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Pedicled Facial Buccinator (FAB) Flap: A New Flap for Reconstruction of Skull Base Defects

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Background: The expansion of endoscopic endonasal skull base surgery has resulted in an increased demand for reconstructive options. Reconstruction with vascularized tissue has proven indispensable for reliably separating the cranial contents from the paranasal sinuses following extended endoscopic endonasal approaches (EEA). The introduction of the Hadad-Bassagasteguy flap (vascular pedicle nasoseptal flap, HBF) at our institution decreased our postoperative cerebral spinal fluid (CSF) leak rates from more than 20% to less than 5%. The HBF is not always available, as the nasoseptal area or its vascular supply can be compromised by tumor or prior surgery. In an attempt to keep pace with rapidly expanding reconstructive requirements, we present the anatomic and cadaveric foundations for novel modifications of the facial artery musculo (-mucosal) (FAM[M]) and buccinator flaps to allow vascularized reconstruction of the skull base.

Study Design: Feasibility. Cadaveric study.

Methods: Using cadaver dissections and measurements, we investigated the feasibility of transposing pedicled buccinator myo/myomucosal flaps into the nasal cavity and skull base. Both muscular and myomuscular flaps were raised, and techniques for transposition into the nasal cavity were investigated. Three fresh and six preserved human specimens were dissected.

Results: Pedicled facial buccinator flaps with and without mucosa were transposed into the nasal cavity using a variety of maxillary osteotomies. No facial incisions were required. It was demonstrated that the flaps reach the anterior skull base and planum sphenoidale.

Conclusions: The transposition of pedicled buccinator muscle flaps with and without mucosa into the nasal cavity could reach the anterior skull base and planum sphenoidale, if the appropriate surgical technique is used. The pedicled Facial Buccinator Flap holds significant potential as a reconstructive alternative for a variety of skull base defects, alone or in combination with existing reconstructive options.

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

Level of evidence: 4.

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INTRODUCTION

The expansion of endoscopic endonasal skull base surgery has resulted in an increased demand for reconstructive options. Free tissue grafting is a reliable technique to reconstruct small defects that communicate the arachnoid space and the nasal cavity.[1] However, their use for the reconstruction of larger defects resulted in an unacceptable incidence of postoperative cerebrospinal fluid (CSF) leaks at our institution.[2] Reconstruction with vascularized tissue has proven indispensable for reliably separating the cranial contents from the paranasal sinuses following extended endoscopic endonasal approaches (EEA). The introduction of the Hadad-Bassagasteguy flap (vascular pedicle nasoseptal flap, HBF) at our institution decreased our postoperative CSF leak rates from more than 20% to less than 5%.[3] The HBF is not always available, as the nasoseptal area or its vascular supply can be compromised by tumor or prior surgery. In an attempt to keep pace with rapidly expanding reconstructive requirements, our group has focused on developing alternative reconstructive techniques, several of which have been recently reported.[4,5]

In this report, we present the anatomic and cadaveric foundations for novel modifications of the well-described facial artery musculo (-mucosal) (FAM[M]) and buccinator flaps to allow vascularized reconstruction of the skull base.

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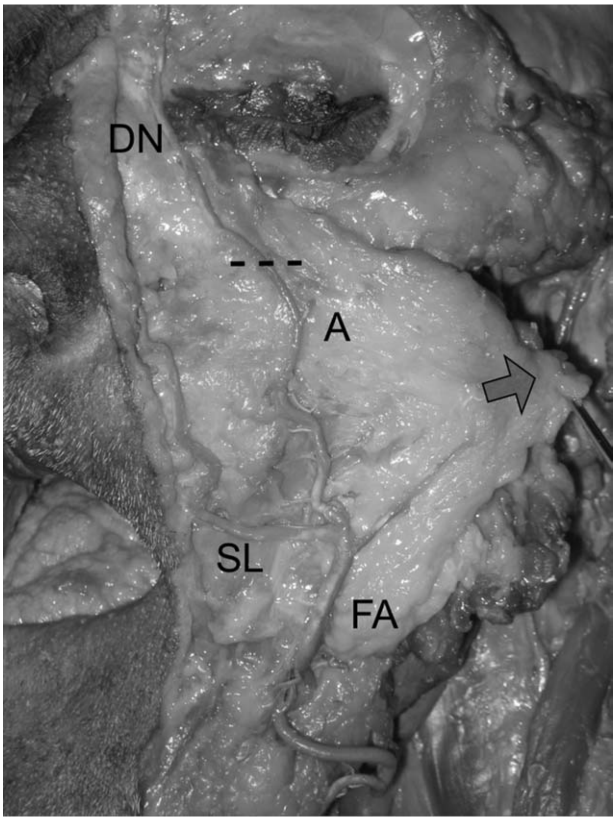

Fig. 1. Facial artery axis. FA = facial artery; SL = superior labial artery; A = angular artery; DN = dorsal nasal artery. Dashed line = approximate pivot point of the flap. Please note that the midfacial soft tissue and FA have been retracted posteriorly in this picture (arrow).

