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What is This?
Endoscopic Nasoseptal Flap Repair of Skull Base Defects: Is Addition of a Dural Sealant Necessary?

Jean Anderson Eloy, MD1,2,3, Osamah J. Choudhry3, Mark E. Friedel, MD, MPH1, Arjuna B. Kuperan, MD1, and James K. Liu, MD2,3

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Abstract

Objective. We compared the incidence of postoperative cerebrospinal fluid (CSF) leaks in patients undergoing endoscopic skull base repair with a pedicled nasoseptal flap (PNSF) with or without the addition of a dural sealant.

Study Design and Setting. Retrospective analysis at a tertiary care medical center.

Methods. A retrospective analysis was performed at our tertiary care medical center on patients who underwent endoscopic repair of high-flow CSF leaks using a PNSF between December 2008 and August 2011. Repair materials, incidence of postoperative CSF leaks, and demographic data were collected.

Results. Thirty-two high-flow CSF leaks were repaired with a PNSF alone without dural sealant (group A), and 42 were repaired with a PNSF with the addition of a dural sealant (group B). In group A, there were no postoperative CSF leaks (0%), whereas in group B, there was 1 delayed postoperative CSF leak, resulting in a 2.4% leak rate. The incidence of postoperative CSF leakage was not significantly different between the 2 groups (P = .38). The overall postoperative CSF leak rate was 1.4%.

Conclusions. The use of dural sealants when performing endoscopic PNSF repair of high-flow CSF leaks is not supported by our data. In addition, this practice may significantly increase surgical cost. We encountered no postoperative CSF leaks in patients with high-flow CSF leaks treated with PNSF alone without dural sealants. Meticulous surgical technique and proper positioning of the PNSF seem to obviate the need for dural sealants during endoscopic skull base reconstruction of high-flow CSF leaks.

Keywords

skull base defect, nasoseptal flap, CSF rhinorrhea, tissue glue, CSF leak, dural sealant, endoscopic skull base surgery, endoscopic endonasal approach, dural defect, tissue sealant

Repair of high-flow cerebrospinal fluid (CSF) leaks after skull base surgery has been a challenge through the years. Numerous techniques, grafts, materials, tissue glues, and dural sealants have been used with various degrees of success.1-6 The goal of repair, however, has not changed and remains watertight closure with complete separation of the intra-arachnoid compartment from the sino-nasal cavity. To achieve such a vital goal, multilayered graft closure with or without the addition of a dural sealant has been promoted. Recently, the vascularized pedicled nasoseptal flap (PNSF) has gained significant popularity for endoscopic repair of skull base dural defects due to a recently reported decreased incidence in postoperative CSF leak.7-10 This technique allows repair of large skull base and dural defects with healthy vascularized tissue harvested from the mucoperichondrium and mucoperiosteum of the nasal septum. This flap, which is pedicled on the nasoseptal branch of the posterior septal artery, can be configured and sized in multiple fashions, allowing ample versatility. The PNSF is often combined with other grafting materials and dural sealants in our institution. Given the robustness and reported high success rate of these flaps, the purpose of this study was (1) to assess the necessity for dural sealant utilization when skull base defects with high-flow CSF leaks are repaired using the PNSF and (2) to determine our overall postoperative CSF leak rate using the PNSF.

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Materials and Methods

A retrospective chart analysis was conducted to identify patients who underwent skull base surgery with high-flow CSF leaks and dural defects repaired endoscopically with a PNSF between December 2008 and August 2011 in our tertiary care institution by the senior authors (J.A.E. and J.K.L.). Records of consecutive patients undergoing these procedures were evaluated for patient age, sex, diagnosis, surgical procedure, repair techniques, and postoperative CSF leak. All eligible patients in the chosen time frame were included in this study. The protocol for this study was reviewed and approved by the Institutional Review Board of the University of Medicine and Dentistry of New Jersey–New Jersey Medical School, Newark, New Jersey.

