Endonasal Endoscopic Repair of Cerebrospinal Fluid Leaks of the Sphenoid Sinus

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Background: Multiple reports have demonstrated the efficacy of the transnasal endoscopic repair of cerebrospinal fluid (CSF) leaks of the anterior cranial base. The literature, however, lacks a comprehensive clinical study specifically addressing the transnasal endoscopic repair of CSF leaks of the sphenoid sinus.

Objective: To ascertain the factors that significantly affect the surgical outcome after transnasal endoscopic repair of CSF leaks of the sphenoid sinus.

Methods: We retrospectively reviewed the medical records of all patients who underwent an endoscopic transnasal repair of CSF leaks of the sphenoid sinus at our teaching hospitals.

Results: Twenty-four patients with CSF leaks of the sphenoid sinuses that were repaired by the transnasal endoscopic approach were included in our study. Causes of the CSF leaks included trauma, surgery, neoplasms, and idiopathic causes. Obliteration was the most common technique used to repair the CSF fistulas (used in 15 [58%] of 26 procedures). Grafting materials included banked pericardium, mucosa, turbinate bone, and mucoperichondrium placed by underlay or onlay grafting or abdominal fat used to obliterate the sphenoid sinus. Twenty-two patients were successfully treated on the first attempt. A persistent leak in 2 patients with previously unrecognized high-pressure hydrocephalus was repaired during a second endoscopic surgery, quickly followed by ventriculoperitoneal shunting.

Conclusions: Assuming an adequate repair, other factors such as the cause, the size of the defect, the technique and material used to repair the defect, and perioperative management do not affect the surgical outcome significantly. Untreated high-pressure hydrocephalus can lead to a recurrence or persistence of the leaks and should be suspected in patients with posttraumatic, idiopathic, or recurrent CSF leaks.


THE POPULARIZATION of oncologic skull base surgery and endoscopic sinus surgery during the past 2 decades has produced more iatrogenic cerebrospinal fluid (CSF) leaks.1-3 Unintentional injuries from craniofacial trauma and transcranial neurological surgery are other common causes of CSF leaks.3,4

Initially, transcranial approaches were used to repair all CSF leaks. Extracranial approaches were subsequently developed and popularized.6 Continuing this trend, multiple reports indicating a high success rate for the transnasal endoscopic and/or microscopic repair of CSF fistulas have been published during recent years. Most of these reports, however, include a heterogeneous group of patients with CSF leaks that arise in various sites. Reports of transnasal endoscopic repair of CSF leaks of the sphenoid sinuses are limited to a few cases.

Cerebrospinal fluid leaks of the sphenoid sinus have their own features. Transcranial approaches to this area are extensive and associated with significant morbidity. Microscopic transseptal approaches may not provide direct visualization of the lateral walls (Figure 1). Thus, CSF fistulas at this site may not be visualized without angled-lens endoscopes. Furthermore, CSF fistulas in the lateral recesses may even require an extended sphenoidotomy approach through the pterygopalatine fossa (Figure 1 and Figure 2). Epidural (underlay) placement of the grafting material may not be possible in these cases because of the adjacent neurovascular structures. Obliteration of the sinus or the lateral recess is generally advocated for this reason.7

We present our experience with 24 patients with CSF leaks of the sphenoid sinus that were repaired using an endoscopic transnasal approach. We aimed to ascertain the effect of different factors, such as cause, associated disorders, grafting materials, surgical technique, size of the defect, and perioperative management, on surgical outcome.

METHODS

We retrospectively reviewed the clinical data of all patients who underwent an endoscopic...
transnasal repair of a CSF leak of the sphenoid sinus from January 1, 1989, to March 31, 2001. Patients with CSF leaks at other sites and/or leaks that were repaired using approaches other than transnasal endoscopic approaches were excluded from the study. Cerebrospinal fluid leaks created during pituitary surgery and those that were immediately repaired (ie, single-stage surgery) were not included in our study.

