Modern Endoscopic Management of Sellar and Suprasellar Pathologies: Anatomy, Technique, and Evidence-Based Outcomes

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Abstract

Background: The management of sellar and suprasellar lesions has undergone a profound transformation over the past three decades with the widespread adoption of endoscopic endonasal surgery. Originally introduced as an alternative to microscopic transsphenoidal techniques, the endoscopic approach has evolved into the preferred surgical strategy for a broad spectrum of sellar and suprasellar pathologies owing to its panoramic visualization, improved illumination, enhanced anatomical orientation, and expanded surgical reach. Advances in endoscopic instrumentation, neuronavigation, high-definition imaging, and skull base reconstruction techniques have significantly improved the safety and efficacy of these procedures, enabling surgeons to address increasingly complex lesions while minimizing morbidity.

Sellar and suprasellar pathologies encompass a diverse group of neoplastic and non-neoplastic lesions, including pituitary neuroendocrine tumors (PitNETs), craniopharyngiomas, Rathke cleft cysts, meningiomas, chordomas, and other skull base tumors. Successful surgical management requires a thorough understanding of the intricate anatomy of the nasal cavity, sphenoid sinus, sella turcica, cavernous sinus, optic apparatus, and surrounding neurovascular structures. Detailed anatomical knowledge is essential for selecting appropriate surgical corridors, achieving maximal lesion resection, preserving neurological and endocrine function, and preventing complications.

This review provides a comprehensive overview of the anatomical foundations, surgical principles, and contemporary endoscopic techniques used in the management of sellar and suprasellar lesions. Particular emphasis is placed on endoscopic anatomical landmarks, variations of sphenoid sinus pneumatization, parasellar and suprasellar relationships, operative strategies, and reconstruction methods. Furthermore, current evidence regarding surgical outcomes, extent of resection, visual and endocrine recovery, complication profiles, and comparisons with traditional microscopic approaches is critically examined. Emerging technologies, including intraoperative imaging, fluorescence-guided surgery, augmented reality, and robotic assistance, are also discussed.

Current evidence demonstrates that endoscopic endonasal surgery provides excellent visualization, favorable resection rates, and improved functional outcomes while maintaining acceptable complication rates when performed by experienced multidisciplinary teams. Continued refinement of surgical techniques and technological innovations is expected to further expand the role of endoscopic surgery in the treatment of sellar and suprasellar pathologies.

Keywords: Endoscopic endonasal surgery; Sellar lesions; Suprasellar pathology.

Introduction

The management of sellar and suprasellar lesions has undergone substantial evolution over the past several decades, progressing from transcranial operations to microscopic transsphenoidal surgery and ultimately to contemporary endoscopic endonasal approaches. The introduction of endoscopic visualization has significantly expanded the surgeon's ability to access the ventral skull base through minimally invasive corridors while minimizing brain retraction and reducing surgical morbidity. Compared with traditional microscopic techniques, endoscopy provides superior illumination, panoramic visualization, and enhanced appreciation of complex anatomical relationships within the sellar and parasellar regions, facilitating safer and more effective lesion resection.[1,2]

Sellar and suprasellar pathologies comprise a diverse group of neoplastic and non-neoplastic lesions, including pituitary neuroendocrine tumors (PitNETs), craniopharyngiomas, Rathke cleft cysts, meningiomas, chordomas, and selected hypothalamic lesions. Among these entities, PitNETs represent the most frequently encountered pathology and account for approximately 10–25% of intracranial neoplasms.[3] Epidemiological studies have demonstrated that pituitary adenomas are considerably more common than previously believed, with a prevalence approaching 17% in the general population.[4] Although most lesions are histologically benign, they can produce significant morbidity through hormonal hypersecretion, hypopituitarism, visual dysfunction, and mass effect on adjacent neurovascular structures.[5,6]

Successful endoscopic surgery requires a comprehensive understanding of the intricate anatomy of the nasal cavity, sphenoid sinus, sella turcica, cavernous sinus, optic apparatus, and suprasellar cisterns. Anatomical variations involving sphenoid sinus pneumatization, intersinus septation, optic nerve prominence, carotid artery protuberance, and diaphragma sellae morphology may substantially influence surgical planning and intraoperative decision-making.[7,8] Detailed knowledge of these anatomical relationships is essential to avoid complications such as internal carotid artery injury, visual deterioration, cerebrospinal fluid leakage, and postoperative endocrinological dysfunction.[9,10]

