



ENDONASAL ENDOSCOPIC APPROACHES FOR SINONASAL, NASOPHARYNGEAL AND ANTERIOR SKULL BASE NEOPLASMS

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ABSTRACT

The advent of rigid telescopes has revolutionized the management of rhinologic disease. Improved visualization, angled view, and a wider panoramic perspective of the important anatomic relationships of the sphenoid and the sella turcica were the obvious advantages. Direct endonasal transsphenoidal approach is the most minimally invasive. Transnasal endoscopic-assisted techniques to the clivus region can be safe and effective. Endoscopic-assisted approaches provide improved visualization and are a superior alternative to open surgical approaches in most cases. These instruments have been used as a diagnostic and therapeutic tool for paranasal sinus inflammatory diseases, intranasal pathology, including nasolacrimal duct obstruction, cerebrospinal fluid leaks/encephaloceles, optic neuropathy, also have been used successfully to manage selected tumors, inverting papilloma, angiofibromas, hypophyseal tumors.

Surgeons can now approach the resection of skull-base lesions with greater confidence, knowing that most collaterally induced skull-base defects are endoscopically reparable. In transsphenoidal pituitary surgery, use of endoscopic technique has resulted in shorter hospitalization times and decreased patient morbidity. Angled nasal endoscopy also offers the ability to visualize areas where residual hypophyseal tumor may persist unrecognized. Beyond the sella, lesions of the clivus, petrous apex, and orbital apex have also been successfully approached endoscopically. In addition to the obvious cosmetic advantage of an endonasal approach, there are also practical advantages.

Surgeons must always remember that although high technology, such as endoscopes, image-guided surgery systems, imaging studies, and advanced anesthetic drugs were essential for the development and improvement of the skull base surgery, the success of this type of surgery depends on perfect knowledge of the anatomy, intense endoscopic surgery training, and a multidisciplinary partnership.

KEYWORDS: tumor, endonasal approaches, sinus surgery, skull base surgery.

INTRODUCTION

Since its introduction in the mid-1980s, functional endoscopic sinus surgery has become the standard surgical intervention for patients with chronic sinusitis refractory to medical therapy. Functional endoscopic sinus surgery was the first procedure to address the underlying pathophysiologic mechanisms of sinusitis as first described by W. Messerklinger (1978). Through his endoscopic examination of the

nose, W. Messerklinger made of a number of discoveries that were instrumental in the development of functional endoscopic sinus surgery.

Although functional endoscopic sinus surgery initially represented a less invasive, more targeted, and more effective techniques than its predecessors, conventional functional endoscopic sinus surgery has evolved beyond this description. Originally, proponents emphasized that functional endoscopic sinus surgery provides a conservative and effective surgical intervention, rarely requiring a middle meatal antrostomy or stripping of diseased nasal mucosa. Over time, however, there has been a departure from these conservative princi-

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ples, with a tendency toward more aggressive intervention. As a result, surgeons have excessive freedom in the nose, and the procedures are not standardized [Wormald P, 2005].

Surgical technique has been influenced by an improved understanding of wound healing and mucosal physiology. The concept of mucosal preservation has become central to modern endoscopic surgical technique. Histologic studies support the principle that minimizing the trauma to and the denuding of sinus mucosa accelerates postoperative wound healing and optimizes recovery of sinus mucosal function [Wormald P, 2005]. New instrumentation has facilitated the consistent execution of mucosal-preserving technique. A variety of through-cutting forceps allows the precise removal of diseased mucosa without stripping adjacent tissue. Microdebriders also provide a means of efficient sharp tissue dissection that minimizes mucosal stripping [Bernstein J et al., 1998]. Microdebriders have also transformed the technique of nasal polypectomy, offering better visualization and reduced blood loss than possible with standard resection techniques. Furthermore, tissue resected through microdebriders retains adequate histologic integrity to allow pathologic diagnosis of resected specimens [Zweig J et al., 2000].

One of the more important technologic advances that has directly influenced the discipline of rhinology is computer-aided navigation in endoscopic surgery. Derived from stereotactic technologies in brain and spinal surgery, image-guidance technology as developed for rhinologic surgery has enabled the intraoperative localization of critical intranasal and skull-base surgical anatomy during endoscopic procedures. The two primary modalities of localization, optical and electromagnetic, offer accuracy within 2 mm under optimal circumstances [Anon J, 1998; Metson R et al., 1998].

