

Endoscopic cerebrospinal fluid leak closure in an infected field

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ABSTRACT

Background: Sinonasal cerebrospinal fluid (CSF) leaks during an active infection present the unique challenge of preventing spread of infection without compromising the integrity of the closure. We describe the technique and clinical course of patients undergoing endoscopic CSF leak repair in an actively infected field.

Objective: To evaluate the safety and efficacy of endoscopic CSF leak repair in an actively infected field.

Methods: Retrospective chart review of patients with sinonasal CSF leaks that were endoscopically repaired during an acute infection.

Results: Nine patients were identified. Etiologies of CSF leak were iatrogenic after endoscopic sinus surgery ($n = 5$, 55.6%) or revision craniopharyngioma resection ($n = 1$, 11.1%), spontaneous ($n = 1$, 11.1%), anterior skull base meningocele with CSF leak ($n = 1$, 11.1%), and posttraumatic ($n = 1$, 11.1%). The locations of the leaks were ethmoid in five patients, frontoethmoid in three patients, and sphenoid in three patients. Seven patients had acute sinusitis (77.8%) and two patients had meningitis (22.2%) at the time of closure. Two patients (22.2%) had failure of previous CSF leak closure. All leaks were repaired in a multilayered fashion with multiple graft types, including septal or conchal cartilage, temporalis fascia, fascia lata, fat, Medpor, and tissue sealant. Three patients additionally had mucosal flaps or grafts. The patients were treated with an average of 11.1 days (range, 6–14 days) of antibiotics. The average hospital stay was 4.1 days (range, 2–7 days), and the mean follow-up time was 8.7 months (range, 2.9–19.3 months). No patients experienced recurrence of CSF leak or postoperative complication or infection.

Conclusion: Endoscopic closure of skull base defects was successfully performed in nine patients during acute infections without complications, recurrent infection, or need for revision CSF leak closure. Endoscopic CSF leak repair appears to be safe and effective in patients with active infection with sinusitis or meningitis.

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Sinonasal cerebrospinal fluid (CSF) leak can occur as a result of various etiologies. Iatrogenic causes include surgical defects after resection of skull base lesions and incidental skull base injury during functional endoscopic sinus surgery (FESS). Sinonasal CSF leak can also occur spontaneously or after skull base trauma. Endoscopic closure of sinonasal CSF leak in a noninfected field is a standard procedure with high published success rates. However, the presence of an acute infection concurrently with CSF leak presents an additional challenge. Ideally, skull base defects should be closed expediently to prevent the risk of seeding the meninges with infection from the sinuses. For patients who already have meningitis, the optimal closure time remains to be determined. The safety and efficacy of closure of endoscopic CSF leak in an infected surgical field is not well described in the medical literature. The purpose of this study was to demonstrate the clinical course of a group of patients with CSF leak of various etiologies who underwent endoscopic closure during acute infection. Surgical technique is also described.

MATERIALS AND METHODS

Appropriate Institutional Review Board approval was obtained from Weill Cornell Medical College and George Washington University. The medical records of a consecutive series of patients undergo-

ing endoscopic closure of a CSF leak in an infected field were reviewed. All procedures were performed by the senior investigators (AS, TS, VA, AK) as a combined otolaryngologic and neurosurgical approach. Inclusion criteria were patients with nasal CSF leak of any etiology who had a concurrent infection, with sinusitis or meningitis. Patients were not excluded if they had a history of prior CSF leak closure. Records were reviewed for primary indications for procedure, type of procedure, graft materials, hospital course, and complications. Complications were defined as epistaxis that required intervention, persistent sinonasal or intracranial infection, or recurrent CSF leak.

A preoperative diagnosis of acute bacterial rhinosinusitis was made by clinical history and endoscopic findings based on published clinical practice guidelines for adult sinusitis requiring 10 days of purulent nasal drainage accompanied by nasal obstruction, facial pain/pressure, or both.¹ Nasal cultures have not been shown to correlate well with cultures obtained by direct sinus aspiration and were not required to diagnose infection.² Intraoperative diagnosis of sinusitis was based on endoscopic findings of mucosal inflammation with purulent drainage and was later confirmed with positive bacterial cultures.

