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Skull base reconstruction with pedicled nasoseptal flap: Technique, indications, and limitations

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ABSTRACT

Endoscopic skull base surgery allows extensive tumor resection but results in large defects requiring robust dural repair. The vascularized nasal septal flap pedicled on the posterior nasal septal artery is known to have an excellent success rate for dural defect coverage. Detailed step-by-step descriptions of the harvest and placement of this flap are scarce. Using a sketch, images, and a video, we describe a detailed method for endoscopically harvesting and placing a nasoseptal flap (NSF). We also describe the indications and the decision process leading to the use of NSF.

1. Introduction

Endoscopic nasal surgery has evolved tremendously in recent years due to advances in endoscopic instrumentation and neuronavigation. The expanded endoscopic approach to the skull base has allowed access to intracranial and extracranial lesions that were previously deemed unreachable via this route. Yet, at the same time, the expanded endonasal approaches create large cranial base defects, and this connection between the intracranial space and the sinonasal cavity can be the cause of major complications, such as cerebrospinal fluid (CSF) leaks and meningitis.

Small skull base defects can be effectively reconstructed using a variety of avascular techniques. However, in the case of larger surgical defects, these closure techniques, employing fat grafts, lyophilized dural graft, or fascia lata graft, show a relatively high CSF leak rate.

For over a decade, the use of a pedicled nasoseptal flap (NSF), based on the posterior nasal septal artery for skull base reconstruction, as described previously (Hadad et al., 2006), along with a multilayer closure technique, has diminished the risk of postoperative CSF leaks and morbidity associated with extended endoscopic skull base approaches (Zanation et al., 2009, 2011). Nevertheless, we found the literature lacking in step-by-step descriptions of the harvest and placement of an NSF. Here we share our experience of the implementation of this technique, which over a short period of time led to a decrease in potential complications. We stress important points on preoperative planning, intraoperative decision making, harvesting, and placing.

2. Material and Methods

The interventions were performed using the two-surgeon single or bi-nostril technique, involving concomitant dissection by the otolaryngologist and the neurosurgeon. The general idea was to prepare for closure from the very beginning of the intervention.

Patients were intubated and placed in a supine position. The head was fixed in a Mayfield clamp. Navigation by preoperative computed tomography (CT) scanning and magnetic resonance imaging (MRI) was used to localize landmarks such as the sphenopalatine foramen and the roof of the ethmoid bone, especially in cases where a pathological process had modified normal anatomy and/or impinged clear visualization.

Depending on the location of the lesion, extension of the head was increased or decreased. The more anterior the lesion, the more extension was needed, using a slight reverse Trendelenburg.

The thigh was systematically prepared for fat and/or fascia lata or illio-tibial tract harvesting if needed.

The nasal septum was bilaterally infiltrated with 1% lidocaine mixed with 1:200,000 epinephrine. All patients received antibiotics (cefazolin) 30 min before the incision.

The infiltration was initiated in the most anterior portion of the septum with gentle lateral displacement of the columella under

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strict arterial pressure surveillance. Cotonoids with 1:1000 adrenaline were placed above the middle turbinate, between the middle turbinate and the inferior turbinate and under the inferior turbinate in each nasal fossa in order to achieve good decongestion. A 0° endoscope was used at the beginning of the procedure.

In cases where the use of NSF was certain (see Indications below), we began with a posterior septal incision — starting below the sphenopalatine pedicle to the floor of the nasal fossa and then anteriorly (first incision) and then between the sphenoid ostium and the roof of the nasal fossa, and then anteriorly (second incision) (Figs. 1, 2 and 5). A diathermy ball-tipped needle was used to cut the mucosa, taking care not to injure the sphenopalatine artery around the sphenopalatine foramen. With gravity causing the blood to run from anterior to posterior, it was decided to begin with this initial posterior incision rather than a secondary posterior incision, to avoid blood falling from the vascularized NSF into the surgical field. The first incision was carried all the way anteriorly, parallel to the floor of the nasal cavity, until it reached the muco-cutaneous junction. In the second incision, if olfactory function had to be preserved, dissection remained below mid-height of the middle turbinate and 1 cm below the cribriform plate. The last incision was carried anteriorly to connect the inferior and superior incisions (Fig. 3). This procedure can be performed under direct vision, with nasal speculum and fiber-optic light, or with the endoscope.

The whole flap was then elevated from anterior to posterior, remaining attached to the sphenopalatine pedicle. The NSF was either placed in the nasopharynx or into the maxillary sinus if it was opened (Fig. 4). During surgery, the NSF was taken into account when entering and removing instruments in the sphenoid sinus, because the flap pedicle was located in the infero-lateral part of the surgical field when the endoscope was placed in the ipsilateral nostril. This video shows a step-by-step technique for harvesting a left-side nasoseptal flap: https://youtu.be/GLzWrgg8CiQ.

When the resection was complete, three layers of biocompatible material were placed in the defect before placing the flap. The first layer was intradural; the second layer was intracranial and extradural. (In cases where viable bone was preserved in the approach, either from the middle turbinate, the nasal septum, or the sphenoidal rostrum, it was used as an effective and resistant natural barrier to CSF outflow.) The third layer was extracranial.

