

Outcome of Different Endoscopic Endonasal Flaps

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Abstract

Introduction: Endoscopic endonasal surgeries have been evolved in the last two decades, it has an advanced and expanded role in many anterior & middle and posterior skull base diseases like CSF rhinorrhea, pituitary lesions. Reconstruction of the dura after these kinds of surgeries is remaining a big challenge for rhinologists. This is a review article aiming to discuss the different endoscopic endonasal pedicled flaps and their outcome.

Methods: Online searching for articles in English on <https://pubmed.ncbi.nlm.nih.gov>, <https://scholar.google.com>, <https://www.researchgate.net>, <https://onlinelibrary.wiley.com>.

Results: Fifty-five articles have been found fulfilling the criteria needed for data collection for outcome of different types of flaps in different journals, 54 articles published from 2000 to 2022 and just one article published in 1988.

Conclusion: Endonasal flaps give surgeons many solutions for reconstruction of the cranial base after extended endonasal skull base surgeries, they carry the advantages of being nearby, carry their blood supply, easy to harvest and no cosmetic drawbacks. Little complications like crustations, hyposmia and some degree of nasal obstruction may be noted.

Keywords: nasoseptal flap; middle turbinate flap; inferior turbinate flap; lateral wall flap

Introduction

Endoscopic endonasal surgeries have been evolved in the last two decades, nowadays this entity of surgeries is not limited for just dealing with enlarged turbinates, sinusitis or inflammatory polyps but also it has more advanced and expanded role in many anterior & middle and posterior skull base diseases like CSF rhinorrhea, pituitary lesions and even more extensive tumors like chordoma and craniopharyngioma. [1,2]

This evolution was aided by many facilities like angled instruments, high resolution cameras and monitors which help in more precise visualization and good dealing with the pathology. Also, the navigation system helps surgeons to be aware of the anatomy to avoid injury of important structures. This also leads to development of a teamwork between rhinologists and neurosurgeons work via two or four handed techniques. [3]

Reconstruction of the dural defects after these kinds of surgeries still a big challenge for rhinologists, anciently they used the extra nasal pedicled structures as transfrontal peri cranial

flaps and trans pterygoid temporoparietal flaps or even external fascial grafts from lateral aspect of thigh to reconstruct the anterior and middle cranial base dural defects. These were associated with co-morbidity & much cosmetic drawbacks and the surgical technique was very difficult. [4-6]

Recently, rhinologists invented techniques to use the intra nasal lining mucoperiosteum and mucoperichondrium as a pedicled flap to reconstruct

the dural defects or to cover a bare bone. Aided by adding fat or adhesive synthetic material between the flap and the defect or supporting the flap by gel foam or surgical, another limited local use of the endonasal flaps is to repair small septal perforations. [7,8]

This is a review article aiming to discuss the different endoscopic endonasal pedicled flaps and their outcome in reconstructing cranial base and septal perforation.

Methods

Keywords used for online searching were: nasoseptal flap, middle turbinate flap, inferior turbinate flap, lateral wall flap, posterior septal flap, choanal atresia, septal perforation, grafts, skull base defect, extended endonasal, pituitary adenoma, CSF leak, chordoma, craniopharyngioma.

Articles dealing with patients with describing their demographic data, lesions and outcome of reconstruction were included in this article, also articles demonstrating cadaveric dissection were included to describe the techniques of harvesting the flaps.

Online searching for recent articles in English on <https://pubmed.ncbi.nlm.nih.gov>, <https://scholar.google.com>, <https://www.researchgate.net>, <https://onlinelibrary.wiley.com>. other languages were excluded

Results

Fifty-five articles have been found fulfilling the criteria needed for data collection for this article in different journals, 54 articles published from 2000 to 2022 and just one article published in 1988.

Discussion

Different types of endonasal flaps have been found in literature were discussed regarding their techniques and outcome.

1-Nasoseptal flap (NSF) - Hadad Bassagasteguy Flap (HBF)

A study by Hadad et al used the nasoseptal posterior pedicled flap, based on nasoseptal branch of posterior septal artery from sphenopalatine which is a branch of internal maxillary artery. After decongesting the nasal cavity with xylometazoline and saline/ adrenaline they did out fracture and lateralization of the inferior turbinate with resection of the middle turbinate to allow proper visualization of the entire nasal septum and to allow easy moving and manipulation of the pedicled flap and instruments. A sagittal incision is done in the mucoperichondrial and mucoperiosteum layers inferiorly just above the maxillary crest and another similar incision is done superiorly just below

the olfactory mucosa by 0.5 cm to avoid its injury, the two incisions connected anteriorly then dissection of the mucoperichondrial and mucoperiosteal layers from anterior to posterior with keeping the posterior-inferior attachment for vascularization (figure 1). Then flap is rotated into the postnasal space and elevated to cover the target defective area, vigorous torsion or twisting should be avoided to prevent devascularization of the flap, this flap could be refashioned according to the size and shape of the defect, it services to cover defects in anterior, middle and posterior cranial fossae. The flap is supported by inflated Foley's catheter. [1]

The huge donor site cartilage is now exposed and liable for crust formation or infection, some authors preferred to cover it as possible by using the mucosa of the resected middle turbinate supported by silicone splint for 14 days. Others used the reverse posterior nasoseptal flap. [2]