Surgical Technique

A complete history, nasal endoscopy, and sinonasal imaging were performed routinely before the procedure. Depending on indications for surgery and etiology of CSF leak, endoscopic sinus surgery or removal of tumor was performed as necessary via an endonasal approach under general anesthesia. Sinuses were opened as necessary for identification and adequate visualization of the leak. If present, dead space in the defect was filled with autologous fat harvested from the abdomen in order to prevent CSF from pooling into the closure. The next layer consisted of fascia lata or temporalis fascia, although bovine pericardium or acellular dermis (Alloderm; LifeCell, Bridgewater, NJ) was used instead of fascia in some patients. This tissue graft was then centered such that it extended past the edges of the bony defect by at least 1 cm. A rigid graft roughly the size of the

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Table 1. Etiology and location of CSF leak

Case No.	Etiology	Diagnosis	CSF Leak Site	Infection	Repair Type
1	Iatrogenic	Pansinusitis after dental extraction	Ethmoid	Unilateral pansinusitis	Bovine pericardium, BioGlue
2	Postresection	Meningoencephalocele	Ethmoid	Meningitis	Abdominal fat, bovine pericardium, Medpor, middle turbinate flap, DuraSeal
3	Trauma	Skull base fracture after motor vehicle accident	Sphenoid	Meningitis	Temporalis fascia, conchal cartilage, fibrin glue, Floseal
4	Iatrogenic	Recurrent sinusitis after biopsy of ethmoid mass	Ethmoid	Ethmoid sinusitis	Temporalis fascia, conchal cartilage, fibrin glue, Gelfoam
5	Postresection	Recurrent craniopharyngioma	Sphenoid	Ethmoid, sphenoid sinusitis	Abdominal fat, fascia lata, Medpor, nasoseptal flap
6	Iatrogenic	Bilateral CSF leaks after failed transcranial repair of iatrogenic leak during FESS	Frontoethmoid, sphenoid, ethmoid	Ethmoid sinusitis	Abdominal fat, fascia lata, Medpor, DuraSeal
7	Iatrogenic	Iatrogenic during FESS	Frontoethmoid	Ethmoid sinusitis	Abdominal fat, DuraGen, DuraSeal
8	Spontaneous	Recurrent spontaneous CSF rhinorrhea after failed endoscopic repair, encephalocele, empty sella	Frontoethmoid	Ethmoid sinusitis	Abdominal fat, Alloderm, DuraSeal
9	Iatrogenic	Iatrogenic during FESS	Ethmoid	Ethmoid sinusitis	Abdominal fat, septal cartilage, mucosal graft, DuraSeal

defect was fashioned for the next layer by using either septal or conchal cartilage or Medpor (Stryker, Kalamazoo, MI). The rigid graft was centered over the tissue graft such that the tissue graft extended ~1 cm circumferentially around the rigid graft. The rigid graft was then countersuck into the bony defect to form a water-tight closure.³ A nasoseptal or turbinate flap, depending on the size and location of the defect and the leak flow rate, was sometimes used for an additional layer of closure.

The closure was then inspected for signs of CSF leakage. If leakage was present, the closure was redone. The area was then covered with tissue sealant, usually polymerized hydrogel (DuraSeal; Covidien, Mansfield, MA), followed by placement of nasal packing with either nonabsorbable Telfa packing (Covidien, Mansfield, MA) for 48 hours or bioresorbable packing with Nasopore (Stryker, Kalamazoo, MI).⁴ A lumbar drain was placed if a high-volume leak was present, as after resection of large skull base lesions. After closure, all the patients were treated with antibiotics and admitted to the hospital for observation.

RESULTS

Nine patients were identified. The study group consisted of five male (56%) and four female (44%) patients, and the mean age at the time of the procedure was 50.3 years (range, 36–70 years). Etiologies of CSF leak were iatrogenic following endoscopic sinus surgery ($n = 5$, 55.6%) or revision craniopharyngioma resection ($n = 1$, 11.1%), spontaneous ($n = 1$, 11.1%), anterior skull base meningocele with CSF leak ($n = 1$, 11.1%), and posttraumatic ($n = 1$, 11.1%). The locations of the leaks were ethmoid in five patients, frontoethmoid in three patients, and sphenoid in three patients. One patient had three separate skull base defects in the left frontoethmoid region, left planum sphenoidale, and right ethmoid skull base. The etiology and location of each CSF leak are summarized in Table 1.

