Endoscopic treatment of meningoencephaloceles of the anterior skull base

Review Article

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Abstract

Objectives: to review the casuistry of anterior skull base meningoencephaloceles and evaluate the effectiveness of endoscopic endonasal surgical treatment.
Study Design: retrospective descriptive study.
Materials and Methods: review of clinical and surgical records of patients undergoing endoscopic meningoencephalocele repair in a tertiary hospital center between 2017 and 2023.
Results: thirteen patients were included, totaling 14 meningoencephaloceles. Etiologies encompassed benign intracranial hypertension (n=6), traumatic (n=5), idiopathic (n=2), and tumoural (n=1). The cribriform plate of the ethmoid (n=6) and the sphenoid sinus (n=6) were the most frequent locations. The surgical success rate was 100% (n=14). No major complications were observed.
Conclusion: endoscopic endonasal correction of meningoencephaloceles demonstrated high efficacy and low morbidity, supporting existing literature.
Palavras-chave traduzidas: meningoencephalocele, meningoencephalic herniation, cerebrospinal fluid fistula, anterior skull base

Introduction

Meningoencephalocele is the herniation of meninges and brain tissue through a defect in the skull base, resulting from constant pressure exerted by the dura mater on an established bone defect corresponding to a weakened portion of the skull base.[1]

The etiology can be classified into **traumatic** (accidental and iatrogenic), **non-traumatic**, further subdivided by elevated intracranial pressure (ICP) or normal ICP (congenital – incidence of 1 in 35,000 live births[2], tumour-related, or erosive inflammatory pathology), and **spontaneous/idiopathic**, when no cause is identified.[1,3] Rhinorrhea is the most common presenting symptom, although

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it may be absent or undetected in some cases due to low flow or intermittent nature. Meningoencephalocele is often associated with severe infectious complications, such as meningitis or brain abscess, as well as a valve-like phenomena with risk of pneumocephalus. Surgical intervention is generally recommended as the first-line treatment.[3,4]

Historically, CSF fistulas and meningoencephaloceles were addressed through external craniotomy, with success rates of 70–90%.[4–6] The main advantages of the transcranial approach include direct visualization of the defect and option to use pericranial flaps. However, this approach is associated with significant morbidity, including anosmia, intracranial hemorrhage, brain retraction, memory deficit, seizure, cosmetic deformity, and surgical wound infection.

In 1990, Mattox and Kennedy published the first case series of meningoencephaloceles treated using an endoscopic endonasal approach.[7] This technique provides a direct, inferior intranasal access to the area of the meningoencephalocele defect, being less invasive, offering excellent visualization of the residual skull base defect following hernia sac reduction, and enabling both intradural and extradural reconstruction to sufficiently support the defect area. The evolution and development of new endoscopic techniques, surgical materials, and optics with the potential for endonasal instrumentation in hard-to-reach areas, along with accumulated experience in skull base defect reconstruction, have progressively improved surgical efficacy, ensuring excellent outcomes with lower risks of complications and morbidity in the management of patients with anterior skull base defects. This has enhanced the safety and success rate of endonasal endoscopic access, including in pediatric patients.[2,8,9]

To assess surgical efficacy and report data on the etiology, location, complications, and reconstruction methods for these defects, the authors proposed a retrospective descriptive study of patients diagnosed with meningoencephalocele who underwent endonasal endoscopic correction.

Materials and methods

This retrospective study analyzed 15 consecutive patients diagnosed with sinunasal meningoencephalocele who underwent endoscopic endonasal surgery at a tertiary hospital between 2017 and 2023. Patients with isolated CSF fistula without imaging or intraoperative evidence of herniation were excluded.

The medical records were reviewed, and the following information was recorded: demographic data (age and sex), medical history, etiology, location, laterality, size (in mm), preoperative complications (CSF fistula, meningitis, and pneumoencephalocele), ancillary diagnostic tests, surgical technique (herniation reduction method, materials used for defect reconstruction, and packing), intra- and postoperative complications, surgical antibiotic prophylaxis, postoperative care, postoperative follow-up period, surgical success, and need for revision surgery. The etiology was classified as traumatic, tumoral, congenital and idiopathic/spontaneous. The latter were further categorized according to the presence of signs of intracranial hypertension (ICH) to identify this as a potential risk for increased predisposition to recurrence or the development of multiple skull base defects.

