Endonasal Endoscopic Closure of Cerebrospinal Fluid Rhinorrhea

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ABSTRACT

The authors review their experience with endoscopic repair of skull base defects associated with cerebrospinal fluid (CSF) rhinorrhea involving the paranasal sinuses. A total of 22 patients was treated endoscopically between 1992 and 1998. The repair method consisted of closure of the CSF fistula with a free autologous abdominal fat graft and fibrin glue, supported with a sheet of silastic. The primary closure rate was 82% (18/22), and the overall closure rate was 95.5% (21/22) without recurrence or complications within an average follow-up of 5 years (14–83 months). A single patient still complains of cerebrospinal rhinorrhea, although this was never proved by any clinical, endoscopic, or biological (β_2-transferrin) examination. The repair of ethmoidal-sphenoidal cerebrospinal fluid fistulae by endonasal endoscopic surgery is an excellent technique, both safe and effective. Fat is a material of choice, as it is tight and resists infection well. The technique and indications for endoscopic management of cerebrospinal fluid leaks are discussed.

KEYWORDS: Cerebrospinal fluid rhinorrhea, fat graft, endoscopic treatment, anterior cranial fossa, ethmoid, sphenoidal sinus, MRI cisternography

The management of cerebrospinal fluid (CSF) leaks has been a controversial topic from many points of view. The accurate localization of a CSF fistula presenting as rhinorrhea is an essential requirement for successful dural repair. Although the diagnosis of the CSF fistula is not a difficult task, the precise localization and surgical closure are much more difficult, depending mostly on its etiology and on the size of the osteodural defect. Craniofacial trauma is still the main cause of CSF rhinorrhea, representing 75% of cases. The relatively high morbidity and failure rate of an in-

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tracranial approach have led to a search for other methods. Extracranial approaches have been developed since the early 1980s but have not gained acceptance. Endonasal endoscopic techniques since the first reports by Wigand[1] and Stankiewicz[2] have been widely used, using different tissues for closure of the bony defect. More recently, several reports on limited numbers of patient have been published that describe different endoscopic techniques used to manage CSF rhinorrhea.[3–6] Since 1992, we have adopted the use of the free abdominal fat graft, introduced by Dodson et al.[7] in 1989. We present a retrospective review of 22 patients who underwent transnasal endoscopic repair of CSF fistulae during the past 6 years.

METHODS AND PATIENTS

Between February 1993 and January 1996, 22 patients underwent transnasal endoscopic repair for CSF rhinorrhea. There were 15 women and 7 men, ranging in age from 22 to 74 years (mean, 49 years). All patients had unilateral CSF rhinorrhea, and confirmation that the fluid was CSF was obvious in all patients but one who had a detection test by immunofixation of β_2-transferrin. The duration of CSF rhinorrhea before surgery is shown in Table 1. Three patients suffered from recurrent episodes of CSF rhinorrhea for longer than a 1-year period; one of these patients had recurrent CSF leakage over 30 years. Five patients had meningitis prior to diagnosis of a CSF fistula; two patients had recurrent meningitis. Six patients had spontaneous onset of CSF rhinorrhea, 10 patients had traumatic craniofacial injury resulting in prolonged CSF rhinorrhea, and six patients suffered from a CSF leak after surgery (three after transfrontal meningioma surgery of the anterior skull base, three after functional endoscopic sinus surgery).

Direct signs of fractures of the middle anterior skull base and indirect signs such as sinus cavities filling with soft-tissue material or fluid were sought in the 22 patients. MRI examination was performed in five patients with a 1.5-tesla Magnetom (Philips). The following parameters were used in most patients: TR 4000 ms, TE: 80–85 ms, a field of view of 20 × 20 cm, a slice thickness of 3 mm with no interslice gap, a 256 × 192 matrix. Acquisition included axial, coronal, and sagittal T_1-weighted, T_2-weighted, fast spin-echo (FSE) images, slow-flow MRI (SFMR) pulsing sequences and MRI cisternography (MRC). MRI was necessary to specify the extension of a meningioma of the anterior skull base (three cases), or meningoencephaloceles (three cases). Three patients underwent CT cisternography (Fig. 1). The location of the skull base defect was the sphenoid sinus in 10 patients, the fovea ethmoidalis in 9 patients, and the cribriform plate in three cases. Table