To lower intracranial pressure, pulmonary hyperventilation was used during the placement of the NSF. The perichondrial face of the

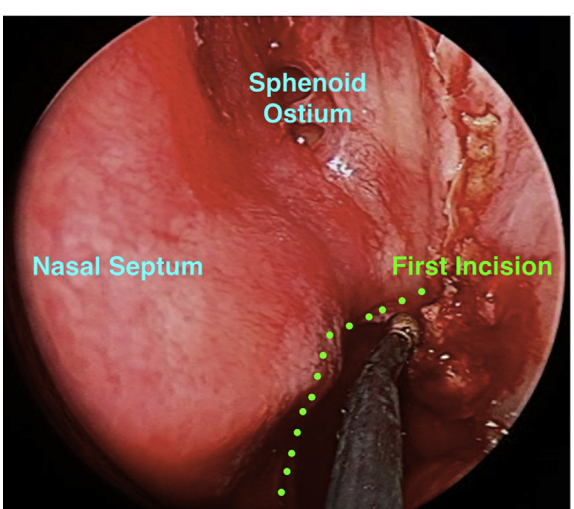

Fig. 1. First incision of nasoseptal flap.

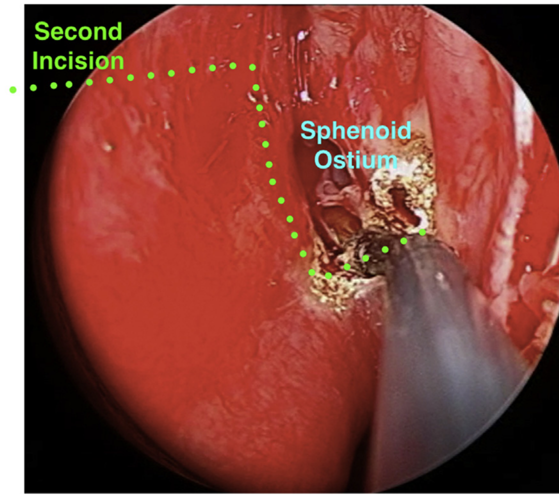

Fig. 2. Second incision of nasoseptal flap.

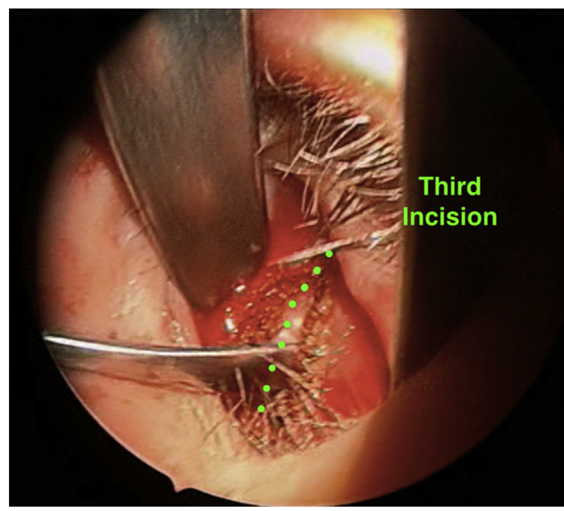

Fig. 3. Third incision and detachment of the nasoseptal flap.

Fig. 4. Placement of the nasoseptal flap in the nasopharynx.

NSF was identified by its white and nacreous aspect, and then placed on the defect using the four-hands technique. Primary adherence of the NSF was better when placed on a bare, bony surface. The flap was held in place with TachoSil® and/or fibrin glue

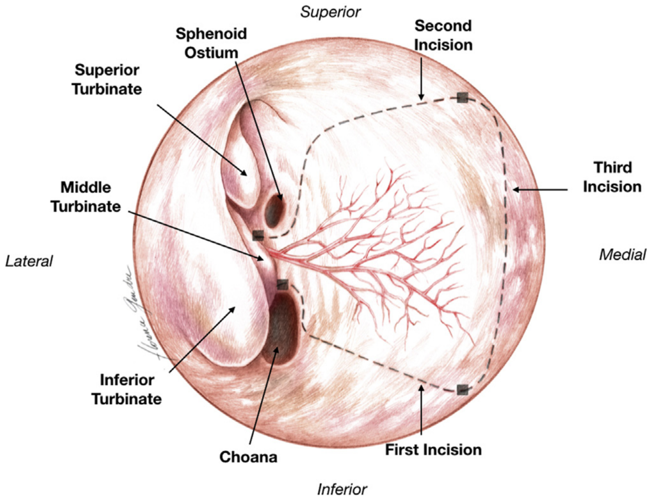

Fig. 5. Endoscopic illustration of the anatomy and three incisions of a nasoseptal flap harvested on the right nasal fossa septum.

sealant. This created a strong primary attachment. We avoided twisting the NSF, so as to leave a large part of the flap freely ascending in the nasal cavity. If possible, we tended to bring up the flap against the defect with a major contact with the lateral part of the surgical area to keep the flap moist. If the flap was freely ascending in the nasal cavity it could desiccate and retract, and expose the defect.