The development of extended endoscopic endonasal approaches has further broadened the indications of minimally invasive skull base surgery. Through tailored surgical corridors, surgeons can now access lesions involving the suprasellar, parasellar, planum sphenoidale, and clival regions with increasing precision.[11] Several contemporary studies have demonstrated favorable rates of tumor resection, visual recovery, and functional preservation following endoscopic surgery, particularly when procedures are performed by experienced multidisciplinary skull base teams.[12,13]

Despite significant advances in surgical techniques and perioperative care, important challenges remain regarding patient selection, management of giant and invasive lesions, optimization of skull base reconstruction, prevention of cerebrospinal fluid leakage, and preservation of pituitary function. Furthermore, ongoing developments in intraoperative imaging, neuronavigation, fluorescence-guided surgery, and other emerging technologies continue to reshape modern skull base practice.[14,15]

Therefore, the aim of this review is to provide a comprehensive overview of the anatomical foundations, surgical techniques, reconstruction strategies, clinical outcomes, and current evidence supporting the modern endoscopic management of sellar and suprasellar pathologies.

Historical Evolution of Endoscopic Endonasal Surgery

The surgical treatment of sellar lesions has evolved considerably since the early twentieth century. Traditional transcranial approaches initially represented the primary surgical option for pituitary and suprasellar lesions; however, these procedures were associated with significant brain retraction and postoperative morbidity. The introduction of transsphenoidal surgery provided a less invasive route to the sella turcica, offering direct access to the pituitary gland through the sphenoid sinus. With the advent of the operating microscope, transsphenoidal surgery became the standard treatment for most sellar lesions and achieved favorable clinical outcomes for several decades.[16,17]

The development of modern endoscopic technology revolutionized skull base surgery by providing panoramic visualization and angled views that were not achievable with the microscope. Initial applications of the endoscope were primarily as an adjunct to microscopic surgery; however, continuous improvements in optics, illumination, and instrumentation eventually enabled purely endoscopic procedures. Endoscopic endonasal surgery rapidly gained acceptance because it allowed enhanced visualization of critical anatomical structures, improved identification of tumor margins, and expanded access to regions beyond the sella, including the suprasellar and parasellar compartments.[18,19]

Over the last two decades, endoscopic techniques have continued to evolve through the integration of neuronavigation systems, high-definition imaging, vascularized flap reconstruction, and multidisciplinary collaboration between neurosurgeons and rhinologists. These advances have significantly improved surgical safety and broadened the indications for endoscopic surgery to include giant pituitary adenomas, craniopharyngiomas, tuberculum sellae meningiomas, and other complex skull base lesions. Consequently, endoscopic endonasal surgery has become a cornerstone of contemporary skull base practice and is now considered the preferred approach for many sellar and suprasellar pathologies.[20,21]

Surgical Anatomy of the Nasal Cavity and Endonasal Corridor

A thorough understanding of nasal cavity anatomy is fundamental for safe and effective endoscopic surgery of sellar and suprasellar lesions. The nasal cavity serves as the natural surgical corridor through which the sphenoid sinus and skull base are accessed. It extends from the anterior nares to the posterior choanae and is divided into two compartments by the nasal septum. The cavity is bounded superiorly by the cribriform plate, inferiorly by the hard palate, medially by the nasal septum, and laterally by the turbinates and meatal structures. Familiarity with these anatomical landmarks is essential for establishing a safe operative trajectory while minimizing mucosal trauma and preserving sinonasal function.[22]

The lateral nasal wall contains the inferior, middle, and superior turbinates, which play a crucial role in endoscopic orientation. Among these structures, the middle turbinate represents one of the most important landmarks encountered during the initial stages of surgery. Gentle lateralization of the middle turbinate exposes the sphenoethmoidal recess, where the sphenoid ostium is typically identified. The superior turbinate also serves as a reliable landmark because the sphenoid ostium is usually located medial to its inferior portion. Accurate identification of these structures facilitates direct access to the sphenoid sinus while reducing the risk of injury to adjacent anatomical structures.[23]

