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Endonasal Endoscopic Approach in Osteomeningeal Defects of the Skull Base: A Retrospective Study of 11 Cases

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Abstract **Original Research Article**

An osteomeningeal defect (OMD) is a discontinuity in the osteomeningeal barrier that allows cerebrospinal fluid (CSF) to leak into an air-filled cavity at the skull base. Our study is a retrospective analysis of 11 cases of osteomeningeal breaches treated using the endonasal endoscopic approach between January 2016 and January 2025. The study involved epidemiological, clinical, radiological, therapeutic, and evolutionary analyses. Our series was characterized by female predominance. The age of our patients varied between 3 and 58 years, with an average age of 36.7. The most frequently revealed symptom is cerebrospinal fluid rhinorrhea. CT scan and MRI were performed on all patients. The location of the defect was ethmoidal in eight cases, sphenoidal in three cases, associated with a meningoencephalocele in four cases, and a meningocele in two cases. All cases were operated on using an endonasal endoscopic approach performed by a dual team of ENT and neurosurgery specialists. A combination of different materials was used for reconstruction, including abdominal fat, fascia lata aponeurosis, septal cartilage, nasoseptal flap, and biological glue. Early endoscopic management of cerebrospinal fluid rhinorrhea is the first-line therapeutic option as it reduces morbidity and mortality, preserves olfactory function, and does not preclude classical neurosurgical closure in case of failure.

Keywords: Osteomeningeal Defect, Ethmoid, Sphenoid, Meningocele, Endoscopic Surgery.

1. INTRODUCTION

Osteomeningeal defects result from disruption of the osteomeningeal barrier, leading to cerebrospinal fluid leakage into an air-filled cavity at the skull base. The most common causes are trauma and surgical complications. Clinically, it presents as CSF rhinorrhea, otorrhea, or both, with a major risk of central nervous system infection, particularly meningitis.

Diagnosis is based on clinical, biological, and radiological evaluation, with CT scan and MRI being the gold-standard to confirm the defect and guide surgery.

The endonasal approach has become the preferred treatment, replacing traditional open neurosurgical techniques because of its minimally invasive nature, high success rate, and low morbidity. It allows for better preservation of the olfactory function and reduces postoperative complications.

Consequently, early endoscopic repair is now considered the gold standard for managing osteomeningeal defects.

2. MATERIALS AND METHODS

We conducted a retrospective study of 11 patients diagnosed with osteomeningeal defects using the endonasal endoscopic approach between January 2016 and January 2025.

This study aimed to analyze the clinical, paraclinical, and evolutionary aspects of osteomeningeal defects and evaluate the outcomes of this surgery in the treatment of anterior and middle skull base defects.

3. RESULTS

We collected data from 11 patients with osteomeningeal breaches during the study period. The estimated frequency of operated patients in our department is one case per year.

- The average age was 36.7 years (range, 3–58 years). The distribution by age group showed a clear predominance in patients aged > 40 years.
- Among the patients, 8 were women and 3 were men.
- History of recurrent meningitis was found in three patients (27%).
- History of craniofacial trauma was observed in five patients (45%).

- One patient had previously undergone endonasal surgery for nasal polyposis.
- One patient had a history of ischemic stroke.
- No obesity or known intracranial hypertension (HTIC) was noted in our patients.

The average time between the onset of initial symptoms and diagnosis in our patients was 16 months, with extremes ranging from 7 days to 4.5 year.

The clinical signs were mainly otorhinolaryngological, ophthalmological, and neurological. Rhinorrhea was present in 10 cases (91%), unilateral in 9 cases, bilateral in 1 case, and intermittent in 6 cases. The most frequent neurological symptom was headache, which occurred in five patients (45%). Other signs of intracranial hypertension were absent in all patients, whereas a decrease in visual acuity was observed in two patients (18%) (Table I).

Table I: Different Symptoms Found in our Series

Clinical sign	Number	Percentage (%)
Rhinorrhea	10	90
Anosmia	1	9
Nasal obstruction	1	9
Headache	5	45
Decreased visual acuity	2	18

A complete otorhinolaryngological examination was performed in all patients, and the results of the examination are presented in Table II.

