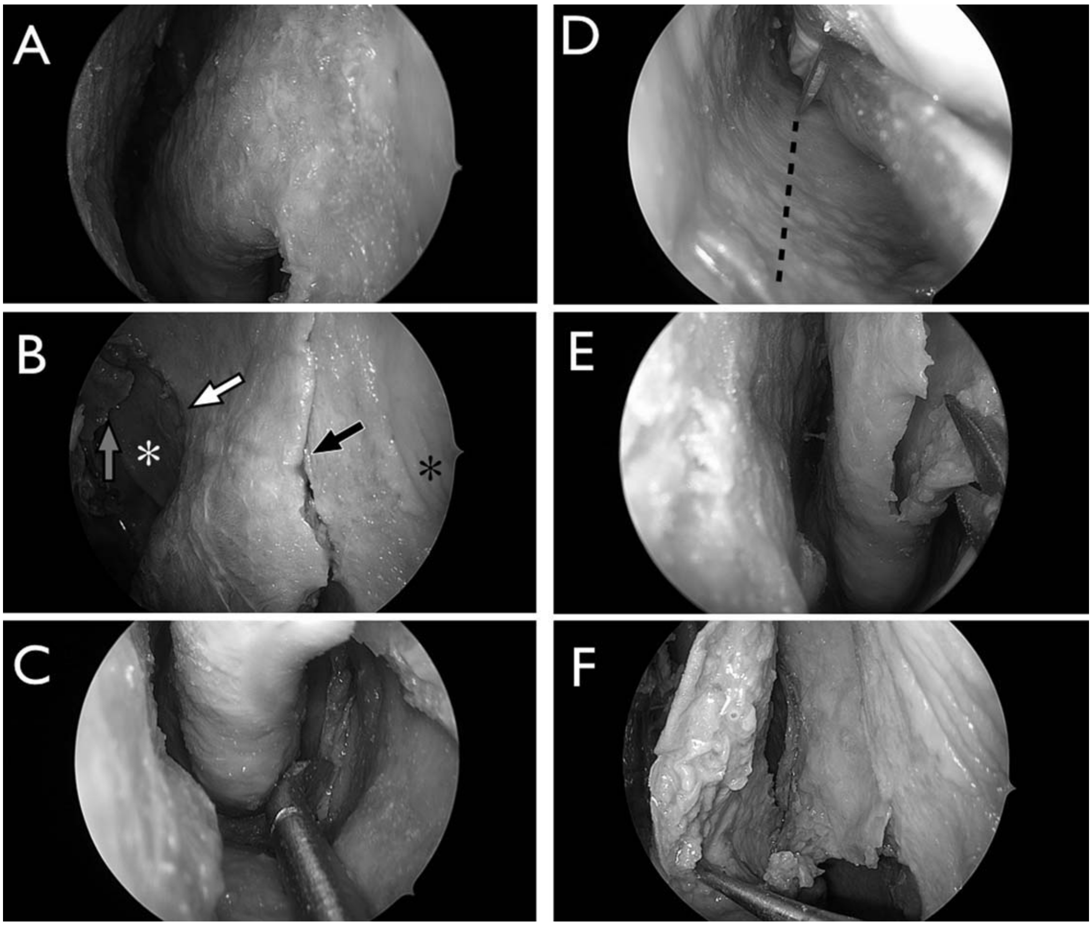

Fig. 2. Endoscopic photographs of the left nasal cavity during a cadaveric dissection of the anterior pedicle lateral nasal wall flap (HB2). (A) Head of inferior turbinate. (B) Flap's pedicle. Black arrow = anterior incision. White arrow = posterior incision. Gray arrow = stump of middle turbinate. White asterisk = uncinate process. Black asterisk = nasal vestibule. (C) Perpendicular incision from the lateral nasal wall (inferior meatus) to the septum (across the nasal floor). (D) The two horizontal incisions at the floor of the nose are joined by another incision that follows the junction of the floor of the nose and nasal septum (dashed line). (E) A separate vertical incision over the head of the inferior turbinate is extended laterally to intersect the pedicle's anterior incision. (F) The flap is elevated subperiosteally with a Cottle or other periosteal elevator, and the dissection is continued along the medial aspect (bone) of the inferior turbinate.

