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WILEY
Seventy Three Rotation Flap Pedicled on Ethmoidal Arteries for Endoscopic Skull Base Reconstruction

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Object: Expanded endonasal approaches have dramatically changed how skull base surgery is performed, and nasoseptal flap (NSF) has significantly improved skull base reconstruction. However, challenges remain when the pterygopalatine artery is invaded by tumors; when it must be sacrificed to approach the lateral sphenoidal recess; when late-occurrence leak occurs in the sella after transsphenoidal surgery; and also when the leak is on the posterior wall of the frontal sinus, which is too distant for NSF to reach. This article describes a septal floor rotational flap pedicled on ethmoidal arteries for endoscopic skull base reconstruction in certain cases.

Study Design: Case series.

Method: In this article, we retrospectively review a series of 19 patients who underwent skull base reconstruction with a septal floor rotational flap pedicled on the ethmoidal arteries.

Result: All 19 flaps, including the anterior and posterior artery pedicled flaps, survived without significant complications, and no postoperative cerebrospinal fluid leak occurred during follow-up.

Conclusion: Ethmoidal arteries pedicled septal floor rotational flap, with their strong blood supply and large coverage area, are ideal replacements for NSF. These flaps are qualified in locations ranging from the posterior wall of the frontal sinus to the lateral sphenoidal recess and in cases ranging from tumor invading the pterygopalatine fossa to sellar late-occurred leak after transsphenoidal surgery.

Key Words: Endoscopic endonasal, skull base reconstruction, septal floor rotational flap, ethmoidal artery.

Level of Evidence: 4

INTRODUCTION

The endoscopic endonasal approach has become mainstream for skull base operations over the past decades; therefore, reconstructions for traumatic and spontaneous cerebrospinal fluid (CSF) leak and resulting skull base defects after tumor resection continue to be significant. A wide variety of free grafting techniques, such as autologous, allogeneic, heterologous, and synthetic grafts, have been adapted and validated in small skull base defects, with a success rate of 94%. Since the nasoseptal flap (NSF) was advocated in 2006, there have been great breakthroughs in the reconstruction of large skull base defects and high-flow CSF leak due to its large coverage area, strong blood supply, and convenience for harvest.

However, there remain some cases for which NSF is unavailable or invalid. The first is when the defect is located on the posterior wall of the frontal sinus, which is too far for NSF to reach. The second is when the tumor invades the pterygopalatine fossa and destroys the sphenopalatine artery, which gives off the posterior nasal septal artery to supply the NSF. The third is when there is late-occurred leak in the sella after transsphenoidal surgery with the sacrifice of sphenopalatine artery. Last, when the leak occurs on the lateral recess of the sphenoidal sinus, the sphenopalatine artery may have to be sacrificed for a transpterygopalatine fossa approach.

Anterior ethmoidal artery septal flap, which is a rotational nasal mucosal flap based on the anterior ethmoidal artery, has been reported by Castelnuovo et al. for the management of septal perforation. The article proved that a flap supported by the anterior ethmoidal artery is a practicable and effective one that can survive without significant morbidity.

Seyedhadi et al.’s report strongly recommends the septal mucosal flap based on the anterior ethmoidal artery during Draf III operation to decrease the incidence of scar and the recurrence of common frontal recess stenosis. The authors declare that this flap is also beneficial for blocking CSF leak in the anterior areas of the anterior crania fossa. Battaglia et al. report the technique of a septal flip flap based on the contralateral anterior and posterior ethmoidal artery for anterior skull base reconstruction and describe good results. In their view, the septal flip flap might be more adequate in cases of anteriorly extended skull base defects and in conditions when it is necessary to resurface the orbital content.

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In this study, we will further describe the pedicled flap based on ethmoidal arteries. We retrospectively reviewed a series of 19 patients in our department who underwent reconstruction of skull base defects with septal floor rotational flaps pedicled on ethmoidal arteries. Different than Battaglia et al.’s use of the septal flip flap, we adapt the ipsilateral ethmoidal arteries as the pedicle and usually only select the anterior ethmoidal artery or the posterior ethmoidal artery as the blood supply for the flap. In this way, we narrow the pedicle of the flap, making the flap more flexible so that it can be rotated anteriorly as far as the posterior wall of the frontal sinus and posteriorly as far as the lateral sphenoidal sinus.

