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Endoscopic repair of frontal sinus cerebrospinal fluid leaks

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Abstract

Objective: To describe endoscopic management of frontal sinus cerebrospinal fluid (CSF) leaks.

Study design: Retrospective.

Methods: We reviewed all frontal sinus CSF leaks treated using an endoscopic approach at our institutions from 1998 to 2003. CSF leaks originated immediately adjacent to or within the frontal recess or frontal sinus proper for inclusion in the study. Data collected included demographics, presenting signs and symptoms, site and size of skull-base defect, surgical approach, repair technique, and clinical follow up.

Results: Seven frontal sinus CSF leaks in six patients were repaired endoscopically. Average age of presentation was 45 years (range 25–65 years). Aetiology was idiopathic (three), congenital (one), accidental trauma (one), and surgical trauma (two). All patients presented with CSF rhinorrhea; two patients presented with meningitis. Four defects originated in the frontal recess, while two others involved the posterior table and frontal sinus outflow tract. Four patients had associated encephaloceles. We performed endoscopic repair in all six patients with one patient requiring an adjuvant osteoplastic flap without obliteration. All repairs were successful at the first attempt with a mean follow up of 13 months. All frontal sinuses remained patent on both post-operative endoscopic and radiographic exam.

Conclusions: Endoscopic repair of frontal sinus CSF leaks and encephaloceles can be an effective method if meticulous attention is directed toward preservation of the frontal sinus outflow tract, thus avoiding an osteoplastic flap and obliteration. The major limiting factor for an endoscopic approach is extreme extension superiorly or laterally within the posterior table beyond the reach of current instrumentation.

Key words: Frontal Sinus; Endoscopic Surgical Procedures; Cerebrospinal Fluid

Introduction

Cerebrospinal fluid (CSF) leaks of the sinonasal cavity have been repaired with relatively high success rates using accepted endoscopic techniques for nearly 20 years.[1] In fact, a meta-analysis by Hegazy *et al*.[2] reported an overall success rate of 97 per cent after tabulating a decade of endoscopic repairs described in the literature. However, little has been published regarding repair of frontal sinus defects. The frontal sinus is the most technically demanding area of the sinonasal cavity in which to address pathology in an endoscopic manner. CSF leaks originating from the frontal sinus and the frontal sinus drainage pathway are difficult to repair endoscopically. The use of 70-degree endoscopes and giraffe instruments allows excellent access to the frontal recess, but post-operative stenosis, anatomic variability, and CSF leaks of the posterior table can make repair of these defects very challenging and push the limits of endoscopic repair.

Traditional external approaches to frontal sinus CSF leaks include osteoplastic flap with obliteration or cranialization. These approaches are designed to remove all functional sinus mucosa; thus frontal patency is not a concern. Endoscopic approaches to skull-base defects of the ethmoid roof, cribriform and some areas of the sphenoid sinus can also be approached with an obliterative type repair, where graft material and packing are placed without concern for maintaining patency of the affected sinus. In contrast, frontal CSF leaks must be approached keeping two goals in mind: (1) repair of the skull-base defect and leak cessation, and (2) maintaining patency of the frontal sinus.

This report outlines our experience and current treatment algorithm in endoscopic management of frontal sinus CSF leaks based upon the collective experience of the authors in treating this difficult problem.

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Materials and Methods

After obtaining institutional review board (IRB) approval, we retrospectively reviewed all cases of frontal sinus CSF leaks treated at our institutions from 1998 to 2003. CSF leaks originated either immediately adjacent to the frontal recess (requiring a complete frontal sinusotomy during repair), or within the frontal recess or frontal sinus proper for inclusion in the study. Data collected included demographics, presenting signs and symptoms, site of skull-base defect, surgical approach, repair technique, and clinical follow up.