ANATOMY

The anatomy of the buccinator and facial vessels has been extensively described in the literature.[6–10] In brief, the facial artery branches from the external carotid artery and enters the face by crossing the inferior border of the mandible and ascending toward the nasal alae (Fig. 1). It is located superficial to, and at the anterior aspect of the buccinator,[11] deep to facial mimetic musculature[10,12] and 1 to 1.6 cm[8] (mean 1.38) from the oral comissure.[10] The facial artery supplies the buccinator through inferior and anterior buccal branches[10] and ascends in the nasofacial groove to the medial canthus as the angular artery.[10,13] Variations in the course of the facial artery exist and have been well documented.[9,14] The facial artery and vein are in close proximity at the angle of the mandible, but diverge superiorly.[15] The facial vein is generally located 1 to 1.5 cm (11 mm[8]) posterior to the facial artery at the midbuccinator level.[11] As expected, venous anatomy displays increased variability compared to the arterial system.[15]

MATERIALS AND METHODS

Three fresh and six preserved human specimens were used for anatomic dissections in accordance with institutional protocols. Utilizing anatomic and surgical dissections, we investigated the feasibility of transposing superiorly based buccinator myo/myomucosal flaps into the nasal cavity and skull base. Both muscular (FAM) and myomuscular (FAMM) flaps were raised, and techniques for transposition into the nasal cavity were investigated. Additionally, measurements were taken to support our investigations.

PEDICLED FACIAL BUCCINATOR FLAPS (FAB)

Incisions used for the harvest of a myomucosal (FAB) flap are outlined in Figure 2 and are similar to previous reports of the reverse flow FAMM flap (Fig. 2). The facial artery was localized and ligated lateral to the inferior incision (Fig. 3A). The superior extent of the flap is limited by the orifice of the parotid duct. Tissue was included posteriorly to increase the likelihood of incorporating the facial vein in the flap (Fig. 3B). An additional segment of tissue can be included inferior to the parotid duct if necessary (L or “boot” configuration of the flap) (Fig. 3C). The inferior and superior labial arteries were found during the anterior dissection (Fig. 3B). An additional anterior vestibular incision was performed to facilitate subperiosteal elevation along the anterior wall of the maxilla, preserving the infraorbital neurovascular bundle, which represents the pivot point of the FAB flap (Fig. 4). The FAB flap was then elevated in the plane of a traditional FAMM flap just superficial to the facial artery. When mucosa was harvested, a 180°

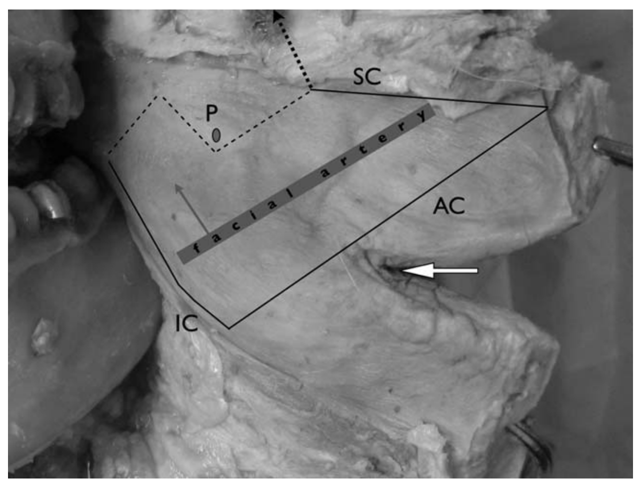

Fig. 2. Facial buccinator flap markings and model. The soft tissues of the face were reflected away from the bone for illustration purposes. The inferior, anterior, and posterior incisions should include mucosa and buccinator muscle. First, the inferior incision (IC) is made just superior to the gingivobuccal sulcus. The facial artery (FA) is localized, transected, and ligated, and its axis toward the nasal alae marked. The anterior incision (AC) is marked parallel to the FA axis, just lateral to the oral commissure (aprox. 1–1.5 cm from the axis). The superior incision (SC) is made from the superior aspect of the AC until grossly intersecting an imaginary line (dashed line) that is parallel to the facial axis at the level of the parotid duct opening, and should only include mucosa. Last, the posterior incision is made (dashed line). White arrow = oral commissure; P = parotid duct opening. Red arrow = inferior buccal branch supplying the posteroinferior aspect of the muscle. Dashed black arrow = direction of the dissection superior to the buccal mucosa (ensures a wide pedicle). Dashed line = posterior incision (in myomucosal flap) or posterior limit of submucosal dissection (in the muscular flap). Please note reversed L or “Boot” configuration of the flap.