Fig. 1. Preoperative coronal (A) and sagittal (B) MRI images of patient diagnosed with inverted papilloma invading pterygopalatine fossa and anterior skull base. Intraoperative photographs (C, D) from expanded endonasal endoscopic approach showing iatrogenic skull base defect and flap pedicled on anterior ethmoidal artery. Coronal (E) and sagittal (F) MRI images adopted immediately postoperatively. Tumor invading pterygopalatine fossa (black arrow), defect on cribriform plate (white arrow), and flap pedicled on anterior ethmoidal artery (white star). MRI = magnetic resonance imaging.
MATERIALS AND METHODS

Surgical Anatomy

The arterial supply for the nasal septum has been described in detail. Five main arteries, including the posterior septal artery, the anterior and posterior ethmoidal arteries, the superior labial artery, and the greater palatine artery, are responsible for the nasal septum arterial supply system. The posterior septal artery originates from the sphenopalatine artery, which is the terminal branch of the maxillary artery. It divides into two or three branches at the septum, supporting most of it, especially the posterior portion. The superior labial artery and the greater palatine artery, respectively, derive from the facial artery and the descending palatine artery, and both contribute to Little’s area.6 We here focus on the ethmoidal arteries, which originate from the ophthalmic artery of the internal carotid system and mainly irrigate the superior wall of the septum.

The anterior ethmoidal artery, originating from the ophthalmic artery, leaves the orbit through the anterior ethmoidal foramen and enters the anterior ethmoidal canal. It then reaches the anterior cranial fossa by breaking through the lateral lamella of the cribiform plate. It next enters the nasal cavity via the crista galli sutures on the cribiform plate after it gives off a meningeal branch intracranially.7–9 The anterior ethmoidal artery traverses three cavities: the orbit, ethmoid labyrinth, and cranial fossa. The septal branches of the anterior ethmoidal artery anastomose with the middle branch of the posterior septal artery at Little’s area. The anterior ethmoidal artery also provides a septal branch to the anteroseptal septum that is responsible for irrigating anterior ethmoidal cells and the frontal sinus, as well as the anterior third portion of the nasal septum and the lateral wall of the ipsilateral nasal cavity.7

The posterior ethmoidal artery originates from the second or third part of the ophthalmic artery. It passes perpendicular to the medial orbital wall and enters the posterior ethmoidal canal. This artery then traverses the roof of the ethmoid labyrinth inside the homonymous canal into the anterior cranial fossa. Finally, it crosses the ethmoid roof and enters the nasal cavity.10 The posterior ethmoidal artery anastomoses with the superior branch (not always present) of the posterior septal artery.9,10

Others have demonstrated the presence of the middle ethmoidal artery. However, in view of its unstable appearance, we do not regard it as a dependable artery supply.11

Surgical Technique

To harvest the ethmoidal artery pedicled flaps, a wider operation space is necessary to expose the upper part of the nasal septum through fracturing the middle turbinate laterally. Moreover, to reconstruct the posterior wall of the frontal sinus, the frontal sinus ostium should be opened widely so that the distant part of the flap can traverse in combination with an open approach. Then we manipulate the flap to cover the defect with periosteum surface while keep the musus side faced outwardly to sinus cavity (shown in Figs. 1–3).

Anterior Ethmoidal Artery Pedicled Flap. This flap can be rotated anteriorly to cover the defect on the posterior

Fig. 2. Preoperative sagittal MRI (A) and computed tomography (B) images of patient diagnosed with traumatic cerebrospinal fluid leak on posterior wall of frontal sinus. Contralateral anterior ethmoidal arterial pedicled flap is adopted for ipsilateral nasoseptal flap used in previous reconstructive surgery. Sagittal (C) and coronal (D) MRI images adopted immediately postoperatively. Intraoperative photographs (E–G) from expanded endonasal endoscopic approach showing bath-plug technique and flap pedicled on anterior ethmoidal artery. Defect on posterior of frontal sinus (white arrow), bath-plug technique with adipose tissue (white triangle), and flap pedicled on anterior ethmoidal artery (white stars). MRI = magnetic resonance imaging.
wall of the frontal sinus. To obtain this flap, we selected the posterior wall of the frontal sinus as the anterosuperior point of the flap pedicle and the midpoint between the anterior and posterior arteries as the posterosuperior point. From these two points, we cut the septal mucosa vertically downward to the nasal floor. The two incisions were then turned laterally to the inferior nasal meatus on the lateral nasal wall until the inferior nasal concha was reached. The two parallel incisions were then connected by a sagittal incision. Once the territory of the flap was outlined, the flap detached from the septum until reaching the cribriform plate. In this way, a flap with a narrow pedicle and long peduncle is harvested and can be freely rotated. For a larger coverage area, the two incisions on the nasal floor and inferior nasal meatus can sometimes be made forward and backward, respectively, including the complete area of the nasal floor mucosa.

