

Complications of Skull Base Surgery

Mofiyinfolu Sokoya, MD¹ Moustafa Mourad, MD² Yadranko Ducic, MD²

¹ Department of Otolaryngology, University of Colorado School of Medicine, Aurora, Colorado

² Department of Facial Plastic and Reconstructive Surgery, Otolaryngology and Facial Plastic Surgery Associates, Fort Worth, Texas

Address for correspondence Yadranko Ducic, MD, Department of Facial Plastic and Reconstructive Surgery, Otolaryngology and Facial Plastic Surgery Associates, Fort Worth, Texas
(e-mail: yducic@sbcglobal.net).

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Abstract

Keywords

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- ▶ complications

Approaches to surgical management of skull base pathology and reconstruction of skull base defects have evolved over the past several decades. The goal, however, remains the same—to effectively address the pathology with minimal complications. In this article, the authors try to explore multiple complications of skull base surgery, discussing their incidence, natural course, and prevention. This will prove beneficial in optimal management of patients with a myriad of skull base disorders.

Approaches to surgical management of skull base pathology and reconstruction of skull base defects have evolved over the past several decades. Surgical management of this area requires complex surgical planning and execution and is associated with a myriad of potential complications. The goal, however, remains the same—to effectively address the pathology with minimal complications.

Walter Dandy initially described a combined craniofacial approach to an orbital tumor in 1942.¹ Ray and McLean utilized this approach for the surgical management of retinoblastoma 2 years later.² In 1954, Smith et al reported the application of the craniofacial approach for resection of sinonasal tumors. Ketcham et al also reported a series of 89 patients with malignant skull base tumors resected through a craniofacial approach. This approach was associated with a low mortality rate of 3%.^{3,4}

Later in the 20th century, endoscopy became to be more widely used in surgery. Endoscopy-assisted skull base surgery became the mainstay of surgical management of sinonasal and skull base tumors. Yuen et al reported a series of patients, with olfactory neuroblastoma, treated with endoscopy-assisted craniofacial resection, with minimal complications.⁵ Stammberger was one of the pioneers of complete transnasal endoscopic resection of anterior skull base tumors.⁶

Comparisons of craniofacial resection (CFR) and transnasal endoscopic resection (TER) have been performed by multiple groups. Most notably, Batra et al compared 16

patients who underwent CFR with 9 patients who underwent TER. Patients who underwent TER had shorter operative times, shorter intensive care unit stay, lower rates of major complications, and decreased mortality.⁷

Endoscopic approaches are applied not only to sinonasal and skull base malignancies but also to other disorders, such as encephaloceles, cerebrospinal fluid (CSF) leaks, mucoceles, and pituitary neoplasms. Advantages of endoscopic approaches include better visualization of the clivus and parasellar regions. These approaches also allow the surgeon to avoid manipulating intracranial structures such as the frontal lobe.

Effective management of skull base pathology requires involvement of a multidisciplinary team. This team of otolaryngologists, neurosurgeons, plastic surgeons, ophthalmologists, radiation oncologists, medical oncologists, anesthesiologists, and rehabilitation specialists is vital to ensure optimal surgical results. This multidisciplinary approach is essential to decreasing complications and mortality.

Commonly reported complications of skull base surgery include meningitis, CSF leak, visual changes, cerebral infarct, subdural hemorrhage, epidural abscess, hydrocephalus, chronic rhinosinusitis, sinonasal mucocele, hematoma, epistaxis, and death. The likelihood of these complications is largely dependent on the nature of pathology that is being treated, whether it be malignant diseases, such as esthesioneuroblastoma, or benign pathologies, such as a pituitary macroadenoma. Understanding of the possibility of these

complications, as well as their relative incidences, is crucial to the surgical management of any skull base pathology.