Pre-operative evaluation of all patients consisted of a thorough history and physical examination, nasal endoscopic exam, and radiographic imaging. All patients had standard computed tomography (CT) and magnetic resonance imaging (MRI) performed. Frameless, stereotactic surgical navigation was used in all cases. Three-dimensional CT scans and triplanar reconstructions are useful for pre-operative planning and visualization of the skull-base defects, but not required.[3]

Although the technique for endoscopic management generally outlines those previously described,[4] endoscopic repair of frontal sinus CSF leaks is significantly more challenging than that of defects isolated to the ethmoid or sphenoid areas. Lumbar drains were typically used in all patients. This provides a means to measure intracranial pressure (ICP)[5] and the ability to inject intrathecal fluorescein. Pre-operative injection of intrathecal fluorescein is useful for localizing defects and inspecting for a watertight closure at the conclusion of the case. Fluorescein is not FDA approved for intrathecal injection, because seizures and neurotoxicity have been reported when using higher concentrations or more rapid injections. We have had no complications using a mixture of 0.1 cc of 10 per cent fluorescein diluted in 10 cc of the patient's CSF slowly injected over 10–15 minutes. We obtained informed written consent regarding the risks and benefits of intrathecal fluorescein and its lack of FDA approval in all patients. A blue light filter was used to improve the detection of dilute fluorescein when needed. Lumbar drains can be removed immediately post-operatively if the patient has normal intracranial pressure and a satisfactory repair has been performed. In cases of spontaneous CSF leaks and elevated CSF pressures, we typically leave lumbar drains in for 2–3 days post-operatively.

To obtain adequate anterior exposure, any agger nasi, accessory frontal cells, or residual bony partitions were removed with frontal giraffe instruments. A complete anterior ethmoidectomy and skeletonization of the skull base with through-cutting instruments was performed to provide ample exposure in the posterior aspect of the frontal recess. Turbinectomies, posterior ethmoidectomies, and maxillary antrostomies were performed when needed for exposure.

Using 0, 45, and 70 degree nasal endoscopes, any encephalocele encountered in the frontal recess was fulgurated with bipolar or suction monopolar cautery to the skull base. Upon identification of the bony skull-base defect, the graft site was prepared by removing a cuff of normal mucosa for at least 3–4 mm surrounding the defect. Next, larger bony defects (generally >6 mm) were reconstructed using septal or turbinate bone shaped to the defect and placed in an underlay fashion in the epidural space followed by an overlay soft tissue graft. Successful use of mastoid bone grafts has also been documented.[6] Overall, grafts may be free or pedicled, including alone or in combination, bone, mucosa, fascia, and irradiated cadaveric dermis. Care was taken to avoid entrapment of mucosa in the epidural space since this may lead to an intracranial mucocele. Following any bone grafts, a second layer of repair using temporalis fascia or nasal mucosa as an overlay graft was placed over the bony defect followed by Gelfoam and additional removable packs as needed for support.

Even with meticulous dissection and wide exposure of the frontal recess, the potential for obstruction of the frontal recess is high. To avoid this, we often placed a rolled silastic stent within the frontal recess for one week. Removable nasal packs, such as finger cots, placed inferiorly within the nasal cavity, were also removed at approximately one week post-operatively. After ensuring patency of the frontal sinus and all other dependent sinuses, no further debridement was performed in order to avoid disrupting the Gelfoam and/or grafting material.

Adjuvant therapy, particularly acetazolamide, was used in cases of documented elevation of ICP. This provides a method to medically reduce ICPs and may reduce recurrence rates.[7,8]

Results

Six patients underwent endoscopic repair of seven frontal sinus CSF leaks (Table I). Average age of presentation was 45 years (range 25–65 years). All patients presented with CSF rhinorrhea and two patients presented with meningitis. Aetiologies included three idiopathic CSF leaks, while the others included accidental trauma (one), surgical trauma (two), and congenital (one). Two of the idiopathic leaks appeared to be related to elevated ICPs, as measured via lumbar drains as previously described.[7] The third idiopathic leak had normal ICPs, but other accompanying anatomic abnormalities, i.e. facial dysmorphism and low-lying skull base, and may have been developmental. Four defects were limited to the frontal recess, while two others involved the posterior table with extension to the frontal sinus outflow tract. Four patients had associated encephaloceles. We performed endoscopic repair alone in five patients. One patient (Table I, patient no. 4) underwent a combined endoscopic approach and an osteoplastic flap without obliteration for a defect that extended from the superior apex of the posterior table down through the frontal recess and into the ethmoid roof. All repairs at our institutions were successful at the first attempt with a mean follow up of 13 months.