Table II: Results of Rhinoscopy in our Patients

Results of rhinoscopy	Percentage of patients
Clear fluid discharge	81%
Nasal septum deviation	27%
Inflammatory and edematous mucosa	9%
Nasal polyps	9%
Whitish mass filling the entire nasal cavity	9%

Ophthalmological examination revealed strabismus with unilateral ptosis in one patient and a progressive decrease in visual acuity in two patients, related to ocular trauma in one case and unilateral cataract in the other. Neurological examinations were normal in all cases.

All patients underwent craniofacial CT scans with millimetric sections in sagittal and coronal reconstructions, which revealed the following:

- A single osteomeningeal discontinuity in all patients (100%).
- Suspended opacity was observed in the air-filled sinus cavity in five cases (45%).
- Unilateral sphenoidal sinus opacification in 3 cases (27%) Figure 1.
- Ethmoid cell opacification related to defects in the ethmoidal bone was observed in four cases (36%) (Figure 2).
- Two meningoencephalocele cases were observed through a sphenoidal bony defect and two through the anterior ethmoid.

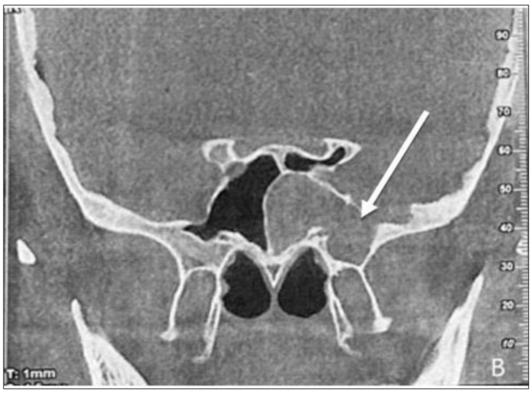

Figure 1: Coronal CT scan of the skull base showing opacification of the left sphenoidal sinus, related to a bony defect (white arrow) in the roof of the lateral recess of the left sphenoidal sinus

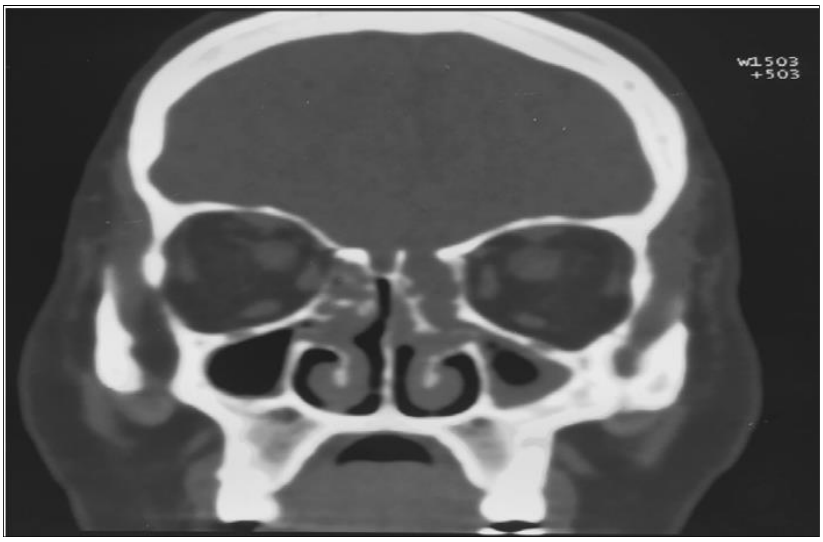

Figure 2: Frontal CT scan showing a large bony defect in the left ethmoidal roof, with bilateral nasal polyposis (ENT department, CHU Mohamed VI)

The locations of the osteomeningeal defects according to etiology in our series are listed in Table III.