They used this flap with 44 cases including twenty cases of pituitary adenoma, nine cases of post traumatic and spontaneous CSF leak, five cases of meningiomas, one case of neuroblastomas, five cases of clival chordomas and one case of craniopharyngiomas, only 2 cases (5%) showed postoperative intermittent CSF leak. [1]

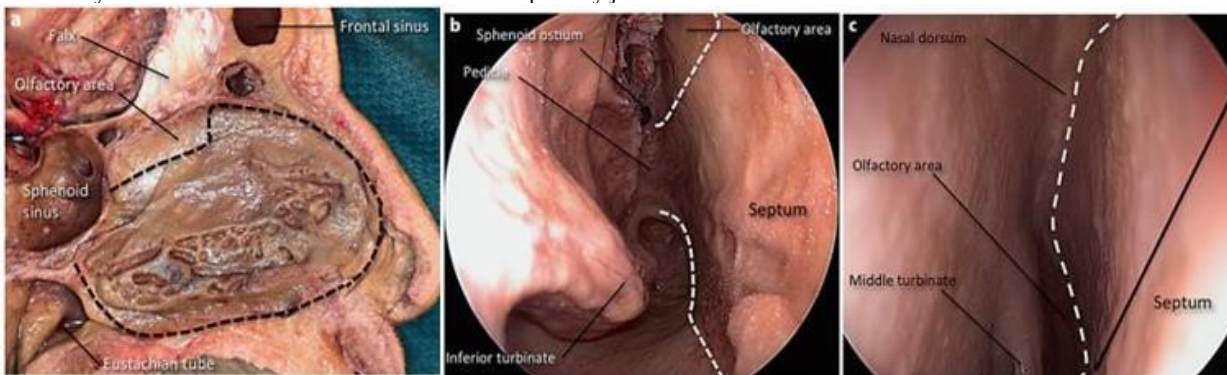


Figure 1: Cadaveric Dissection illustrates the outlines of the nasoseptal flap ²

A study by Wardas et al has applied the nasoseptal flap on 23 skull base patients, seven cases of pituitary macro adenomas, seven cases of chordomas, two cases of Rathke's cleft cysts, two cases of petroclival meningioma, two cases of craniopharyngioma, one case of fibrous dysplasia, one case of neurinoma and they reported one failure case (3%) of persisting CSF leakage after removing a chordoma. [3]

This is compared with a higher percentage of post operative CSF leak in another study by Kassam et al, they entailed twenty-five cases with skull base surgery and reconstructed by nasoseptal flap, [11] cases of pituitary adenoma, 4 cases of chordoma, 4 cases of meningioma, 2 cases of neuroblastoma, 2 cases of CSF leak and 2 cases of malignant neoplasm, they reported postoperative CSF leakage in 8 patients (30%). [4]

A study by Luginbuhl et al included 16 cases of CSF rhinorrhea reconstructed by the nasoseptal flap, they reported failure in one case (6%).⁹ A study by Zanation et al, included larger number of cases, they included 70 cases of pituitary macroadenomas and meningiomas and malignant neoplasm were reconstructed after removal of the lesion by nasoseptal flap, with failure in 4 cases (5%). [10]

Nearly the same with Lui et al have entailed 93 cases of CSF leak reconstructed by the nasoseptal flap, 3 cases only showed post operative leakage (3%). [11]

A study by Garcia-Navarro et al was conducted on 21 cases of pituitary adenomas, meningiomas and craniopharyngiomas, the defect was reconstructed by nasoseptal flap, they reported failure in 4.5%. [12]

Another study by Barger et al included 21 patients with pituitary adenoma reconstructed with nasoseptal flap, only one case showed postoperative CSF leak (5%). [13]

A huge number of cases were included in a study by Thorp et al, they included 144 cases of different pathologies between pituitary adenomas, chordomas, meningiomas, CSF leaks and malignant tumors, they reported failure rate in 3 cases only (2%) after reconstruction using nasoseptal flap. [14]

A study by Cavallo et al included 25 cases, 9 meningiomas, 8 craniopharyngiomas, 6 pituitary macro adenomas, one pituitary adenoma and one Rathke's cleft cyst, they reported failed reconstruction in one case (4%). [15]

Also, a study by Conger et al, entailed 509 cases of extended skull base surgery, only 83 reconstructed by nasoseptal flap with failure rate 4%. [16]

Hadad Bassagasteguy nasoseptal Flap carries the advantages being large in surface area gives up to 20 cm², could be refashioned according to the defect, well vascularized, could reconstructs two adjacent defects. It may be limited in use in patients with nasal septal problem like perforations due to heroin & cocaine addiction or cold frosting weather, previous nasal septal surgery or granulomatous disease and tumors invading the nasal septum, also sphenopalatine artery ligation & posterior septectomy and sphenoid surgery considered a limitation for using the Hadad Bassagasteguy nasoseptal Flap. Little drawbacks were reported in the form of olfactory changes (3%) & synechia and crust formation. [4-7,17]

2-Modifications of Nasoseptal flap

2-1-Rescue Nasoseptal flap

Nasoseptal flap is used to reconstruct the teared dura in skull base defects, CSF leakage couldn't be anticipated in each patient, on the other hand the flap has some drawbacks as crust formation, synechia & olfactory changes and septal cartilage infection or necrosis. If there is no defect no need for reconstruction and in small defect surgeons can use fat or mucosal grafts.