Clinical data were retrospectively analyzed for the characteristics of the patients, the CSF fistulas, the surgical technique used for the repair, and adjunctive therapies. These variables were correlated to outcome (closure of the fistula and morbidity). They included cause; associated medical problems; timing of the repair; size of the fistula; presence of high-pressure hydrocephalus (HPH); type of grafts and surgical technique used for the repair; type of fixator and perioperative management, including the use of nasal packing, a lumbar spinal drain, or a ventriculoperitoneal (VP) shunt; and the use of perioperative prophylactic antibiotics. Data were recorded and analyzed using computer software (Statistix; Analytical Software Co, Tallahassee, Fla). Univariate analysis was performed by the Fisher exact test.

**RESULTS**

**CHARACTERISTICS OF THE PATIENTS**

Between January 1, 1989, and March 31, 2001, 24 patients presented with a CSF leak of the sphenoid sinus. Our study population was composed of 16 male subjects (67%) and 8 female subjects (33%); their ages ranged from 12 to 72 years (mean, 31 years). Follow-up ranged from 6 to 126 months (mean, 36 months). Complications associated with the CSF leak (before the repair) included meningitis in 3 patients (12%), pneumocepha- lus in 3 patients (12%), and HPH in 4 patients (17%); 2 patients had more than 1 complication; there were no complications in 16 patients (67%).

**CHARACTERISTICS OF THE CSF LEAKS**

Causes of the CSF leaks included surgery in 9 patients (38%), unintentional injuries from trauma in 7 patients (29%), idiopathic or spontaneous causes in 7 patients (29%), and neoplasms in 1 patient (4%).

**CHARACTERISTICS OF THE ENDOSCOPIC REPAIR**

Methods that were used to identify the site of the CSF fistula included nasal endoscopy in 15 patients, a computed tomographic (CT) metrizamide cysternogram in 8 patients, and intraoperative intrathecal fluorescein imaging in 1 patient.

Of the 24 CSF leaks, 22 were repaired after some delay from their onset. Abdominal fat was the most commonly used grafting material. Other grafting materials included homologous pericardium, mucoperichondrium, hydroxyapatite cement, and middle turbinate bone. In addition, a septal mucoperiosteal flap was used in 2 patients. The type of surgical repairs included obliteration in 15 patients, overlay grafting in 9 patients, and underlay grafting in 2 patients. Various materials were used to fixate the grafting materials, including fibrin glue, an absorbable knitted fabric (Surgicel), an absorbable gelatin sponge (Gelfoam), and an absorbable gelatin film (Gelfilm) (Table).

Perioperative management for the 26 procedures (2 patients required revision surgery) included perioperative prophylactic antibiotics (used in 23 procedures [96%]), nasal packing consisting of gauze or a sponge (Merocel) (used in 18 procedures [69%]), a lumbar drain (used in 16 procedures [62%]), and a VP shunt (used in 4 procedures [15%]). The lengths of lumbar spinal drain-
Cerebrospinal fluid leaks of the sphenoid sinus may be the result of surgery, trauma, neoplasms, and HPH, or they may be idiopathic. Iatrogenic trauma is cited as the most common cause of sphenoidal CSF leaks in recent years.\textsuperscript{5,8-11} Our study showed a similar incidence of iatrogenic and posttraumatic leaks to that reported in the literature. In this study, iatrogenic trauma and unintentional injuries from trauma were the most common causes of CSF fistulas; they occurred in 16 (67\%) of the patients.

Idiopathic CSF leaks were also common in our series (occurring in 7 [29\%] of the patients). An idiopathic or spontaneous CSF fistula presumably results from some type of congenital defect of the skull base and/or HPH.\textsuperscript{12,13} Other less common, but important, causes of CSF leaks include erosive lesions of the skull base, such as mucocles, fungal sinusitis, osteomyelitis, brain cysts, and primary or metastatic intracranial or extracranial tumors. Tumors of the pituitary gland are common pretreatment complications of pituitary tumors; they occurred in 16 (67\%) of the patients.

Cerebrospinal fluid leaks of the sphenoid sinus have the potential to cause devastating intracranial complications, such as pneumocephalus, meningitis, brain abscesses, and seizures.\textsuperscript{15-17} Indeed, meningitis and pneumocephalus are common pretreatment complications of CSF leaks of the sphenoid sinus.\textsuperscript{14,17} In our patients, the frequency of complications arising from the untreated CSF leak was consistent with that reported in the literature. Meningitis and pneumocephalus developed in 3 patients each (13\%). Prompt treatment is critical to prevent these life-threatening complications.