Table III: Locations of the osteomeningeal defects according to the etiology in our series

Location Etiology	The cribriform plate of the ethmoid	The ethmoidal roof	Sphenoid sinus		Total number
			Roof	Lateral recess	
Spontaneous	2	0	2	1	5
Traumatic	4	2	0	0	6

All patients underwent brain and skull base MRI in T1 and T2 sequences with and without gadolinium injection, which allowed for a positive and topographical diagnosis in 10 of 11 cases and helped rule out a tumoral cause or other secondary etiologies as part of the differential diagnosis.

MRI confirmed the diagnosis of bony defects through the presence of:

- An interruption of the osteomeningeal hyposignal with cerebrospinal fluid in T2 hyperintensity was observed in seven cases.
- Presence of a meningocele in 2 cases.
- Meningoencephalocele in 4 cases (Figures 3 and 4).

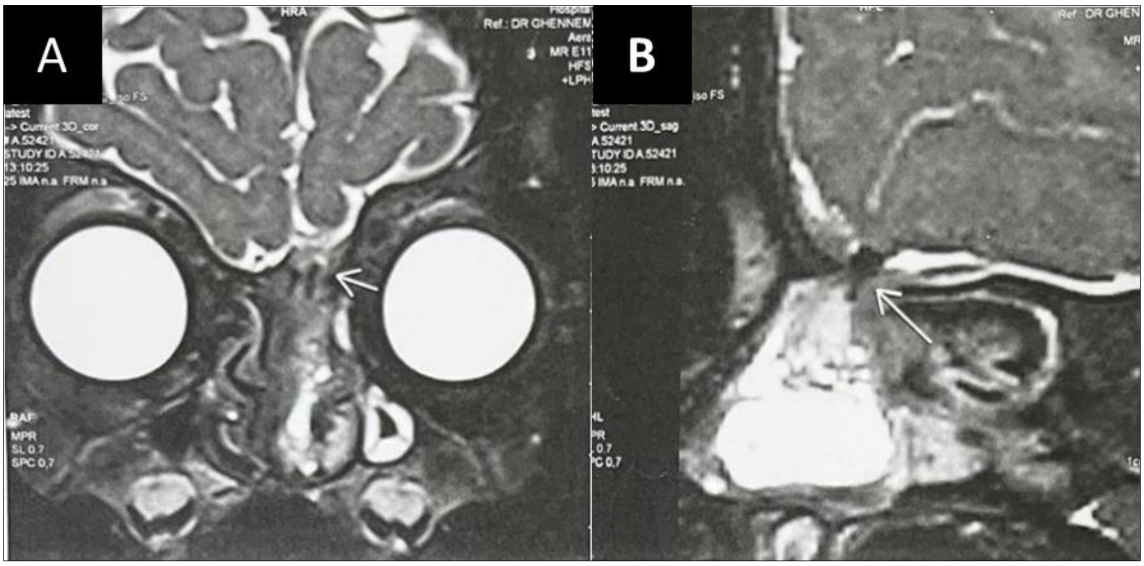

Figure 3: Coronal (A) and sagittal (B) T2 sections showing left ethmoidal meningoencephalocele filling the nasal cavity and extending to the inferior meatus in a three years old child (ENT department, CHU Mohamed VI)

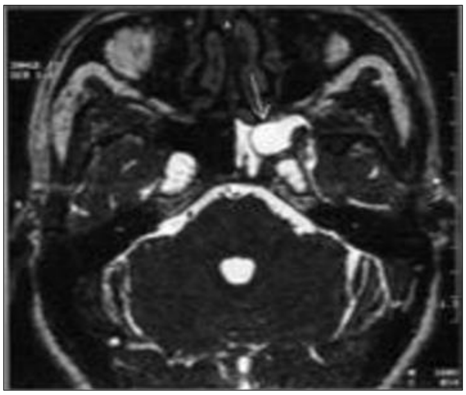

Figure 4: Left meningoencephalocele in the lateral recess of the sphenoidal sinus on MRI (ENT department, CHU Mohamed VI)

Intracranial hypertension (ICH) was suspected in two patients because of an empty sella appearance. No other signs of ICH were identified on the other MRIs.