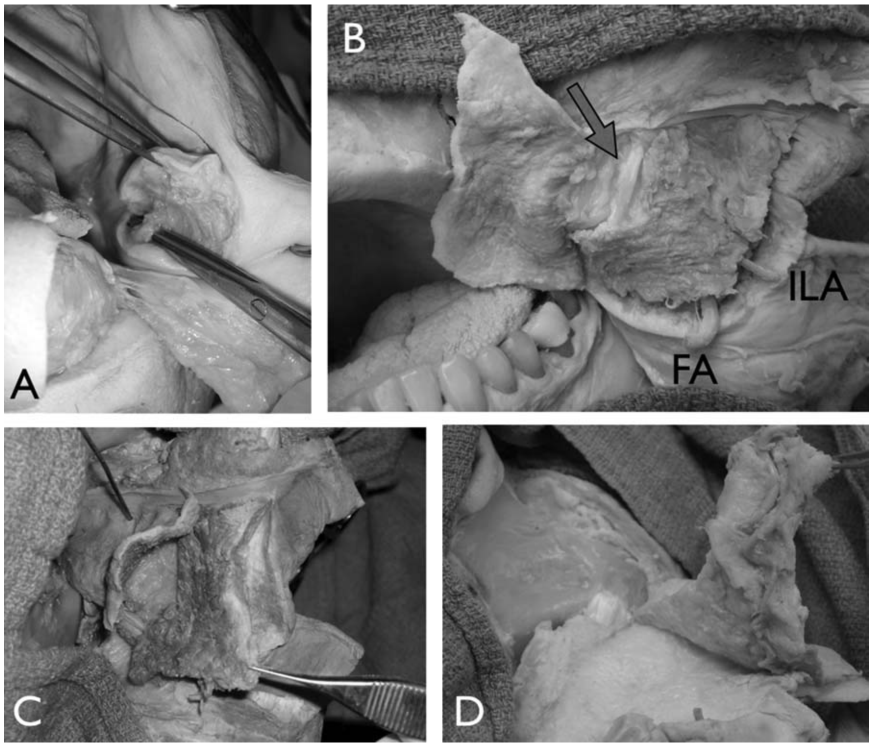

Fig. 3. (**A**) The facial artery is localized along the inferior gingivobuccal incision. (**B**) The facial vein (gray arrow) can be encountered and incorporated in the most posterior aspect of the flap. In this figure, the facial vein was dissected for illustration purposes. FA = facial artery; ILA = inferior labial artery. (**C**) Reverse L or "Boot" shape configuration of the flap. (**D**) Flap raised in a preserved specimen with dissection of the facial artery for illustration of axiality. Please notice the wide pedicle.

rotation of the flap was required to keep the mucosa in the nasal cavity (Fig. 5). In dissections that did not include mucosa, a posteriorly based mucosal flap was elevated prior to buccinator elevation (Fig. 6).

The flaps were then delivered into the nasal cavity through a maxillary window outlined below. Figure 7 represents the harvest and transposition of the FAB flap with its relation to the ventral skull base.

DELIVERY OF THE FLAPS

Several techniques for maxillary osteotomy and flap delivery were investigated (Fig. 8). Using standard and high-speed instrumentation wide ipsilateral maxillary osteotomies were made and enlarged. The superior limit of the osteotomy is represented by the ION; the posterior extent is of less consequence as it accommodates only the bulk of the flap rather than representing a critical obstacle; the inferior limit was the level of the hard palate and maxillary floor. The anterior and anterior/superior osteotomies were modified to simulate different reconstructive needs. The osteotomy can be carried along the ascending process of the maxilla, including transection of the nasolacrimal duct to allow increased access to the anterior skull base (Fig. 8C). If needed, a transconjuntival incision allows for significant extension of the superomedial aspect of the osteotomy.

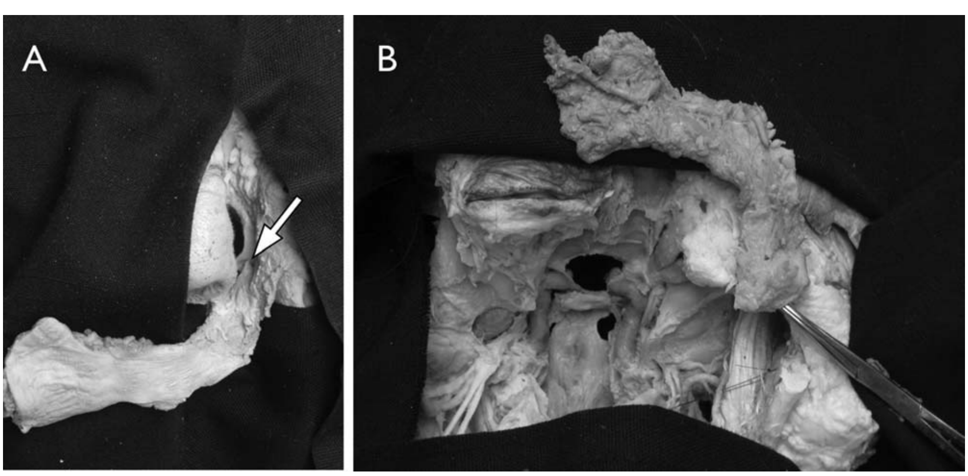

Fig. 4. (**A**) Illustration of the infraorbital nerve, pivot point of the flap. The soft tissues of the face were reflected away from the bone for illustration purposes. (**B**) Flap in relation to anterior cranial base.