similar to the rotation required for the Hadad-Bassagasteguy nasoseptal flap. The flap needs to be bolstered in place with some type of packing, but the rotation of the pedicle did not seem to significantly retract the flap away from the defect. The flap dimensions were sufficient to reconstruct the area from the crista galli to the tuberculum sella (anteroposterior) and from orbit to orbit (laterolateral). As with the posterior pedicle inferior turbinate flap, the mucoperiosteum of the turbinate tends to retain the shape of the turbinate. This area is stretched and flattened using a bimanual technique as the flap is transposed (Fig. 3D).

RESULTS

In the cadaveric model, the HB2 flap was transposed into various defects of the ventral skull base without major difficulty (from crista galli to the tuberculum sella). Other than some tendency of the inferior turbinate portion of the flap to recreate its original shape, the transposition and rotation into the surgical defect was uncomplicated. The flap covered a combined transcribiform and transplanum defect (from the back wall of the frontal sinus to the sella turcica) in all specimens.

Similarly, the HB2 flap was used for the successful and uneventful reconstruction of anterior skull base defects resulting from the resection of ENB in two patients and a large spontaneous meningoencephalocele in one patient. All three defects were effectively covered by the HB2 flap, which was rotated in place and anchored with fibrin glue and a combination of gauze packing and the balloon of a 14 French Foley catheter. No perioperative lumbar spinal drain was used and the packing was removed 5 days postoperatively. All three patients healed uneventfully with no CSF leak or intracranial complication. Our only significant postoperative complication was that of a severe nosebleed that occurred 10 days after surgery, requiring surgical intervention (patient with the meningoencephalocele). Bleeding arose from the ipsilateral posterior nasal artery, which had been transected and coagulated at the time of the flap harvesting. After control of the vessel with electrocoagulation we encountered no other