All leaks were repaired in a multilayered fashion with multiple graft types, including septal or conchal cartilage, temporalis fascia, fascia lata, fat, Medpor, and tissue sealant. Three patients additionally had mucosal flaps or grafts. One patient had a middle turbinate flap after resection of an anterior skull base meningoencephalocele. A second patient had a nasoseptal flap after removal of a recurrent craniopharyngioma. A third patient had a mucosal graft placed during repair of an iatrogenic CSF leak in the right fovea ethmoidalis (Table 1).

Seven patients had acute sinusitis (77.8%) and two patients had meningitis (22.2%) at the time of closure. Of the seven patients with sinusitis, five patients were diagnosed preoperatively and two patients were diagnosed intraoperatively. One patient had a skull base fracture after a motor vehicle accident and subsequently developed meningitis. Another patient was diagnosed with an ethmoid meningoencephalocele after presenting with two episodes of meningitis. Two patients (22.2%) had failure of previous CSF leak closure. One patient had an iatrogenic CSF leak from endoscopic sinus surgery and had a prior failed transcranial repair performed at an outside institution. A second patient presented with a recurrent spontaneous frontoethmoid CSF leak after a failed endoscopic repair. Of the five patients with iatrogenic CSF leaks related to FESS or nasal biopsy, two patients were repaired during the same procedure when the leak occurred. One of the patients presented with facial pain and swelling secondary to pansinusitis after dental extraction and had injury to the ethmoid skull base just medial to the frontal recess. The second patient had an injury to the fovea ethmoidalis during FESS that was repaired immediately.

Culture information was available in six of nine patients (66.7%) and is summarized in Table 2. Patients were treated with an average of 11.1 days (range, 6–14 days) of perioperative and postoperative antibiotics. The average hospital stay was 4.1 days (range, 2–7 days),

Table 2. Patient culture information

Case No.	Infection Type	Culture Site	Culture Results
1	Sinusitis	Sinonsasal	<i>Candida albicans</i> , sparse <i>Viridans streptococcus</i> , few <i>Peptostreptococcus</i>
2	Meningitis	n/a	No culture information
3	Meningitis	Sinonasal Cerebrospinal fluid	Sparse coagulase negative <i>Staphylococcus</i> , sparse yeast <i>Acinetobacter baumannii</i>
4	Sinusitis	Sinonasal	Sparse coagulase negative <i>Staphylococcus</i>
5	Sinusitis	n/a	No culture information
6	Sinusitis	n/a	No culture information
7	Sinusitis	Sinonasal	<i>Staphylococcus aureus</i>
8	Sinusitis	Sinonasal	Methicillin-resistant <i>Staphylococcus aureus</i>
9	Sinusitis	Sinonasal	<i>Staphylococcus aureus</i> , <i>Klebsiella pneumoniae</i>

n/a = not applicable.

and the mean follow-up time was 8.7 months (range, 2.9–19.3 months).

Five patients (55.6%) had a lumbar drain placed intraoperatively. One patient (11.1%) with a history of obesity and spontaneous CSF leak had a ventriculoperitoneal shunt placed due to a large encephalocele and empty sella. One patient had a tension pneumocephalus on presentation. The remaining two patients had small, intraoperative iatrogenic CSF leaks and were managed without adjunctive methods to reduce CSF pressure. There were no complications in this series. No patients experienced epistaxis that required intervention, recurrence of CSF leak, ascending intracranial infection, or persistent postoperative infection.

DISCUSSION

Endoscopic CSF leak closure in an actively infected field presents a unique challenge. The safety and efficacy of repair during an acute infection is not well described in the literature. Patients in our series presented with CSF leak of various etiologies and a concurrent infection with either sinusitis or meningitis.