Surgical success was assessed postoperatively, established from 6 months onward, and defined as complete closure of the defect, with no residual or recurrent herniation and no secondary complications such as meningitis or signs of CSF fistula, under direct endoscopic control and imaging to assess stability parameters in the defect reconstruction area, checking for signs of herniation or fistula using additional imaging techniques (CT/myelo-MRI).

The surgical technique performed by the authors is briefly described as follows: under general anaesthesia, nasal mucosa decongestion with a solution containing

adrenaline (1:5000 dilution); depending on the primary location of the skull base defect, the endoscopic technique was adapted to ensure adequate exposure of the defect area, performing the necessary sinusotomies in each case; reduction of the meningoencephalocele with bipolar diathermy or radiofrequency[2]; identification of the bony defect edge around the full circumference; removal of mucosa and bone trabeculae at the defect's periphery, using powered instruments such as a drill when necessary, to create a smooth, circumferential area able to accommodate a graft or mucosal flap and facilitate adhesion. The removal of mucosa from the area surrounding the defect and the path of the flap pedicle prevented overlap of grafts/flaps on nasal mucosa, avoiding mucocele formation. The dura was detached around the bone dehiscence area to create an epidural plane, providing intracranial support for the defect.

Duraplasty was consistently performed with an onlay dural matrix (DuraGen®) and mucosaplasty with a nasoseptal flap or overlay mucosal graft from the middle turbinate, ensuring endonasal reconstruction. Whenever reconstruction was near sinus drainage areas, overlay positioning of the reconstruction was maintained to prevent obstruction and preserve normal nasosinusal function. Other synthetic materials, such as fibrin glue and/or oxidised cellulose polymer (Surgicel®), were used, along with nasal packing, with a preference for absorbable materials. All patients received antibiotic prophylaxis and postoperative care including bed rest and head elevation.

Results

Between 2017 and 2023, 15 meningoencephaloceles were operated on 14 patients, including nine women (64%) and four men (36%), with a mean age of 50.7 years (σ = 22.3, minimum 9 – maximum 80). The etiologies were benign intracranial hypertension (n = 6); trauma (n = 4); spontaneous (n = 3), and tumoral (n = 1, associated with an olfactory neurofibroma), and congenital (n=1).

The most common locations were the cribriform plate of the ethmoid bone (n=7) and the sphenoid sinus (n=5, with three in the planum and two in the wall), followed by the transition from the posterior frontal table to the ethmoidal fovea (n=3). Laterality was right-sided in seven cases, left-sided in seven, and central/bilateral in one case. Regarding comorbidities, six patients were obese, seven had hypertension, and four had diabetes mellitus. A summary characterisation of the population is presented in **Table 1.**

Notably, CSF fistula was present in twelve cases at the time of diagnosis (80%), and seven patients experienced at least one episode of meningitis (47%), with cultures positive for *Streptococcus pneumoniae* in four cases, *Enterococcus* in one, and no isolated agent in the others. In one of these cases, a brain abscess developed, and in another, a pneumoencephalocele was observed.

All patients underwent preoperative computed tomography and magnetic resonance imaging, neuronavigation assisted in nine surgeries. Defect size was less than 10 mm in twelve cases and equal to or greater than 10 mm in three cases. Once being properly exposed, the herniation was reduced using bipolar diathermy (n=14) or coblation (n=1), allowing for full identification of the skull base bone defect. Reconstruction was performed with collagen matrix underlay in cases where, after reduction/excision of herniated tissue, the dural defect allowed for insertion/anchoring of the material into the subdural space; or onlay in the epidural space by detaching the bone from the intact dura mater surrounding the dural defect to cover the defect resulting from the removal of the meningocele. Pedicled nasoseptal flap (n=13) or overlay mucosal graft from the middle turbinate (n=2), were used for endonasal reconstruction, covered with oxidised cellulose mesh (n=14) and fibrin glue (n=11). Absorbable nasal packing, such as Nasopore® (n=12), was used in most cases; in three cases involving gunshot trauma or tumoral pathology, the nasal cavity was additionally packed with non-absorbable material (Merocel®).

