



# Principles of Endoscopic Endonasal Surgery

1

Tyler J. Kenning, Varun R. Kshetry, Christopher J. Farrell,  
and James J. Evans

## 1.1 Introduction

Endoscopic endonasal surgery has revolutionized the field of cranial base surgery; however, these surgical approaches involve complex anatomy and require a unique set of skills which its practitioner must master to optimize their use. There is a steep learning curve with the techniques as the endoscopic endonasal approach (EEA) represents a crossroads between the rhinologic principles of otolaryngology and traditional cranial base surgery familiar to specialized neurosurgeons. As a result, EEA is best practiced as a joint venture between the disciplines. This chapter will focus on many of the principles of endoscopic endonasal surgery and the considerations necessary for its successful application to cranial base pathology.

The EEA has expanded from being used for purely sellar pathology to addressing lesions from the frontal sinus to the upper cervical spine and from the midline to the lateral aspects of the infratemporal fossa (Fig. 1.1). When applied to intradural pathology, the endonasal corridor is largely utilized to target ventral median and paramedian structures. Intradural pathology that extends lateral to the cranial nerves and internal carotid arteries is typically best approached through more “traditional” or “keyhole” open techniques, although these can be combined with extended endonasal approaches.

---

T. J. Kenning (✉)

Pituitary and Cranial Base Surgery, Department of Neurosurgery,  
Albany Medical Center, Albany, NY, USA  
e-mail: [kennint@amc.edu](mailto:kennint@amc.edu)

V. R. Kshetry

Skull Base, Pituitary and Cerebrovascular Surgery, Department of  
Neurosurgery, Cleveland Clinic, Cleveland, OH, USA

C. J. Farrell · J. J. Evans

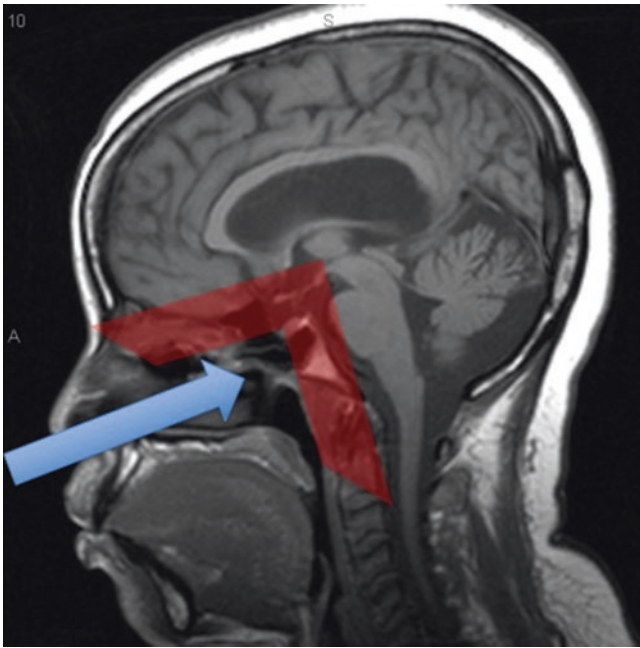
Cranial Base and Pituitary Surgery, Department of Neurosurgery,  
Thomas Jefferson University, Philadelphia, PA, USA

## 1.2 Anatomy

The hallmark of any successful surgeon is proficiency with pertinent anatomy. As the sinonasal cavity is familiar territory to the rhinologist but typically less so to the traditional neurosurgeon, its use as a surgical corridor can appear daunting to those with less experience with sinonasal anatomy. Similarly, the intracranial space, as the purview of the neurosurgeon, can seem very foreign to the otolaryngologist. Again, we believe this further supports our assertion that EEA should be undertaken by a surgical team, consisting of both a neurosurgeon and a rhinologist in order to achieve optimal outcomes. The anatomy of the endoscopic endonasal cranial base approaches that must be mastered, as well as the many anatomical variants that can exist, is extensively covered in Chap. 2.

## 1.3 Patient Positioning and Surgical Planning

As the EEA addresses ventral lesions, patients are placed supine with the head in a neutral position. We prefer to use a navigation system (when necessary) that does not require rigid pin fixation of the head. This allows for easy repositioning of the head during surgery as well as prevents excessive pressure against sinonasal structures by allowing some slight movement if too much force is applied. When accessing pathology of the anterior cranial base, a varying extent of head extension is recommended, while slight flexion is helpful for clival and craniocervical junction lesions. The operative table should be placed in reverse Trendelenburg to enhance venous drainage and minimize bothersome oozing from the sinonasal mucosa of nasal structures. While some surgical teams will place the assistant driving the endoscope on the same side of the table as the operating surgeon



**Fig. 1.1** Area of the cranial base able to be surgically accessed by the endonasal endoscopic approach



**Fig. 1.2** Surgeon orientation on opposite sides of the patient's head for endonasal endoscopic surgery

(typically the right side for right-handed surgeons), we prefer that the neurosurgeon and the otolaryngologist stand on opposite sides of the patient's head so that they may work simultaneously in an ergonomic fashion (Fig. 1.2). This surgeon positioning is quite versatile as the operating surgeon can

stand on either side of the table depending on his/her handedness or on the laterality of the pathology while the assistant driving the endoscope stands on the opposite side. The anesthesia team is placed at the foot of the patient as the surgeons, navigation system, and endoscopic monitors occupy the space at the head of the bed.