Upon this it's preferred not to harvest the nasoseptal flap in each patient. Other authors preferred to do what's named by rescue nasoseptal flaps which means the surgeon starts to harvest the nasoseptal flap at the beginning of surgery and returning it to the septum if not needed for reconstruction. [6]

2-2-Re-use of nasoseptal flap

The nasoseptal flap could be reused in recurrent cases of benign lesion as meningioma and pituitary adenomas, it is preferred to be the same surgeon of the primary surgery, it is important to precisely know the operative details and mapping of the primary surgery and to know the side of the pedicle of the nasoseptal flap if the surgical details were not available doppler could be used to detect the side of the pedicle. Technique entails separation of the pedicle from the edges of the defect or from the recurrent benign lesion, repositioning of the flap, removing the recurrent lesion then reconstruction the defect. This kind of modification couldn't be helpful in malignant lesion. [2]

A study by Zanation et al included 12 revision cases with re-use of the nasoseptal flap with success rate 100%. [2]

2-3-Extending nasoseptal flap including the nasal floor

In case of extensive dural defects surgeons may need to extend the nasoseptal flap to reconstruct the defect, this extended flap includes the nasal floor mucoperiosteal layer with the nasoseptal flap. Technique is similar to routine nasoseptal flap but the incision starts posteriorly at the septum just below the floor of sphenoid downward to floor passing laterally between the hard and soft palate till reach the inferior surface of inferior turbinate, then the incision extended anterior in sagittal plane below the inferior turbinate preserving the inferior meatus till reach the level of the head of inferior turbinate then the incision runs on the floor medially to reach the septum then the incision runs upward on the anterior part of the septum till the olfactory mucosa then extends backwards to the face of sphenoid sinus, then dissection is done preserving the vascular pedicle at posterior part of the septum above the choana, healing takes about 8 weeks for re-epithelialization. [8]

2-4-Extending nasoseptal flap including the nasal floor and inferior turbinate

For more extended flap, like the previously described technique but the incision passes laterally above the inferior turbinate preserving the

nasolacrimal duct opening to include the mucoperiosteal layer of the floor and inferior turbinate with the nasoseptal flap, it gives a surface area up to 28 cm². [8,17]

2-5-360o nasoseptal flap including nasal floor and lateral nasal wall

In this modification, the lateral incision extends to include the middle and superior turbinates mucoperiosteum, it's technically difficult & time consuming and associated with high incidence of nasolacrimal duct opening stenosis. [8]

A study by Moon et al included 5 cases of CSF rhinorrhea, 2 cases needed an extended nasoseptal flap with inferior turbinate flap only and 3 cases needed an extended nasoseptal flap with lateral wall flap with no post operative CSF leak, one case complicated with nasolacrimal duct opening stenosis and treated by Dacryocystorhinostomy (DCR). [8]

2-6-Double (bilateral) nasoseptal flap

It is preferred to be done by two teams, a team for each side for harvesting the flaps and for reconstruction of the dural defect, in this modification, the surgeon start with right side harvesting the flap with removal of the vomer and sphenoid rostrum, the contralateral flap should be harvested along the line of removed vomer and rostrum. [18]

A study by Kim et al included 17 bilateral nasoseptal flap out of 92 cases of nasoseptal flap and contralateral rescue flap, success rate 100%. [18]

2-7-Reverse nasoseptal flap (reverse Hadad flap)

Using a contralateral anteriorly based pedicled nasoseptal flap to cover the donor side of the original Hadad flap, this reverse flap is rotated posteriorly 180o, it is beneficial when posterior septectomy is extended anteriorly, this gives the length to the contralateral flap to cover the donor side. [19]

A study by Kasemsiri et al, included 47 skull base lesions of variable pathologies, they did nasoseptal flap for reconstruction with reverse flap to cover the donor site, one case showed failure (2%). [19]

The following table 1 entails outcome of different studies used nasoseptal flaps and its modifications in reconstruction skull base defects.

Study	Year	Number of cases	Failure rate
Hadad et al ¹	2006	44	5%
Kassam et al ⁴	2008	25	30%
Zanation et al ¹⁰	2009	70	5%
Zanation et al ²	2010	12 "re-use"	0%
Luginbukl et al ⁹	2010	16	6%
Liu et al ¹¹	2012	93	3%
Garcia-Navarro et al ¹²	2013	21	4.5%
Kim et al ¹⁸	2013	17 "bilateral"	0%
Kasemsiri et al ¹⁹	2013	47 "reverse"	2%
Thorp et al ¹⁴	2014	144	2%
Barger et al ¹³	2018	21	5%
Wardas et al ³	2019	23	3%
Cavallo et al ¹⁵	2019	25	4%
Conger et al ¹⁶	2019	83	4%
Moon et al ⁸	2019	5 "extended"	20% "lacrimal duct stenosis"

Table 1: Outcome of nasoseptal flap in different studies

3-Middle turbinate flap (MTF)

In this entity of endonasal pedicled flap the mucoperiosteum of both medial and lateral surface of the middle turbinate is dissected with preserving the vascular supply, it gives up to 5.5 cm² surface area and it is suitable to cover

defects in fovea ethmoidalis and planum sphenoidale and to less extend sellar defect, this was firstly described on 6 cadaveric dissection (twelve middle turbinate flaps). [20]