From an endoscopic perspective, the nasal septum forms the medial boundary of the surgical corridor and provides access to both sphenoid ostia. Modern binostril approaches exploit the natural space between the septum and middle turbinates, allowing the introduction of multiple instruments alongside the endoscope. This technique enables bimanual microsurgical dissection and significantly improves maneuverability during tumor removal. Preservation of mucosal integrity and maintenance of adequate visualization throughout this stage are important factors that contribute to favorable surgical outcomes and reduced postoperative nasal morbidity.[24,25]

Sphenoid Sinus Anatomy and Surgical Landmarks

The sphenoid sinus represents the principal gateway to the sellar region during endoscopic endonasal surgery. Located within the body of the sphenoid bone, it is composed of two frequently asymmetrical cavities separated by one or more bony septa. Considerable anatomical variability exists in sphenoid sinus size, septation pattern, and degree of pneumatization, making preoperative radiological assessment indispensable for surgical planning. Computed tomography remains the gold standard for evaluating these anatomical variations and identifying potential hazards related to neighboring neurovascular structures.[26,27]

Based on the degree of pneumatization, the sphenoid sinus is commonly classified into conchal, presellar, sellar, and postsellar types. The sellar configuration is the most frequently encountered pattern and provides the most favorable surgical corridor because the sinus extends beneath the sella turcica, allowing direct access to the pituitary fossa. In contrast, conchal and presellar variants may limit surgical exposure and increase drilling requirements during sphenoidotomy. Recognition of these anatomical variants is particularly important when planning surgery for large sellar and suprasellar lesions.[28]

Following wide sphenoidotomy, several critical anatomical landmarks become visible within the sphenoid sinus. The sellar floor occupies the central portion of the posterior sinus wall, while the planum sphenoidale is located superiorly and the clival recess inferiorly. Laterally, prominences produced by the parasellar and paraclival segments of the internal carotid arteries create essential landmarks that guide safe bone removal. In well-pneumatized sinuses, the optic nerve canals can also be identified as distinct elevations in the superolateral walls. Together, these structures create the characteristic endoscopic appearance often described as a "surgical roadmap" to the sellar and suprasellar regions.[29,30]

One of the most important anatomical considerations during surgery is the presence of sphenoid sinus septations. The main intersinus septum is frequently eccentric and may insert directly onto the bony covering of the internal carotid artery rather than the midline sellar floor. Additional accessory septa are common and may similarly terminate on carotid prominences. Aggressive manipulation of these septations can result in catastrophic vascular injury; therefore, careful drilling and controlled removal under direct visualization are mandatory. Detailed preoperative imaging should always be reviewed to identify septal attachments before surgery.[31]

The opticocarotid recesses constitute additional key landmarks within the sphenoid sinus. The lateral opticocarotid recess corresponds anatomically to the optic strut and marks the junction between the optic canal and carotid prominence. The medial opticocarotid recess serves as an important reference point during extended endoscopic approaches to the suprasellar region and planum sphenoidale. Accurate identification of these structures assists in orientation, facilitates safe skull base drilling, and reduces the risk of injury to the optic apparatus or internal carotid artery during expanded approaches.[32]

Sellar, Parasellar, and Suprasellar Anatomy

Sella Turcica and Pituitary Gland

The sella turcica is a saddle-shaped depression located on the superior surface of the sphenoid body and serves as the osseous container of the pituitary gland. Anatomically, it consists of the tuberculum sellae anteriorly, the hypophyseal fossa centrally, and the dorsum sellae posteriorly. The pituitary gland occupies the majority of the sellar cavity and is connected to the hypothalamus through the pituitary stalk. Superiorly, the gland is covered by the diaphragma sellae, a dural reflection containing a central aperture that permits passage of the infundibulum. Variations in the size and morphology of this opening influence the pattern of suprasellar extension of pituitary lesions and may affect surgical exposure during endoscopic procedures.[33,34]