TABLE I

PATIENTS UNDERGOING ENDOSCOPIC REPAIR OF FRONTAL SINUS CSF LEAKS

Patient	Age (years)	Skull-base defect	Defect size (mm)	Aetiology	Repair	Months of follow up
1	38	Left FR	8 × 6	Idiopathic	Septal bone, mucosa & fibrin glue	14
2	36	Right FR	4 × 6	Idiopathic	Septal bone & mucosa	14
3	65	Left posterior FR, posterior table	6 × 10	Idiopathic	Septal bone, mucosa & fibrin glue	9
4	49	Right FR, posterior table	20 × 2	Accidental trauma	Temporalis fascia & osteoplastic flap	17
5	25	Right anterior cribriform, FR	1.5 × 1.5	Congenital	Temporalis fascia	15
6	57	Bilateral FR	7 × 14 and 4 × 7	Surgical trauma	Septal cartilage (left), septal bone (right), cadaveric dermis	9

FR, frontal recess.

Discussion

Anatomic sites

Based upon our experience, we now divide frontal sinus CSF leaks into three anatomic sites: (1) those immediately adjacent to the frontal recess; (2) those with direct involvement of the frontal recess; and (3) those located within the frontal sinus proper. While most leaks are limited to one of these distinct sites, some defects encompass multiple anatomic areas. This anatomic classification of skull-base defect sites is clinically relevant, as it often determines the surgical approach needed for repair.

Skull-base defects located in the anterior most portion of the ethmoid roof just posterior to the frontal recess do not directly involve the frontal sinus or its outflow tract. However, due to their close proximity, the frontal recess must be opened surgically to avert iatrogenic mucoceles from graft material, packing, or synechiae formation obstructing the outflow tract following repair.

A CSF leak that directly involves the frontal recess is one of the most difficult sites to approach surgically, because the superior extent of the defect may be difficult to reach endoscopically and the inferior/posterior extension of the defect may be difficult to reach from an external approach (Figures 1 and 2).

The final anatomic site for frontal sinus CSF leaks is within the frontal sinus proper involving the posterior table above the isthmus of the frontal recess. The limits of endoscopic approaches continue to expand with improved equipment and experience; however, defects located superiorly or laterally within the frontal sinus may still require an osteoplastic flap with or without obliteration. Additionally, frontal trephination and an endoscopic modified Lothrop procedure are adjuvant techniques that are useful for unique cases of leaks that are either located in the frontal sinus proper or possibly extend into the frontal recess itself. The specific approach depends upon the site and size of the defect, the equipment available, and surgical experience.

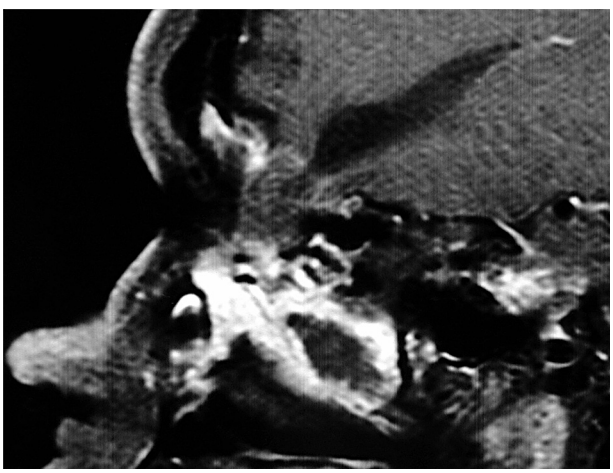

FIG. 1

T1 sagittal MRI scan reveals a skull-base defect originating from the frontal recess. Note the large encephalocele formation with herniation of frontal lobe and part of the lateral ventricle into the defect.