Table 1
Characteristics of the study population

Sex	Age (y)	Etiology	Site	Size (mm)	Reconstruction	Follow-up (months)	Success
M	26	Traumatic	Sphenoid – planum	7 × 5	NSF	6	Yes
F	77	Tumoral	Cribriform plate	10 × 9	MT graft	74	Yes
M	43	Traumatic	Sphenoid – planum	3 × 4	NSF	52	Yes
M	15	Tumor-related	Cribriform plate	9 × 9	NSF	39	Yes
F	48	Benign ICH	Cribriform plate	7 × 6	NSF	24	Yes
		Benign ICH	Sphenoid – lateral	4 × 5	NSF	22	Yes
F	50	Benign ICH	Cribriform plate	8 × 3	NSF	14	Yes
F	9	Traumatic	Sphenoid – planum	7 × 5	NSF	21	Yes
F	65	Traumatic	Cribriform plate	14 × 14	NSF	14	Yes
F	64	Benign ICH	Cribriform plate	6 × 6	NSF	16	Yes
F	79	Benign ICH	Ethmoidal fovea	9 × 7	NSF	15	Yes
F	51	Benign ICH	Sphenoid – lateral	11 × 8	NSF	14	Yes
F	67	Spontaneous	Cribriform plate	4 × 3	MT graft	12	Yes
M	80	Spontaneous	Ethmoidal fovea	5 × 4	MT graft	9	Yes
M	39	Spontaneous	Frontal	6 x 4	NSF	6	Yes

Legend: M, male; F, female; ICH, intracranial hypertension; NSF, nasoseptal flap; MT, middle turbinate.

In the postoperative period, all patients received antibiotic prophylaxis: ceftriaxone (n=14) and vancomycin (n=1) during hospitalization, followed by oral antibiotics, typically cefuroxime, for one week. Additionally, intraoperative prophylaxis was provided with meningeal-dose ceftriaxone. The average duration of intravenous antibiotic therapy was 3.5 days. On average, patients remained on strict bed rest for 2.4 days, and hospitalization lasted an average of 4 days (minimum 2 days, maximum 10 days).

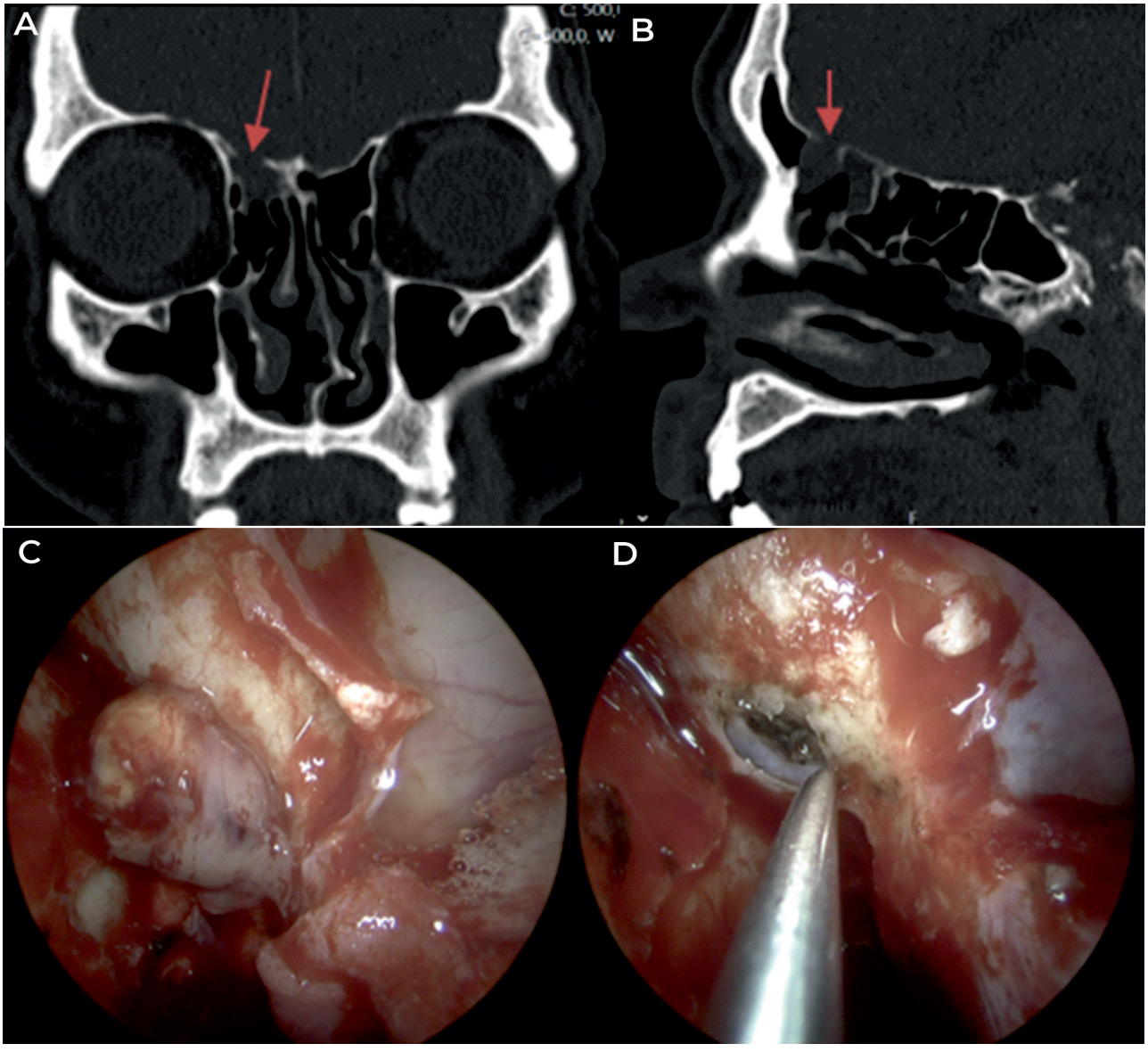
The surgical success rate was 100% (n=15). In one case (a 48-year-old woman with a history of obesity and idiopathic ICH), following reconstruction of an ethmoidal defect (cribriform plate), postoperative follow-up revealed recurrent CSF rhinorrhoea and was found to have a new meningoencephalocele in the left sphenoid lateral recess, requiring reoperation. Intrathecal fluorescein was used in this second intervention. The patient has since been followed with no recurrence or new defect development after two years.