The pituitary gland consists of two embryologically and functionally distinct components: the adenohypophysis and the neurohypophysis. The anterior lobe is responsible for secretion of growth hormone, prolactin, adrenocorticotropic hormone, thyroid-stimulating hormone, follicle-stimulating hormone, and luteinizing hormone, whereas the posterior lobe stores and releases vasopressin and oxytocin synthesized within the hypothalamus. Preservation of normal pituitary tissue and its vascular supply is a major objective during endoscopic surgery because postoperative hypopituitarism can significantly affect long-term patient outcomes.[35,36]

Cavernous Sinus Anatomy

The cavernous sinuses are paired venous compartments situated lateral to the sella turcica and represent one of the most critical anatomical regions encountered during endoscopic skull base surgery. These structures extend from the superior orbital fissure anteriorly to the petrous apex posteriorly and are bounded medially by the pituitary fossa and laterally by the temporal dura. The medial wall of the cavernous sinus is particularly important because it constitutes the principal barrier separating pituitary tumors from the neurovascular structures contained within the sinus.[37]

Several vital neurovascular structures traverse the cavernous sinus. The cavernous segment of the internal carotid artery courses through its venous compartment and serves as the dominant surgical landmark during endoscopic approaches. Cranial nerves III, IV, V1, and V2 travel within the lateral wall of the sinus, whereas the abducens nerve courses adjacent to the internal carotid artery within the sinus proper. Understanding these anatomical relationships is essential when treating invasive pituitary adenomas or lesions extending into the parasellar compartment, as inadvertent injury may result in significant neurological morbidity.[38]

Optic Apparatus and Suprasellar Region

The suprasellar region contains numerous critical structures that determine both the clinical presentation and surgical strategy for sellar lesions. The optic nerves converge superior to the sella to form the optic chiasm, which lies immediately above the diaphragma sellae in most individuals. Compression of the optic chiasm by expanding sellar masses commonly produces visual field defects, most characteristically bitemporal hemianopia. Anatomical variations in chiasmal position, including prefixed and postfixed configurations, may influence symptomatology as well as the surgical corridor required for lesion resection.[39]

Beyond the optic apparatus, the suprasellar compartment contains the pituitary stalk, hypothalamus, lamina terminalis, anterior cerebral arteries, anterior communicating artery complex, and multiple perforating vessels. These structures form a densely populated neurovascular environment that requires meticulous dissection during extended endoscopic approaches. The relationship between the pituitary stalk and surrounding vascular structures is particularly important when managing craniopharyngiomas and other suprasellar lesions, where aggressive resection must be balanced against preservation of neurological and endocrine function.[40]

From an endoscopic perspective, the suprasellar space has been described as a pyramidal compartment bordered anteriorly by the optic apparatus and anterior communicating complex, laterally by the supraclinoid internal carotid arteries and optic tracts, and posteriorly by the upper brainstem and basilar apex structures. Detailed appreciation of these anatomical boundaries is essential for achieving safe tumor removal while minimizing the risk of visual, vascular, or hypothalamic injury.[41]

Endoscopic Surgical Techniques and Approaches to Sellar and Suprasellar Lesions

The success of endoscopic surgery for sellar and suprasellar lesions relies on meticulous surgical planning, comprehensive anatomical knowledge, and careful execution of each operative step. Modern endoscopic procedures are typically performed through a binostril approach using a collaborative neurosurgical and otolaryngological technique. Patients are positioned supine with slight head elevation and extension to optimize venous drainage and facilitate direct alignment of the nasal corridor with the sphenoid sinus and sella turcica. Image-guided neuronavigation is frequently employed, particularly in patients with distorted anatomy, recurrent tumors, or extended skull base lesions.[42,43]

Standard Endoscopic Transsphenoidal Approach

The standard endoscopic transsphenoidal approach remains the preferred surgical route for the majority of pituitary adenomas and intrasellar lesions. Following identification of the sphenoid ostia, a wide sphenoidotomy is performed to expose the sellar floor and relevant anatomical landmarks. Removal of the sellar bone allows direct visualization of the dura mater, which is subsequently opened to expose the lesion. Tumor debulking is generally initiated centrally, followed by careful extracapsular dissection to separate the lesion from normal gland tissue, diaphragma sellae, and surrounding neurovascular structures. The panoramic endoscopic view facilitates inspection of hidden recesses and may improve the extent of resection compared with microscopic techniques.[44,45]