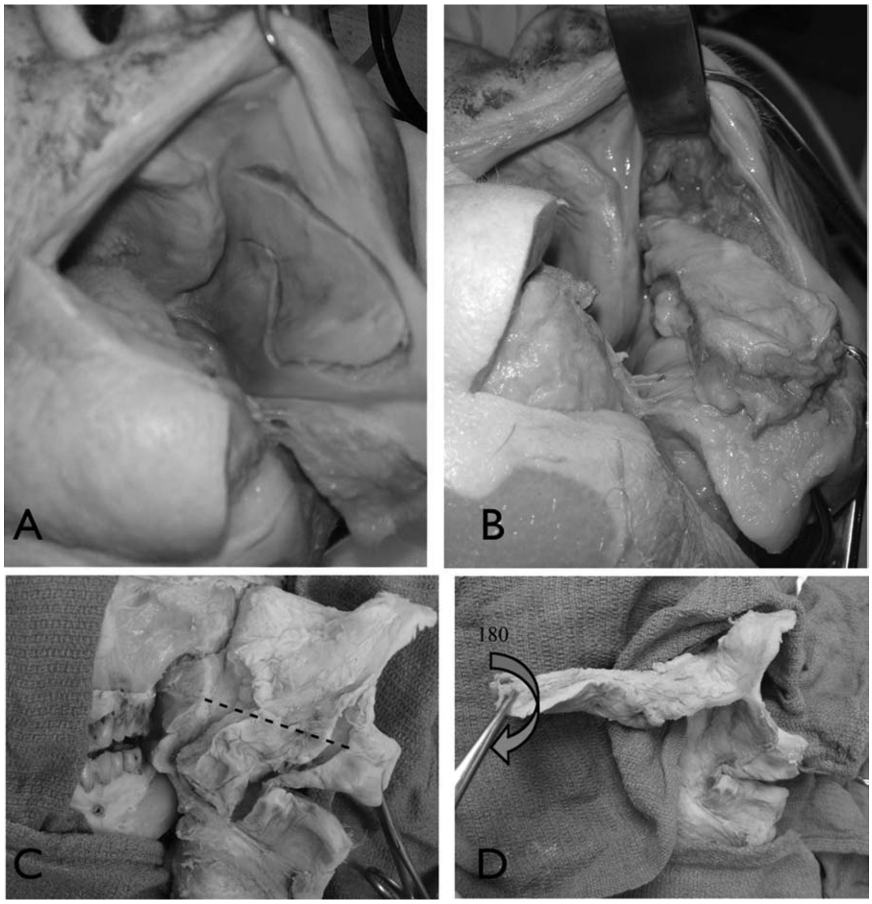

Fig. 5. Facial buccinator myomucosal flap. (A) Flap in situ in a fresh specimen. (**B**) Flap raised in a fresh specimen. (**C**) Flap in a preserved specimen. Notice the wide pedicle superior to the buccal mucosa (dashed line). (**D**) 180° rotation necessary place the mucosa facing the nasal space. The soft tissues of the face were reflected away from the bone for illustration purposes.

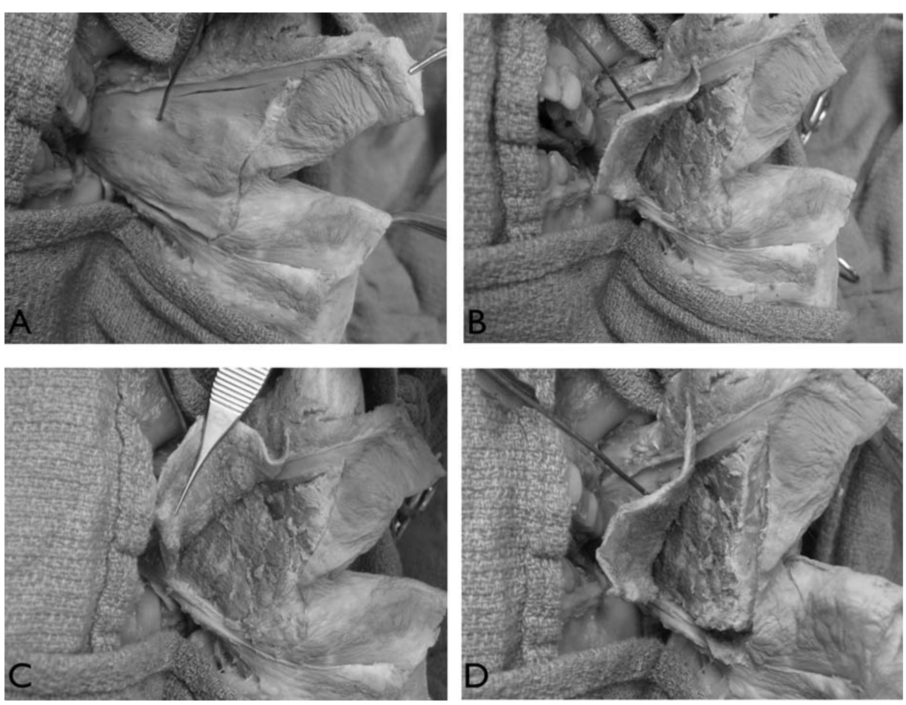

Fig. 6. Elevation of mucosal flap. (**A**) Inferior, anteromedial, and superior incisions are made. (**B**) A posteriorly based mucosal flap is raised. (**C**) The mucosal flap elevation goes more posteriorly in the inferior aspect, as the parotid duct opening prevents superior dissection. (**D**) Once the mucosal flap is elevated, the buccinator is transected. The parotid duct was canulated in **A–D**.

