

# Bilateral meningoencephaloceles with cerebrospinal fluid rhinorrhea after facial advancement in the Crouzon syndrome

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## ABSTRACT

**Background:** Cerebrospinal fluid (CSF) rhinorrhea and encephaloceles are rare complications of craniofacial advancement procedures performed in patients with craniofacial dysostoses (CD) to address the ramifications of their midface hypoplasia including obstructed nasal airway, exorbitism, and impaired mastication. Surgical repair of this CSF rhinorrhea is complicated by occult elevations in intracranial pressure (ICP), potentially necessitating open, transcranial repair. We report the first case in otolaryngology literature of a patient with Crouzon syndrome with late CSF rhinorrhea and encephalocele formation after previous LeFort III facial advancement surgery.

**Objectives:** Describe the case of a patient with Crouzon syndrome who presented with CSF rhinorrhea and encephaloceles as complications of Le Fort III facial advancement surgery. Review the literature pertaining to the incidence and management of post-operative CSF rhinorrhea and encephaloceles. Analyze issues related to repair of these complications, including occult elevations in ICP, the utility of perioperative CSF shunts, and the importance of considering alternative repair schemes to the traditional endonasal, endoscopic approach.

**Methods:** Review of the literature describing CSF rhinorrhea and encephalocele formation following facial advancement in CD, focusing on management strategies.

**Results:** CSF rhinorrhea and encephalocele formation are rare complications of craniofacial advancement procedures. Occult elevations in ICP complicate the prospect of permanent surgical repair, potentially necessitating transcranial repair and the use of CSF shunts. Though no consensus exists regarding the utility of perioperative CSF drains, strong associations exist between elevated ICP and failed surgical repair. Additionally, the anatomic changes in the frontal and ethmoid sinuses after facial advancement present a challenge to endoscopic repair.

**Conclusion:** Otolaryngologists should be aware of the possibility of occult elevations in ICP and sinonasal anatomic abnormalities when repairing CSF rhinorrhea in patients with CD. Clinicians should consider CSF shunt placement and carefully weigh the advantages of the transcranial approach versus endonasal, endoscopic techniques.

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Cerebrospinal fluid (CSF) leakage is a well-documented complication of traumatic, neurologic, and iatrogenic events. It occurs through a pathologic channel between the subarachnoid space and the floor of the cranium, most commonly as CSF rhinorrhea. Although the Roman philosopher and physician, Galen, in second century C.E., first incorrectly identified CSF rhinorrhea as a normal, physiologic phenomenon, its importance as a vehicle for central nervous system infection and as an indication of an underlying intra-

cranial pathology has since been realized. In fact, it has been suggested that the overall risk of meningitis in the setting of persistent CSF rhinorrhea is 19%.<sup>1</sup>

Individuals with craniofacial dysostoses (CD), such as Crouzon and Apert syndromes, represent a unique subset of patients with a congenital predisposition for CSF leaks. The craniomaxillofacial surgical corrections that these patients undergo place them at additional iatrogenic risk of developing CSF leaks and meningoencephaloceles. Crouzon syndrome is an autosomal dominant syndrome associated with mutations in the gene encoding of the fibroblast growth factor receptor 2 on chromosome 10. The syndrome is characterized by a triad of premature craniosynostosis, exophthalmos, and midface hypoplasia, and is implicated in 4.8% of all cases of craniosynostosis. Importantly, it has been suggested that 63% of individuals affected by Crouzon syndrome have elevated intracranial pressure (ICP).<sup>2</sup> Intracranial venous congestion, hydrocephalus, and obstructive sleep apnea are all potential complications of Crouzon syndrome that may contribute to eleva-

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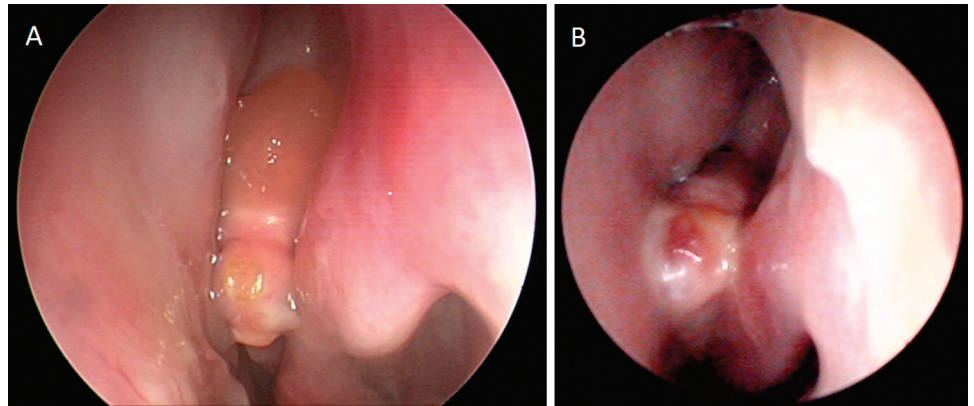
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**Figure 1.** Ethmoid encephaloceles in the left nasal cavity. (A) Nasal endoscopy, showing intranasal masses extending through the middle meatus at initial presentation. (B) Recurrent encephalocele after failed endonasal repair.