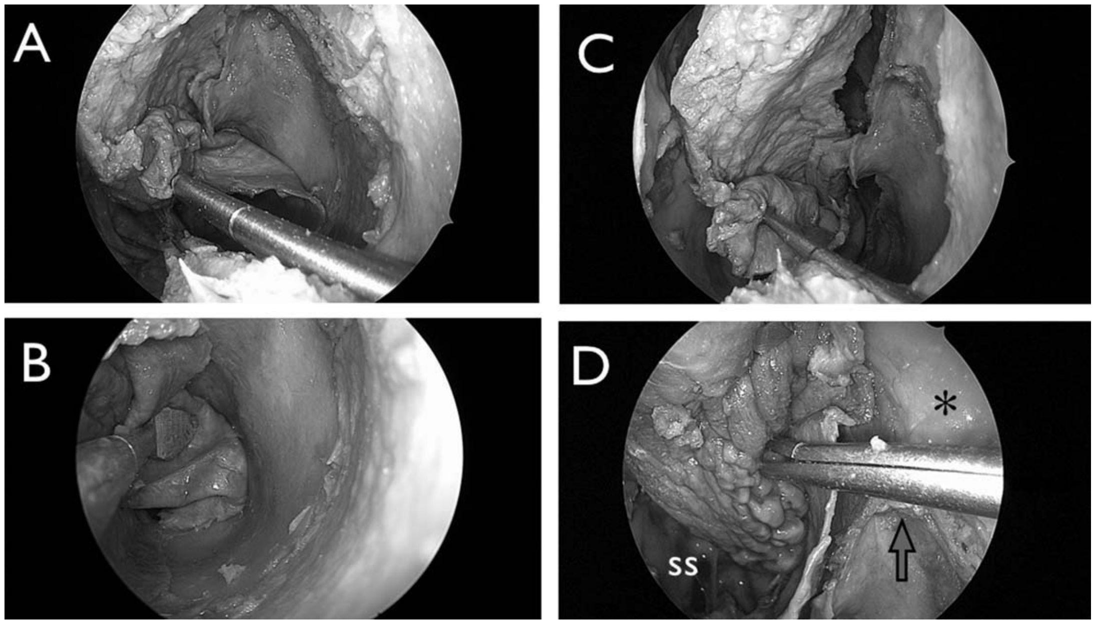

Fig. 3. Endoscopic photographs of the left nasal cavity during a cadaveric dissection of the anterior pedicle lateral nasal wall flap (HB2). (A) The flap (mucoperiosteum) is then elevated posteriorly towards the palatine bone. (B) The nasal floor mucosa is elevated and the flap is freed posteriorly. (C) Flap completely harvested. (D) Flap transposed to the skull base. SS = Sphenoid sinus. Gray arrow = Lacrimal duct opening. Black asterisk = ascending process of the maxilla.

postoperative complication. The viability and complete healing of the HB2 flap were corroborated during the postoperative surveillance (Figs. 4 and 5). Significant postoperative crusting required weekly or biweekly debridement of the nasal cavity for 6 to 8 weeks.

DISCUSSION

The HB2 flap is based on a rich vascular supply based on an anterior pedicle comprising branches of the facial (angular and lateral nasal) and ethmoidal arteries. The vascular anatomy of the lateral nasal wall has been well described.[8–11] The inferior turbinate (IT) receives a dual blood supply.[11–13] Its posterior blood supply arises from a terminal branch of the posterolateral nasal artery, which in turn is a branch of the sphenopalatine artery,[1] and its anterior supply originate from the angular artery[1,12,13] and other intranasal vessels.[11] It has been observed that the posterior terminal branch supplying the inferior turbinate increases in size as it travels anteriorly, suggesting significant anterior contributions

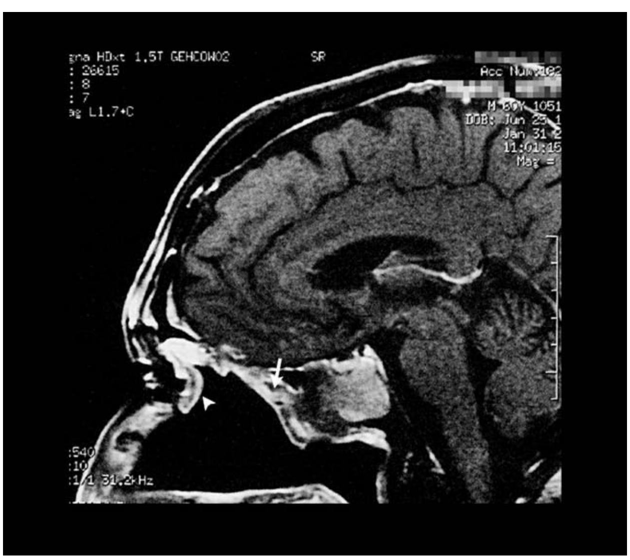

Fig. 4. Postoperative contasted MRI (sagittal view) demonstrating the vascularity of the HB2. The arrowhead points to the pedicle while the arrow demonstrates the posterior reach of the flap at the planum sphenoidale (the image cut is off plane laterally).

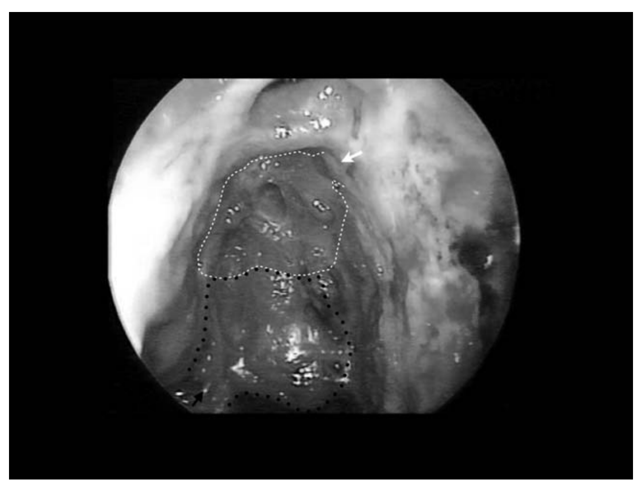

Fig. 5. Postoperative endoscopic photograph demonstrating the use of the HB2 (marked white by arrow on its pedicle and dotted line for boundaries) and an HB nasoseptal flap (marked black by arrow on its pedicle and dotted line for boundaries) to reconstruct a very large defect comprising the area between clivus to cribiform plate area. The left based HB2 reconstructed the anterior cranial fossa while the nasoseptal flap reconstructed the posterior area.