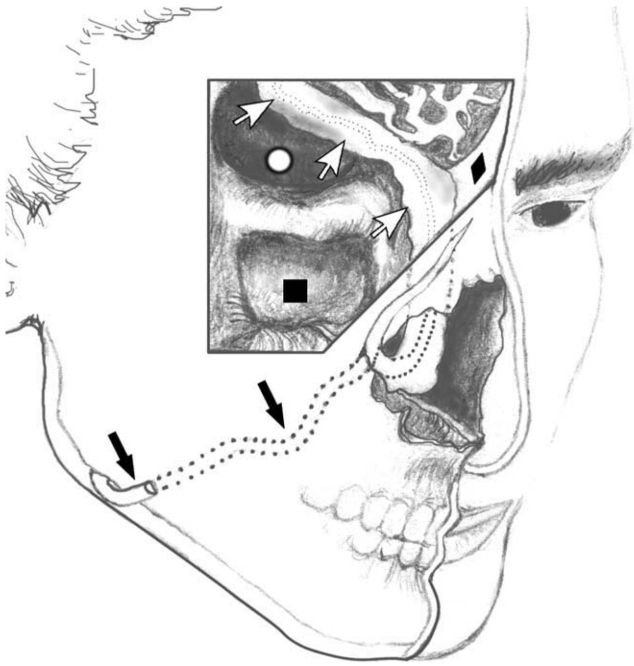

Fig. 7. Illustration of the FAB flap with transposition. Black arrows = facial artery; white arrows = FAB flap inset on anterior skull base; white circle = sphenoid sinus with wide sphenoidotomy; black square = nasopharnx; black triangle = frontal sinus. The infraorbital vascular contribution to the flap was not included in this illustration.

The flaps were introduced into the nasal cavity through a maxillary osteotomy following an aggressive medial maxillectomy to facilitate flap delivery and placement (Fig. 8). The buccal mucosa flap was repositioned and closed primarily (Fig. 9B).

Measurements were taken by flexible surgical rulers (Kendall, Covidien, Mansfield, MA, USA) and rigid rulers (Wescott, Bankstown, Australia).

RESULTS

The facial buccinator flaps was harvested with and without mucosa and transposed into the nasal cavity using a variety of maxillary osteotomies. It was demonstrated that the FAB flap reliably reached the anterior skull base and planum sphenoidale (Figs. 10–12). The distance from the anterior mid-maxillary wall to the posterior planum, ranged from 6 to 7 cm (Fig. 13). The distance from the anterior mid-maxillary wall to the anterior skull base measured approximately 4.5–5 cm. The distance of the FAB flap from the pedicle to the tip measured 7–8 cm.

DISCUSSION

Reconstruction of the skull base recreates the separation between the sinonasal tract and the cranial cavity, avoids postoperative CSF leaks, exposure of neurovascular structures, and decreases the risk of ascending bacterial meningitis. As experience and technology have increased, EEAs have expanded and now commonly result in defects comparable in size to those produced by traditional open approaches. As such, there is significant interest in reliably reconstructing these defects without the addition of significant morbidity. Vascularized tissue flaps have the advantage of promoting faster healing and are relatively radioresistant. Recently described vascular methods of skull base reconstruction include the HBF,[3] the posterior pedicled inferior turbinate flap,[4] the transpterygoid temporoparietal fascia flap,[5] and the Oliver pedicled palatal flap.[16] The "workhorse" HBF flap is able to contribute ~ 25 cm^2 of vascularized tissue, but is precluded in patients with a prior septectomy or extensive sphenoidotomies. The posterior pedicled inferior turbinate flap, based on the posterior lateral nasal artery, has a somewhat limited arch of rotation and contributes a maximum 5 cm^2 of vascularized tissue. The transpterygoid temporoparietal fascia flap offers a large volume of reconstructive tissue