Particular attention is directed toward preservation of normal pituitary tissue, maintenance of the pituitary stalk, and avoidance of injury to the cavernous carotid arteries. Angled endoscopes and specialized instruments permit visualization beyond the direct line of sight, allowing identification of residual tumor tissue that may remain concealed within suprasellar or parasellar extensions. These advantages have contributed to the increasing adoption of endoscopic surgery as the primary treatment modality for sellar lesions in many specialized centers.[46]

Extended Endoscopic Endonasal Approaches

The evolution of extended endoscopic approaches has significantly broadened the surgical indications beyond conventional pituitary surgery. By expanding bone removal to include the tuberculum sellae, planum sphenoidale, clivus, or adjacent skull base regions, surgeons can access lesions involving the suprasellar, parasellar, and retrochiasmatic compartments through a direct midline corridor. These approaches have proven particularly valuable in the management of craniopharyngiomas, tuberculum sellae meningiomas, Rathke cleft cysts with suprasellar extension, and selected skull base tumors.[47]

A major advantage of extended approaches is the ability to reach lesions from below without significant brain retraction. Early identification of the optic apparatus, pituitary stalk, and major vascular structures facilitates safe microsurgical dissection while preserving critical neurological function. Nevertheless, increasing surgical exposure is associated with a greater risk of cerebrospinal fluid leakage, making meticulous reconstruction an integral component of the procedure.[48]

Tumor Resection Principles

Regardless of the lesion type, several fundamental principles guide endoscopic tumor resection. Internal decompression is usually performed first to reduce tumor volume and create working space. Subsequent extracapsular dissection allows progressive mobilization of the lesion away from surrounding structures. For invasive tumors involving the cavernous sinus or encasing critical vessels, the goal may shift from gross-total resection to maximal safe resection in order to preserve neurological and endocrine function. This strategy is particularly relevant for giant pituitary adenomas and lesions with extensive parasellar invasion.[49]

Successful surgery requires continuous awareness of anatomical landmarks, careful hemostasis, and avoidance of excessive traction on the optic apparatus and hypothalamic structures. The use of angled endoscopes has substantially improved visualization of suprasellar extensions and blind corners, contributing to higher resection rates while maintaining acceptable complication profiles.[50]

Skull Base Reconstruction and Prevention of Cerebrospinal Fluid Leakage

Skull base reconstruction represents a critical component of endoscopic surgery for sellar and suprasellar lesions. While standard transsphenoidal procedures are often associated with relatively small dural defects, extended endoscopic approaches frequently create large communications between the subarachnoid space and the sinonasal tract. Failure to achieve a watertight reconstruction may result in postoperative cerebrospinal fluid (CSF) leakage, meningitis, pneumocephalus, prolonged hospitalization, and the need for revision surgery. Consequently, advances in reconstruction techniques have played a pivotal role in expanding the indications and safety of endoscopic skull base surgery.[51]

The choice of reconstruction strategy is largely determined by the size of the skull base defect and the presence or absence of an intraoperative CSF leak. Small sellar defects without significant arachnoid violation may be managed with simple closure techniques using autologous fat, fascia, collagen matrices, or synthetic dural substitutes. In contrast, high-flow CSF leaks encountered during extended approaches require multilayer reconstruction to provide durable separation between the intracranial and sinonasal compartments.[52]

One of the most significant advances in endoscopic skull base surgery has been the introduction of vascularized pedicled flaps. The vascularized nasoseptal flap has become the workhorse reconstructive technique because of its robust blood supply, large surface area, and high success rate in preventing postoperative CSF leakage. Following tumor removal, reconstruction is typically performed using a multilayer technique that may include autologous grafts, synthetic substitutes, and coverage with a vascularized flap. This strategy has dramatically reduced postoperative leak rates and has become standard practice in many skull base centers.[53]