tions in ICP.<sup>3</sup> It has been proposed that persistent intracranial hypertension contributes to the inferior displacement of the cribriform plates and thinning of the anterior cranial base in these patients, which may eventually facilitate the passage of CSF, meninges, and brain parenchyma into the paranasal sinuses.<sup>4</sup>

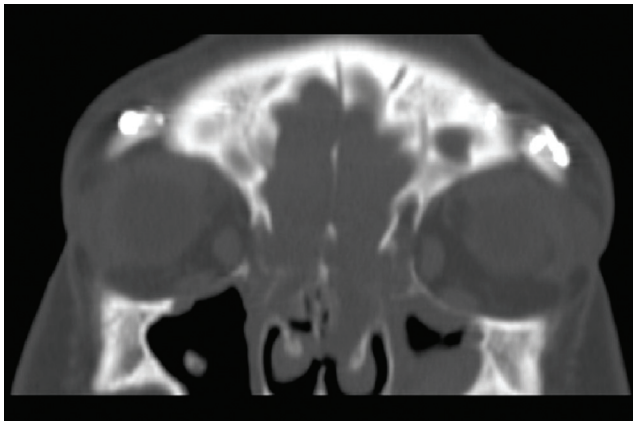
Le Fort III midface advancements are often used to address the ramifications of midface hypoplasia, including obstructed nasal airway, exorbitism, and impaired mastication. The procedure involves osteotomies made through the frontozygomatic suture, floor of the orbit, and the nasion; midline separation of the ethmoid from the anterior cranial base; and subsequent advancement of the resulting segment.<sup>3</sup> In patients with Crouzon syndrome, high-level nasofrontoethmoidal osteotomy has been associated with tearing of the anterior cranial base dura, CSF leakage, and parenchymal herniation.<sup>4</sup> Ridgway *et al.*<sup>4</sup> studied 31 patients with eponymous craniosynostoses who underwent Le Fort III procedures; 11 of them had confirmed depressions of the anterior skull base, including two patients (6.5%) who presented with postoperative CSF rhinorrhea. One additional patient, who demonstrated both anterior skull base depression and bilateral flattening of the fovea ethmoidalis, developed a meningoencephalocele. None of the patients included in the study with radiographically confirmed normal morphology of the anterior cranial fossa experienced CSF leakage. Other documented complications of Le Fort III osteotomies in patients with CDs include lethal subarachnoid hemorrhage, which results from a transverse skull base fracture of the middle cranial fossa (Crouzon syndrome); internal carotid artery dissection (Apert syndrome); and carotid-cavernous sinus fistulas, which result in blindness.<sup>5</sup> Akita *et al.*<sup>5</sup> propose that, similar to CSF rhinorrhea, these untoward effects may be averted by preventing high-level craniofacial fractures.

In 1926, Zweig<sup>6</sup> reported the first intracranial repair of CSF rhinorrhea *via* a frontal craniotomy. Since then, extracranial and endoscopic approaches have evolved. Various studies have corroborated the low complica-

tion and recurrence rates of minimally invasive endoscopic repair. One study that examined 166 endoscopic CSF leak repairs, with a mean of 21 months of follow-up, found an overall success rate of 98% and an initial success rate of 91%.<sup>7</sup> Factors such as morbid obesity, impaired wound healing, and an inability to visualize the dural defect endoscopically increase the chance of leak recurrence. Basu *et al.*<sup>8</sup> emphasize that endoscopic repair failures are more likely in cases of leaks secondary to skull base tumor resections accomplished by craniotomy, noting the particular difficulty of endoscopic leak visualization. Notably, elevated ICP after the first attempted endoscopic repair has been associated with leak relapse in as many as seven of eight repair failures by one retrospective study.<sup>9</sup> For this reason, some surgeons<sup>10</sup> have advocated for placement of lumbar drains when addressing recurrent CSF leaks. However, the collective literature does not definitively establish the efficacy of lumbar drains in reducing the incidence of leak recurrence. In any event, it is important to consider the possibility of endoscopic repair failure and the value of alternative repair methods in cases of refractory CSF rhinorrhea.