Endoscopic closure of sinonasal CSF leak in a noninfected field is a standard, accepted procedure, with most published series reporting success rates over 90% for primary repair of CSF leaks of all etiologies.^{5–7} Even without a concurrent infection, patients with CSF rhinorrhea have a risk of ascending bacterial meningitis from nasal flora. The risk of infection persists as long as a leak is active, but the overall occurrence of meningitis decreases with time from onset of leak.⁸ The risk of meningitis may also depend on the etiology of CSF leak, with traumatic head injury showing the highest rate of ascending infection in one series.⁸ The concern for intracranial spread of infection is potentially increased in the case of simultaneous acute sinus infection during an active CSF leak, although this risk has not been well defined in the literature. Furthermore, whether closure of a skull base defect can be performed successfully in a patient with acute sinusitis has not been previously well described in the literature.

A plausible concern is whether or not the chance of successful CSF leak repair will be decreased during infection. The technical difficulties associated with working with inflamed tissues could possibly impair the ability to achieve a good operative closure. Alternatively, the infection itself could potentially impact the healing process and prevent or delay closure of the leak. Another theoretical consideration is whether operating in the presence of infected sinus tissue could

actually facilitate the spread of infection by manipulating the skull base in an actively contaminated field. Acutely inflamed mucosa and tissue are frequently encountered during endoscopic sinus surgery. In our series, no additional intraoperative techniques were used because of the presence of acute infection. Particular care was taken to avoid traumatizing inflamed tissues and causing additional swelling or bleeding. Thrombin pledgets were routinely placed intraoperatively to assist in hemostasis and improve visualization. The presence of acute infection also did not impact repair technique, nor did it preclude the usage of a vascularized flap if deemed necessary, such as in the case of a high-flow leak.⁹ In addition, the surgical management of acute bacterial rhinosinusitis was not altered due to the presence of a CSF leak in either preoperatively diagnosed leaks or iatrogenic leaks during FESS. All sinuses that were identified as infected preoperatively or discovered to be infected intraoperatively were opened as indicated. Sinuses were also opened as necessary for adequate visualization and exposure of the skull base defect.

In our series, seven patients underwent closure of ethmoid, frontoethmoid, and sphenoid skull base defects during an acute sinus infection. The etiologies of CSF leak were iatrogenic trauma during FESS, postsurgical resection of recurrent craniopharyngioma, and spontaneous. In all the patients with sinusitis, infection was present near the site of the skull base defect (Table 1). There were no occurrences of recurrent CSF leak after repair. No patients had persistent sinus infection postoperatively, and none of the patients developed postoperative meningitis during the follow-up period. Endoscopic closure of a skull base defect during an acute sinus infection by using standard closure techniques was effective in this series of patients.

One patient with sinusitis presented with a recurrent spontaneous frontoethmoid CSF leak, which was successfully repaired with multilayered closure after a failed initial endoscopic repair. Psaltis *et al.*¹⁰ demonstrated a success rate of 94% in the endoscopic repair of 63 spontaneous CSF leaks when using a variety of repair techniques. The authors found that patients with spontaneous CSF leaks had thinner skull bases in the regions of the ethmoid roof, lateral lamella, and anterior face of the sella, as compared with patients with traumatic leaks and nonleaking controls. Although historically spontaneous CSF leak closure is associated with a higher failure rate, the investigators found their success rate to be comparable with the published 92% pooled primary success rate of endoscopic repair of CSF leaks of any etiology.¹⁰ The investigators postulated that their results along with other recent published high success rates for endoscopic repair of spontaneous CSF leaks may be related to improved recognition and management of elevated intracranial pressure with acetazolamide and lumbar drains, which were used in nearly 80% of patients.

Adjunctive methods for reducing CSF pressure are widely used to enhance repair, although the indications for their use have not been well defined. In a prospective randomized study, Albu *et al.*¹¹ evaluated the effectiveness of lumbar drains on recurrence rates in endoscopic repair of CSF leaks of multiple etiologies. The difference in success rates of initial repair between patients managed with lumbar drains (95%) versus those without lumbar drains (92%) was not statistically significant. Increased intracranial pressure was associated with leak recurrence, regardless of whether or not a lumbar drain was used. Lumbar drains were used in five of the nine patients in our study, and one patient had placement of a VP shunt. The major consideration used to assess the need for lumbar drain placement was leak flow rate, in addition to size of dural or bony defect, presence of preoperative CSF leak, and patient medical comorbidities. The effect of lumbar drains on operative success could not be assessed in our small sample size.