Study Population

A total of 74 consecutive patients with high-flow CSF leaks were repaired with a PNSF. These were divided into 2 groups. Group A included 32 leaks that were repaired with a PNSF alone without a dural sealant. Group B included 42 leaks that were repaired with a PNSF with the addition of a dural sealant (either Duraseal, Tisseel, or Evicel). The overall mean age was 49.8 years (range, 14-77 years). The mean age was 46.4 years (range, 14-75 years) in group A and 51.7 years (range, 15-77 years) in group B (P = .09). Seventy-one percent of the patients were females in group A, compared with 55% females in group B (P = .13). A summary of the patients’ diagnoses is listed in Table 1.

Statistical Methods

Statistical comparison between the 2 groups was performed using χ² analysis for categorical variables and Student t test for continuous variables. Two-tailed tests were performed for each scenario, and the significance level was set at P < .05. All analyses were performed using Microsoft Office Excel 2007 (Microsoft Corp, Redmond, Washington).

Surgical Technique

We typically harvest the PNSF at the beginning of the operation if a high-flow CSF leak is anticipated, such as in cases of transcribriform or tranplanum approaches for intradural lesions. After the approach and resection of the tumor, or after exposure of a skull base defect and leak site preparation, approximately 1 cm of mucosa is denuded around the skull base defect to prevent the possibility of developing a future intracranial mucocele from trapped intracranial mucosa. Inellar and parasellar repair, care is also taken to denude the sphenoid sinus completely, including the lateral recess, to prevent potential sphenoid sinus mucocele formation. In addition, this preparation of the bony edges of the defect optimizes adherence of the PNSF to minimize flap dehiscence.

The CSF leak is repaired by initially reducing a high-flow CSF leak to a low-flow CSF leak using either Gelfoam (Pharmacia, Kalamazoo, Michigan), autologous fat graft with or without Porex (Porex Surgical Inc, Newman, Georgia) implant, acellular dermal allograft (LifeCell Corporation, Branchburg, New Jersey), fascia lata, pericranium, or DuraGen (Integra LifeSciences Corp, Plainsboro, New Jersey). The PNSF is then rotated and carefully positioned over the skull base dural defect. A monolayer of Surgicel (Ethicon, Somerville, New Jersey) is then placed at the edge of the flap for apposition against the bone. At this juncture, a dural sealant (Duraseal or fibrin glue) is applied over the PNSF in group B patients. Group A patients did not receive a dural sealant. The decision whether or not to use a dural sealant was made based on the surgeon performing the closure. All closures performed by J.K.L. included a dural sealant, while those performed by J.A.E. did not use a dural sealant during closure. This was mainly based on surgeon’s preference and prior training. The PNSF is then bolstered by multiple large pieces (1- to 2-cm diameter) of gentamicin-soaked Gelfoam. This repair is further buttressed by a Merocel nasal tampon (Medtronic Xomed, Jacksonville, FL) covered with bacitracin ointment (Figures 1 and 2).

Postoperative Management

We routinely obtain a postoperative computed tomography scan of the head and parasinal sinuses within 24 hours and a magnetic resonance image within 2 days after surgery. Patients are maintained on postoperative antibiotics with a third-generation cephalosporin or a penicillin-based antibiotic with a β-lactamase inhibitor until the nasal packings are removed approximately 10 days after surgery. Patients are placed on stool softeners and are also asked to avoid straining, nose blowing, or any activity that raises intracranial pressure. We do not routinely use postoperative lumbar drainage because patients are already in a CSF hypovolemic state at the end of surgery to avoid complications of CSF hypotension. Absence of a lumbar drain allows patients to

Table 1. Diagnoses of 74 Patients Treated with a PNSF

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Group A (No Sealant)</th>
<th>Group B (Sealant)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pituitary adenoma</td>
<td>21</td>
<td>19</td>
<td>40</td>
</tr>
<tr>
<td>Meningioma</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Cranioopharyngioma</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Traumatic cerebrospinal fluid leak</td>
<td>—</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Olfactory neuroblastoma</td>
<td>2</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Adenoid cystic carcinoma</td>
<td>1</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Chordoma</td>
<td>1</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Melanoma</td>
<td>1</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Osteoblastoma</td>
<td>1</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Squamous cell carcinoma</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Teratocarcinoma</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Schwannoma</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Skull base osteomyelitis</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rathke clef cyst</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Basilar invagination</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Encephalocele</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>42</td>
<td>74</td>
</tr>
</tbody>
</table>
recover more quickly and mobilize sooner, thus avoiding thromboembolic and pulmonary complications. Patients were followed postoperatively with nasal endoscopy on an outpatient basis with minimal debridement to prevent manipulation of the repair.