Table 1 Duration of Cerebrospinal Fluid Rhinorrhea (n = 22)

Rhinorrhea	No. of Patients
None	0
Repaired at time of iatrogenic procedure	2
7–14 days	4
14–30 days	8
1–6 months	4
7–12 months	1
>12 months	3

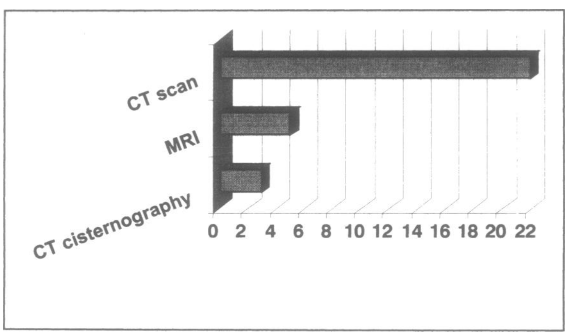

Figure 1 Preoperative imaging (n = 22).

Table 2 Comparison of Skull Base Defect Location by Cause

Neurosurgical		FESS		Spontaneous		Traumatic	
Anteromedial fovea	2	Anteromedial fovea	2	Posterosuperior sphenoid wall	3	Posterolateral fovea	2
Cribriform plate	1	Posteromedial fovea	1	Posterolateral sphenoid wall	2	Posterosuperior fovea	2
				Cribriform plate	1	Posterosuperior sphenoid wall	3
						Posterolateral sphenoid wall	2
						Cribriform plate	1
Total	3		3		6		10

2 details specific locations of the defects with respect to their causes.

Operative Technique

All patients were operated on by a single surgeon. Preoperative endonasal endoscopy was performed without intrathecal injection of 5% fluorescein. We operated on all our patients under general anesthesia. An intravenous injection of amoxicillin acid clavulanic was given during the induction of general anesthesia and 8 h later. Ethmoidectomy was conducted anterior to posterior, according to the usual technique. In isolated sphenoidal CSF, the sphenoid was accessed either by the direct approach through the sphenoidal ostium, or through the ethmoidosphenoidal recess. The opening was enlarged only to the point of adequate exposure, in order to provide the maximal anterior support to the graft.

Once the defect was identified, the mucosa remnants were carefully removed from the surrounding bone for at least 5 mm in all directions with small cupped forceps. A fat graft was harvested from the abdomen and carefully placed against the defect in the dura in the sphenoid or ethmoid area by means of fibrin glue, to secure the graft immediately. Care was taken to push the fat graft into the enlarged ostium of the sphenoid in much the same way as snuff (Fig. 2). The repair of the CSF leak in the fovea ethmoidalis and olfactory placoid was identical to the repair of sphenoid CSF leaks.

Additional support was established with a thick Silastic sheet (0.51-mm thickness, 5×2.5 cm), placed in the nasal cavity as a support for the lower part of the fat graft. Precise and careful placing of Silastic is probably one of the major steps of the surgery. Each foot of the Silastic sheet was applied against the floor of the nasal cavity (Fig. 3). Silastic combines the advantages of low cost, very good biocompatibility, and its elasticity supports and pushes the fat graft against the roof of the ethmoid or sphenoid very tightly. The nose was firmly packed with Merocel under the Silastic sheet.

Postoperative Care

Postoperatively, the patients were kept in bed with the head of the bed elevated. A lumbar drain was used for one patient for 7 days after surgery. The

Figure 2 The fat graft in place in the sphenoidal sinus after removal of the mucosa. Anatomic preparation on fresh cadaver head. Sagittal view.