Meticulous surgical technique remains equally important for successful reconstruction. Preservation of mucosal integrity during the nasal phase of surgery, accurate identification of dural defects, careful graft placement, and secure flap positioning are essential steps. In selected patients, temporary lumbar drainage may be considered when extensive skull base defects or persistent high-flow leaks are encountered, although its routine use remains controversial. Modern reconstruction protocols emphasize individualized treatment strategies based on defect size, lesion location, and intraoperative findings.[54]

Contemporary studies have demonstrated substantial reductions in postoperative CSF leak rates compared with the early era of expanded endoscopic surgery. As reconstructive methods have evolved, endoscopic approaches have become increasingly applicable to complex suprasellar and skull base lesions that were previously considered unsuitable for endonasal treatment. Effective reconstruction is therefore not merely the final stage of surgery but rather a fundamental determinant of overall surgical success and long-term patient outcomes.[55]

Clinical Applications and Outcomes of Endoscopic Surgery for Sellar and Suprasellar Pathologies

Pituitary Neuroendocrine Tumors (PitNETs)

Pituitary neuroendocrine tumors (PitNETs), formerly known as pituitary adenomas, represent the most common indication for endoscopic endonasal surgery. These tumors may be functioning or non-functioning and can present with endocrine disturbances, visual impairment, headaches, or symptoms related to mass effect. Surgical intervention is generally indicated for symptomatic non-functioning macroadenomas, medically refractory functioning tumors, lesions causing optic apparatus compression, and tumors demonstrating progressive growth. The endoscopic endonasal approach has become the preferred surgical technique for most PitNETs because it provides direct access to the sella with excellent visualization of the tumor-gland interface and surrounding neurovascular structures.[56,57]

Numerous studies have reported high rates of tumor resection and favorable clinical outcomes following endoscopic surgery. Gross-total resection is most commonly achieved in microadenomas and non-invasive macroadenomas, whereas cavernous sinus invasion remains a major limiting factor for complete removal. The panoramic view offered by the endoscope facilitates identification of residual tumor tissue within suprasellar recesses and parasellar extensions, potentially improving resection rates compared with traditional microscopic approaches. Furthermore, significant improvement in visual symptoms and endocrine control has been consistently reported following successful tumor removal.[58,59]

Craniopharyngiomas

Craniopharyngiomas are benign epithelial tumors arising along the craniopharyngeal duct pathway and frequently involve the sellar and suprasellar regions. Surgical management is challenging because these lesions often adhere to the optic apparatus, hypothalamus, pituitary stalk, and major vascular structures. The endoscopic endonasal approach offers a direct midline route to the tumor without brain retraction, allowing early identification of critical anatomical structures and improved visualization of the tumor-stalk interface.[60]

Recent surgical series have demonstrated encouraging outcomes using endoscopic techniques, particularly for predominantly midline tumors located below or behind the optic chiasm. Improved visualization may facilitate more complete resection while reducing manipulation of surrounding neural structures. Nevertheless, preservation of hypothalamic and endocrine function remains a major concern, and treatment strategies should prioritize long-term neurological and quality-of-life outcomes rather than aggressive resection alone.[61]

Rathke Cleft Cysts

Rathke cleft cysts are benign cystic lesions originating from remnants of Rathke's pouch and are commonly located within the sellar or suprasellar region. Symptomatic lesions typically present with headaches, visual dysfunction, pituitary insufficiency, or endocrine disturbances. Endoscopic transsphenoidal surgery provides excellent access for cyst drainage, decompression of the optic apparatus, and selective cyst wall removal while minimizing injury to normal pituitary tissue.[62]

Compared with traditional microscopic techniques, endoscopic surgery offers enhanced visualization of the cyst cavity and surrounding structures, facilitating effective decompression and symptom relief. Long-term outcomes are generally favorable, although recurrence remains possible, particularly when complete cyst wall excision is not feasible. Therefore, surgical management is often directed toward safe decompression rather than radical resection.[63]

Tuberculum Sellae Meningiomas

Tuberculum sellae meningiomas account for a significant proportion of anterior skull base meningiomas and frequently present with progressive visual deterioration due to compression of the optic nerves and chiasm. Traditionally managed through transcranial approaches, selected tumors can now be treated successfully using extended endoscopic endonasal techniques. The endonasal route provides early access to the tumor attachment site and enables direct decompression of the optic apparatus without brain retraction.[64]