Technique of harvesting this flap includes a vertical in the head of middle turbinate after proper decongesting the nose the incision extends horizontally

and posterior on its medial surface just below cribriform plate of ethmoid, good precise dissection of the mucoperiosteal layer is done, then removing the bone of middle turbinate in piecemeal manner to prevent its avulsion and CSF leak, dissecting the lateral surface mucosa and may include mucosa over

lacrimal bone, the mucosa will be like an open book, preserve the posterior attachment which carries the middle turbinate branch of sphenopalatine artery (figure 2). [20]

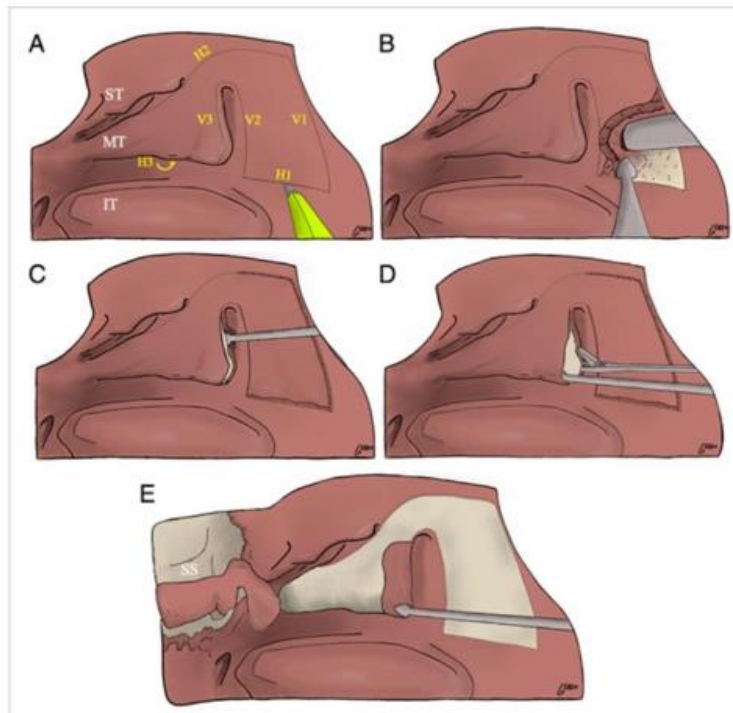


Figure 2: A diagram illustrates technique of harvesting the middle turbinate flap ²⁰

A study by Simal-Julian et al, has applied middle turbinate flap on 10 cases, 8 pituitary macroadenoma and 2 CSF rhinorrhea at anterior cranial base, they reported 100% success rate.

21 Another use in a study by Chen et al, authors have used the pedicled middle turbinate flap to reconstruct the surgical bed after endoscopic nasopharyngeal resection of 18 patients with recurrent nasopharyngeal carcinoma after failed chemoradiotherapy, this is carrying the advantage to cover the prevertebral muscle and to protect the petroclival segment of the internal carotid artery, on the other hand it may prevent early detection of recurrence, they reported failure of reconstruction in 3 cases (16%). [22]

A study by Elmorsi et al conducted on 31 patients of CSF rhinorrhea from anterior cranial fossa, they used a septal graft supported by middle turbinate flap, they reported failure in 4 cases (13%).[23]

Another different indication in the study by Hanci et al, not included cranial base defects, they used the middle turbinate flaps to repair septal perforations in 31 cases, they reported failure in 2 patients (6.5%). [24]

Tamura et al have reported a study of 3 cases of anterior cranial base pathology, 2 cases of spontaneous CSF leak and a case of Schwannoma with

no postoperative CSF leakage after reconstruction by middle turbinate flap. 25 Another study by Amin et al, middle turbinate flap was conducted on twenty-five cases of CSF leak after endoscopic transsphenoidal pituitary surgery, they reported failure in one case (4%), they also reported that the surface area of this flap can reach to 9.5 cm². [26]

Wang et al have included 4 cases, 2 pituitary, 1 craniopharyngioma and 1 spontaneous CSF leak, all cases were reconstructed by using fascia lata graft aided by middle turbinate flap with success rate 100%. 27 on the other hand a study by Manimaran et al conducted on 13 cases of anterior cranial base non tumorous lesions, 10 cases of CSF leak, 3 cases of meningocele, they reported failure rate in 3 cases (23%). [28]

A recent study by Carnevale et al, middle turbinate flap was conducted on 25, 7 of them with gasket seal technique, they reported postoperative leak in one case who did gasket seal technique, failure rate 3 %. [29] Another recent study by Kento et al on one case of spontaneous CSF rhinorrhea from cribriform plate of ethmoid and fovea ethmoidalis reconstructed by middle turbinate flap with no post operative complications or failure. [30]

The following table 2 entails outcome of different studies used middle turbinate flaps in reconstruction skull base defects.