**Surgical Outcome**

Twenty-two fistulas were successfully repaired by a single endoscopic transnasal surgery. The size of the defect (data available for 18 patients) was less than 1 cm in 10 patients (56\%) and 1 cm or greater in 8 patients (44\%). Two patients required a second endoscopic surgery to control a persistent CSF leak. The 2 persistent fistulas were associated with untreated HPH, which had not been recognized previously. Both CSF fistulas were successfully repaired with the second endoscopic surgery, followed by VP shunting. The first patient presented with an idiopathic fistula of approximately 1 cm in diameter, located in the lateral recess of the sphenoid sinus. The leak was initially repaired by obliterating the left sphenoid sinus with abdominal fat. Recurrence of the CSF leak was noted within a month after the repair, and the sphenoid sinus was reobliterated with abdominal fat. To measure the CSF pressure, a lumbar spinal tap was performed 2 weeks after the second repair, corroborating the presence of HPH. A VP shunt was inserted.

The second patient had a CSF fistula in the midline of the posterior wall of the sphenoid sinus (ie, the clivus). This patient was injured by an industrial air blast and experienced severe craniofacial trauma that fractured and displaced the anterior skull base and clivus in the sagittal plane. The fistula was 1 cm in diameter and was initially repaired by an overlay technique using turbinate bone and hydroxyapatite cement. A persistent leak was noticed, and the sinus was then obliterated with abdominal fat and fibrin sealant (Tissueel; Baxter Company, Vienna, Austria). Posttraumatic HPH was diagnosed by measuring the CSF opening pressure via a lumbar spinal tap within 72 hours of the second repair. A VP shunt was inserted in this patient also. Neither one of these patients has experienced a recurrence of the CSF leak.

Cross correlations between the recurrence of a CSF leak and the variables contained in our database were submitted to univariate statistical analysis (Fisher exact test). A positive correlation was found only between the presence of HPH and the recurrence of the leak ($P = .006$).

After our experience with these 2 patients, we decided to identify patients at risk for HPH (namely, those after skull base surgery, who suffered a closed head injury, and those who presented with spontaneous CSF leaks) and treat the HPH within the same hospitalization. This was performed by providing a temporary CSF diversion (ie, a lumbar drain after the repair), measuring the lumbar spinal opening pressure 3 to 5 days after the repair (the pressure will be low or normal during the early postoperative period), and immediate VP shunting if necessary. We applied this protocol in our last 2 patients, who presented with spontaneous CSF leaks. Both patients had HPH, and both underwent shunting successfully. Neither one has experienced a recurrence at a follow-up of 6 and 20 months, respectively.

### Characteristics of the Endoscopic Repairs

<table>
<thead>
<tr>
<th>Identification of the fistula*†</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Endoscopy</td>
<td>15 (62)</td>
</tr>
<tr>
<td>Computed tomographic cisternogram</td>
<td>8 (33)</td>
</tr>
<tr>
<td>Fluorescein imaging</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Timing of the repair*</td>
<td></td>
</tr>
<tr>
<td>Delayed</td>
<td>22 (92)</td>
</tr>
<tr>
<td>Immediate</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Type of material used for the repair‡§</td>
<td></td>
</tr>
<tr>
<td>Abdominal fat</td>
<td>15 (58)</td>
</tr>
<tr>
<td>Pericardium</td>
<td>4 (15)</td>
</tr>
<tr>
<td>Mucoperichondrium</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Hydroxyapatite cement</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Flap (septal mucosa)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Bone (middle turbinate)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Type of repair‡</td>
<td></td>
</tr>
<tr>
<td>Obliteration</td>
<td>15 (58)</td>
</tr>
<tr>
<td>Overlay graft</td>
<td>9 (35)</td>
</tr>
<tr>
<td>Underlay graft</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Type of fixator used for support‡§</td>
<td></td>
</tr>
<tr>
<td>Fibrin glue</td>
<td>10 (38)</td>
</tr>
<tr>
<td>Absorbable knitted fabric (Surgicel)</td>
<td>9 (35)</td>
</tr>
<tr>
<td>Absorbable gelatin sponge (Gelfoam)</td>
<td>9 (35)</td>
</tr>
<tr>
<td>Absorbable gelatin film (Gelfilm)</td>
<td>3 (12)</td>
</tr>
<tr>
<td>None</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Success*</td>
<td></td>
</tr>
<tr>
<td>First attempt</td>
<td>22 (92)</td>
</tr>
<tr>
<td>Second attempt</td>
<td>24 (100)</td>
</tr>
</tbody>
</table>

*The denominator used was 24.
†Percentages may not total 100 because of rounding.
‡The denominator used was 26.
§More than 1 type was used in some repairs.