**Results**

In group A, 32 high-flow CSF leaks were repaired with a PNSF alone without a dural sealant, whereas in group B, 42 were repaired with a PNSF with the addition of a dural sealant. The postoperative CSF leak rate in group A was 0%,
Compared with 2.4% in group B. There was no statistically significant difference in CSF leakage between the 2 groups (P = .38). The overall postoperative CSF leak rate was 1.4%. There were no complications of flap necrosis in either group. Table 2 illustrates a subgroup analysis of the patients. No significant difference was noted between the 2 groups for dural defect size (P = .84), percentage of revision surgery (P = .52), or morbid obesity (P = .90). The 2 groups were comparable for the number of sellar/sphenoid (P = .05), anterior cranial fossa/cribriform (P = .76), or clival/odontoid defects (P = .72). There was significantly more suprasellar/planum defects in group B compared with group A (P = .02). However, although the lone CSF leak in this cohort occurred in a patient with a suprasellar/planum defect in group B, a subgroup analysis comparing the different defect sites showed no significant difference in CSF leak regardless of the defect location.

The only leak in this series was in a patient who underwent primary resection of a craniopharyngioma through an endoscopic transplanum transtuberculum approach followed by PNSF repair with a dural sealant (group B). This patient was not morbidly obese, and her defect size was more than 1 cm². The patient presented with a delayed postoperative CSF leak that resulted in meningitis at 1-month follow-up shortly after outpatient endoscopic nasal debridement. This CSF leak was successfully repaired with revision endoscopic PNSF with a dural sealant using the same flap. She was treated with intravenous antibiotics without any postoperative neurologic sequelae.

### Discussion

In the past decade, endoscopic skull base surgery has evolved significantly due to the many advances in surgical instrumentation, optical devices with enhanced visualization, development of novel surgical techniques, and close collaboration between neurologists and otolaryngologists with a shared interest in endoscopic skull base surgery. Currently, many skull base tumors (both benign and malignant) previously thought inaccessible through an endoscopic endonasal approach are being successfully removed through this route.11-21 One key factor for successful endoscopic resection of skull base lesions is the development of numerous reconstructive techniques to repair the iatrogenic skull base, dural, and arachnoid defects using either autologous tissue, synthetic substitutes, or a combination of materials.1-6 In 2007, Germani et al reported on the use of acellular dermal allograft for repair of skull base defects with a success rate of 97% overall and 100% for large skull base defects (>2 cm). The recently introduced PNSF has been one of the most promising techniques, with success rates reported between 89% and 95%.7-10 Given the success with the PNSF, we have adopted this technique as our preferred method for closure of high-flow CSF leaks in our institution.

Our repair technique for reconstruction of high-flow CSF leaks using the PNSF consists of a multilayered closure with initial autologous and/or synthetic substitutes to transform high-flow CSF leaks into low-flow leaks, prior to PNSF rotation and apposition. We usually place Surgicel over the initial graft to prevent graft migration. After the PNSF is rotated into its final position, we use a second layer of Surgicel at the edge of the flap for apposition to the demucosalized skull base. Care is always taken to prevent trapping of sinus mucosa under the PNSF to prevent mucocoele formation and potential flap dehiscence. We also denude 1 cm of mucosa around the skull base defect prior to repair since intracranial mucocoele from a prior skull base repair with mucosa graft has been reported.22 In many cases, we use a layer of dural sealant based on the surgeon’s preference and previous experience.

In this study, we found no significant difference when a dural sealant was added to the PNSF (P = .38). No CSF leak occurred in any patients treated with a PNSF without the addition of a dural sealant (group A). One CSF leak occurred 4 weeks after surgery in a patient with a craniopharyngioma who had a primary transplanum transtuberculum skull base dural defect that was repaired with autologous fat, DuraGen, PNSF, and Tisseel fibrin glue. This CSF leak occurred shortly after debridement in the office and was successfully repaired with acellular dermal allograft, the previously used PNSF, and DuraSeal sealant. We postulate that this leak occurred because of overaggressive debridement that may have denuded the underlying skull base.