Study	Year	Number of cases	Failure rate
Simal-Julian et al ²¹	2011	10	0%
Chen et al ²²	2012	18	16%
Elmorsi et al ²³	2014	31	13%
Hanci et al ²⁴	2015	31 "septal perforation"	6.5%
Tamura et al ²⁵	2015	3	0%
Amin et al ²⁶	2016	25	4%
Wang et al ²⁷	2016	4	0%
Manimaran et al ²⁸	2020	13	23%
Carnevale et al ²⁹	2021	25 "7+ gasket seal"	3%
Kento et al ³⁰	2022	1	0%

Table 2: Outcome of middle turbinate flap in different studies

4-Inferior turbinate flap

Posterior pedicled Inferior Turbinate flap (PITF)

In this type of flaps surgeons preserve the mucoperiosteum of both sides of inferior turbinate, technique includes proper decongesting the nose, vertical incision on the anterior end of inferior turbinate, the incision passes in

sagittal direction towards nasopharynx, this helped by gentle medialization of the inferior turbinate for proper visualization of lateral surfaces. Then dissection of the mucoperiosteal layer of the inferior turbinate is done with preserving the posterior attachment which carries the vascular pedicle containing the inferior turbinate branch from the sphenopalatine artery, the bony turbinate is removed (figure 3). This is more suitable to cover defects in clivus and to less extend sellar defects and it provides about 4.5 cm². [31]

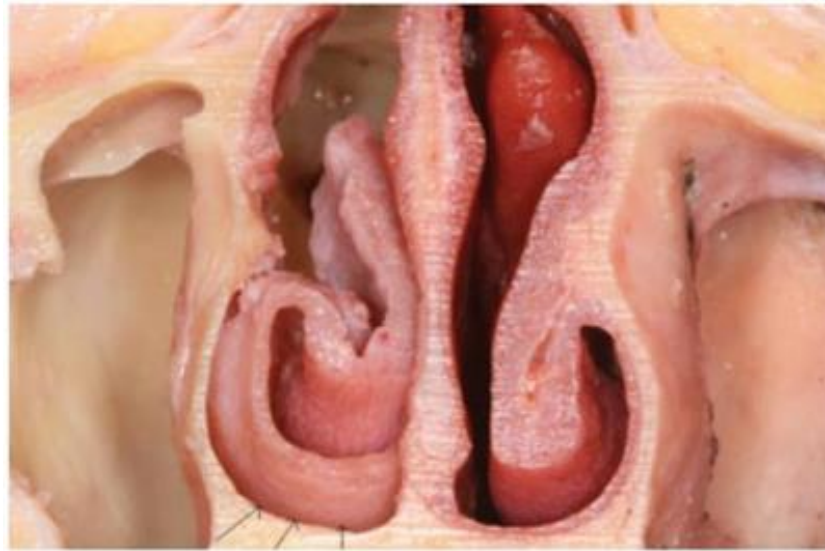


Figure 3: A cadaveric illustration of anterior dissection of both sides of inferior turbinate mucoperiosteum 31

A study by Fortes et al included 4 cases, 2 cases of clival chordoma, one case of clival basilar artery aneurysm, one case of pituitary macroadenoma, were reconstructed by inferior turbinate flap with success rate 100%. [31]

In a study by Yib et al, they reported two cases of revision endoscopic transsphenoidal pituitary surgery with utilized nasoseptal flaps in the prior surgeries, scarifying both old nasoseptal flaps was done and new reconstruction with posterior pedicled inferior turbinate flap with no postoperative leak. [32] The same in the study by Boetto et al, two revision cases of clival chordoma, they used the inferior turbinate flap in the new reconstruction after utilized nasoseptal flaps in prior surgeries, no post operative leak. [33]

An old study by Vuyk et al used the posterior pedicled inferior turbinate flap to repair anterior small septal perforations in 31 cases, this surgery required a second stage to section the posterior pedicle of the flap after requiring its vascularity from the recipient site. This study reported failure in 10 cases to

cover the septal perforation (33%). [34] Another study by Friedman et al, used this flap in septal perforations in 10 cases, reported failure in 3 cases (30%). [35]

4-2-Anterior pedicled Inferior Turbinate flap (AITF)

In this flap the incision started from posterior end of the inferior turbinate with preserving the pedicle anteriorly carrying the vascular branch from anterior ethmoidal artery. More suitable to reconstruct the anterior skull base defects. [3] A study by Gil et al, seven cases of anterior skull base reconstruction using the anterior pedicled inferior turbinate flap, 4 of these 7 cases were supported with nasoseptal flap due to wide defects, authors reported no post operative CSF leak. [36]

The following table 3 entails outcome of different studies used inferior turbinate flaps in reconstruction skull base defects and septal perforations.

Study	Year	Number of cases	Failure rate
Vuyk et al ³⁴	1988	31 "septal perforations"	33%
Friedman et al ³⁵	2003	10 "septal perforations"	30%
Fortes et al ³¹	2007	4	0%
Gil et al ³⁶	2012	7 "4+ nasoseptal flap"	0%
Yip et al ³²	2013	2	0%
Boetto et al ³³	2018	2	0%

Table 3: Outcome of inferior turbinate flap in different studies

5-Lateral wall flaps

5-1-Posterior pedicled lateral nasal wall flap (PLNW)

Technique starts with proper decongesting the nasal cavity, followed by middle meatal antrostomy with preserving the mucoperiosteum on lacrimal bone anterior to uncinate process as it will be included in the flap, a vertical incision is done anterior to inferior turbinate extends upward, a second

posterior vertical incision is done in front of the Eustachian tube on medial pterygoid plate, both incision connected to each other by horizontal incision below the inferior turbinate and include a portion of nasal floor mucoperiosteum, dissection started with elevation of the mucoperiosteum of both sides of the inferior turbinate and lateral nasal wall with preserving the middle turbinate, the flap is posterior pedicled (figure 4), suitable for sellar and clival defects, it provides about 13 cm² surface area. [37,38]