No major complications were reported, with only one case of documented palpebral ecchymosis. The mean postoperative follow-up time was 22 months (minimum 6, maximum 74).

Discussion

Meningoencephalocele is a rare condition, the most common clinical manifestation of which is cerebrospinal fluid (CSF) rhinorrhea. It can be misdiagnosed as allergic rhinitis, non-allergic rhinitis, or chronic rhinosinusitis. Delays in its identification and diagnosis lead to an increased incidence of potentially fatal complications, thus a high index of suspicion for this condition is warranted.[10] The use of beta-trace protein or beta-2 transferrin can confirm the presence of a CSF leak, complemented by high-resolution computed tomography (CT) to visualise bone defects and magnetic resonance imaging (MRI) to identify herniation.

Figures
Clinical case of spontaneous meningoencephalocele from the transition of the posterior wall of the frontal sinus to the right ethmoidal fovea. A and B. Preoperative CT-SPN, coronal (a) and parasagittal (b) views (arrow – bone defect); C. intraoperative image of the herniation after dissection of the defect's periphery; D. surgical field after reduction with bipolar cauterisation and excision of the meningoencephalocele, highlighting the importance of identifying the bony margin of the defect around the entire circumference and detaching the dura on the intracranial side to allow onlay placement of reconstruction material.



The most common locations were the ethmoid (47%) and sphenoid (33%), consistent with literature findings[4,5,11,12], followed by the transition between the posterior frontal plate and ethmoid fovea (20%), supporting that the endonasal endoscopic approach enables repair of these defects across multiple locations in the ventral skull base.

In our case series, approximately half of the patients had a history of meningitis, a higher rate compared to other studies.[4,11,13] In two cases, brain abscess and pneumoencephalocele were also present, highlighting the impact of this condition and the need for early treatment to prevent these complications.

Our results are in line with values reported

in the literature, with clinical success rates ranging from 88-100%.[4–6,9,13,14] The average follow-up period was 22 months. However, two patients had follow-up periods of less than one year, which may represent a study limitation, considering that most recurrences occur within the first two years post-surgery.[4,6,11]

Similar to other authors, we preferred vascularized pedicled flaps for larger defects. In two cases, middle turbinate mucosal grafts were used for smaller defects (≤ 5 mm), offering an advantage in placement and preservation of septal mucosa. In our cases, no dislodgement, mobilization, or retraction of grafts/flaps was observed. Notably, the surgeon's experience and preference with a given technique are among the most important factors guiding defect reconstruction choices. Other authors have also used fascia lata and middle turbinate flaps, abdominal or auricular lobule fat (the "bath plug" technique), muscle, turbinate bone, or septal cartilage.[2,9,11,15,16]