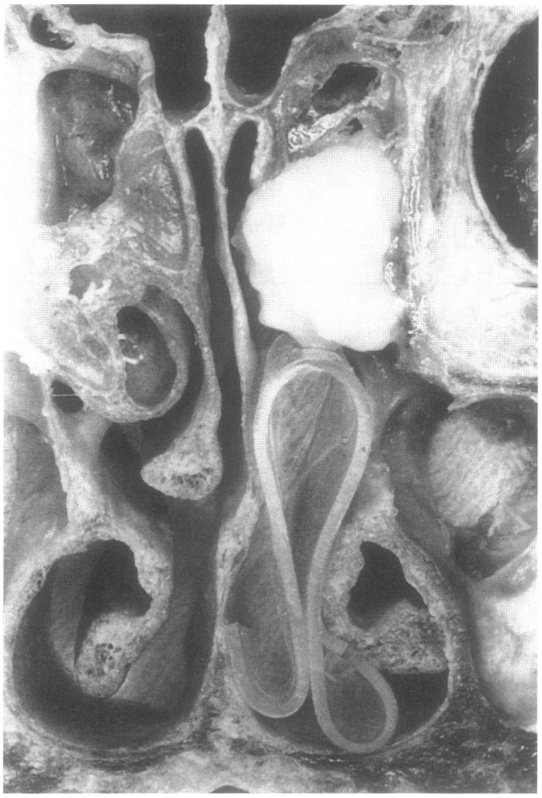

Figure 3 Silastic sheet supporting the graft. Anatomic preparation on fresh cadaver head. Coronal view.

nasal packing was removed after 4 days. Stool softeners were prescribed to reduce straining. The average hospital stay was 7 days for all patients but two remained hospitalized for prolonged periods for medical care unrelated to the repair of CSF leaks. There was no postoperative complication. Among patients who still had their sense of smell, none lost it after surgery. One month after surgery, the Silastic sheet which supported the fat graft was removed under local anesthesia, and the vitality and proper position of the fat graft were checked. Six months after surgery, a clinical endonasal examination and a CT scan were performed to check the fat graft, its retraction, position, and continuity with the sphenoethmoidal roof. The average follow-up period was 5 years (range 14 to 83 months).

RESULTS

Imaging in 20 out of 22 patients identified the CSF fistula and radiosurgical correlation was positive in 20 cases: the CT scan was positive in 19 out of 22 cases (86.4%), showing the bony defect, or an opacity into the sinuses corresponding to soft tissue or fluid filling. In one patient, MRI confirmed a CSF leakage through an empty sella suspected at the CT scan. In five patients, MRI provided the most useful information on soft tissue, after the localization of the fistula was identified by CT scan. Radionuclide cisternography was positive in two out of three cases. In these two cases, the CT scan showed indirect signs of CSF leakage such as opacity in the sphenoidal sinus. In two cases presenting transient rhinorrhea, no defect could be identified by imaging or surgical exploration. Nevertheless, a fat graft was impacted in the sinus, and there was no recurrence within a follow-up of 60 months (case 1) and 64 months (case 2). These two cases were classified as primary successes. In 18 patients, there was no postoperative CSF rhinorrhea. Endoscopic and CT scan examination at 6 months postoperatively confirmed the correct position of the fat graft.

Recurrence of CSF rhinorrhea was noted in four patients. Revision surgery using the endonasal endoscopic approach in these four patients did not identify the location of the fistula in the sphenoidal sinus and a new fat graft was put in place using the same technique. Three of these patients had a final success, while the fourth one complained again of rhinorrhea. Because of a negative β_2-transferrin detection test and negative imaging (MRI, CT scan, and isotopic cisternography), a second revision operation was performed using the transfrontal approach, and a pericranium graft was put in place. Postoperative anosmia occurred in this last case. After this final surgery, the patient continued to complain, but no CSF rhinorrhea could be detected on several outpatient clinical and biologic (β_2-transferrin) examinations. Nevertheless,

Table 3 Results of Endoscopic Closure

Results	Patients n	%
Successful first repair	18/22	82
Successful second repair	3/4	75
Total successes	21/22	95.5

this patient was considered unsuccessful. Overall success rate was achieved in 21 out of 22 patients (95.5%) (Table 3).