The overall complication rate of endoscopic endonasal approaches is often quoted to be between 10 and 20%.^{8,9} Complications are often categorized as early or late, based on postoperative timing of onset. Dias et al reported early complications (<14 days) in 79% of patients and late complications (>14 days) in 24.5% of patients who underwent anterior craniofacial resection.¹⁰

In this article, we delve into multiple complications of skull base surgery, discussing their incidence, natural course, and prevention. This will prove beneficial in optimal management of patients with a myriad of skull base disorders.

Cerebrospinal Fluid Leak

Cerebrospinal fluid (CSF) leak could present as the skull base pathology being treated or as a complication of surgical management of other skull base pathologies. CSF leaks were reported to occur as commonly as in 13.8% of endoscopic cases¹¹ and 8.2% of open anterior craniofacial resection.¹⁰ Depending on severity, these cases can be managed conservatively with bedrest. Lumbar drains can be inserted for reduction in intracranial pressure. Ventriculostomy and ventriculoperitoneal shunts are options for prolonged and recalcitrant CSF leaks.

Multiple studies have explored various surgical treatment options.^{3,12,13} According to a systematic review comparing endoscopic endonasal approach to open repair of CSF leaks, there is no significant difference in the rate of successful repair between the open and endoscopic cohorts.¹⁴ Nevertheless, complications were significantly lower in the endoscopic group.

Intrathecal fluorescein is a valuable adjunct to identifying the location of CSF leaks. It is safe and efficient in detecting skull base defects in patients with otherwise normal preoperative imaging.¹³ A nasoseptal flap provides a vascularized soft tissue covering that could be used to address CSF leaks.¹⁵ Other options for reconstruction of skull base defects and CSF leaks include temporalis muscle flap,¹⁶ as well as various free tissue transfer options.¹⁷

Meningoencephalocele

A meningocele is a herniation of cranial meninges through a skull base defect. If brain tissue is involved in the herniation, it is termed an encephalocele or meningoencephalocele. Brain and meninges herniation could be congenital or acquired due to a complication of prior surgery. Anterior skull base herniation is typically classified as sincipital or basal. Sincipital encephaloceles typically herniate between the frontal and ethmoid bones, anterior to the cribriform plate. These are associated with external masses. Basal encephaloceles do not present as external masses and are typically associated with herniation around the sphenoid bone. These manifest as intranasal masses with CSF leakage.¹⁸ Whether a meningoencephalocele is congenital or acquired, excision of the intranasal aspect of the lesion followed by a watertight closure of the skull

base defect is the recommended treatment. This can be performed through an endonasal, endoscopic approach or via a craniotomy.^{19,20} Surgical approaches to anterior skull base encephaloceles have evolved in the recent decades. Endoscopic endonasal surgery has become more widely adopted as a viable approach. Craniotomy-associated complications of hemorrhage, bleeding, anosmia, as well as longer operative times, and hospital stays have been largely reduced. CSF leak control rates have also increased.^{21,22}

Meningitis

Infection and inflammation of the meninges can be a source of significant morbidity and mortality. Meningitis has been reported to occur 1 to 10% of the time, during craniofacial approaches to skull base lesions.⁸ It is usually an early complication; however, a case has been reported to occur > 6 months after surgery.¹¹ Completing the intradural portion of the resection prior to entering the nasal cavity to prevent intracranial seeding of bacteria from the nose has been proposed as a way of mitigating postoperative intracranial infections.⁸ This theory has not been supported in endoscopic cases. Rates of meningitis have not been shown to be higher in endoscopic approaches where there is an intimate communication between the intracranial and intranasal cavities.

Intracranial infections usually resolved after antibiotic treatment. The length of treatment is usually dependent on severity and duration of patients' symptoms.

Cerebral Infarct

Strokes can be a devastating cause of morbidity and mortality as a result of anterior skull base surgery. This complication rarely occurs, but its possibility should be considered by every skull base surgeon. Naunheim et al reported its occurrence in one patient, likely due to vasospasm secondary to aseptic meningitis in the postoperative period.¹¹ Downstream effects of cerebral or brainstem infarcts could include cranial nerve deficits, leading to diplopia, dysphagia, dysarthria, among others. Management of this complication should focus on rehabilitation and return of function and preserving independent performance of activities of daily living.