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Comment

Cerebrospinal fluid leaks of the sphenoid sinus may be the result of surgery, trauma, neoplasms, and HPH, or they may be idiopathic. Iatrogenic trauma is cited as the most common cause of sphenoidal CSF leaks in recent years. Our study showed a similar incidence of iatrogenic and posttraumatic leaks to that reported in the literature. In this study, iatrogenic trauma and unintentional injuries from trauma were the most common causes of CSF fistulas; they occurred in 16 (67\%) of the patients.

Idiopathic CSF leaks were also common in our series (occurring in 7 [29\%] of the patients). An idiopathic or spontaneous CSF fistula presumably results from some type of congenital defect of the skull base and/or HPH. Other less common, but important, causes of CSF leaks include erosive lesions of the skull base, such as mucocles, fungal sinusitis, osteomyelitis, brain cysts, and primary or metastatic intracranial or extracranial tumors. Tumors of the pituitary gland are the most common neoplasms causing CSF leaks. Cerebrospinal fluid leaks of the sphenoid sinus have the potential to cause devastating intracranial complications, such as pneumocephalus, meningitis, brain abscesses, and seizures. Indeed, meningitis and pneumocephalus are common pretreatment complications of CSF leaks of the sphenoid sinus. In our patients, the frequency of complications arising from the untreated CSF leak was consistent with that reported in the literature. Meningitis and pneumocephalus developed in 3 patients each (13\%). Prompt treatment is critical to prevent these life-threatening complications.
Confirmation of the CSF leak is critical before commencing the treatment. Cerebrospinal fluid–related rhinorrhea may be suspected in the presence of a unilateral, watery, clear, nonsticky nasal discharge that is commonly associated with a headache. A gush of fluid that occurs with a forward tilt of the head suggests a collection of fluid in the sphenoid sinus. An intranasal endoscopic examination may help to corroborate the diagnosis and establish the site of the leak. A clear pulsatile fluid arising from the sphenoid ostium can be seen with a 30° to 70° rod lens or with flexible fiberoptic endoscopes.

Skull radiograms are minimally helpful and not cost-effective. However, they can show an intracranial aerocele, an opacified sphenoid sinus, an enlarged sella turcica, or an air-fluid level within the sphenoid sinus. A skull base defect is better demonstrated by high-resolution coronal and axial CT scans (Figure 2). A CT scan identifies the skull base defects in greater than 80% of the cases. Computed tomographic cisternography, using intrathecal metrizamide, is recommended to establish the site of a CSF leak that is not obvious on endoscopic or high-resolution coronal and axial CT evaluation.

Skull base defects can be repaired using unlay or overlay grafting or by obliteration of the sphenoid sinus using different types of grafting materials. An underlay technique involves inserting the grafting material a few millimeters between the bone and the dura on all sides of the defect. If there is a risk of damaging nerves and vessels while dissecting the dura from the surrounding bone or while inserting the graft (ie, at the lateral wall of the sphenoid sinus), an overlay graft may be used. To complete this technique, the mucosa around the defect is removed and a free tissue graft is placed over the dural tear and is then secured with some type of fixator.

Different types of autologous or homologous materials, such as middle turbinate bone or mucosa, fascia lata, a septal mucoperichondrial graft, temporalis fascia and acellular dermal grafts, and rectus abdominis fascia, can be used as free grafts to repair a CSF fistula of the anterior cranial base. Fascia lata and middle turbinate mucoperiosteal grafts are most commonly advocated. However, poor visualization, particularly of the lateral aspect of the sphenoid walls, may prevent proper placement of the graft. Obliteration of the sinus, alone or in combination with an overlay graft, is generally preferred to close the defect. Abdominal fat, muscle, hydroxyapatite cement, or acellular dural grafts can be used for obliteration. In our study, most of the CSF fistulas of the sphenoid sinus were repaired by obliteration of the sinus after thorough removal of the mucoperiosteum. The use of different grafts was based mainly on the surgeon’s preference, availability of the material, and ease of use. The most commonly used grafting material was autologous abdominal fat (used in 15 [58%] of the repairs).
In addition, fibrin glue, an absorbable gelatin film, an absorbable gelatin sponge, and an absorbable knitted fabric were used to support or fixate the grafting material.