Lumbar puncture with intracranial pressure measurement was performed in both patients with signs of intracranial hypertension on imaging.

ICH was confirmed in only one patient, and intracranial pressure was measured at 17 mmHg.

Preoperative pneumococcal vaccination was administered to all patients.

All patients underwent endoscopic endonasal surgery under general anesthesia, performed by a dual team of ENT and neurosurgeons.

Intraoperative endoscopic exploration allowed localization of the osteomeningeal defect in all cases. The surgical procedure included two main steps: identification of the defect and its repair.

Ethmoidectomy was performed in all cases of ethmoidal osteomeningeal defects. Exploration confirmed localization at the cribriform plate in six cases and the ethmoidal roof in two cases (Figure5). Closure was performed using a single-layer graft technique in five cases with abdominal fat, secured with biological glue and Surgicel.

The multilayer graft technique was used in three patients, in which septal cartilage was used in both overlay and underlay positions, combined with other materials.

- In one case (defect of the cribriform plate of the ethmoid measuring 7 mm (Figure 5), the septal cartilage was placed in an underlay position, secured with biological glue, covered with fascia lata in an overlay position, and secured with Surgicel.
- In the second case (large Iatrogenic OMD of the left ethmoidal roof) septal cartilage was placed in an underlay position, covered with fascia lata aponeurosis, and reinforced by a homolateral Hadad nasoseptal flap. Stability was ensured using biological glue and placement of a urinary catheter for five days. (Figure 6).
- In the last case (wide defect of the cribriform plate of the ethmoid extending over 2 cm), the septal cartilage in an underlay position was covered with abdominal fat and Surgicel.

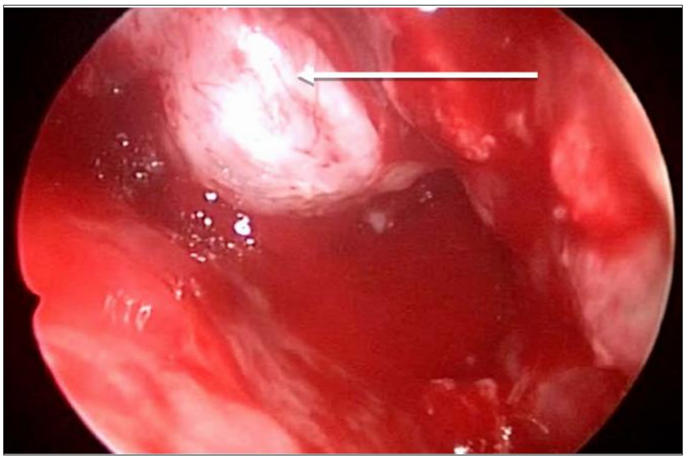

Figure 5: **Endoscopic image of a meningocele of the left ethmoidal roof after ethmoidectomy (ENT department, CHU Mohamed VI)**

