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Nasoseptal Flap Closure of the Eustachian Tube for Recalcitrant Cerebrospinal Fluid Rhinorrhea

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INTRODUCTION

Recalcitrant cerebrospinal fluid (CSF) rhinorrhea after vestibular schwannoma surgery can be a challenging complication.1–6 CSF rhinorrhea can occur following retrosigmoid, middle fossa, or translabyrinthine approaches with approximately equal frequency, and represents a dural breach of CSF transmitted via the eustachian tube (ET) to the nasal cavity. Many postoperative CSF leaks can be successfully managed with conservative measures, such as bedrest and lumbar drain placement. However, as many as 41% ultimately require surgical intervention.7 In the absence of serviceable residual hearing, the first-line surgical approach typically involves transotic external auditory canal (EAC), middle ear, and ET obliteration with fat, muscle, and/or bone wax. Second-line treatment for refractory cases may include additional mastoid obliteration or ventriculoperitoneal (VP) shunt placement.8 For intractable cases of CSF rhinorrhea, endoscopic transnasal techniques for ET closure have also been introduced, including cautery of the ET orifice, suture closure, closure with acellular dermal matrices, or combinations thereof.9–11 However, these methods have proven to have variable levels of success. The pedicled nasoseptal flap (NSF) was first described in 2006 for closure of anterior skull base defects.12 Based on the posterior septal branch of the sphenopalatine artery, the NSF offers significant advantages over traditional free graft techniques, including preserved vascularity, a broad anatomic reach, and a large potential area of coverage. The NSF has become the workhorse reconstructive technique for repair of skull base defects in endoscopic anterior skull base surgery, decreasing postoperative CSF leak rates from greater than 20% to less than 5%.12–14 Here, we describe the application of the NSF for endoscopic endonasal closure of the ET for recalcitrant CSF rhinorrhea following lateral skull base surgery for vestibular schwannoma.

MATERIALS AND METHODS

Two patients with persistent CSF rhinorrhea after retrosigmoid resection of a vestibular schwannoma were offered an endonasal closure of the ET using an ipsilateral NSF.

Case 1

Patient 1 was a 59-year-old woman who underwent a retrosigmoid approach for resection of a 3.2-cm left vestibular schwannoma. She had intermittent CSF rhinorrhea for 2 weeks despite conservative measures including lumbar drain placement. She subsequently underwent middle ear obliteration and transotic closure of the ET with temporalis muscle. She had temporary resolution of symptoms, but 3 months later had recurrent symptoms of CSF rhinorrhea. A VP shunt was then placed 4 months postoperatively. Despite optimal control of CSF pressures, the patient continued to leak intermittently and was then referred to our clinic 7 months postoperatively.

Case 2

Patient 2 was a 64-year-old woman with a 4.0-cm right vestibular schwannoma who developed CSF rhinorrhea 1 week after undergoing a retrosigmoid approach for resection. Despite conservative measures, she continued to leak, and at 1 month postoperatively she underwent EAC closure, middle ear obliteration, and transotic ET closure with bone wax and temporals muscle plug. Although she had temporary resolution of symptoms, she presented with a relapse of CSF rhinorrhea 6 months later, and underwent revision ET and middle ear obliteration with bone wax and temporals muscle grafting. One year later, she again had recurrent CSF rhinorrhea and underwent placement of a VP shunt. Despite a functional shunt, she had continued CSF leakage and was referred to our clinic.

Surgical Technique

**Step 1: raising the NSF.** Prior to raising the NSF, the ET opening was first identified with CSF leaking from its...
Technical details of raising the NSF have been previously well described. Under visualization with a 0° endoscope, the NSF was outlined on the ipsilateral side of the CSF leak using a needle-tipped monopolar electrocautery. The pedicle of the NSF containing the posterior septal artery was defined by parallel incisions above the choana along the rostrum of the sphenoid and along the posterior nasal septum at the level of the natural os of the sphenoid sinus (Fig. 1).

A septal flap measuring approximately 6 × 8 cm was demarcated by electrocautery and elevated in a submucoperichondrial and submucoperiosteal plane in continuity with the pedicle. The flap dimensions were measured and planned to provide adequate length to completely cover the ipsilateral torus tubarius. Once elevated, the NSF was rotated and adequately stored in the contralateral nasopharynx to prevent inadvertent injury during preparation of the ipsilateral recipient bed.

**Step 2: Preparation of the Recipient Bed.** A microdebrider (0° and 40° blades, unidirectional setting at 12,000 rpm) was used to de-epithelialize the mucosal surface of the torus tubarius, fossa of Rosenmuller, medial pterygoid plate, posterior nasal floor, and nasal surface of the lateral soft palate. Special care was taken when de-epithelializing over the medial pterygoid plate to not injure a branch of the sphenopalatine artery. The torus tubarius musculature and posterior one-third of the inferior turbinate was also partially resected with the microdebrider to provide an extended, flat surface for adherence of the septal flap. The medial 1 cm of the ET orifice was then de-epithelialized circumferentially with a curette and microdebrider (Fig. 2).

**Step 3: Closure of the ET with NSF.** Prior to inserting the flap, the de-epithelialized ET orifice was occluded with a small abdominal fat graft wrapped in oxidized cellulose polymer (Surgicel; Ethicon Surgical Products, Somerville, NJ).

The NSF was then retrieved from the nasopharynx and rotated into position, taking care to ensure that there was complete contact of the flap to the de-epithelialized surface of the recipient bed, with particular attention to the region of the torus tubarius (Fig. 3). Posteriorly, the flap was then carefully
A flap was performed in this area, and the underside of the flap was noted to be the site of the leak. A focal re-elevation of the flap in this region, we presumed this site of subtle buckling. Although there was no visible fluorescein, the flap was noted to be viable and examination under anesthesia with placement of intranasal saline irrigations and that the flap was laying flat in a secure position. A fibrin sealant was placed over the edges of the flap. No nasopharyngeal packing was used and no lumbar drains were placed.