Indication for the use of computer-aided localization for endoscopic endonasal surgery continues to evolve. The technology has been used to confirm the location of critical structures, such as the orbit, cranial base, optic nerve, and carotid artery. Localization is particularly useful when critical landmarks are missing or altered because of previous surgery or erosive or distorting effects of disease [American Academy of Otolaryngology-Head and Neck Surgery Foundation, 2002].

Technical advances in instrumentation and surgical method have broadened the application of endoscopic surgery to a wide variety of indications [Schulze S et al., 2002; Kountakis S, Gross C, 2003].

As endoscopic sinus surgery has progressed over the last decade, new techniques have been introduced to aid with the resection of tumors in regions that traditionally have been difficult to access or have required significant resection of normal tissue to access the tumors [London S et al., 2002; Anand V, Schwartz T, 2007]. In general the approaches are more suitable for benign tumors (inverted papilloma, juvenile angiofibroma), but as techniques and adjuvant therapy develop, these techniques will become useful for the resection of some malignant tumors (adenocarcinoma, olfactory neuroblastoma, carcinosarcoma squamous cell carcinoma, melanoma, chondrosarcoma).

Endoscopic techniques have also been successfully applied to a wide variety of skull-base lesions. In the endoscopic era, the newly acquired facility for approaching the skull base transnasally has created a new standard for minimally invasive approaches to cerebrospinal fluid leaks and encephaloceles, especially those involving the ethmoid or medial sphenoid sinuses. Surgeons can now approach the resection of skull-base lesions with greater confidence, knowing that most collaterally induced skull-base defects are endoscopically repairable. In transsphenoidal pituitary surgery, use of endoscopic technique has resulted in shorter hospitalization times and decreased patient morbidity [Jho H, 2001; Nasser S et al., 2001]. Angled nasal endoscopy also offers the ability to visualize areas where residual hypophyseal tumor may persist unrecognized. Beyond the sella, lesions of the clivus, petrous apex, and orbital apex have also been successfully approached endoscopically [Kingdom T, DelGaudio J, 2003].

Endoscopic endonasal surgery is a minimally invasive technique used mainly in neurosurgery and otolaryngology. A neurosurgeon or an otolaryngologist, using an endoscope that is entered through the nose, fixes or removes brain defects or tumors in the anterior skull base. Normally an otolaryngologist performs the initial stage of surgery through the nasal cavity and sphenoid bone: a neurosurgeon performs the rest of the surgery involving drilling into any cavities containing a neural

organ such as the pituitary gland. One criticism might be that it is impossible to remove a tumor of any significant size en bloc using this approach. From a practical standpoint, it is rarely possible to remove these tumors en bloc through any open approach currently popular (e.g., a combined subcranial and midfacial degloving approach has been described for large inverted papillomas by D. Fliss and co-authors (2000)). An experienced endoscopic sinus surgeon, however, would have no difficulty removing these same tumors through a transnasal approach with much lower hospital stays and associated morbidity rates [Chee L, Sethi D, 1999; Califano J et al., 2000].

In addition to the obvious cosmetic advantage of an endonasal approach, there are also practical advantages. The midface degloving approach and the lateral rhinotomy, medial maxillectomy approach for inverted papilloma have the potential for cosmetic deformity and an adverse functional impact on nasal airflow. An endonasal approach avoids both problems [Lueg E et al., 1998].

Surgical approaches to the anterior skull base:

The transnasal approach (Fig. 1, 2) is used when the surgeon needs to access the roof of the nasal cavity, the clivus. This approach is used to remove chordomas, chondrosarcoma, inflammatory lesions of the clivus, or metastasis in the cervical spine region. The anterior septum or posterior septum is removed so that the surgeon can use both sides of the nose. One side can be used for a microscope and the other side, for surgical instruments, or both sides can be used for surgical instruments [Ciric I et al., 1997; Anand V, Schwartz T, 2007].

This approach is the most common and useful technique of endoscopic endonasal surgery and was first described in 1910 concurrently by Harvey Cushing and Oskar Hirsch [Liu J et al., 2005; Lanzino G et al., 2002]. This procedure allows the surgeon to access the sellar space or sella turcica. The sella is a cradle, where the pituitary gland sits. Under normal circumstances, a surgeon would use this approach on a patient with a pituitary adenoma. The surgeon starts with the transnasal approach prior to using the transsphenoidal approach. This allows access to the sphenoid ostium and sphenoid sinus. The sphenoid ostium is located on the anterosuperior surface of the sphenoid sinus. The anterior wall of the sphenoid sinus and the sphenoid rostrum