Appropriate patient selection remains critical because tumor size, vascular encasement, lateral extension, and optic canal involvement significantly influence surgical feasibility. In carefully selected cases, endoscopic surgery has demonstrated favorable visual outcomes and satisfactory resection rates, although large lesions with extensive lateral extension may still require transcranial management.[65]

Visual and Endocrine Outcomes

Improvement of visual function is one of the most important goals of surgery for sellar and suprasellar lesions. Multiple studies have demonstrated substantial postoperative recovery of visual acuity and visual fields following adequate decompression of the optic apparatus. Early intervention before irreversible optic nerve damage occurs is associated with the greatest likelihood of functional recovery.[66]

Preservation of endocrine function represents another major determinant of long-term outcome. Although postoperative hormonal disturbances may occur, careful microsurgical technique, preservation of normal gland tissue, and maintenance of pituitary stalk integrity can reduce the risk of permanent hypopituitarism. For functioning PitNETs, successful surgery frequently results in biochemical remission and significant improvement in disease-related morbidity. Overall, contemporary evidence supports endoscopic endonasal surgery as an effective and safe treatment modality for a broad spectrum of sellar and suprasellar pathologies when performed in experienced skull base centers.[67,68]

Complications and Their Management

Despite the significant advances achieved in endoscopic skull base surgery, complications remain an important consideration when managing sellar and suprasellar lesions. The close relationship of these lesions to critical neurovascular and endocrine structures places patients at risk for both intraoperative and postoperative adverse events. Careful patient selection, meticulous surgical technique, detailed anatomical knowledge, and multidisciplinary perioperative management are essential for minimizing morbidity and optimizing outcomes.[69]

Cerebrospinal Fluid Leakage

Postoperative cerebrospinal fluid (CSF) leakage remains one of the most frequently reported complications of endoscopic endonasal surgery, particularly following expanded approaches involving large skull base defects. Persistent CSF leakage increases the risk of meningitis, pneumocephalus, and reoperation. The incidence of postoperative leakage has markedly decreased with the adoption of multilayer reconstruction techniques and vascularized nasoseptal flaps. Early diagnosis and prompt management are essential to prevent secondary intracranial complications.[70,71]

Endocrine Complications

Disturbances of pituitary function may occur following surgery because of manipulation of the gland, pituitary stalk, or hypothalamic structures. Transient diabetes insipidus is among the most common endocrine complications and usually resolves spontaneously; however, a subset of patients may develop permanent disease requiring long-term hormonal replacement therapy. Other endocrine abnormalities include adrenal insufficiency, hypothyroidism, hypogonadism, and panhypopituitarism. Careful postoperative hormonal monitoring is therefore mandatory, particularly during the early postoperative period.[72,73]

Vascular and Neurological Complications

Injury to the internal carotid artery is a rare but potentially catastrophic complication of endoscopic skull base surgery. Anatomical variations such as carotid artery dehiscence, abnormal sphenoid sinus septations, and invasive tumors increase surgical risk. Immediate recognition and management are critical to prevent severe hemorrhage, ischemic stroke, or death. Thorough preoperative imaging evaluation and strict adherence to anatomical landmarks remain the most effective preventive strategies.[74]

Neurological complications may include visual deterioration, cranial nerve deficits, hypothalamic injury, and cerebrovascular events. Visual outcomes are generally favorable following decompression of the optic apparatus; however, direct optic nerve injury, vascular compromise, or postoperative hematoma may result in visual worsening. Fortunately, these events are uncommon in experienced skull base centers.[75]

Sinonasal Morbidity and General Complications

Although endoscopic surgery avoids many complications associated with transcranial approaches, postoperative sinonasal symptoms may occur. Patients may experience nasal crusting, congestion, reduced olfaction, synechiae formation, or transient discomfort during the healing period. Most symptoms improve significantly with appropriate postoperative nasal care and endoscopic follow-up. Additional complications such as epistaxis, infection, electrolyte disturbances, and postoperative hematoma may occur but are generally manageable when identified early.[76]