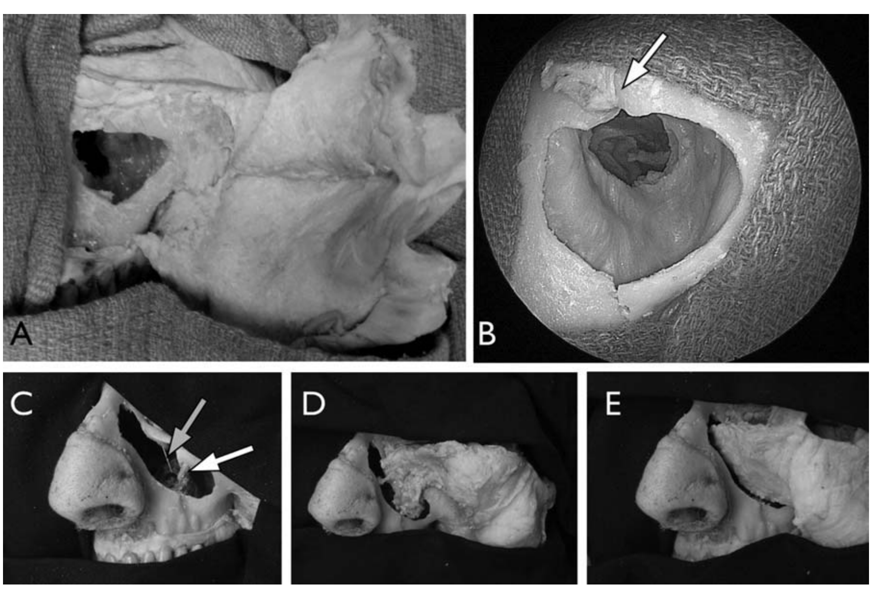

Fig. 8. (A) Nasoantromaxillary corridor: flap raised, and maxillary antrostomy and anterior maxillary osteotomy performed. (**B**) Closeup. The internal carotid, planun sphenoidale, and pituitary gland are visualized. Notice the infraorbital nerve at the most superior aspect of the osteotomy (white arrow). The soft tissues of the face were reflected away from the bone for illustration purposes. (**C**) Wide anterior nasomaxillary osteotomies, external view; white arrow = probe in nasolacrimal duct; gray arrow = infraorbital nerve. (**D, E**) Delivery of the flap. Please note in **E** the width of the flap base, which requires a wide osteotomy that goes as high as the nasal bones at the level of the medial canthus. The soft tissues of the face were reflected away from the bone for illustration purposes.

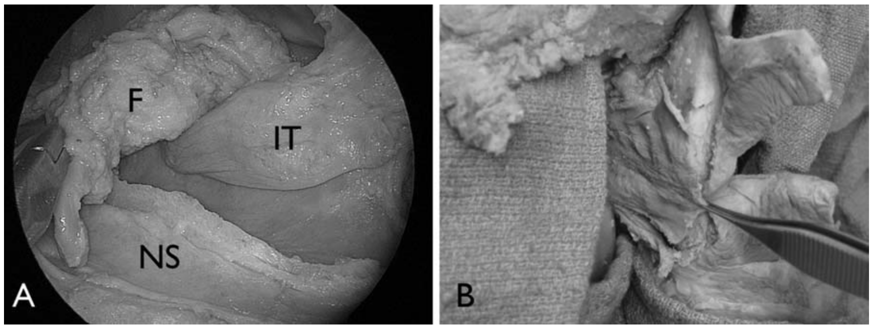

Fig. 9. (**A**) Delivering of the flap into the nasal cavity through the maxillary antrostomy. IT = inferior turbinate; NS = nasal septum; F = flap. (**B**) Repositioning of mucosal flap for primary closure.

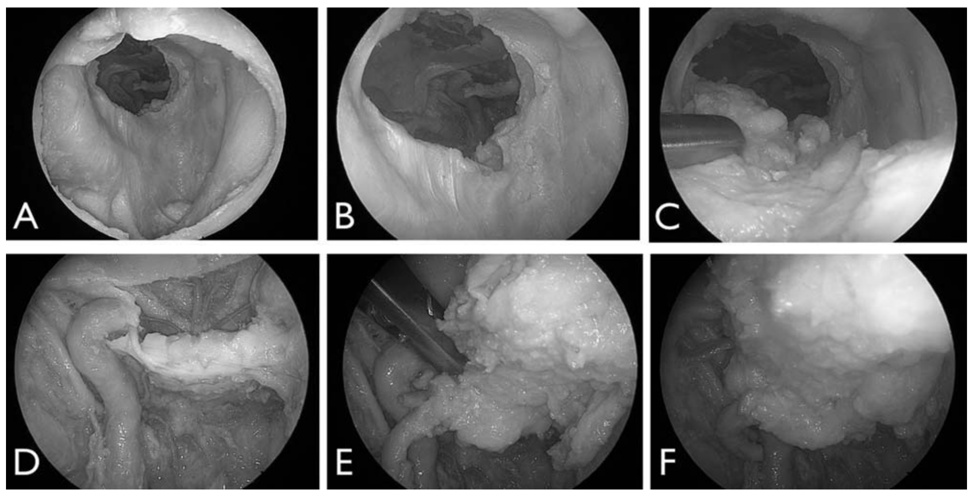

Fig. 10. Sequence of flap delivering of the flap into the nasal space and planun sphenoidale. (**A**) External view of the nasoantromaxillary corridor at the level of the anterior maxillary wall. (**B–D**) Closeups showing the right carotid artery, planun esphenoidale and pituitary gland. (**E**) Aproximation. (**F**) Flap covering planum esphenoidale.