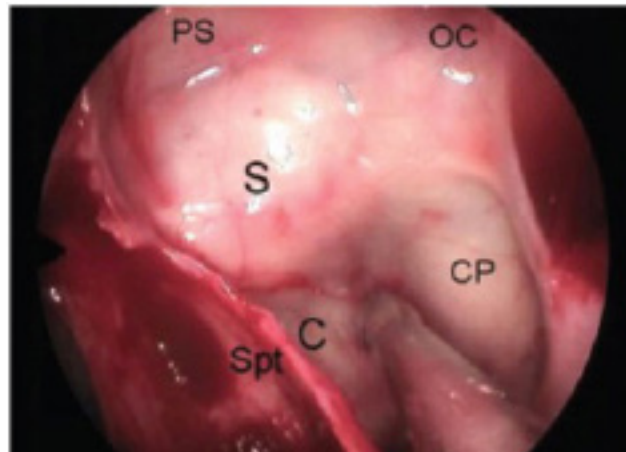


FIGURE 1. Transnasal approach to the sella and clivus. Remove the intersphenoidal septae (Spt) and identify the sella (S), planum sphenoidale (PS) superiorly and the clivus (C) inferiorly. The carotid protuberances (CP) overlie the vertical segment of the carotid artery, opticocarotid recess (OC) on each side of the clivus



FIGURE 2. The intraoperative endonasal view of planum sphenoidale and sella

is then removed to allow the surgeon a panoramic view of the area [Kabil M et al., 2005; Kaylie D et al., 2006; Anand V, Schwartz T, 2007].

The invention of the angled endoscope is used to go beyond the sella to the suprasellar region. This is done with the addition of four approaches. First the transtuberular and transplan approaches are used to reach the suprasellar cistern. The lateral approach is then used to reach the medial cavernous sinus and petrous apex. Lastly, the inferior approach is used to reach the superior clivus. It is important that the Perneczky triangle is treated carefully. This triangle has optic nerves, cerebral arteries, the third cranial nerve, and the pituitary stalk. Damage to any of these could provide a devastating post-surgical outcome [Alfieri A, Jho H, 2001; Anand V, Schwartz T, 2007; Lanzino G et al., 2002].

The transpterygoidal approach enters through the posterior edge of the maxillary sinus ostium and posterior wall of the maxillary sinus. This involves penetrating three separate sinus cavities: the ethmoid sinus, the sphenoidal sinus, and the maxillary sinus. Surgeons use this method to reach the cavernous sinus, lateral sphenoid sinus, infratemporal fossa, pterygoid fossa, and the petrous apex. Surgery includes a uninectomy (removal of the osteomeatal complex), a medial maxillectomy (removal of maxilla), an ethmoidectomy (removal of ethmoidectomy (removal of ethmoid cells and/or ethmoid bone), a sphenoidectomy (removal of part of sphenoid), and removal of the maxillary sinus and the palatine bone. The posterior septum is also removed at the beginning to allow use of both nostrils [Anand V, Schwartz T, 2007; Cantu G et al., 2010].

The transethmoidal approach makes a surgical corridor from the frontal sinus to the sphenoid sinus. This is done by the complete removal of the ethmoid bone, which allows a surgeon to expose the roof of the ethmoid, and the medial orbital wall. This procedure is often successful in the removal of small encephaloceles of the ethmoid osteomas of the ethmoid sinus wall or small olfactory groove meningiomas. However, with larger tumors or lesions, one of the other approaches listed above is required [Anand V, Schwartz T, 2007].

Approach to sellar region (Fig. 3): For removal of a small tumor, it is accessed through one nostril. However, for larger tumors, access through both nostrils is required and the posterior nasal septum

must be removed. Then the surgeon slides the endoscope into the nasal choana until the sphenoid ostium is found. Then the mucosa around the ostium is cauterized for microadenomas and removed completely for macroadenomas. Then the endoscope enters the ostium and meets the sphenoid rostrum where the mucosa is retracted from this structure and is removed from the sphenoid sinus to open the surgical pathway. Then the floor of the sella turcica is opened with a high speed drill being careful to not pierce the dura mater. Once the dura is visible, it is cut with microscissors for precision. If the tumor is small, the tumor can be removed by an *en bloc* procedure, which consists of cutting the tumor into many sections for removal. If the tumor is larger, the center of the tumor is removed first, then the back, then the sides, then top of the tumor to make sure that the arachnoid membrane does not expand into the surgical view. This will happen if the top part of the tumor is taken out too early. After tumor removal, cerebrospinal fluid leaks are tested for with fluorescent dye, and if there are no leaks, the patient is closed [Anand V, Schwartz T, 2007; Zhang Y et al., 2008; Hobbs C et al., 2011].