The size of the defect did not seem to affect the success rate in our study. Defects larger than 2 cm were closed successfully on the first attempt, whereas revision cases consisted of defects that approximated 1 cm in their greatest dimension. A mucosal or composite graft may be used, based on the size of the defect, for CSF leaks of the fovea ethmoidalis or cribiform plate. However, obliteration of the sinus regardless of size of the defect is the most commonly used technique by many surgeons for CSF fistulas of the sphenoid sinus.14,18

Perioperative management after surgical repair of the CSF leaks is important to prevent complications and promote healing of the repair. It includes the use of nasal packing, the administration of perioperative prophylactic antibiotics, and the insertion of a lumbar spinal drain or a VP shunt. Perioperative prophylactic antibiotics are recommended for skull base surgery.20 Perioperative prophylactic antibiotics were used in 23 (96%) of the patients in our study. Indications for a postoperative lumbar drain are not clearly defined in the literature. Lanza,17 Mao,2 and Wormald14 and colleagues used a lumbar drain postoperatively after the repair of the CSF leak. On the other hand, others13,19,20 reported a similar success rate without using a lumbar spinal drain. In our series, a lumbar drain was used only if HPH was suspected (in 16 patients). Our results support the notion that a lumbar drain is not routinely necessary for the successful closure of CSF leaks.

The literature14,10,14,12,11 supports a high success rate, between 83% and 100%, for the endoscopic repair of CSF leaks of the sphenoid sinus. Our success rate was 92% (22 of 24 patients) after a single endoscopic repair, and the remaining 2 CSF fistulas (8%) were repaired during a second surgery. The type of grafting material, the type of repair, the size of the defect, perioperative management, and the cause of the CSF leak did not correlate with the recurrence of the leak. We found a significant correlation only between the presence of HPH and the recurrence of the CSF leak.

High-pressure hydrocephalus is defined as overaccumulation of CSF within the ventricular system, with a resultant increase in intraventricular pressure. High-pressure hydrocephalus may be the result of a subarachnoid hemorrhage due to trauma, stroke, or surgery. In addition, HPH could be the result of obstruction of the arachnoid villi, which absorb the CSF, as a result of infection or posttraumatic fibrosis. Untreated HPH in adults may present as cognitive changes, gait difficulty, balance problems, headaches, or visual problems due to optic nerve edema or paralysis of the abducens nerve (cranial nerve VI). In patients with CSF leaks, the subarachnoid space is decompressed by the fistula; thus, these symptoms are usually absent. Cerebrospinal fluid diversion after surgical repair decreases the CSF pressure in these patients, allowing healing of the reconstructive technique during the early postoperative period. An alternative treatment protocol would be to repair the leaks in all patients without concern for the presence of HPH, and to study and place a shunt in only those who experience a recurrence with the CSF leak. Although reasonable under certain circumstances (eg, patient’s choice and temporary HPH), this may subject the patients to the risk of a recurrent CSF leak and the effects of HPH. Causative factors, particularly those associated with HPH, must be identified for the planning of proper adjunctive management.

In conclusion, CSF leaks of the sphenoid sinus may cause serious complications; therefore, once a diagnosis is established, the defect must be repaired. The transnasal endoscopic approach is the easiest way to access the sphenoid sinus. A high success rate can be achieved with minimal morbidity using an endoscopic transnasal approach. Obliteration with abdominal fat is most commonly used for the repair of a CSF fistula of the sphenoid sinus, particularly in cases with limited visualization at the lateral wall of the sinus. Our study also suggests that grafting material and technique used for the repair, size of the defect, and perioperative management do not seem to affect the success rate. The only variable that correlated with the persistence or recurrence of the leak is the presence of HPH.

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