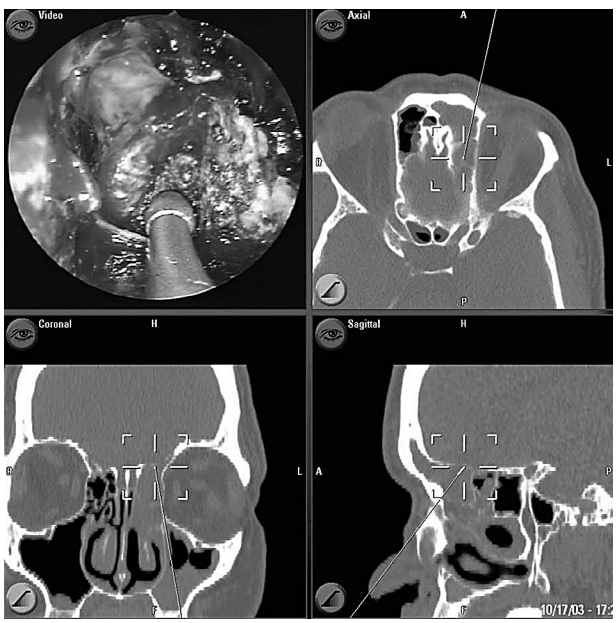

FIG. 2

CT imaging of the same patient with a skull-base navigation system reveals the bony detail and boundaries of the encephalocele intra-operatively. This shows the defect in the frontal recess at the transition of the posterior table of the frontal sinus from a vertical to a horizontal plane. The encephalocele has been meticulously ablated with bipolar cautery.

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Aetiology

Most CSF leaks can be broadly classified into traumatic (including accidental and surgical trauma), tumour, spontaneous, and congenital. These aetiologies influence the size and structure of the bony defect, degree and nature of the dural disruption, associated ICP differential, and meningoencephalocele formation. In particular, iatrogenic trauma and spontaneous aetiologies deserve special mention. As a surgical subspecialty, otolaryngologists perform procedures that are fraught with potential complications. We are the only surgical subspecialty trained to perform sinus surgery. In the age of endoscopic sinus surgery and powered instrumentation, the potential for creating skull-base defects is high. As otolaryngologists, the ability to handle our complications, such as repairing iatrogenic skull-base defects, should be a routine part of our armamentarium.

Patients with spontaneous, idiopathic CSF leaks frequently have elevated CSF pressure; this increases hydrostatic force at the weakest sites of the skull base. In the frontal sinus, spontaneous leaks rarely occur through the posterior table itself and are more likely to occur in the ethmoid roof or anterior cribriform plate immediately adjacent to the frontal recess. The elevated CSF pressures seen in this subset of patients lead to the highest rate (50–100 per cent) of encephalocele formation, and the highest recurrence rate following surgical repair of the leak: 25–87 per cent compared to less than 10 per cent for most other aetiologies.[9-11] Underlay bone grafts in these patients, and those with large skull-base defects, are particularly important, since they help prevent encephalocele herniation and disruption of the repair. In addition, we recommend lumbar drains and acetazolamide to lower documented elevation of the ICP.

FIG. 3

An endoscopic view of the frontal recess and skull base 6 months' post-operatively. This defect was repaired with an underlay septal bone graft and overlay free septal mucosa graft with fibrin glue. Here, the defect is well healed without evidence of encephalocele formation, and the frontal sinus drainage pathway is still intact following meticulous preservation of the mucosa.