Approach to suprasellar region: This technique is the same as to the sellar region. However, the tuberculum sellae is drilled into instead of the sella. Then an opening is made that extends half-way down the sella to expose the dura, and the intercavernous sinuses are exposed. When the optic chiasm, optic nerve, and pituitary gland are visible, the pituitary gland and optic chiasm are pushed



FIGURE 3. The intraoperative endoscopic view. (a) Endonasal transsphenoidal approach to the planum sphenoidale and tuberculum sellae and identification of the meningioma. (b) The tumor was removed completely under endoscopic vision

apart to see the pituitary stalk. An ethmoidectomy is performed the dura is then cut, and the tumor is removed. These types of tumors are separated into two types [Badie B et al., 2000; Jane J et al., 2002; Anand V, Schwartz T, 2007]:

Prechiasmal lesions: This tumor is closed to the dura. The tumor is decompressed by the surgeon. After decompression, the tumor is removed taking care to not disrupt any optic nerve or major arteries.

Postchiasmal lesions: This time the pituitary stalk is in the front because the tumor is pushing it towards the area the dura was opened. Removal then starts on both sides of the stalk to preserve the connection between the pituitary and the hypothalamus and above pituitary gland to protect the stalk. The tumor is carefully removed and the patient is closed up.

Skull base reconstruction: When there is a tumor, injury, or some type of defect at the skull base whether the surgeon used an endoscopic or open surgical method, the problem still arises of providing separation of the cranial cavity and cavity between the sinuses and nose to prevent cerebrospinal fluid leakage through the opening referred to as a defect [Perneczky A et al., 1988; Zhang Y et al., 2008; Abou-Al-Shaar H et al., 2016].

Pituitary gland surgery: This surgery is turned from a very serious surgery into a minimally invasive one through the nose with the use of the endoscope.

The traditional sublabial-transseptal-transsphenoidal and the transseptal-transsphenoidal approaches are associated with postoperative sequelae that include facial and endonasal swelling and pain. Postoperative morbidity may be compounded by the frequent need for nasal packing or septal splints. Sinonasal complications such as sinusitis, nasal synechiae, septal perforation, and numbness of the upper incisors are common. Other rare but significant complications include sagittal fracture of the maxilla and bilateral optic nerve injury caused by the excessive opening of the self-retainer speculum. Direct endonasal approaches (i.e., not involving a transseptal approach) using a microscope technique

may produce less sinonasal complications [Griffith H, Veerapen R, 1987; Stevens M, Apfelbaum R, 1990; Cooke R, Jones R, 1994].

Endoscopic transsphenoidal approaches, by way of transnasal or transseptal routes, have been the subject of multiple reports. Endoscopes with angled lenses provide direct visualization of the surgical field. Several reports demonstrate that endoscopes provide superior exposure when compared with microscopes [Sheehan M et al., 1999; Spencer W et al., 1999]. Some investigators report superior outcomes comparing endoscopic techniques with microscopic techniques [Wurster C, Smith D, 1994; Jarrahy R et al., 2000; Hormann K, 2000; Kabil M et al., 2005; Schaberg M et al., 2010]. In addition, the endoscopic transnasal-transsphenoidal approach obviates the need to use a nasal speculum with its potential for complications.

The role of endoscopically assisted resection of malignancies remains poorly defined and somewhat controversial. The current literature, when analyzed using an evidence-based approach, lacks well-designed controlled series to adequately evaluate the efficacy of endoscopic approaches. Skull-base malignancies are rare and diverse in nature, and wide variations in tumor grade, stage, and type make outcome comparisons difficult. Most reports are either case reports or case series. These case series do indicate that prudent application of endoscopic techniques can be of value, at least as an adjunct to traditional resection techniques [Alfieri A, Jho H, 2001; Cappabianca P et al., 2004; Snyderman C et al., 2007; Hobbs C et al., 2011]. The primary advantages of endoscopically assisted craniofacial or skull-base resection include improved illumination of posterior lesions, increased precision in resecting tumor margins, and potentially less destructive approaches that facilitate more rapid healing. It is hoped that larger clinical experience will allow the development of consensus regarding appropriate guidelines for endoscopically assisted skull-base and craniofacial resections.

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