Overall, contemporary series demonstrate that endoscopic endonasal surgery is associated with low complication rates and favorable safety profiles when performed by experienced multidisciplinary teams. Continuous refinement of surgical techniques, reconstruction methods, and perioperative protocols has contributed substantially to reducing morbidity and improving patient outcomes over the last two decades.[77]

Endoscopic Versus Microscopic Transsphenoidal Surgery: Evidence-Based Comparison

The transition from microscopic to endoscopic transsphenoidal surgery represents one of the most significant developments in modern pituitary and skull base surgery. For many years, microscopic transsphenoidal surgery served as the gold standard for the treatment of sellar lesions because it provided a minimally invasive route to the pituitary gland while avoiding craniotomy. However, limitations related to restricted illumination, narrow visualization, and difficulty inspecting hidden anatomical recesses prompted the development and widespread adoption of endoscopic techniques. Advances in optical technology have subsequently enabled endoscopic surgery to become the preferred approach in many specialized skull base centers worldwide.[78,79]

One of the principal advantages of endoscopic surgery is the panoramic visualization provided by modern endoscopes. Unlike the microscope, which offers a straight-line view through a narrow surgical corridor, endoscopes provide wide-angle visualization and permit the use of angled lenses to inspect regions beyond the direct line of sight. This enhanced visualization improves identification of critical neurovascular structures, facilitates assessment of tumor margins, and allows more complete exploration of suprasellar and parasellar extensions. Consequently, endoscopic approaches may improve the extent of tumor resection, particularly in lesions with complex anatomical configurations.[80]

Several comparative studies and meta-analyses have demonstrated favorable outcomes associated with endoscopic surgery. Reported benefits include higher rates of gross-total resection, improved visualization of residual tumor, shorter hospital stays, and reduced postoperative discomfort. Endoscopic approaches have also been associated with superior visualization during revision procedures, where distorted anatomy may limit the effectiveness of microscopic techniques. These advantages have contributed to the increasing preference for endoscopy in both primary and recurrent sellar lesions.[81,82]

Visual outcomes represent another important measure of surgical success. The enhanced ability to directly visualize the optic apparatus and suprasellar structures allows precise decompression while minimizing manipulation of surrounding tissues. Several studies have reported excellent rates of postoperative visual improvement following endoscopic surgery, particularly in patients with pituitary macroadenomas and other lesions causing optic chiasm compression. Preservation of neurological function remains a primary objective regardless of the surgical approach employed.[83]

Despite these advantages, microscopic surgery continues to demonstrate excellent outcomes in experienced hands and remains an effective treatment option for many sellar lesions. Furthermore, the success of either approach is influenced by multiple factors including surgeon experience, tumor characteristics, institutional volume, and patient-specific anatomy. Current evidence suggests that the superiority of one technique over another may be less important than the expertise of the surgical team performing the procedure.[84]

Overall, contemporary literature supports the growing role of endoscopic endonasal surgery as the preferred approach for most sellar and selected suprasellar lesions. Its superior visualization, expanded surgical reach, and ability to access complex skull base regions have fundamentally transformed modern pituitary surgery. Nevertheless, both microscopic and endoscopic approaches remain valuable tools, and surgical strategy should be individualized according to lesion characteristics, anatomical considerations, and surgeon experience.[85]

Conclusion

Endoscopic endonasal surgery has fundamentally transformed the management of sellar and suprasellar pathologies by providing a minimally invasive corridor that combines excellent anatomical visualization with effective lesion access. Advances in endoscopic optics, surgical instrumentation, neuronavigation, and skull base reconstruction have expanded the applicability of this approach from conventional pituitary surgery to a broad spectrum of complex skull base lesions, including craniopharyngiomas, Rathke cleft cysts, and selected meningiomas. A comprehensive understanding of endonasal, sellar, parasellar, and suprasellar anatomy remains essential for maximizing surgical safety and achieving optimal outcomes. Current evidence demonstrates that endoscopic techniques offer high rates of tumor resection, favorable visual and endocrine outcomes, and acceptable complication profiles when performed by experienced multidisciplinary teams. As technological innovations continue to evolve, endoscopic endonasal surgery is expected to further refine the treatment of sellar and suprasellar lesions, reinforcing its role as a cornerstone of modern skull base surgery.

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