DISCUSSION

Over the past 20 years, various methods of imaging have been used in the detection and localization of CSF leaks, particularly those involving the anterior skull base. All etrologia forms of CSF leaks, which are divided into two groups, traumatic and nontraumatic (high-pressure leaks vs normal pressure leaks) according to the Ommaya[8] classification, are a result of a dural tear in the ethmoid and/or sphenoid roof. Iatrogenic effractions during functional endoscopic sinus surgery (FESS) are more frequent in the anterior ethmoid region, due to variability of the thickness of the ethmoidal roof, increasing anteriorly to posteriorly.[9] Regions directly neighboring the lamina cribrosa are very fragile, in particular the internal hillside of the ethmoidal roof,[10] the main zone of fragility. Bony defects or dehiscences can occur in other regions, such as the tectal insertion of the middle turbinate, the canals of the anterior and posterior ethmoidal artery, dehiscent in 11 to 14% of cases.[11]

Diagnosis

The test for determining the concentration of glucose utilizing a glucose-oxydase-peroxidase and orthotolidine combination on filter paper is still widely used clinically when CSF rhinorrhea is suspected, because of its simplicity, rapidity, and low cost. But the test of the glucose oxidase test paper is unreliable, and sources of false-positive tests are various: rhinitis and/or rhinosinusitis, contamination with blood, and allergy.[12] When the CSF leakage is abundant, it is relatively easy to collect it and take a sample for glucose analysis. In many cases, the fluid is heavily contaminated and the detection of β_2-transferrin assay is mandatory. β_2-Transferrin (or τ-transferrin) is a desialated form of transferrin normally found only in CSF. The method, using immunofixation, was first described by Irjala et al.,[13] modified by Oberascher[14] and recently by Middelweerd et al.,[15] by using a two-buffer electrophoresis system and a specific staining process. A few studies have shown that there can be very few false-positive results.[16–18] One drop of CSF is sufficient for sample analysis. Oberascher[14] described a sensitivity of 97.7% on 88 tests, and Skedros et al. [19] noted a sensitivity of 97% on 68 tests. The most significant advantage of the method is its high specificity: a demonstrated absence of β_2-transferrin in the nasal discharge is reassuring and may avoid investigative surgery to close a presumed cranionasal leak.

Topographic Localization

DYES OF THE CSF

Attempts to show the site of CSF leakage using intrathecal dyes (indigo-carmine, Evans' blue, methylene blue, fluorescein) are all unreliable as they depend on CSF actually leaking at the time of investigation. This method of study fell into disrepute following several reports of neural complications, including the occurrence of paraplegia, resulting in particular from the use of methylene blue. Intrathecal fluorescein, first used by Kirschner[20] (1960), was developed preoperatively by Messerklinger,[21] with the introduction of rigid endoscopic examination. Transient neurologic complications were also reported by the use of fluorescein, up to 25%.[21] Because the CSF leakage can be diagnosed by β_2-transferrin and the precise localization achieved by imaging, the use of intrathecal fluorescein is no longer recommended.

Metrizamide CT Cisternography

The accurate demonstration and localization of CSF leaks have depended for many years on various forms of cisternography (Crow et al.[23]). Metrizamide CT cisternography has been used since Drayer et al.[24] developed the technique in 1977. However, the method was static and cumbersome and was responsible for minor complications in 30 to 50% of cases.[25] The technique involving placement of cotton pledgets in various parts of the nasal cavity that were later retrieved after intrathecal isotope injection and isotope counting of each pledget did not provide satisfactory localization.[18] There were many false-negative results and exact anatomic localization of the site involved was not achieved, due to insufficient spatial resolution of the technique.[22] In cases of recurrent meningitis, investigators such as Curnes et al.[25] and De Tovar et al.[26] advocated overpressure radionuclide cisternography as a reliable method. A theoretical advantage of the overpressure technique is the potentiation of inactive pinhole-sized CSF leaks. The overpressure technique is dangerous because it risks transforming a pinhole intermittent CSF leak to a profuse and continuous one. The sensitivity of radionuclide cisternography was not acceptable, ranging from 31% to 81% in active leaks,[27] dropping to 40% in cases of inactive leaks.[28] We used radionuclide cisternography in three patients. In two cases, it did, in fact, confirm the suspected anatomic site on the CT scan. In one case, the CT scan was negative and radionuclide cisternography did not help diagnosis. In our experience, metrizamide CT cisternography is no longer indicated for management of CSF rhinorrhea.