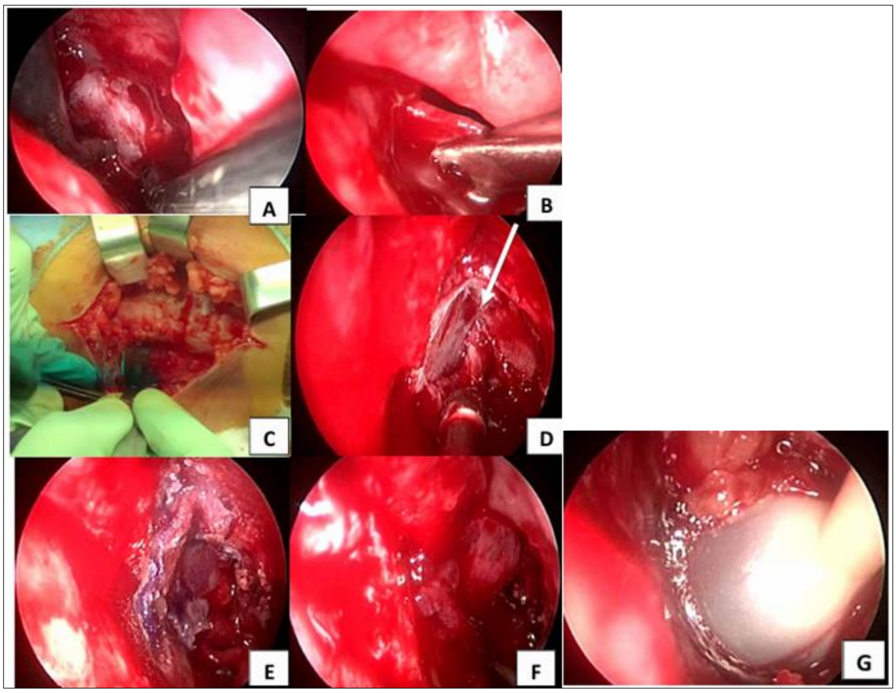

Figure 6: Endoscopic repair of a bony dural defect of the left ethmoidal roof:
(A) oagulation of the meningocele, (B) elevation of the nasoseptal flap, (C) harvesting of the fascia lata, (D) placement of the septal cartilage in an underlay position, (E) placement of the fascia lata and biological glue, (F, G) application of the nasoseptal flap and urinary catheter.

For defects in the sphenoidal lateral recess with meningoencephalocele, surgical access was achieved via a transpterygoid approach, including:

- Middle meatal antrostomy.
- Identification of the sphenopalatine foramen.
- Cauterization of the sphenopalatine artery.
- Resection of the medial part of the posterior wall of the maxillary sinus.
- Drilling of the pterygoid process.
- Sacrifice of the Vidian nerve.
- Exposure of the foramen rotundum and the V2 nerve.
- Identification of a highly lateralized meningoencephalocele, with cauterization at the neck.
- Closure of the defect using abdominal fat, biological glue, and reinforcement with Surgicel.

An endoscopic approach via a simple sphenoidotomy was used to repair the defect in the sphenoidal sinus roof with closure using abdominal fat, reinforced with Surgicel and biological glue.

A depletion lumbar puncture in the lateral decubitus position was performed in one patient (defect of the cribriform plate of the ethmoid of 7 mm) on day one postoperative.

Medical treatment included prophylactic antibiotic therapy with amoxicillin-clavulanic acid, which was continued for seven days postoperatively in all cases. Additional measures included strict bed rest with head elevation at 30°and prescription of antitussives and laxatives for 15 days postoperatively.

Acetazolamide 500 mg twice daily was prescribed for one month postoperatively, with potassium supplementation based on serum potassium levels.

The average hospitalization duration was 4 days, ranging from 3 to 7 days.

Short-term postoperative outcomes were uneventful, except for ocular dryness in the patient who underwent the transpterygoid approach, secondary to Vidian nerve sacrifice.

Follow-up was conducted weekly during the first month with endoscopic evaluations, and then every three months. No recurrence of rhinorrhea was observed in nine patients.

One patient experienced a recurrence of rhinorrhea after 18 months, complicated by an episode of bacterial meningitis. MRI revealed a bony dural defect in the left cribriform plate. The patient underwent revision surgery using an endonasal endoscopic approach. Intraoperative exploration confirmed cerebrospinal fluid leakage, predominantly from the posterior ethmoidal cells of the nose. The defect was sealed using a single-layer technique with abdominal fat and reinforced with biological glue and Surgicel. The outcome was favorable, with complete resolution of rhinorrhea after 2 years of follow-up.

In the other case (a huge arachnoid cyst of the petrous bone responsible for a sphenoidal osteomeningeal breach), the patient showed recurrence of symptoms with three episodes of meningitis one year postoperatively without leakage through the Eustachian tube. The surgical procedure consisted of excluding the left ear by sealing the breaches at the level of the tegmen antri and tegmen tympani with bone powder and ear wax and filling the cavity with abdominal fat and Surgicel.