In order to avoid major synechiae, silastic plates were placed between the medial part of the inferior turbinate and the septum, and sutured to the anterior part of the septum. Nasal packing was not necessary for this procedure.

From the first postoperative day onwards, the nose was gently washed with saline until day 14, when the silastic plates were unstitched. Patients were asked not to blow their nose for the first 14 days after surgery. Lumbar drains, acetazolamide, or repeated lumbar punctures were not necessary.

If we were not sure of the need for an NSF in specific cases, for example with small pituitary adenomas, we could just use the first part of the second incision in order to unveil the sphenoidal rostrum and allow access to the sphenoid sinus. This technique is called a ‘rescue flap’, because if the surgeon decides that an intraoperative CSF leak needs to be closed with a vascularized flap, the NSF can be fully harvested with the two other incisions. If not, the mucosa can just be placed back onto the septum.

3. Results

3.1. Indications: preoperative assessment

Different parameters were taken into account before performing any endonasal surgery. This included evaluation of the risk of high-flow CSF leak during surgery, the risk of high intracranial pressure, the possibilities of watertight repair, and the risk of inadequate natural mucosal healing (Zanation et al., 2009).

CSF flow during surgery depended mostly on two parameters: the size of the attended skull base defect and the number of natural barriers broken down (Patel et al., 2010).

The size of the skull base defect could be preoperatively estimated, based on the area of tumoral extent on preoperative CT and/or MRI. We also considered the necessity of clear margins and dura resection (Nunes et al., 2016). The more natural barriers violated, the more significant the CSF leaks can be. Finally, the probabilities of arachnoid layer and ventricular system opening had to be taken into account. Considering skull base lesions, T2-weighted images on MRI could indicate whether the arachnoid layer was still patent or if it was crossed by the lesion. If there was still a thin CSF film, then the pia mater was probably intact. If not, then the pia could be transgressed. If there was a brain parenchyma T2 hyper signal or pial T1 gadolinium enhancement, pia mater was probably violated (Eisen et al., 1996; Singh et al., 2013).

The risk of postoperative high intracranial pressure was correlated with obesity and respiratory diseases. Obese patients have a higher abdominal pressure, with repercussions for central venous pressure and intracranial pressure. Obese patients are thus more prone to postoperative CSF leaks (Garcia-Navarro et al., 2013; Ivan et al., 2015). Coughing fits also raise central venous pressure and intracranial pressure.

The possibility of watertight repair also depended on the location of the pathological process, the size of the defect, and the expected possibility of inlay placement in the dural defect. In the anterior skull base, inserting an inlay above the orbits was feasible, whereas it was more complicated in the most lateral part of the roof of the sphenoidal sinus.

The patients' healing capacity was also considered. This was lower in elderly patients, in patients with diabetes mellitus, and in those who had received immunosuppressive chemotherapy or preoperative radiotherapy (Tien et al., 2016).

3.2. Indications: intraoperative assessment

During the endoscopic endonasal surgery, one of the first steps in penetrating the sphenoidal sinus was what is known as a ‘rescue flap’. This involves the posterior–superior freeing of the nasal septum mucosa (only during the second cut). In doing so, if a high-flow CSF leak was recognized during surgery, we only had to free the rest of the nasal septum for reconstruction. If there was no leak or minimal leak that could be treated with avascular technique, the mucosa was simply repositioned against the nasal septum.

In practice, the need for an NSF could be evaluated during surgery on an individual basis. A CSF leak was considered high and NSF necessary in cases where CSF was still present, despite single-layer avascular closure, hypoventilation, and 20° head elevation for 5 min. In these cases, a full NSF was harvested.

4. Discussion

This NSF technique may be limited in cases of major tumoral involvement of the septum. If there is only minimal involvement of the septum, an NSF can be used, provided that the mucosa is cut away from the tumoral margin. A frozen section of the most proximal part of the flap relative to the lesion can be performed to rule out mucosal involvement.

In cases of major septal deviation, we selected the widest nasal fossa for the harvest, because harvesting the NSF in an exiguous fossa can be a tedious process, especially in the upper part. In cases of septal spur, there was a risk of tearing the mucosa while elevating the NSF. The drawbacks of NSF use were the possibility of nasal synechiae and nasal obstruction if postoperative care was insufficient.

The NSF technique has made the team more confident about a lower risk of postoperative CSF leaks and meningitis, so we have progressively shifted from open microsurgical procedures to endoscopic procedures for some lesions, for example giant macroadenomas, meningiomas, and skull base traumatic CSF leak.

Almost every procedure was carried out using a four-hands, binostril technique, with an ENT surgeon and a neurosurgeon working together throughout the surgical procedure. Reconstructions of the skull base were mostly performed by the neurosurgeon. Our results suggest that this NSF approach is readily feasible.

2. Conclusions

We have produced a detailed and up-to-date description and diagram of nasoseptal flap harvesting and placement, which may be of use to any clinician interested in skull base reconstruction.

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Conflict of interest

The authors declare that there were no conflicts of interest.

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