from branches of the facial artery.[1,12] The anterior ethmoidal artery arises from the ophthalmic artery, travels forward in an oblique way, and irrigates the superior area of the lateral wall of the nasal cavity.[11]

multiple reports have described the use of anteriorly based inferior turbinate flaps for nasal reconstruction,[12] oronasal fistula closure,[13] and nasal septal perforation[14] with good overall success. Compared with previously described anteriorly based inferior turbinate flaps,[12–14] the anterior pedicle of the HB2 flap is wider and more superiorly based. In addition, a posterior pedicle inferior turbinate flap has been described and used clinically for reconstruction of clival and sellar defects.[1] As opposed to the inferior turbinate flap, the HB2 flap incorporates the mucosa from the nasal lateral wall and floor, and its pedicle includes not only the territory of the facial (angular) artery but also the territory of the anterior ethmoidal artery. Its pivot, design, and surface area seems adequate for the reconstruction of large anterior skull base defects.

Our reconstructive goals after a skull base resection via EEA are similar to those of open skull base surgery. The cranial cavity should be separated from the paranasal sinuses, and the neurovascular structures protected,[2,4] thus eliminating or decreasing the risk of cerebrospinal fluid (CSF) leaks and bacterial infections.[1] It has been demonstrated that the high success rate associated with the repair of small defects (>95%) is independent of which technique or biologic tissue is used.[3] However, success rates decrease when free grafting techniques are applied to larger skull base defects, such as those resulting from EEA.[1]

Reconstruction with vascularized tissue has significantly decreased the incidence of CSF leaks. The introduction of the Hadad-Bassagasteguy flap (i.e., posterior pedicle nasoseptal flap) decreased our postoperative CSF leak rates to <5%.[1] However, the Hadad-Bassagasteguy flap (HBF) is not always available as the donor site or its vascular supply may be compromised by tumor or prior surgery. As a result, alternative reconstructive flaps have been developed, but these are yet not sufficient to satisfy the increasing variability of clinical scenarios and size of the defects (Fig. 5).[1,4,15–18] In addition, one must consider that some of these flaps are technically challenging, are associated with some donor site morbidity, or may not be available due to compromise of the donor site or its blood supply.

An ideal candidate for the HB2 flap is a patient with a large defect resulting from transcribiform/transplanum approach when a nasoseptal flap is not available. Donor site morbidity will be acceptable in the great majority of cases. Its initial morbidity includes transitory nasal crusting, which continues until complete remucosalization occurs. Because the nasolacrimal duct opening is not transected, we have not encountered problems with lacrimal outflow. Contraindications to the HB2 include direct tumor involvement of its surface area or pedicle or its proximity requiring the sacrifice of the flap. These conditions preclude its use or limit its potential surface area. Prior high dose radiotherapy or chemoradiotherapy raises some concern, as it is not clear whether or not the HB2 blood supply can tolerate such injury. Alternatively, extranasal vascularized flaps, such as the transpterygoid temporoparietal fascia flap,[4] the transfrontal pericranial flap,[15] the Oliver palatal flap,[16] or a facial artery buccinator flap (FAB),[17] can be used for the reconstruction of large defects of the anterior skull base.

Endoscopic skills are required to harvest the HB2 flap; however, it is not a very difficult endeavor and the process is greatly facilitated by the absence or removal of the posterior nasal septum. This latter scenario is relatively common, either because the need to sacrifice the septum for oncologic reasons or as a result of previous surgery. In turn, this implies the lack of possibility to use a nasoseptal flap.

CONCLUSION

Cadaveric anatomic dissections and our early clinical experience support the use of the anterior pedicle inferolateral nasal wall for reconstruction of large ventral skull base defects.

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