Previous studies have indicated that inadequate preparation of the defect area for graft placement, size of the lesion, volume of the CSF fistula, and displacement or incomplete apposition of the flap on the skull base are the primary causes of surgical failure associated with the endoscopic endonasal approach.[1,9] However, due to our sample size and success rate, it was not possible to conduct a statistical analysis of risk factors and predictors of surgical success. Nyquist et al (n=28)[5] demonstrated that female sex was a statistically significant risk factor for developing encephalocele and CSF leak. In the series published by Rawal et al (n=133)[4], meningoencephalocele recurrence rates were not significantly associated with any specific etiology, location or type of reconstruction. Similarly, Kapitanov et al (n=141)[11] reported no statistically significant correlation between initial defect size, etiology, location, reconstruction type, or CSF opening pressure, measured during lumbar puncture, and recurrence rates. Intrathecal fluorescein can be used intraoperatively in low doses to safely help locate the defect, exclude multiple defects, determine extent, and confirm watertight closure after reconstruction.[9,15] While some authors routinely use this technique, in our cases it was used only once, in the context of a lateral sphenoid recess defect in a patient with intracranial hypertension (ICH) who had previously undergone surgery for a cribriform meningoencephalocele. It was used to exclude other dehiscence sites that might be hidden during revision surgery and to confirm the watertight seal of the previously repaired defect.

Chronic ICH may play a role in the development of meningoencephaloceles through the pulsatile forces of arachnoid villi that erode the skull base, especially in inherently weakened locations (cribriform plate, lateral ethmoid lamella, and lateral sphenoid recess).[3,17] Idiopathic ICH is more common in obese patients and women over 50 years old. It presents clinically with headaches, visual changes, pulsatile tinnitus, dizziness, vomiting, or cognitive changes. Typical imaging findings include an empty sella and arachnoid pits, present in 90% of cases[3,18], Meckel's cave dilation, optic nerve sheath distension, or herniation of the cerebellar tonsils.[17] Diagnosis is based on CSF opening pressures above 25 cmH2O in adults; however, an active CSF leak may act as a pressure-relief valve, limiting measurement. Skull base defect repair associated with this condition tends to be less effective, with a higher risk of recurrence.[17] Late recurrences at secondary locations can also occur, as previously described in one of the cases in our series, underscoring the need to optimize intracranial pressure management in these patients. Treatment options include acetazolamide, serial lumbar punctures, CSF shunting, weight loss, or bariatric surgery.[10,17–19] Lumbar drainage was used postoperatively in only one patient, for 72 hours, reflecting the shift in paradigms for skull base reconstructions (in the absence of large dural defects).[12,20] Some authors recommend it's use in cases considered to have a higher recurrence risk, such as body mass index over 30–40 kg/m^2; revision surgeries or previous CSF leak or

meningoencephalocele at a different site; large defects; traumatic etiology; empty sella syndrome; extensive dural defects located in the ventral region of the anterior and posterior cranial fossae.[4,5,12] Nyquist et al.[5] used low flow rates of approximately 5 mL/hour, removing the drain at the end of the first postoperative day. After discharge, patients were advised on nasal irrigation and measures to limit increases in intracranial pressure, such as extensive dural defects located in the ventral region of the anterior and posterior cranial fossa. Debridement at follow-up consultations was conservative, avoiding direct manipulation of the reconstruction site and only ensuring the absence of infection in the operated area, with limited crust removal to facilitate the clearing of debris and packing material through nasal irrigation. In the literature, endoscopic complication rates vary between 2-11%. Meningitis is described as the most common neurological complication (1.1-6%), and surgical site infection occurs in 0.7%.[4,6,11] No major complications were recorded in our series, supporting the safety of the endonasal endoscopic approach.

Conclusion

Our results demonstrate the effectiveness of the endoscopic endonasal approach in treating anterior skull base meningoencephaloceles. This minimally invasive technique has been proven to be safe, has low morbidity and is now considered the primary approach for this managing this condition.

Conflict of Interests

The authors declare that they have no conflict of interest regarding this article.

Data Confidentiality

The authors declare that they followed the protocols of their work in publishing patient data.

Human and animal protection

The authors declare that the procedures followed are in accordance with the regulations established by the directors of the Commission for Clinical Research and Ethics and in accordance with the Declaration of Helsinki of the World Medical Association.

Privacy policy, informed consent and Ethics committee authorization

All the processed data were based in published reports that fulfilled privacy policy and ethical considerations.

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Scientific data availability

There are no publicly available datasets related to this work.

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