CT Scan

High-resolution CT scans combining fine slices in two planes provide excellent definition of the paranasal sinuses and particularly the ethmoid, a prerequisite for endoscopic surgery. Small osteodural defects can be shown, and do not depend on active CSF leakage at the time of investigation. Indirect signs of the CSF fistula such as soft tissue abnormalities and pneumocephalus are helpful. A liquid level in the sinuses is not sufficient to assess the CSF fistula, because the radiologic density of CSF is similar to blood or mucus. The data manipulation requires bone algorithm, with a wide window of 4000 Hounsfield Units (HU). The coronal CT acquisition is the most important to detect osteodural breaches of the ethmoidal-sphenoidal roof. In some cases, direct coronal CT acquisition is not possible because of neck trauma or coma. However, reconstructive coronal images from axial views should not be performed because of the possibility of false-positive results with increment images. The sensitivity of the high-definition CT scan is within a range of 50 to 100%.[29,30]

The CT scan is superior to magnetic resonance imaging (MRI) for identifying bone erosion, and is highly sensitive in detecting arachnoid granulations (AG) frequently responsible for spontaneous CSF fistula.[31] The radiologic and surgical findings did not detect any AG in these 22 patients, six of whom had spontaneous rhinorrhea (normal pressure), indicating that this method is very efficient in identifying fractures of the sphenoidal and/or ethmoidal roof. In our study, the CT scan helped determine the precise site of the fistula in 84.5% of the cases.

MRI

Magnetic resonance imaging in the detection of the CSF fistula has been used since 1991, providing two kinds of information: topographic information by visualization of the defect, and functional information by indicating the CSF leakage through the defect, in particular with new dynamic sequences. There have been few published studies[32–35] and to date no large series have been reported. While T_1-weighted images provide excellent anatomic information, T_2-weighted sequences are the most precious for identification of CSF leaks. On T_2 images, CSF appears on hypersignal, whereas the bone has a very weak signal: this important difference in contrast improves the definition of the image and the power to detect a CSF fistula. Sequences are acquired generally without gadolinium, except in the case of intracranial lesion.

MRC, based on a very long TR (10,000 ms) is the method of choice.[36,37] It does not require intrathecal administration of a contrast agent. It takes advantage of the intrinsic contrast generated between CSF and adjacent structures by T_2-weighted images. MRC can also be performed with a fast spin-echo heavily T_2-weighted sequence using fat suppression, and video reversal of the image (Fig. 4). The MRC criteria for locating CSF leakage included a CSF column communicating from the subarachnoid space extracranially and/or herniation of brain tissue/meninges extracranially. MRC is considered negative for a CSF fistula if a definite separation is seen between the CSF of the cranial cavity and the high signal in the paranasal sinuses. MRC is able to detect either active or inactive CSF fistulae.[36] In inactive CSF fistula, conventional imaging (radionuclide cisternography, CT scan) has a low sensitivity, 28 to 60%.[24,28] Using MRI, Eljamel[30] reported a sensitivity of 100% in 11 patients who had inactive CSF leaks, and Stafford Johnson et al.[33] a sensitivity rate of 100% in 24 patients, 9 of whom had inactive leaks on the day of imaging. Gupta et al.[38] reported an MRI sensitivity of 80% in 33 patients. There was no difference in sensitivity between active or inactive CSF fistulae. Results suggest that MRI is capable of demonstrating leaks with high sensitivity and less than 1-mm spatial resolution. The main drawbacks of MRI are the higher cost, limited access to the machine, especially in cases of coma, and reanimation material that is not always compatible with the magnet field. We suggest that MRC should be the radiologic investigation of secondary choice, in combination with plain high-resolution CT, included in cases of actual inactive leaks.