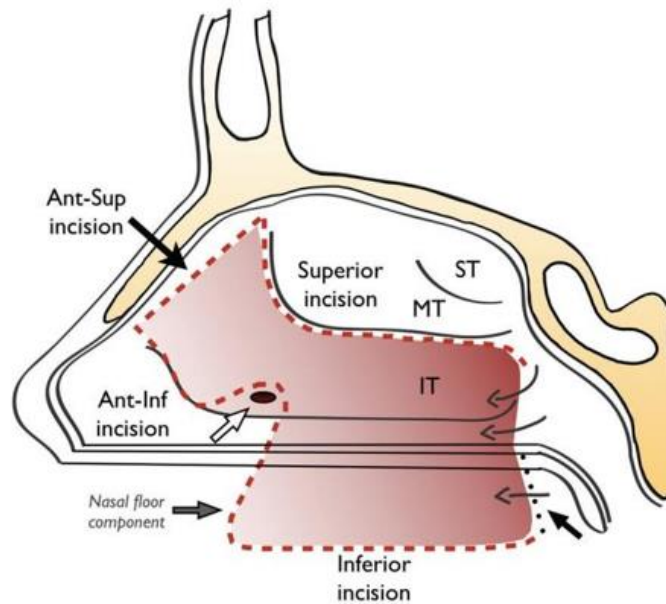


Figure 4: A diagram illustrating the posterior pedicled lateral nasal wall flap ³⁸

A study by Lavigne et al included 24 cases, 13 chordomas, 6 pituitary adenomas, 3 meningiomas, 1 neuroblastoma, 1 chondrosarcoma, reconstructed by lateral nasal wall flap, they reported failure in 6 cases (24%). ³⁷ Another study by Rivera-Serrano et al has included four cases of middle and clival cranial fossa defects, they used the lateral nasal wall flap with no failure rate, and what is worth to mention that the authors called it Carrau-Hadad Flap (C-H flap). [39]

A study by Alobid et al included three large septal perforations, they reported failure rate 16% between incomplete repair and post operative nasal obstruction. [40]

5-2Anterior pedicled lateral nasal wall flap (ALNW)

Same technique as posterior pedicled lateral wall flap but the pedicle would be anterior in front of the middle turbinate (figure 5). [41]

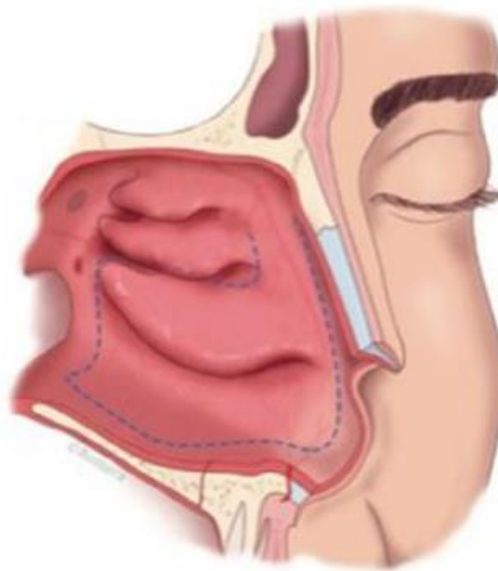


Figure 5: A diagram illustrating the anterior pedicled lateral nasal wall flap ⁴¹

A study by Hadad et al included three case of anterior cranial base lesion, two cases of neuroblastomas and one case of meningoencephalocele, reconstructed by anterior pedicled lateral nasal wall flap, with no post operative failure, it is worth to mention that the authors called it Hadad Bassagasteguy 2 Flap (HB 2 flap). [42]

A different study by Langdon et al included one case of nasal carcinoma, plastic reconstruction of the nasal skeleton is aided by anterior pedicled lateral nasal wall flap. [41]

The following table 4 entails outcome of different studies used lateral wall flaps in reconstruction skull base defects & septal perforations and external nasal skeleton.

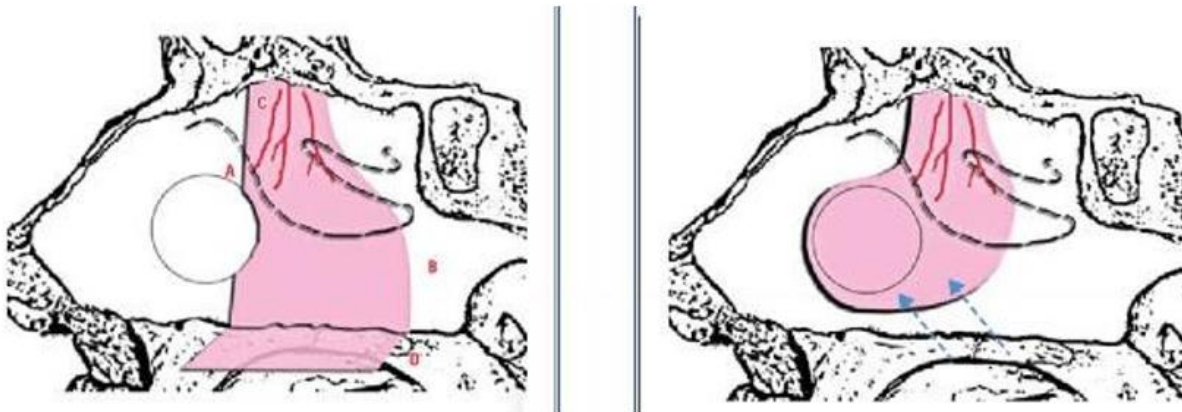
Study	Year	Number of cases	Failure rate
Hadad et al ⁴²	2011	3	0%
Rivera- Serrano et al ³⁹	2011	4	0%
Alobid et al ⁴⁰	2015	3 "septal perforations"	16%
Lavigne et al ³⁷	2020	24	24%
Langdon et al ⁴¹	2020	1 "Rhinoplasty"	0%