4. DISCUSSION

Osteomeningeal defects are rare, and estimating their frequency is challenging, although their incidence has been increasing in recent years owing to advances in imaging and endonasal endoscopic surgery. The reported incidence varies between 1 and 5 cases per year, depending on the study. In our series, the incidence was one case per year.

Their occurrence results from a combination of anatomical vulnerabilities, genetic predispositions, and environmental factors. They frequently occur in vulnerable regions of the skull base, such as the cribriform plate and posterior ethmoid roof, where the bone is thin and prone to dehiscence. Iatrogenic causes have also been documented: surgical trauma during endoscopic sinus surgery; injury to the lateral lamella of the cribriform plate, posterior ethmoidalis, or frontal recess can create acute dural defects [1]. In addition to anatomical and surgical factors, several systemic conditions are associated with spontaneous leaks. Elevated intracranial pressure (ICP), either idiopathic or secondary to obesity, is strongly implicated in the gradual erosion of the skull base, leading to CSF rhinorrhea [2]. Demographic factors such as obesity, female sex, and older age further increase the risk of spontaneous or postoperative leaks [3]. These elements highlight the multifactorial pathophysiology of osteomeningeal defects and the importance of considering both local anatomy and systemic conditions when evaluating patients with CSF rhinorrhea.

Patient history plays a crucial role in assessing possible osteomeningeal breaches. It should thoroughly explore the patient's medical and surgical history. The studies by Zainine [4], Bahaj [5], and Chiboub [6] reported that a history of craniofacial trauma was the most common cause, with respective rates of 42.8%, 50%, and up to 57%. In contrast, Okasha *et al*., [7], showed that endonasal surgery is the most frequent antecedent, with a prevalence of 25%. In our series, a history of craniofacial trauma was found in 45% of the cases.

In all literature series, the main symptom was predominantly unilateral cerebrospinal rhinorrhea. However, rhinorrhea may go undetected. Other symptoms, such as headaches, fatigue, hyposmia, and/or posterior rhinorrhea, sometimes accompanied by a sweet aftertaste, should raise suspicion [8].

Preoperative endoscopic examination is a crucial step in assessing and preparing for the management of cerebrospinal fluid leaks. It provides a detailed exploration of the nasal cavities to identify potential anatomical anomalies that could complicate the procedure, such as septal deviation, concha bullosa, and synechiae [9]. This examination optimizes surgical planning and helps to precisely locate the osteomeningeal breach. In our study, all patients systematically underwent this examination to rule out any local causes that could make the surgical approach more challenging.

Brain CT is the first-line examination. The explored region included the anterior and middle cranial bases. The best imaging plane is the coronal plane, with sequential slices from the anterior part of the frontal bone to the posterior part of the sphenoid bone. Shetty [10], estimated the sensitivity of CT scans to be 92%. The risk of false negatives may be related to the technical factors. For instance, acquiring images with excessively thick slices of 3 mm or more may fail to detect a fracture line of millimetric size.

In VARLET's [11], series, CT was performed on all patients, but an anterior skull base osteomeningeal breach was diagnosed in only six cases (84%), with one additional case confirmed after cisternography.

GUEVARA [12], and YILMAZLAR [13] performed this examination in 100% of his cases, successfully diagnosing skull base defects in all patients (100% sensitivity).

Regarding the frequency based on localization**,** Chiboub *et al*., [6], reported in a series of 23 cases that 18 (78.2%) involved ethmoidal bony dural defects, three (13.1%) involved sphenoidal defects, and two (8.7%) involved frontal defects.

In a series by Zainine [4], ethmoidal defects accounted for 85.7% of the defects, while sphenoidal and frontal defects each represented 7.15%.

Dodson [14], reported in a series of 29 cases that 58.6% of bony dural defects were ethmoidal, while 41.4% were sphenoidal. In our series (11 cases), the ethmoidal localization was the most frequent, accounting for 72%, followed by sphenoidal localization at 27% (Table IV), while no cases of frontal skull base defects were observed (Figure 7).