### Case Summary

We present the case of a 19-year-old African American woman with Crouzon syndrome and Graves disease. In 2011, she underwent a subcranial Le Fort III midface osteotomy and advancement to address issues related to her midface hypoplasia, including nasal obstruction, exorbitism, and malocclusion. The procedure was performed without any immediate postoperative complications. However, within a year of this procedure, the patient developed near-constant clear rhinorrhea and frequent sinus pain and pressure. She was referred to our department for consideration of endoscopic orbital decompression due to her exophthalmos secondary to Graves disease. Rigid nasal endoscopy demonstrated large intranasal pulsatile masses that were concerning for bilateral ethmoid encephaloceles



*Figure 2. Ethmoid encephaloceles after facial advancement surgery. Orbital CT, showing bilateral soft-tissue masses extending into the nasal cavities through skull base defects overlying the patient's ethmoid sinuses.*

(Fig. 1A). A computed tomography (CT) of the sinuses revealed multisinus opacification and bilateral soft-tissue masses that extended into the nasal cavities through bony defects overlying her ethmoid sinuses (Fig. 2). A CT from 2009, performed before the Le Fort III osteotomy, showed an intact skull base without evidence of an intranasal mass or sinusitis.

Several months after the diagnosis, our patient underwent endonasal resection of bilateral encephaloceles with anterior skull base reconstruction by using an underlay graft with nasal septal bone and inferior turbinate-free mucosa grafts. Tissue sealants and appropriate collagen- and gelatin-based materials were used as adjuvant packing materials. The patient had no immediate complications after surgery and no clinical evidence of CSF leak at her 3-week postoperative visit. However, within 6 months of her initial repair, she did note intermittent clear rhinorrhea and occasional headaches, although no definitive signs of CSF leak were ever noted on surveillance examinations. Unfortunately, our patient developed new-onset seizures presumed to be secondary to infectious meningitis, although a workup was inconclusive. Of note, multiple diagnostic lumbar punctures during this episode failed to reveal evidence of increased ICP. In fact, no CTs collected at any point in our patient's care showed signs of elevated ICP. Nasal endoscopy around this time revealed a dehiscence of the anterior skull base repair site with recurrent encephalocele and CSF rhinorrhea (Fig. 1 B).

In preparation for her revision surgery, a lumbar drain with intraoperative fluorescein solution injection was used. Fluorescein was noted to be actively draining from both the left and right skull base repair sites. In addition, there was endoscopic evidence of a recurrent right-sided encephalocele. The decision was made to proceed in a staged manner by addressing the left



*Figure 3. Intact skull base after transcranial repair. CT of the head, showing repair of anterior skull base with bilateral calvarial bone grafts in place.*

side initially with a posterior-based nasoseptal flap and delayed repair of the right side. After encephalocele resection, the left skull base was repaired with an underlay graft of cadaveric skin and septal cartilage with vascularized flap coverage. On the right side, the recurrent encephalocele was resected and the skull base defect was temporized with a cadaveric skin graft, tissue sealant, and standard packing materials.

The patient had no immediate or delayed complications after this surgery. Several months later, the patient once again developed symptoms of CSF rhinorrhea and recurrence of right encephalocele. The patient ultimately underwent open repair with a pericranial flap with a calvarial bone graft used for definitive anterior skull base repair (Fig. 3). Importantly, an extraventricular drain was placed intraoperatively and was kept in place during her entire inpatient stay. It was discontinued before discharge. To date, the patient remains asymptomatic, without clinical or endoscopic evidence of encephalocele or CSF leak recurrence.

## DISCUSSION

Minimally invasive endoscopic surgery has become the preferred technique to repair CSF leaks. Transcranial repair of anterior skull base defects is associated with morbid sequelae, such as anosmia, destruction of intervening neurovascular structures, parenchymal edema, and poorer cosmesis. Indeed, ample data have supported the efficacy of the endoscopic approach, but it is prudent to recognize circumstances under which complementary interventions and alternative repair schemes should be considered.



