Long-Term Effectiveness of a Reconstructive Protocol Using the Nasoseptal Flap After Endoscopic Skull Base Surgery

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Key words
- Cranial base
- Endonasal
- Endoscopic skull base surgery
- Minimal access
- Minimally invasive
- Nasoseptal flap
- Skull base reconstruction

Abbreviations and Acronyms
ASB: Anterior skull base
CSF: Cerebrospinal fluid
MRI: Magnetic resonance imaging
NSF: Nasoseptal flap

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OBJECTIVE: **To describe the effect on postoperative cerebrospinal fluid (CSF) leak after anterior skull base (ASB) surgery and complications associated with the addition of the vascularized nasoseptal flap (NSF) to an existing reconstruction protocol.**

METHODS: **A prospective database of all patients undergoing endoscopic ASB approaches was reviewed. Patients were divided into three groups based on the date the use of the NSF was adopted. Group A included patients with high-volume CSF leak closed using the NSF in addition to a multilayer closure. Group B included patients operated on during the same time period with no high-volume leak and no NSF. Group C included patients operated on before the adoption of the NSF with all types of CSF leak. Rates of intraoperative and postoperative CSF leak were analyzed for statistical significance.**

RESULTS: **Of 415 consecutive patients undergoing endoscopic ASB surgery, there were 96 in group A, 114 in group B, and 205 in group C. CSF leak rates in group A (3.1%) and group B (2.6%) were significantly lower than in group C (5.9%; $P < 0.05$). Lumbar drains and the gasket seal closure were performed more frequently in group A (75% and 32%) compared with group B (21% and 12%) and group C (28% and 11%). NSF carried a 2% risk of postoperative mucocele.**

CONCLUSIONS: **The addition of NSF to an algorithm for multilayer closure can decrease the rate of postoperative CSF leak.**

INTRODUCTION

Endoscopic endonasal approaches to the anterior skull base (ASB) have been criticized as having high rates of postoperative cerebrospinal fluid (CSF) leak. Early methods of reconstruction relied on local flaps, free tissue reconstruction, and artificial materials (3, 11, 12, 18). More recently, several techniques have been developed to reduce this risk, including the gasket seal (9), the button closure (10), direct suturing of graft material (4), and the vascularized nasoseptal flap (NSF) (7).

The NSF is a pedicled regional flap with an axial blood supply derived from the posterior septal branches of the sphenopalatine artery. The substantial length and wide arc of rotation of the NSF allows for intranasal coverage of various ASB targets (8). Several reports have described favorable rates of postoperative CSF leak using the NSF and other vascularized reconstructive techniques (8, 6, 17, 20). Modifications to the NSF have been described in detail by various authors (2, 13, 15). In our center, we adopted the use of the NSF as an additional step in a defined ASB closure algorithm, depending on the pathology and the expected size of the skull base defect, in combination with other closure techniques. The NSF was added to our closure algorithm at a specific point in time, after which it was used for all patients who met the inclusion criteria. Before that point, the algorithm did not include the NSF, which gives us an opportunity to evaluate the efficacy of adding the NSF to our closure algorithm. To our knowledge, the direct comparison of a large series of NSF reconstructions with other reconstruction techniques after endoscopic ASB surgery has not been previously reported. We present long-term data on NSF reconstruction from a large-volume center with regard to indications, outcomes, and complications.

METHODS

A prospectively collected database of all endoscopic endonasal approaches to the ASB performed by the senior authors (V.K.A., T.H.S.) at a tertiary referral center between December 2003 and April 2011 was reviewed. Data on ASB reconstructions were divided into three groups. Group A consisted of all cases that incorporated the NSF for reconstruction. Group B included all cases in which we did not use the NSF concurrent with the cases

accumulated in group A. Group C included all cases that occurred before the adoption of the NSF. Approval for this study was obtained from the institutional review board of the senior authors' academic institution.

All patients underwent a complete preoperative outpatient evaluation by a neurosurgeon and a rhinologic surgeon and an endocrinologist and neuro-ophthalmologist when indicated. Preoperative office-based video-assisted nasal endoscopy was performed to identify the presence of anatomic nasal obstruction and to assess for intranasal tumor extension. Magnetic resonance imaging (MRI) of the brain with gadolinium was performed to assess tumor size, determine resectability, and assist in planning the surgical approach.