Table IV: **Comparative Table of the Frequency of Bony Dural Defects Based on Their Localization**

Series	Ethmoidal defects	Sphenoidal defects	Frontal defects (Figure7)
D. Chiboub [6]	78.2%	13.1%	8.7%
R. Zainine [4]	85.7%	7.15%	7.1%
Dodson [14]	58.6%	41.4%	-
Our series	72%	27%	-

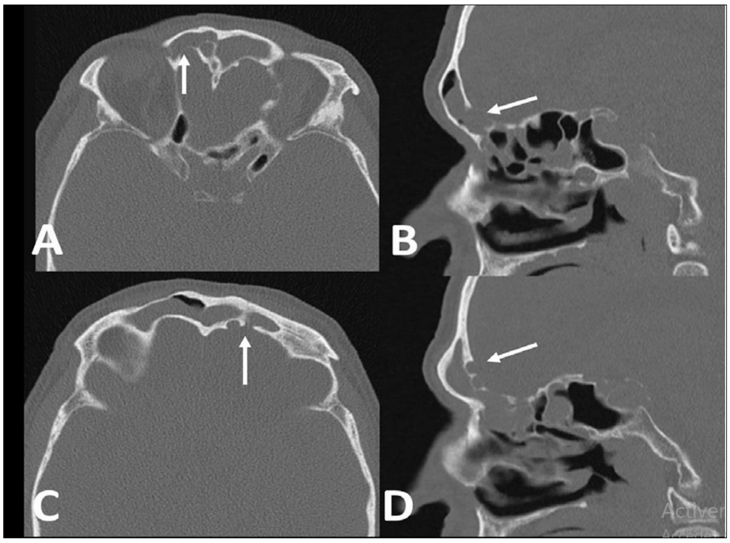

Figure 7: Bilateral post-traumatic frontal skull base defects classified as Schlosser type 3, axial CT scan (A) and sagittal CT scan (B) of the right defect, axial CT scan (C) and sagittal CT scan (D) of the left defect [15]

MRI plays a crucial role in the positive and etiological diagnosis of osteomeningeal breaches (OMB). If no defect is identified or if there is suspicion of a meningoencephalocele on CT, MRI can detect the signal intensity of cerebrospinal fluid (CSF) passing through the skull base [9]. The diagnosis of OMB is confirmed when there is an interruption of the hypointense osteomeningeal signal by a CSF column appearing as T2 hyperintensity and/or by the brain parenchyma. This linear T2 hyperintensity, which connects the air cavities with the subarachnoid spaces, indicates a continuity defect involving both the dura mater and bone.

Biochemical analysis of the cerebrospinal fluid is helpful in cases of mild or intermittent leakage, especially when high-resolution CT scans fail to provide clear results [16, 17]. Traditional biochemical tests measuring protein or glucose levels in the discharge can help identify the presence of cerebrospinal fluid. However, these tests require a significant sample volume and may be ineffective in the event of blood contamination. Similarly, bedside glucose test strips have limited sensitivity and specificity, although they may serve as a rapid screening tool in emergencies when used alongside transferrin β2 and β-protein detection [18]. Owing to contextual limitations, none of these biological tests were conducted in our study.

Medical management is considered first-line treatment for low-flow or traumatic cerebrospinal fluid (CSF) leaks when the defect is small and without signs of infection. Conservative measures include bed rest, head elevation, and avoidance of straining activities, such as coughing or sneezing. Some studies have supported the use of acetazolamide to reduce intracranial pressure [19]. In many cases, these approaches lead to spontaneous closure within days to weeks [20].

Lumbar drainage via continuous subarachnoid drainage or repeated lumbar puncture is considered when conservative management fails for persistent low- to moderate-volume leaks in high-risk surgical candidates or as a supportive measure in the postoperative period [21].