Orbital Complications

Visual disturbances, as a result of orbital complications, can be a source of significant morbidity after skull base surgery. Orbital complications can be early or late, leading to exposure keratopathy, optic neuropathy, or retinopathy. Diplopia is a common complication of pituitary disorders and surgery. Damage to the optic nerve during resection can worsen diplopia in patients already at-risk. Management of this complication must be based on the cause of visual disturbance. Exposure keratopathy can be managed with liberal use of moisture and corneal protection. Tarsorrhaphy should be considered in patients with a high risk of exposure keratopathy.

Calvarial Deformity

When skull base surgery is performed in the treatment of cranosynostosis, understanding the principles of Tessier is important in preventing complications. The basic principles involve (1) wide subperiosteal exposure of the face and orbit, (2) affected orbit can be safely moved in any direction without risking visual or oculomotor dysfunction, (3) osteotomies and repositioning of facial structures result in better outcomes than sole utilization of bone grafting, and (4) correction of as many deformities as possible in the same operative procedure. Adherence to these principles is crucial to the prevention of complications. Complications are usually classified as immediate or delayed. Immediate complications include bleeding, air embolism, CSF leak, while delayed complications involve abnormal bone healing and growth. With the use of an experienced multidisciplinary team and approach, these complications can be largely minimized.^{23,24}

Chronic Rhinosinusitis/Mucocele

Chronic rhinosinusitis (CRS) is a common delayed complication of endoscopic skull base surgery, occurring in 3.4% of all patients.¹¹ Inadequate opening of drainage pathways or iatrogenic obstruction of outflow tracts such as the frontal recess could be a cause of this complication. Frontoethmoidal mucoceles develop due to obstruction of mucociliary drainage of the sinuses. These expansile masses can invade the orbit, leading to proptosis, diplopia, ophthalmoplegia, and blindness.

Maximal medical management is important in the treatment of chronic rhinosinusitis. Nasal saline irrigations, intranasal steroids, and antibiotics are mainstays of treatment of chronic rhinosinusitis. Functional endoscopic sinus surgery, with marsupialization of mucocele, is usually a sufficient initial surgical modality for management of ethmoid mucoceles.

Frontal sinus mucoceles could be recalcitrant due to a bottleneck effect of the frontal recess. Surgery should be aimed at opening the frontal sinus wide enough to facilitate topical management with irrigations and steroids, as well as visual inspection in an outpatient setting. A Draf IIb procedure, opening the frontal sinus from the orbit to the septum in the coronal plane, is commonly used in managing mucoceles.²⁵

Electrolyte Abnormalities

Manipulation of the neurohypophysis potentially leads to disturbances in water/electrolyte balance and osmoregulation. This typically manifests as hyponatremia and/or diabetes insipidus (DI). These complications are commonly associated with pituitary surgery. It is critical to maintain proper postoperative tracking of daily weight, intake, and output, as well as electrolytes after pituitary surgery. Hyponatremia is defined as serum sodium (Na) < 135 mmol/L. It occurs after pituitary surgery, likely due to antidiuretic hormone (ADH) leakage from axons of the neurohypophysis (syndrome of inappropriate antidiuretic hormone secretion [SIADH]) and cerebral salt wasting.²⁶ Hyponatremia is typically managed with fluid restriction. DI is the postoperative

depletion of ADH following surgical manipulation of the pituitary stalk. This is usually managed with gradual fluid repletion and replacement of ADH.

Conclusion

Having an in-depth understanding of possible complications of skull base surgery is paramount to the success of any skull base surgeon. Knowledge is the first step in preventing and recognizing these potentially devastating complications. The surgeon should maintain vigilance in the prevention and management of complications of skull base surgery.

Conflict of Interest

None.

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