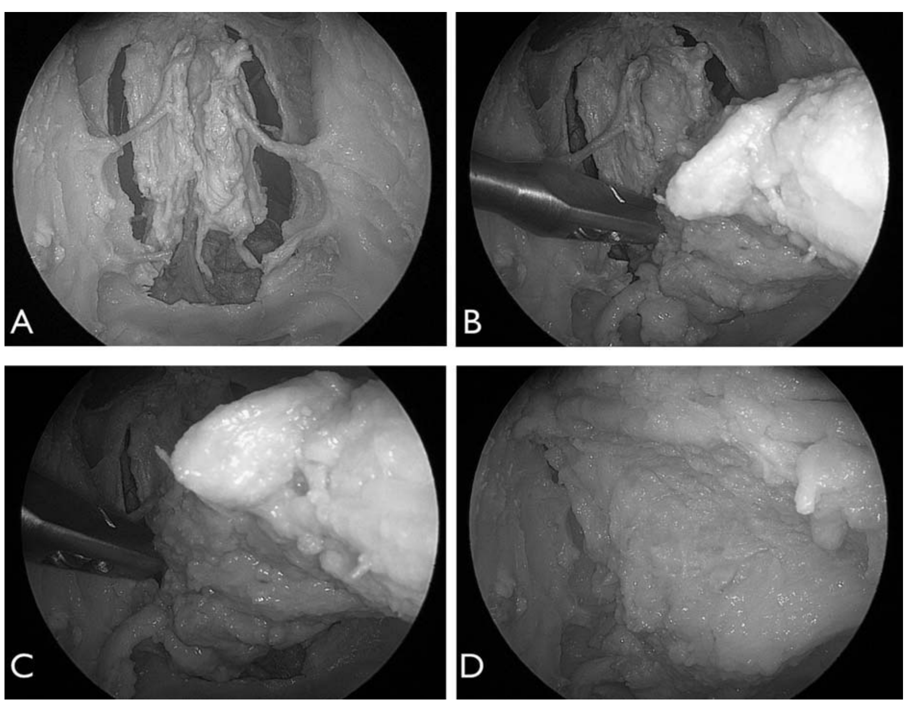

Fig. 11. Sequence of flap delivering into anterior skull base. (**A**) Endoscopic view of the anterior skull base. (**B, C**) Approximation of muscular (withour mucosa) flap. (**D**) Flap covering the anterior skull base.

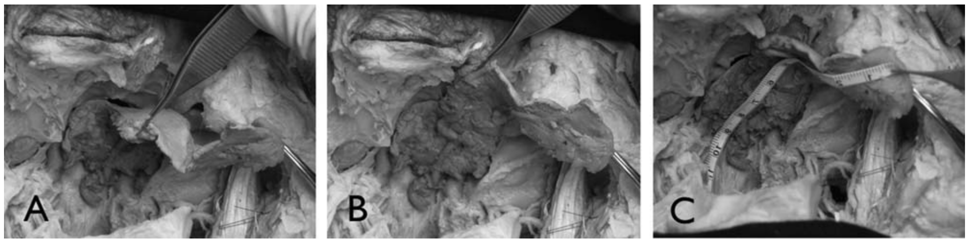

Fig. 12. Simulation of delivery of the flap along the ostetomy of the ascending process of the maxilla. Please note the counturing of the flap to the anterior skull base. The face was removed for illustration purposes. The Infraorbital nerve was exactly reapproximated to simulate the pivot point of the flap.

but contributes significant morbidity in the harvest and transposition. The Oliver pedicled palatal flap can yield up to 10 cm^2 of vascularized tissue, but is technically challenging and risks a persistent oroantral fistula.

Variations of a buccinator flap based on the facial artery[10,11,15,17–20] have been described by multiple authors and will not be elucidated upon. The basis of the FAB flap most closely resembles the buccinator myomucosal reverse flow island flap reported in 1999 by Zhao et al.[10] Similarly, Fan et al.[21] described the use of reversed buccinator musculomucosal flaps for reconstruction of defects resulting from resection of nasal inverted papillomas. Buccal myomucosal flaps have historically been used to reconstruct oral cavity defects,[11,15,18,20,22–25] but have also been employed to repair defects of the nasal septum,[18,26] lower lip,[25] conjunctiva, and midface.[10] The axial arterial supply of the buccal myomucosal flap is the facial/angular artery, although anastomosis/contributions from the infraorbital, dorsal nasal, and ophthalmic arteries cannot be ignored. The venous outflow appears to be more dependent on pedicle width than on the inclusion of named veins. Dupoirieux et al.[8] reported identification of the facial vein in only one of six FAMM flaps, and zero of three in reverse flow flaps, without flap failure. However, Joshi et al.[22] reported some degree of transient venous congestion in 17 FAM flaps with one episode of marginal necrosis. Aggressive bony removal and maximizing pedicle width appears prudent.

Continued dissection along the maxillary face and transposition of the buccal flap into the nasal cavity through a bony defect creates a large (>10 cm^2) myo(mucosal) flap that can easily reach the anterior skull base. In contrast to the HBF and the posterior pedicled inferior turbinate flap, the FAB flap can be harvested and transposed following the surgical resection, thus allowing it to be tailored to the specific reconstructive scenario. Additionally, the FAB flap can be combined with other reconstructive flaps (i.e., the HBF) for more extensive skull base reconstruction.