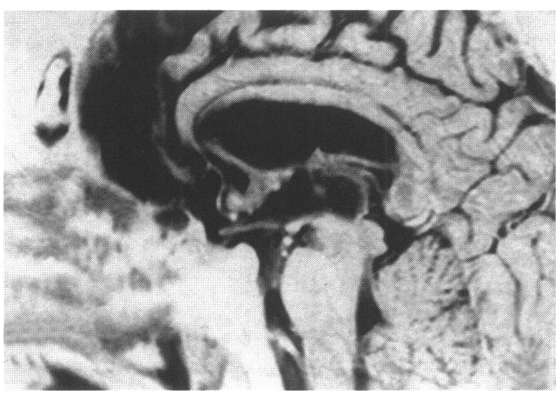

Figure 4 MR Cisternography. Pinhole CSF fistula of the posterior ethmodal roof. On the T_2-weighted fast spin-echo sequence with inverted contrast, the CSF column (in black) is easily seen against the bright background of air in the paranasal sinuses.

Method of Closure

The management of CSF leaks has long been a controversial subject. The spontaneous healing of a CSF fistula, operating on fibrous tissue, is generally of bad quality, and does not offer a tight barrier against ascending infection, a possible source of recurrent meningitis, even without rhinorrhea. In case of dural impairment inside the fracture, adherence to the edges of the bony fracture will be a possible source of continuous CSF fistula that will not close. A variety of techniques and materials has been found appropriate for closure of fistulas in the anterior area of the cranial fossa, including muscle, fascias (lata, temporalis), bone wax, bony paté, mucochondral flaps, dural flaps, tissue adhesives, and fat.[16,18,29,39]

Montgomery[38] first described the usefulness of fat obliteration to prevent or treat CSF leakage in lateral skull base surgery. He demonstrated clearly in animal experiments on cats in 1963 that fat tissue implanted in the frontal sinus was perfectly viable and revascularization was obtained within a few days.

The abdominal fat graft has become standard in our practice, since 1988 in anterior skull base tumor surgery[41] and since 1992 in the closure of CSF fistulas of the ethmoid/sphenoid region. In most cases, fat is available in great quantity at various sites, so that the operator is never limited by an inadequate size of material during the covering of the defect. In our experience, only a single patient has had a constitutional thinness that forced us to harvest the fat from the posterior jaw. Other tissues, and in particular those harvested in the nasal fossa, are often too small and difficult to place against the defect and widely around it,[42] especially in the case of pedicled muconasal flaps, that can retain the flap and limit the sealing of the bony defect.

Among the investigators using a local transplant, the choice between a nonpedicled or pedicled transplant remains controversial. Theoretically, a pedicled flap provides better vascularization, if the pedicle is long enough, but it is more difficult to place precisely in the right position, while a transplant is easier to position correctly. Therefore, a pedicled flap cannot be taken too far away from the donor site, so it can be rotated and thus plug the defect with no tension of the pedicle. Consequently, the pedicled local flap technique applies mainly to CSF fistulae of the ethmoidal roof and is not recommended in the posterior ethmoid and sphenoid. As with the use of any flap, a potential complication is failure to close the defect. The possibility of synechia is increased, making care for the nose more difficult. The closure using the fat graft seems to be a very beneficial modification of the standard mucosal flap technique in cases involving large or otherwise difficult defects. The advantages of the free abdominal fat graft are an excellent field of vision during its placement, ability to precisely clean mucosa from the bony defect without increasing the size of the defect, accurate positioning of the graft, and obliterating dead space, especially in the sphenoid sinus.

Fat is resistant to infection, perfectly isolates the paranasal sinuses from the dura, and its adherence to the surrounding bone, verified histologically in neurosurgical revision surgery, is very strong (Fig. 5). Human and animal histologic analyses in fat grafting have demonstrated varying degrees of fat necrosis.[43,44] Peer[45] reported approximately 50% of the implanted fat disappeared in 1 year and postulated that the survival of the transplanted fat cells depends directly on a rapid revascularization beginning at the fourth day posttransplantation. The fat graft surrounded by histiocytes and multinucleated giant cells are progressively disrupted, and invaded by a fibroblastic and lymphocytic reaction. In the long run, large amounts of fat are surrounded by a fibrous connective tissue. Other areas show multiple cystic spaces with fibrous connective tissue, with a focus of histiocytes with vacuoles probably containing degenerated fat. The degree of resorption of the fat graft is not predictable and we recommend taking a higher fat