More commonly, lumbar drainage is used as an adjunct after surgical repair, particularly in endoscopic approaches for anterior skull base defect repair. Lowering CSF pressure in the early postoperative period facilitates graft adherence and reduces the risk of recurrence. A prospective randomized trial confirmed that continuous lumbar drainage improved closure rates and shortened hospital stay when combined with endoscopic repair compared with surgery alone [22]. However, recent randomized trials have shown that routine lumbar drainage does not lower recurrence rates after endoscopic skull base repair and should therefore be reserved for selected high-risk cases, such as large defects, high-flow leaks, or patients with elevated intracranial pressure [21].

There are two surgical techniques for treating meningoceles and repairing osteomeningeal breaches: the traditional neurosurgical and endoscopic approaches.

Endonasal endoscopy has been demonstrated to be highly effective in managing this condition by identifying the osteomeningeal defect, excising the meningocele, and sealing the bony breach [23]. Various materials have been proposed for reconstruction, including abdominal fat, temporal fascia, fascia lata, and septal cartilage. Among these, fat is preferred because of its rapid healing properties, resistance to local infections owing to its rich vascularization, and ease of harvesting [24].

The selection of reconstruction material depends on factors such as the location and size of the breach, proximity of the cisterns to the skull base, and expertise of the surgical team.

The multilayer graft technique offers superior reinforcement compared to single-layer repair, significantly reducing the recurrence rates of CSF leaks.

This method typically employs the fascia lata harvested from the lateral thigh. The graft can be secured either by sutures or clips placed between the dura and the fascia or stabilized with glue. An intermediate layer of abdominal fat provides additional sealing of the dural defect.

On the endonasal side, a mucosal graft from either the turbinate or nasal septum can be used as an overlay. A vascularized nasoseptal flap, as described by Haddad [25], may be used for further reinforcement.

In our series, the single-layer graft technique was applied in eight patients, using abdominal fat in an underlay position, reinforced with Surgicel, and supported by biological glue.

The multilayer graft technique was used in three patients with large osteomeningeal breaches.

Recurrence of osteomeningeal breach is often associated with high-flow CSF leaks, large dural defects, elevated intracranial pressure, and postoperative infections. Inadequate graft stability or the absence of multilayer reconstruction increases this risk. Preventive strategies include the systematic use of multilayer closure, strict infection control, and management of intracranial hypertension, when present. While lumbar drainage may be considered in selected cases, recent randomized controlled trials have not demonstrated a significant benefit from its routine use [21]. Early detection through endoscopic follow-up remains essential for revision and optimization of long-term outcomes [26].

With the advent of endonasal endoscopic surgery, the success rate is approximately 90% with low morbidity [9]. Although complications are extremely rare, they can be severe and require urgent treatment.

Most authors have reported excellent postoperative outcomes, with a closure rate ranging from 76% to 100% after a single procedure, regardless of the repair technique used.

In the series by Presutti *et al*., [27], complete and definitive closure of the breach was achieved in 88.5% of cases (46/52 patients) following the first endoscopic procedure. Hegazy [20], reported a success rate of 90% in 259 of 289 operated cases. After surgical revision, this rate increased to 96.

In our series, the success rate was 82%, which aligns with the results reported in various published studies.

5. CONCLUSION

The endonasal endoscopic approach has emerged as an effective and minimally invasive technique for the repair of osteomeningeal breaches. This method offers direct access to the skull base, allowing precise localization and closure of defects while minimizing morbidity compared with traditional transcranial approaches. Among the different reconstructive strategies, the multilayer technique has gained particular importance, as it provides stronger and more durable closure by combining the fascia, fat, mucosal grafts, and vascularized flaps when available. This layered reinforcement significantly reduces the risk of recurrence compared with single-layer repair. Continuous advancements in instrumentation and surgical expertise will further refine the efficacy and safety of this approach for the management of skull base defects.

DECLARATIONS

Conflict of Interest: The authors declare no conflicts of interest.

Ethics Approval and Consent to Participate

This retrospective study involving human participants was conducted in accordance with institutional guidelines and the principles of the Declaration of Helsinki. No experimental procedures were performed. Informed consent was obtained from all individual participants included in the study.

Consent for Publication: Not applicable.

Funding: This research received no external funding.

Data Availability: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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