### Table 2. Subgroup Analysis

<table>
<thead>
<tr>
<th>Defect site</th>
<th>Group A, No. of Patients (% of Group)</th>
<th>Group B, No. of Patients (% of Group)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sellar/sphenoid</td>
<td>21 (65.6)</td>
<td>18 (42.9)</td>
<td>.052</td>
</tr>
<tr>
<td>Suprasellar/planum</td>
<td>3 (9.4)</td>
<td>14 (33.3)</td>
<td>.015a</td>
</tr>
<tr>
<td>Anterior cranial fossa/cribriform</td>
<td>7 (21.9)</td>
<td>8 (19.0)</td>
<td>.764</td>
</tr>
<tr>
<td>Clival/odontoid</td>
<td>1 (3.1)</td>
<td>2 (4.8)</td>
<td>.724</td>
</tr>
<tr>
<td>Dural defect &gt;1 cm²</td>
<td>31 (96.9)</td>
<td>41 (97.6)</td>
<td>.845</td>
</tr>
<tr>
<td>Revision surgery</td>
<td>3 (9.4)</td>
<td>6 (14.3)</td>
<td>.522</td>
</tr>
<tr>
<td>Morbid obesity (BMI &gt; 30)</td>
<td>11 (34.4)</td>
<td>15 (35.7)</td>
<td>.905</td>
</tr>
</tbody>
</table>

*aSignificant.*
have resulted in delayed flap dehiscence. This patient did not exhibit the typical risks factors for postoperative CSF leaks.

Our CSF leak rate was 2.4% when dural sealant was added to the PNSF, 0% without dural sealant, and 1.4% overall. Based on these findings, we can potentially say that in our experience, the addition of a dural sealant to the PNSF repair is not warranted. Therefore, we have begun to modify our practice in obviating the need for additional dural sealant. A healthy vascularized PNSF seems to be robust enough for almost all skull base defects when used appropriately without the addition of a dural sealant. Nonetheless, some have hypothesized that defects in the suprasellar/planum region may have an increased risk of non-significant difference in CSF leaks could be due to a beneficial effect of using a dural sealant in this subpopulation. However, a larger population of suprasellar/planum defects treated without a dural sealant would be needed to answer this question.

In the current climate where medical costs are continuously rising, the need for cost-effective medical techniques and practices is paramount. Many of the currently available dural sealants are costly. At our institution, 5 mL of Duraseal costs $2985.00, 5 mL of Evicel costs $644.53, and 10 mL of Tissueel costs $559.14. Given that the addition of dural sealant to the PNSF in this retrospective review does not decrease the rate of CSF leakage, one must question its necessity. Although we are not proposing for endoscopic skull base surgeons to stop a practice with which they are comfortable, we would like to raise the question of the role and place of dural sealants in endoscopic repair of high-flow CSF leaks when used in conjunction with a robust PNSF.

Our preliminary results suggest that the addition of dural sealants is not necessary when a PNSF is used in a multilayered fashion to repair high-flow CSF leaks. Nonetheless, we must caution against these early results. This study is subject to all the limitations of a retrospective study. Consequently, further prospective randomized controlled double-blinded studies should be performed to validate these findings. Furthermore, we believe that experience, familiarity, and technical skills play a significant role in closure of skull base and dural defects regardless of the method used. Metastatic multilayered closure with attention to detail should be the goal in these closures.

Conclusion
The addition of a dural sealant to a PNSF repair of skull base and dural defects with high-flow CSF leakage is not supported by our data. This practice does not decrease the incidence of postoperative CSF leakage and may increase surgical cost. We encountered no postoperative CSF leaks in skull base defects treated with the PNSF alone without a dural sealant. Metastatic surgical technique and proper positioning and buttressing of the PNSF seem to obviate the need for dural sealants during endoscopic skull base reconstruction.

Author Contributions
Jean Anderson Eloy, conception, design, acquisition of data, analysis and interpretation of data; drafting and revision of article; final approval. Osamah J. Choudhry, acquisition, analysis, and interpretation of data; drafting the article; final approval. Mark E. Friedel, acquisition of data, drafting the article, final approval. Arjuna B. Kuperan, acquisition of data, drafting the article, final approval. James K. Liu, conception, design, analysis and interpretation of data, revision, final approval.

Disclosures
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