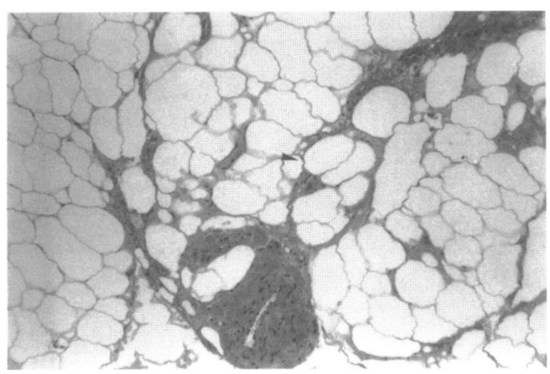

Figure 5 Histological vitality of the transplant at revision surgery (6 months after first surgery). Stroma of connective tissue and wide multicystic zones (→) with a stroma of macrophages and huge multinucleated cells. The cystic aspect, optically empty on histological preparations, is due to the preparation technique that extracts lipid contents from fat cells, leaving a vast colorless space inside the cell.

mass than is really necessary to overcorrect the defect by 30 to 50%. Previous investigations have demonstrated that long-term clinical graft survival in various regions of the body is unpredictable, within a range of 10 to 50%.[43,44,46] Liposuction of fat tissue is not recommended because a high number of fat cells can be disrupted by the high negative pressure of the suction, and these disrupted cells can generate a strong inflammatory reaction.[47]

Fat transplantation, used for many years in surgery of the pituitary gland by the transrhinoseptal approach, is the material of choice in the literature for endoscopic closure of defects of the sphenoid sinus. A variant on the standard technique of fat transplantation has been described by Burns et al.,[17] who used abdominal fat attached to fascia rectis or to the skin for the closure of the sphenoid CSF fistula. However, it is advisable to use only fat that has a greater flexibility and improves the surgeon's ability to place it precisely, even on the lateral wall of the sphenoid. Fat is a voluminal graft, whereas a local mucoperichondral transplant or a fascia are flat. This is a major advantage, as fat perfectly fills all the cavities, even irregular ones, particularly in the sphenoid, where a flat transplant would be difficult to place. The placement of abdominal fat is easy, allowing a perfectly adapted and adjusted closure. It is an ideal soft tissue, easy to harvest, to trim to the appropriate size, and to place into the paranasal sinuses, after careful removal of the mucus from the sinus to prevent mucoceles.

Lumbar Drainage

There have been very few reports concerning the use of lumbar drainage as adjuvant treatment after endoscopic repair and closure of an anterior skull base CSF fistula. Used only as conservative treatment, continuous lumbar CSF drainage is considered as a safe and effective treatment of CSF rhinorrhea by Findler et al.[48] and Shapiro et al.,[49] who reported, respectively, a success rate of 84% and 94%. Because of the retrospective nature of these studies and no randomized control group without drainage, the value of lumbar drainage in tenuous dural closure remains uncertain. In the literature, the overall risk of infection appears to be around 10%,[31] including a 2 to 3% risk of meningitis.[49] Ommaya[6] postulated that the drainage should not be used to treat traumatic CSF fistulae because of the high risk of reversing the flow gradient, thereby inducing infection. In our opinion, lumbar drainage is not useful in most situations and we recommend only bed rest, elevating the head of the bed, avoidance of straining, and stool softeners. Lumbar drainage could be helpful in the case of large defects greater than 2 cm^2 or in long-term CSF rhinorrhea lasting more than 1 month, although a few reports indicate comparable results with or without the use of lumbar drainage.[3]

Advantages of the Mini-Invasive Endoscopic Approach

The failure rate of neurosurgical procedures in closing CSF leaks varied within a range of 10 to 40%.[7,18,50] Transfacial approaches expose the patient to the risks of facial hypoesthesia, residual septal perforation, and optical complications such as diplopia, epiphora, or blindness.

Contemporary management of CSF fistulae using the endonasal endoscopic approach has several advantages. Telescopes of 30 and 70 degrees provide a widened field of vision, both direct and lateral, in the convoluted anatomy of the nose limits that an operating microscope cannot provide. The sphenoid sinus can be inspected even laterally by endoscopes, which other approaches do not permit. In a well-pneumatized sphenoid, particularly one that is pneumatized into the lateral wings or pterygoids, a CSF leak can be adequately visualized. In the sphenoid, a bulky fat graft pushed through the ostia, like a champagne cork, fills the confines of the sinus and effectively seals any defect.