Table 4: Outcome of lateral nasal wall flap in different studies

6-Anterior ethmoidal artery based septal flap (AEA flap) (Castel Nuovo flap)

Mainly used for repairing anterior septal perforations, based on a pedicle of anterior ethmoidal artery branches. Technique started by proper decongestion of the nasal cavity and refreshing the edge of septal perforation,

a vertical incision is done on the septum just behind the perforation, a second vertical incision is done on the septum 1 cm behind the level of axilla of middle turbinate, the two incisions connected to each other including the nasal floor mucoperiosteum, then dissection and anterior rotation to cover the septal hole (figure 6). [43]

**Figure 6:** A diagram illustrates the fashioning of anterior ethmoidal artery based septal flap in repairing septal perforations ⁴³

Four studies by Castel Nuovo et al, Santamaria-Gadea et al, Cavada et al, Alobid et al included 11, 6, 13, 2 patients of septal perforations in order, all showed no failure rate. [43-46] On the other hand a study by Atallah et al included 14 patients with failure rate 28.6%. [47]

A different study by Elhassan et al, they used the AEA flap in recontraction the frontal sinus defects instead for septal perforation, the study included 3

cases, one case of CSF leak from posterior frontal wall, one case of meningocele, one case of frontoethmoidal osteoma with 100% success rate. [48]

The following table 5 entails outcome of different studies used anterior ethmoidal artery base septal flaps in reconstruction skull base defects and septal perforations.

Study	Year	Number of cases	Failure rate
Castelnuovo et al ⁴³	2011	11	0%
Alobid et al ⁴⁶	2017	2	0%
Cavada et al ⁴⁵	2018	13	0%
Atallah et al ⁴⁷	2019	14	28.6%
Elhassan et al ⁴⁸	2020	3 "frontal reconstruction"	0%
Santamaria-Gadea et al ⁴⁴	2022	6	0%

Table 5: Outcome of anterior ethmoidal artery septal flap in different studies

7-Vomer-Rostrum flap

A very recent study by Goates et al has been published few days ago describing what is called vomer-rostrum flap, it's a limited posterior septal flap, the authors used it on four patients, 2 cases of fungal ball and 2 cases of sphenoiditis, one of them underwent 2 prior sphenoidotomy. This flap aims to limit restenosis of sphenoid ostium by covering the hyperostotic bone by mucosal flap. Technique started with ethmoidectomy and sphenoidotomy, the incision started the rostrum of sphenoid then passes anteriorly to the septum then descent on the septum to reach the level just above the vomer bone, dissection is done with removal the bony rostrum and vomer, wide

sphenoidotomy is completed with lining the ostium and the cavity with this flap, the study reported success in all patients with no restenosis after following up 6 months. [49]

8-Posterior septal flap in surgery of choanal atresia (swinging door flap)

Technique entails a vertical incision on the posterior part of the septum just anterior to atretic choana from above downward and extends to nasal floor until reach the lateral nasal wall (L-shaped), the flap then dissected with keeping upper and lateral attachment (figure 7). The aim is to line the newly developed tunnel and to limit restenosis. [50]

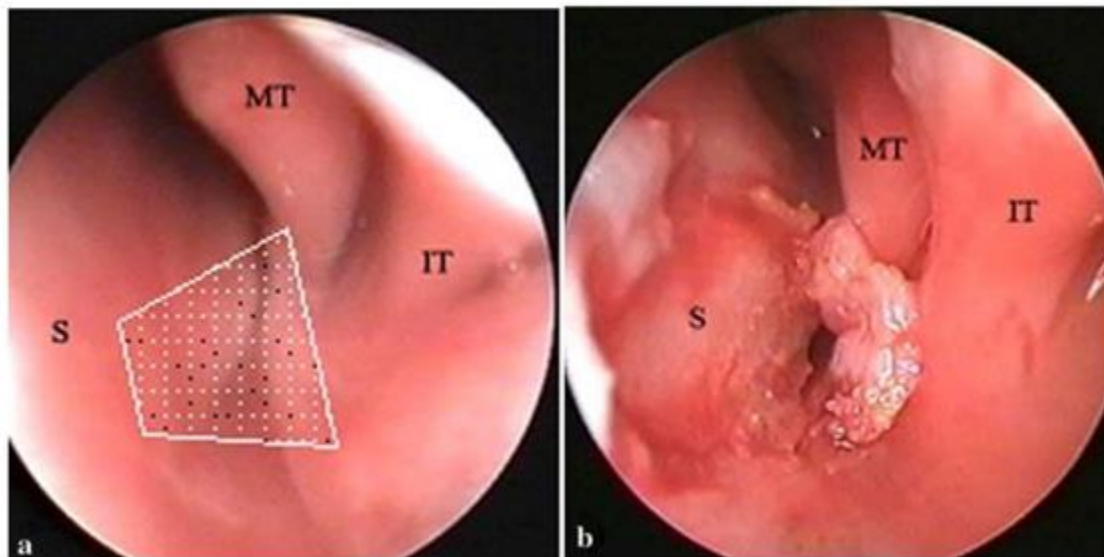


Figure 7: An endoscopic view illustrates the use of posterior septal flap after repairing choanal atresia ⁵⁰