Two patients in our series presented with meningitis and CSF leak. In patients who already have intracranial infection, the pathology itself is often directly related to the patient having meningitis and should be addressed to manage the infection. One patient presented 5 days after a motor vehicle accident, with meningitis and a sphenoid CSF leak in conjunction with a skull base fracture. Patients with skull

base defects secondary to traumatic head injury have a known risk of meningitis and other intracranial infectious processes, *e.g.*, brain abscess. This ascending infection can occur both acutely or in a delayed fashion.^{12,13} Daudia *et al.*⁸ found that, although the cumulative risk of meningitis increased with the duration of leak, the incidence of episodes per year decreased over time, with the majority of cases occurring in the first year after onset of CSF leak. Other series have also shown that repair of CSF leak decreases the overall rate of infection, both in patients with and without a history of meningitis. However, it is unclear from these series whether any patients had acute meningitis at the time of the actual repair.^{7,14} Although a clear indication for closure exists in a patient with meningitis associated with an active posttraumatic CSF leak, the ideal timing for repair is debatable. The patient in this series underwent a successful endoscopic repair during an episode of meningitis.

A second patient presented with CSF leak and two episodes of meningitis secondary to a meningoencephalocele. With the improvement of closure techniques, the indications for endoscopic skull base surgery have expanded to include both benign and malignant lesions.¹⁵ Removal of these lesions can result in a sizable skull base defect postresection that can be successfully repaired in a multilayered fashion with previously described techniques.^{3,15} The efficacy of repair during an acute infection has not been previously addressed in the literature. The patient in our series presented with both a prior history of meningitis and an active infection at the time of CSF leak. Following endoscopic resection of a right cribriform meningoencephalocele, the resulting defect was repaired with fat, bovine pericardium, Medpor, a middle turbinate flap, and DuraSeal. The patient had no recurrence of meningitis or CSF leak at last follow-up.

The optimal timing for CSF leak closure in patients with either acute sinusitis or meningitis remains to be identified. Previous reports in the literature are limited. Tomovic *et al.*¹⁶ described a patient with MRSA sphenoid sinusitis that progressed to meningitis and central skull base osteomyelitis. The patient developed CSF rhinorrhea 5 days after endoscopic sinus surgery and underwent successful urgent endoscopic repair with an abdominal fat graft and pedicled nasoseptal flap. Iatrogenic traumatic CSF leak may occur during endoscopic sinus surgery when a patient has a simultaneous acute sinus infection. Two patients with acute sinusitis underwent immediate successful closure of a CSF leak that occurred during a FESS. In addition, two patients underwent immediate closure of a surgical defect in an infected field, including one patient with craniopharyngioma and another with an anterior skull base meningoencephalocele. These outcomes suggest that a leak that is created during an acute infection can also safely be closed at that time. However, at what point during the acute infection the closure should be performed is unclear. Two patients also underwent successful closure of recurrent leak after previous failed closure, including one patient with bilateral recurrent CSF leaks 1 month after failed transcranial repair, suggesting that revision surgery is not an exclusion criteria for repair during an acute infection.

Limitations of the study include the retrospective design and the small number of patients, which prevented statistical analysis of specific parameters. A larger sample size including more patients and more etiologies of CSF leaks is necessary to characterize the safety of and indications for this procedure. Patient identification for endoscopic closure in an infected field should incorporate multiple factors, including leak flow rate, culture results, size of defect, and location of skull base defect. Complete information, particularly culture information, was not available for all the patients in the current study.

CONCLUSIONS

Endoscopic closure was successfully performed in nine patients with CSF rhinorrhea secondary to either traumatic head injury, a postsurgical defect, iatrogenic injury, or spontaneous leakage. All the patients had an acute infection with either sinusitis or meningitis at the time of endoscopic repair. No patients experienced intraoperative or postoperative complications, persistent sinusitis, recurrent or ascending intracranial infection, or a need for revision CSF leak closure. Endoscopic CSF leak repair in an infected field appears to be safe and effective in patients with active sinusitis or meningitis. Future larger series are needed to further define the indications and limitations of this procedure.

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