Postoperative Care
Both patients were discharged home on the day of surgery with instructions to limit lifting, bending, and straining for 1 week. Patients used saline sprays for the first postoperative week, followed by saline irrigations thereafter. Endoscopic examinations were performed at 1 week, 1 month, and 3 months postoperatively.

RESULTS
The NSF was successfully employed to resolve both cases of lateral skull base CSF leak after retrosigmoid resection of vestibular schwannomas. Patient 1 noted resolution of her CSF rhinorrhea immediately, and endoscopic examinations at 1 month and 3 months postoperatively demonstrated a well-healed and integrated NSF with complete closure of the ET (Fig. 4). She remained without evidence of leak to date, through 8 months postoperative follow-up. Patient 2 was dry immediately postoperatively but then presented with recurrent symptoms of CSF rhinorrhea at 4 weeks postoperatively and required a revision of the surgical closure. On endoscopic examination under anesthesia with placement of intrathecal fluorescein, the flap was noted to be viable and completely adherent to the lateral nasopharynx, but a small buckling of the flap over the medial pterygoid region was noted. Although there was no visible fluorescein in this region, we presumed this site of subtle buckling to be the site of the leak. A focal re-elevation of the flap was performed in this area, and the underside of the flap and the apposing nasal surface were freshened. The re-elevated portion of the flap was then repositioned to resolve the area of buckling. The patient recovered well and subsequently had no recurrence of leak through 5 months of postoperative follow-up.

DISCUSSION
The fundamental principle of skull base repair, regardless of the location or approach, is to separate the intracranial contents from the external environment, thus preventing CSF leak and ascending bacterial infections. Recalcitrant CSF rhinorrhea occurring after lateral skull base surgery can be challenging to treat, particularly when involving patients who have failed traditional neurotologic surgical methods. Endoscopic endonasal ET closure methods that have been previously described include ET cauterization, suturing, and packing with acellular dermal matrices. However, the success of these techniques has been variable. Although a report of three patients undergoing a combination of cautery and suture closure all had resolution of CSF rhinorrhea, a larger case series of nine patients, using the same technique with additional obliteration of the ET with acellular dermal matrices, reported failure in 3/9 patients. In patients who failed endonasal ET closure, revision external approaches were required to resolve the CSF leak.

We successfully applied the NSF technique for two cases of lateral skull base CSF rhinorrhea, refractory to standard repair methods, with complete resolution of the CSF leak in both patients. Both patients underwent several prior external procedures with continued relapse of leak after several months. It is possible that the avascular muscle grafts used for middle ear and ET obliteration underwent atrophy, resulting in the delayed leaks. Endonasal closure with the NSF may provide a minimally invasive approach, less likely to undergo atrophy due to its vascular supply.

The NSF also offers unique advantages in comparison with previously described ET closure techniques. The vascularized nature of the tissue flap enhances its viability and its ability to facilitate wound closure. The proximity of the NSF pedicle to the torus tubarius offers a favorable arc of rotation for flap design and insetting purposes. In addition, the NSF offers versatility in the size of flap raised, and thus is adaptable to varying extents of coverage as required. Although we chose to elevate the flap up front in our cases, an alternative would be to defer flap elevation until after preparation of the recipient bed. This alternative approach may minimize the risk of inadvertent flap injury associated with mobilization of a potentially large flap in and out of the nasopharynx.

Our use of a fat plug as an additional layer of closure at the meatus was derived from prior reports of successful closure techniques that incorporated a layer of fat as part of the closure. Given the robustness of the septal flap, we feel that the fat may in fact be superfluous and that the vascularized flap may be sufficient for successful closure. Alternatively, any number of biomaterials could also be considered as a substitute for the fat to avoid additional morbidity related to donor site harvesting.
As with any nasopharyngeal or eustachian tube procedure, the surgical outcome can be affected by technical factors. In our second case, postoperative shifting of the flap resulted in buckling of a small portion of the distal flap, creating a fistulous tract for CSF to escape. Despite the need for revision, the flap remained vascularized and viable, requiring only a minor adjustment to the position of the distal flap to secure complete apposition to the nasal surface. The irregular surface contours of the nasopharynx and posterior nasal cavity, along with the dynamic movement of the torus tubarius and soft palate musculature, may have contributed to subtle shifting of the flap. Movement of the torus tubarius and soft palate with swallowing and yawning poses challenges in healing not only for this flap closure technique but also for other techniques, such as suture ligation, where ongoing contraction of the eustachian tube musculature can destabilize suture placement.

To secure flap position, we have considered the use of packing such as a Foley balloon catheter or nonabsorbable nasal sponge. However, it is difficult to position nasopharyngeal packing to exert sufficient lateral pressure against the ET orifice without filling the entire nasopharynx. Extensive nasopharyngeal packing carries its own associated risks of aspiration of packing, as well as morbidities of impaired swallowing and patient discomfort. In weighing the risks and benefits of nasopharyngeal packing, we have elected to avoid packing to date, although such use could be considered.

Early results suggest that septal flap closure of the ET may be an effective salvage technique for patients with recalcitrant CSF rhinorrhea, although a larger case experience with longer follow-up times is needed.

CONCLUSION

We report a unique application of the NSF for endoscopic endonasal ET closure for recalcitrant CSF rhinorrhea arising from the lateral skull base with complete resolution in two cases.

BIBLIOGRAPHY