A study by Stamm et al included this flap on 33 patients of choanal atresia, 10 (30%) cases showed restenosis after 1 year follow up. [50] Another study by Nour et al, included 14 neonates of choanal atresia managed by using this flap aided by stenting, with no restenosis on long term follow up.[51]

Adegboyega et al, they included 12 cases, 5 of them showed restenosis (41%). 52 On the other hand a study by Wormald et al on 17 cases managed by the flap without stenting, no cases showed restenosis on long term follow

up.[53] The same with Mladina et al, used this flap on one case 14 years old, with no restenosis. [54] A study by Tomoum et al included 72 patients divided into 2 groups, 42 managed by flap without stenting and 30 managed by stent without flap, restenosis was lower in the 1st group (21%) comparing to that of the 2nd group (33%). [55]

The following table 6 entails outcome of different studies used posterior septal flaps in reconstruction after choanal atresia surgery.

Study	Year	Number of cases	Failure rate
Stamm et al ⁵⁰	2001	33	30%
Nour et al ⁵¹	2008	14 "with stenting"	0%
Mladina et al ⁵⁴	2009	1	0%
Wormald et al ⁵³	2016	17	0%
Tomoum et al ⁵⁵	2018	42	21%
Adegboyega et al ⁵²	2021	12	41%

Table 6: Outcome of swinging door posterior septal flap in different studies

Although this article is a review to demonstrate different types of endonasal flaps and their outcome, it is worth to mention other extra nasal distant flaps were and still being used inside the nasal cavity, usually require both endoscopic and open approaches, radial artery based lipofascial forearm flap has been mentioned in literature as a method of trans nasal skull base reconstruction, it needs a multidisciplinary team, time consuming, needs to access the neck vessels subcutaneously through Caldwell-Luc antrostomy to get vascularity. A prior trial was to use the anterolateral thigh flap carries cosmetic complications and difficult techniques, other nearby flap like pericranial, temporoparietal and Oliver palatal flaps were used before using the endonasal mucosal lining for reconstructing cranial base defects. [56,57]

It's also worth to mention that the use of endonasal flap usually aided by other materials, the materials may be allografts like fascia Lata graft from

lateral aspect of the thigh to lie between the defect and flap (gasket seal closure) also fat tissue from anterior abdominal wall or lateral aspect of the thigh is used. Literature also mentioned the 3F technique (Fat + Fascia + Flap) for better sealing of the defect, other synthetic materials were also used as fibrin glue or surgical.

For better covering and sealing a huge surface area defects many authors have to used more than one endonasal flap e.g., combined Nasa septal flap with middle turbinate flap. [5,9,12,15,16]

The following table 7 entails summary of outcome of different endoscopic endonasal flaps in this study's articles

Flap name	Surface area	Uses	Maximum failure rate	Common drawbacks
Nasoseptal flap	20 cm ² ¹⁷	Reconstruction of cranial base ¹	30% ⁴	1-Olfactory changes & Crustations & Mild nasal obstruction ⁶ 2- Nasolacrimal duct opening stenosis (extended nasoseptal with lateral wall flap) ⁸
Extended nasoseptal flap	28 cm ² ¹⁷	Reconstruction of cranial base ⁸	20% ⁸	
Middle turbinate flap	9.5 cm ² ²⁶	-Reconstruction of cranial base ²⁰ (++ anterior / middle)	23% ²⁸	
		-Repair of septal perforation ²⁴	6.5% ²⁴	
Inferior turbinate flap	4.5 cm ² ³¹	-Reconstruction of cranial base ³¹ (++ middle/posterior)	0% ³¹⁻³³	
		-Repair of septal perforation ³⁵	33% ³⁴	
Lateral wall flap	13 cm ² ³⁸	-Reconstruction of cranial base ³⁸ -Repair of septal perforation ⁴⁰ -Rhinoplasty ⁴¹	24% ³⁷ 16% ⁴⁰ 0% ⁴¹	
Anterior ethmoidal flap	N/A	-Repair of septal perforation ⁴³ -Reconstruction of cranial base ⁴⁸ (++ anterior)	28.6% ⁴⁷ 0% ⁴⁸	
Vomer- rostrum flap	N/A	-Reconstruction of cranial base ⁴⁹ (++ middle)	0% ⁴⁹	
Swinging door flap	N/A	-Tunnelling of the newly developed choana ⁵⁰	41% ⁵²	

N/A: Not Available

Table 7: Summary of outcome of different endoscopic endonasal flaps in this study's articles

Conclusion

Endonasal flaps give surgeons many solutions for reconstruction of the cranial base after extended endonasal skull base surgeries, they carry the advantages of being nearby, carry their blood supply, easy to harvest and no cosmetic drawbacks. Little complications like crustations, hyposmia and some degree of nasal obstruction may be noted.

Still there is a challenge in some cases who have generalized nasal mucosal diseases like granulomas or Mucor mycosis or hypo perfused nasal mucosa like in cocaine addicts or sever cold weather countries; in such patient it may be difficult to use the endonasal cavity mucosa for reconstruction.

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