It has become apparent that spontaneous CSF leaks are associated with elevations in ICP.<sup>6,11–12</sup> Some surgeons have suggested that these leaks are more difficult to permanently repair without ancillary measures to control ICP, such as acetazolamide or ventricular shunts.<sup>13</sup> Zweig<sup>6</sup> retrospectively examined a cohort of 53 patients and found that the only significant positive correlate of leak recurrence after endoscopic repair was high-pressure hydrocephalus among an array of variables, including graft constitution, etiology and location of the leak, timing of repair, and the presence of concurrent meningocele. Patients with Crouzon syndrome typically have bicoronal craniosynostosis and other comorbidities, such as persistent obstructive sleep apnea and anomalous intracranial venous drainage,<sup>12</sup> which contribute to elevations in ICP. Moreover, Ridgway *et al.*<sup>4</sup> describe unique anatomic abnormalities in patients with eponymous craniosynostoses, such as an inferiorly displaced anterior skull base, cribriform plate, and fovea ethmoidalis, and unreliable external markers of the craniofacial bony anatomy, which predispose patients with Crouzon syndrome to CSF rhinorrhea after craniofacial surgeries. Moreover, Basu *et al.*<sup>7</sup> indicate that morbid obesity, more than being a definitive risk factor for ICP elevations and spontaneous CSF leaks, may complicate endoscopic repair. Our patient's body mass index exceeded 34 kg/m<sup>2</sup>, potentially corroborating the aforementioned association.

Importantly, it may be difficult to measure elevated ICP in cases of active CSF leaks because the fistula functions as an open pressure release valve. In this case, the standard measures of diagnosing elevated ICP, such as LP lumbar puncture opening pressure or evidence of hydrocephalus on CT, may prove less reliable. Therefore, the presence of occult elevated ICP should also be considered in patients with active leaking. Similarly, when endoscopic repair of CSF leaks fails, it is logical to suspect elevated ICP and adjust the treatment plan accordingly.

The current literature describes various instances in which the transcranial approach was chosen for definitive CSF leak repair. Bledsoe *et al.*<sup>11</sup> describe the case of a woman with CSF rhinorrhea refractory to endoscopic repair who was later found to have elevated ICP secondary to superior vena cava syndrome. Her CSF leak failed two endoscopic repairs and was corrected with transcranial repair by using a frontal craniotomy. Liu *et al.*<sup>14</sup> detail a retrospective study of 132 cases of CSF rhinorrhea and highlights two refractory cases that were finally corrected by successful transcranial repair after failed endonasal and transnasal repairs. The implication of these studies and our own experience is that recurrent endoscopic repair failure warrants consideration of the transcranial method as an alternative, a technique that allows direct visualization

of the dural defect and use of large vascularized pericranial flaps for repair.

Another consideration includes the use of lumbar or extraventricular drains, although the current literature is equivocal regarding their efficacy and/or necessity in the prevention of leak recurrence. Caballero *et al.*<sup>15</sup> looked at risk factors for recurrent leak in 105 patients who underwent endoscopic repair for CSF rhinorrhea either with or without lumbar drain placement by looking at patient factors, including body mass index, the presence of meningoencephalocele, and concomitant idiopathic intracranial hypertension. They noted that recurrence rates were not significantly different ( $p = 0.15$ ) in the two cohorts (lumbar drain<sup>+</sup>,  $n = 68$ ; lumbar drain<sup>-</sup>,  $n = 37$ ).<sup>14</sup> Hegazy *et al.*<sup>16</sup> performed a meta-analysis of 289 patients with CSF leak, which demonstrated that adjunctive measures, including lumbar drains, did not significantly affect endoscopic repair outcomes. Conversely, Woodworth *et al.*<sup>12</sup> attribute their endoscopic repair success rate (95%) in cases of spontaneous CSF rhinorrhea to prolonged management of elevated ICP by acetazolamide therapy or ventriculoperitoneal shunts. Caballero *et al.*,<sup>15</sup> however, demonstrated that the use of lumbar drains in a cohort of patients with spontaneous CSF leaks did not significantly decrease leak recurrence rates. Their importance in the treatment of traumatic, or iatrogenic, leaks is similarly equivocal. It appears, for the time being, that ancillary measures in the management of CSF rhinorrhea should be tried *per* the clinician's discretion.

## CONCLUSION

Otolaryngologists should be aware of the possibility of occult elevations in ICP as well as sinonasal anatomic abnormalities when repairing CSF rhinorrhea in patients with CDs. Clinicians should consider CSF shunt placement and carefully weigh the advantages of the open, transcranial approach versus endonasal, endoscopic techniques.

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