Surgical approach/technical considerations

In all cases of frontal sinus CSF leak, the surgeon must keep in mind two goals. First and foremost is successful repair of the skull-base defect and cessation of the CSF leak. The second goal is patency of the frontal sinus or a successful obliteration with meticulous removal of all mucosa within the frontal sinus. Both goals must be kept in mind when deciding upon a specific surgical approach and repair for each skull-base defect.

The appropriate surgical approach varies depending upon the exact site and size of the defect, the equipment available, and the experience of the surgeon. Repairing frontal sinus CSF leaks via an endoscopic approach requires a thorough knowledge of frontal recess anatomy and its variants. All air cells encroaching on the frontal sinus outflow tract, such as agger nasi cells antero-laterally or suprabullar cells posteriorly, must be removed in their entirety to increase the chance of long-term frontal patency. At the same time, careful attention to preserving the mucosa surrounding the outflow tract will also increase long-term patency (Figure 3). Stripping the mucosa will ultimately lead to osteitic bone and scar tissue formation, and increase failure rates. Therefore, expertise with frontal giraffe instruments and angled scopes is indispensable for adequate visualization and operating efficiency.

Endoscopic repairs of frontal sinus CSF leaks may result in iatrogenic mucoceles if graft material and/or packing obstruct the frontal sinus outflow tract or contribute to synechiae formation and subsequent frontal sinusitis. After wide exposure of the skull-base defect through a wide frontal sinusotomy, an intra-operative judgment must be made regarding the ability to perform a successful CSF leak repair while maintaining patency of the frontal recess. Even in marginal cases, attempting endoscopic repair is generally recommended, since an open procedure can be performed at a later time if outflow tract obstruction ensues or the CSF leak recurs. When the defect approaches the midline, a modified endoscopic Lothrop procedure can increase surgical access and provide bilateral frontal sinus drainage if ipsilateral stenosis of the duct is expected from the repair. A patient with a skull-base defect extending through the isthmus of the frontal sinus outflow tract was particularly difficult to repair because this area was at the limits of an external osteoplastic approach from above and an endoscopic approach from below.

Although we discourage the use of hard stents to maintain frontal sinus patency secondary to an increased probability of reactive scar formation and osteitic bone formation, we have found soft silastic stents useful in maintaining patency, if the mucosa is preserved and the stent is gently placed in the frontal sinus outflow tract. In repairing frontal CSF leaks, this stent has the added advantage of helping

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maintain placement of the soft tissue overlay graft, especially when the skull-base defect is located in the vertical plane of the posterior table.

- **This paper reports the results of endoscopic repair of frontal sinus CSF leaks in six patients**
- **All repairs were successful at first attempt with a mean follow up of 13 months**
- **The authors emphasize the importance of meticulous attention to mucosal preservation of the frontal sinus outflow tract. The patency of the frontal sinus outflow tract can be maintained in the initial post-operative period with soft stents**

Role of external approaches

While the limits of endoscopic approaches continue to expand with improved equipment and experience, posterior table defects located beyond the reach of frontal sinus instruments superiorly or laterally to the sinus outflow tract still require an open approach. Often this is an osteoplastic flap with thorough removal of all mucosa and unilateral or bilateral obliteration (depending upon the size of the frontal sinus). Repairing a posterior table defect via an osteoplastic flap can be performed without obliteration if the defect is sufficiently superior or lateral to avoid compromising the sinus outflow tract. A well pneumatized frontal sinus with a defect in the lateral recess can be repaired via an osteoplastic flap or trephine without compromising the frontal recess. Since the potential for mucocele formation is significant regardless of surgical approach, close follow up is essential and must be emphasized to the patient.

Conclusion

While frontal sinus CSF leaks are difficult to repair endoscopically, we demonstrate that it is a safe, effective method with little morbidity if meticulous attention is directed towards preservation of the frontal sinus outflow tract. The major limiting factor is extension superiorly or laterally within the posterior table beyond the reach of current instruments. A thorough understanding of the underlying pathophysiology and fundamental principles of treatment will achieve the best possible results for patients.

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