Posterior Ethmoidal Artery Pedicled Flap. This flap can be rotated backward to reach the lateral recess of the sphenoid sinus. The main procedure for harvesting the posterior ethmoidal artery flap is similar to that of the anterior ethmoidal artery pedicled flap. Here, we start the anterior incision from the midpoint of the anterior and posterior arteries. The posterior incision begins with the anterior wall of the sphenoid sinus. Two vertical incisions starting from these two points are made downward to the nasal floor and are then turned lateral to include the inferior nasal meatus mucosa. A sagittal incision was made to connect the two parallel incisions at the attachment point of the inferior nasal concha. The two parallel incisions can also be put adjusted respectively to harvest a larger area of coverage.

RESULTS

When the nasoseptal flap was not available or was useless, we adopted septal floor rotational flaps based on ethmoidal arteries to repair skull base defects. According to the different locations of leak, we adopted anterior ethmoidal artery pedicled flaps or posterior ethmoidal artery pedicled flaps.

We retrospectively analyzed a series of 19 cases of skull base defects that were repaired using these types of flaps from the posterior wall of the frontal sinus to the lateral recess of the sphenoidal sinus (Table I). All flaps survived, and no CSF leak occurred or recurred during 3 months to 4 years of follow-up. None of the patients developed necrosis of the flap after adjuvant radiotherapy, and thus far there are no recurrences of malignant diseases. Only the patient with postoperative CSF leak after pituitary tumor surgery and meningitis underwent epistaxis two times as well as dysfunction.
DISCUSSION

Expanded endonasal approaches have significantly improved the way that we treat skull base malignancies and CSF leak. One of the consequent challenges is how to choose an appropriate graft to reconstruct the skull base defects for an impermeable dural seal. Since NSF became the workhorse for the reconstruction of skull base defects, EEA has been further improved. Previous reports have proved that reconstruction of large anterior skull base defects without pedicled flaps has a causal relationship with a high rate of CSF leak. However, NSF may be unavailable during a surgical approach if the vascular pedicle has been damaged by tumor or by a previous procedure. In addition, the NSF is not always competent due to its limited posterior blood supply, especially when the defect is on the posterior wall of the frontal sinus.

An anterior ethmoidal artery pedicled flap may be considered preferentially when the defect is located on the posterior wall of the frontal sinus. Because this flap is pedicled on the cribiform plate, the flap is more flexible than the NSF to rotate forward. When the sphenopalatine artery is invaded by tumor or when a trans-pterygopalatine fossa approach is needed to reconstruct lateral sphenoid recess leak, the posterior nasal septal artery must be sacrificed. This leads to the unavailability of NSF. In some cases, late-occurred CSF leak on sella may also require a replacement for NSF when prior transsphenoidal approaches have destroyed the posterior nasoseptal artery. In these cases, the superior pedicled rotational flap can serve well as a replacement.

When searching for an ideal flap, we should consider the flap’s dimension, pedicle, and flexibility, as well as convenience of use. The rate of flap survival, efficacy of the watertight seal, and proportion of complications should be considerations in the evaluation. In view of all aspects just discussed, a flap based on the ethmoidal arteries is an excellent candidate. In our analysis of 19 cases, septal floor rotational flaps based on ethmoidal arteries are easy and convenient to harvest and have proved to be a robust and reliable pedicle flap that can be used to repair defects in certain cases.

CONCLUSION

Septal floor rotational flaps based on ethmoidal arteries are excellent alternatives for NSF in reconstruction of the skull base. Ethmoidal arteries pedicled flaps are qualified in locations ranging from the posterior wall of the frontal sinus to the lateral sphenoidal recess and in cases ranging from tumor invading the pterygopalatine fossa to sellar late-occurred leak after transsphenoidal surgery. The flaps can provide a large coverage area with a robust blood supply, which ensures the survival rate of the flap and the success rate of the CSF leak reconstruction.

BIBLIOGRAPHY