The endoscopic closure of the CSF fistula was first described by Wigand et al.,[51] and

Stankiewicz,[52] who used, respectively, a free conchal mucosa graft with fibrin glue and postauricular fat and temporalis fascia. Mattox and Kennedy[3] reported five cases and Papay et al.[4] reported four cases treated endoscopically with success using a mucoperiosteal graft. Stankiewicz[5] later reported six cases treated endoscopically with success. This technique should not give postoperative anosmia similar to the transnasal approach.

Burns et al.[17] published the study with the largest series of patients and reported an overall success rate of 90% in 42 patients, of which 83% were primary successes. Lanza et al.[41] reported 36 cases with a primary success rate of 94%. Wax et al.[53] reported an overall success rate of 95% on a series of 18 patients, of whom a few had a large defect, up to 2.2 cm^2. Hughes et al.[54] were successful in 16 out of 17 patients. Our results (a primary success rate of 82%, and an overall success rate of 95.5%) are similar to those found by these authors. However, one should not forget that patients operated on with the endoscopic approach are preselected "good cases." The most difficult cases, e.g., comminuted fractures of the anterior skull base and the largest breaches are operated on firsthand by the neurosurgical approach.

The upper limit for the size of the breach accessible by the endoscopic approach remains controversial. Gjuric et al.[55] recommend endoscopic closure of dural tears up to 15 mm in length, irrespective of their cause. Burns et al.[17] used transplant mucous membranes in cases of loss of substance less than 0.5 cm^2, a mucosal transplant in cases of loss of substance greater than 0.5 cm^2. Dodson et al.[7] repaired large defects over 2 cm^2 successfully and did not limit the endoscopic approach respective to the size or the defect. For Gjuric and colleagues, the endoscopic approach allows the closure of defects even close to the ostium of the frontal sinus, still preserving a ventilated frontal sinus. We advocate, as do the great majority of investigators, that CSF fistulas close to the frontal sinus must not be repaired by the endoscopic approach. The risk of damaging the nasofrontal duct, well known in standard FESS, is theoretically higher in subfrontal surgery with the use of a graft over the dural defect, in particular at the posterior side of the ostium, where synechia, stenosis, and iatrogenic frontal mucocele can easily occur.

Computer-assisted surgery systems, currently used in FESS since a few years, may be especially helpful in revision surgery and in cases of complicated anatomy of the paranasal sinuses.[56] Prospective studies will be necessary to determine the usefulness of CAS-systems in surgical repair of CSF fistula.

CONCLUSIONS

The endoscopic transethmoidal technique should be considered as a first method of surgical repair in most cases of CSF rhinorrhea. This is an excellent technique, sure and elegant. The rigid nasal endoscope allows excellent visualization and very precise placement of the graft. Operating time is reduced and morbidity is lower compared with craniotomy and other extracranial techniques. The use of abdominal fat is simple, easy to place, and effective immediately. Abdominal fat is a material of great interest, as it is watertight and resistant to secondary infection, even in contaminated sinuses, making it an ideal dural substitute.

Precise indications as to the maximum size of the defect to repair are still not clearly defined. The results appear very encouraging. However, long-term follow-up over decades of this patient group will be required to determine the overall success of this technique.

COMMENTS FOR PUBLICATION

I thoroughly enjoyed reading the article by Schmerber et al. I think they did an excellent job discussing the topic with current diagnostic strategies, imaging studies, and surgical options. I have extensive experience with this type of clinical scenario and endoscopic surgical correction. I also agree with the authors that this should be the first line treatment for correction of cranionasal fistulas. I do differ in diagnosis technique. At our facility, low concentration intrathecal fluorescein (i.e., 0.2%) along with CT metrizamides cisternography is very successful in diagnosing the precise locations of anterior skull base defects. It assists us in our surgical correction. I do acknowledge that in the past there have been complications with the above techniques but, with our modified protocols, they have been very safe and successful over the last few years.

Charles W. Gross, MD
Professor

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