As with previously described buccinator or FAMM flaps, no facial incisions are required for harvesting or inseting the flap[6,10,18,20,23,24,27–29] Although the FAB flap can be harvested with mucosa, we see little utility when used for skull base reconstruction as rapid remucosalization occurs in the nasal cavity, and the additional 180° rotation needed may hinder venous outflow**.** The literature supports rapid healing with minimal donor site morbidity at the harvest site.[6,10,15,18,20] If the flap is harvested with mucosa, closing the donor site primarily should be feasible. In general, buccal myocutanous flaps can be closed primarily if the width is in between 2.5[6,15] and 3 cm.[7] Pribaz et al.[20] reported the primary closure of all vertically oriented FAMM flaps measuring 2 cm in width and 8–9 cm in longitude. Although the literature supports skin grafting for larger defects,[7,15] it might be possible to still close them primarily. Zhao et al.[10] reported the primary reconstruction of donor sites

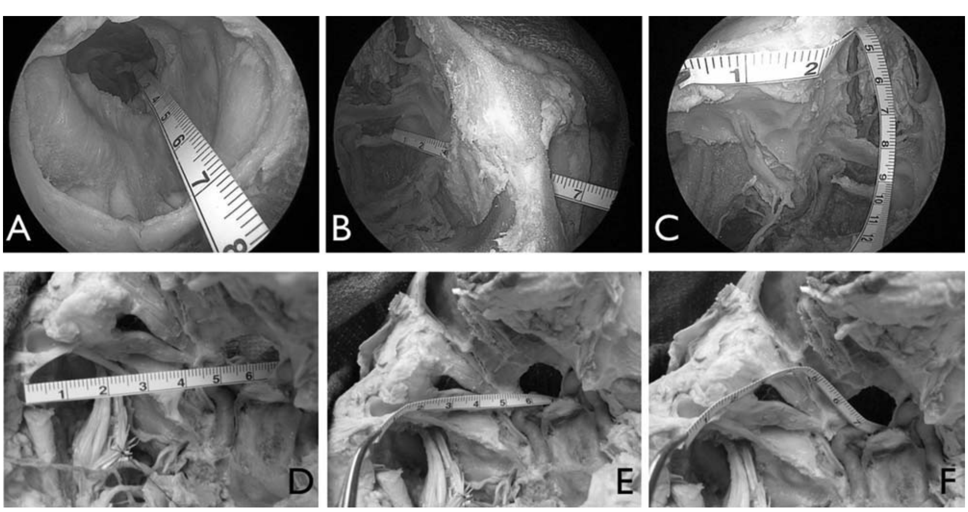

Fig. 13. Multiple measurements were performed from the anterior mid-maxillary wall to the anterior skull base and planum sphenoidale. (**A, B**, **D**) To pituitary gland/planum sphenoidale in a straight line. (**C, F**) To anterior skull base in curved lines. (**E**) To pituitary gland/planum sphenoidale in a curved line.

secondary to larger buccinator myomucosal (superiorly based) reversed-flow arterial island flaps. Van Lierop et al.[18] also reported primary closure of defects after harvesting "large" flaps in 14 patients undergoing buccinator myomucosal flaps; however, specific measurements were not mentioned in his article. Initial tightness at the donor site has been observed to resolve without long-term morbidity[20] or functional problems.[18] As mucosa would not be required for the majority of skull base defects, we would plan on primary closure after harvest and transposition of muscle and soft tissue.

Regardless of the extent of the maxillary osteotomy the risk of flap retraction and postoperative CSF leak should be minimized by aggressive bony/mucosal debridement, allowing intimate approximation of the bone/flap interface with surgical packing.

Potential complications of the FAB flap include ipsilateral dental paresthesia, facial paresthesia, persistent epiphora, flap loss, injury to the vascular pedicle and introduction of new bacterial subtypes into the operative field. As with buccal myomucosal axial flaps, there is no expected damage to the overlying facial nerve or the muscles of facial expression.[30] The plane of dissection should be just superficial to the vascular pedicle, thereby preserving the overlying facial nerve branches.[11] Multiple publications have reported no significant long-term weakness in facial movement following FAMM flap harvest.[10–12,20] Published authors have suggested that dissection in the nasolabial area is well tolerated because the buccinator resides anteriorly in a "spatial hiatus."[11] We plan to address the risk of persistent epiphora primarily by installing Crawford silicone tubes. Balbuena et al.[31] reported an 85% decrease in total oral cavity bacterial counts 4 hours following chlorohexedine gargle. We plan to institute a similar protocol to our existing parenteral antibiotic prophylaxis in EEA patients likely to undergo FAB reconstruction.

CONCLUSIONS

Based on previous reports and our findings, we believe that the FAB flap holds significant potential as a reconstructive alternative for a variety of skull base defects, alone or in combination with existing reconstructive options.

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