Surgery was performed in accordance with endoscopic operative approaches as previously described (16). A team approach that included a neurosurgeon and rhinologic surgeon was used in all cases. On the morning of surgery, all patients underwent repeat MRI of the brain with navigation protocol to assist with intraoperative localization (BrainLab Inc., Westchester, Illinois, USA). Lumbar puncture or lumbar drain placement was performed before the start of each procedure as described subsequently. Intrathecal fluorescein was injected at this time to assist with localization of an intraoperative CSF leak and to ensure a watertight closure (19). Perioperative antibiotics consisted of cefazolin for extraarachnoidal tumors and encephaloceles, and triple-antibiotic prophylaxis for selected larger tumors and tumors requiring extensive meningeal resection (1). Rigid straight and angled Hopkins rod endoscopes (Karl Storz, Culver City, California, USA) with video-capture capability were used for the entire procedure. Partial inferior turbinectomy and posterior septectomy were performed in all patients to provide access for the surgical instruments. After tumor resection, a multilayer reconstruction of the ASB defect was performed in all cases.

Our center uses the following algorithm. Since the adoption of the NSF in March 2008, all patients in whom a large-volume, grade 3 CSF leak (5) is anticipated undergo harvesting of a flap. Patients with intradural tumors such as meningiomas, craniopharyngiomas, and chordomas with intradural extension as well as large macroadenomas that extend >1 cm above the jugum sphenoidale undergo harvesting. For large pituitary tumors, an extended approach is generally used including a transtuberculum transplanum approach with extracapsular dissection. Closure for pituitary tumors is performed with a fat graft to close the dead space within the enlarged sella, followed by a piece of Medpor (Stryker, Newnan, Georgia, USA) to keep the graft in place, the NSF, and a final layer of DuraSeal (Covidien, Mansfield, Massachusetts, USA). For intradural tumors, the algorithm begins with an intracranial fat graft to close the dead space, followed by a gasket seal closure, in which a fascia lata onlay graft slightly larger than the defect is held in placed with an inlaid piece of Medpor, which is covered by the NSF and DuraSeal. For encephaloceles and meningoceles, we place an inlay of DuraGuard (Synovis, St. Paul, Minnesota, USA), which is covered by a small piece of fat, the NSF, and DuraSeal. Whenever possible, a lumbar drain is placed preoperatively, which remains open for 24–48 hours and drains at a rate of 5 mL per hour.

In some patients in group A, a lumbar drain was not placed because of technical difficulties or for fear of subdural hematoma where significant brain atrophy was noted. Additionally, some patients who might otherwise have been included in group A were instead placed in group B; these included patients in whom the NSF could not be created because of the absence of a septum or in whom the NSF was not harvested because a large-volume leak was not anticipated. However, most patients in group B were patients with small pituitary macroadenomas and microadenomas and patients with extradural pathology. These patients generally had no CSF leak or a small leak. Group C consisted of the same types of patients as group A and group B but in whom the NSF was not used in the closure. This group included patients operated on earlier in our series but who had both small and large leaks and both intradural and extradural pathology.

The technique for NSF reconstruction was performed as previously described (**Figure 1**) (7, 13). Nasal packing was limited in all cases to a folded Telfa sponge (Covidien) in each nostril to minimize postoperative nasal discharge.

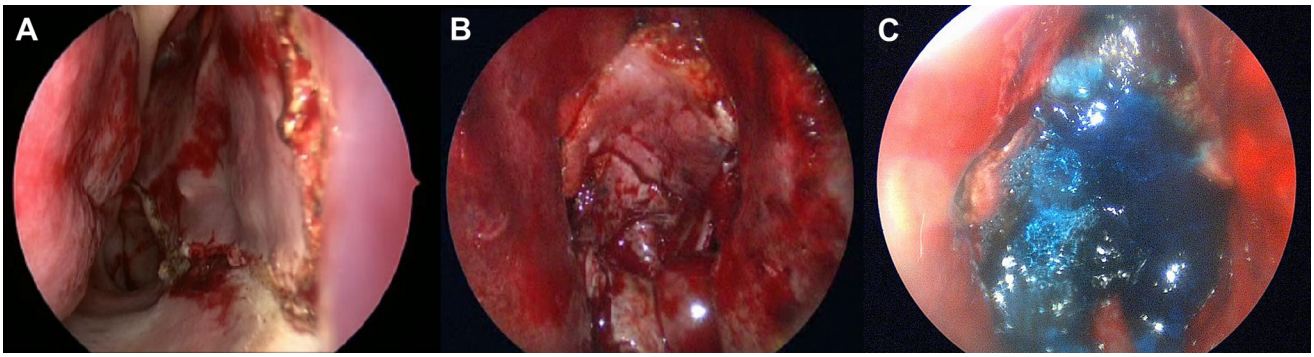

Figure 1. (**A**) Endoscopic appearance of a right-sided nasoseptal flap before flap elevation, showing incisions. (**B**) Endoscopic appearance of the same flap after insetting over a sellar and suprasellar defect. (**C**) Final appearance of reconstruction after application of DuraSeal (Covidien, Mansfield, Massachusetts, USA).