The cranial base exposure, opening, and access to the pertinent pathology must be performed with the closure in mind to minimize the risk of persistent CSF fistulas postoperatively. The various closure techniques and materials, both autografts and allografts, available are detailed in Chap. 3. Abdominal or thigh incisions can be prepared for fat, muscle, and fascia lata grafts, when appropriate, and should be planned for, both in terms of patient positioning and setup of the operative field. Although lumbar drainage is utilized at some centers for postoperative management of high-flow cerebrospinal fluid leaks, we do not feel they are necessary when a well-tailored, multilayered cranial base repair can be achieved. The exception to this rule is in patients with idiopathic intracranial hypertension and an associated cranial base CSF fistula or meningocele requiring repair. In these patients, we utilize lumbar drainage as a bridge until permanent CSF diversion (e.g., ventriculoperitoneal shunt) can be performed to treat the elevated intracranial pressures a few days after the cranial base repair.

#### 1.4 Endonasal Access and Limitation of Postoperative Morbidity

Just prior to introduction of the endoscope, the nasal cavity is decongested with cotton pledgets soaked in 1:1000 epinephrine or oxymetazoline. Injection of the turbinates and nasal septum with 1% lidocaine with 1:100,000 epinephrine can also further reduce intraoperative blood loss. Antibiotic coverage is provided with a third-generation cephalosporin for purely sinonasal and sellar pathology, while the addition of vancomycin can be used for extended cases where there will be significant disruption of the subarachnoid space. The evidence for enhanced antibiotic coverage, however, is lacking and is typically employed at the preference of the surgical team with the consideration for preoperative bacterial nasal colonization assessment.

Typically, binarial access is utilized, although access through a single nare can be performed for more focal lesions such as pituitary adenomas and meningoencephaloceles. In addition to addressing the pathology and repairing any resultant cranial base defects, the goals of endonasal surgery should emphasize minimization of postoperative morbidity while maintaining normal sinonasal function. The nasal mucosa is highly vascularized and allows for rapid healing, which can be tremendously help-

ful to the endoscopic surgeon in terms of repair of the cranial base but also may promote the formation of postoperative adhesions and discomfort.

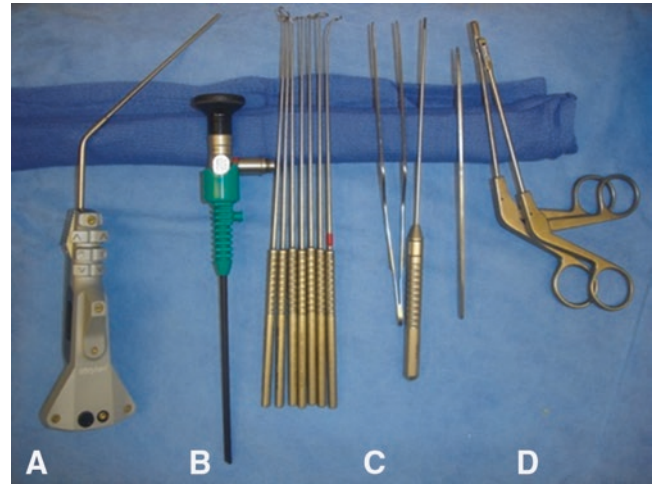
Preservation of normal sinonasal structures when possible, including all turbinates, and minimizing posterior nasal septectomy will avoid excessive cautery for hemostasis and the resultant significant nasal crusting postoperatively. In general, we follow the premise of preserving all structures unless they are directly involved by the pathology. We prefer to use a limited amount of absorbable packing for support of cranial base grafts and flaps and avoid the use of nonabsorbable packs or Foley catheter balloons. Finally, at the conclusion of the procedure, silastic or gelatin sheets are placed between the nasal septum and middle turbinates and potentially even in the middle meatus to limit the development of postoperative synechiae.

Starting on postoperative day 2, all patients are instructed to irrigate the nasal cavity with saline spray at least three times per day for 2–3 weeks. After that time, high-volume saline irrigation can be used to optimize mucosal healing and help debride the nasal cavity. When a nasoseptal flap is not raised, any septal splints or silastic sheets placed can be removed at 1 week; otherwise, they are removed at 2 weeks in cases where the septal mucosa has been elevated. Crusting in the nasal cavity can then be gently debrided in the clinic.

## 1.5 Instrumentation

EEA has largely replaced microscopic transnasal surgery due to the tremendous advantages in visualization and illumination provided by the endoscope. Standard endoscopes utilized for EEA are rigid, 4 mm in diameter, and 18 or 30 cm in length. Smaller 2.7 mm endoscopes can be used for pediatric patients. Although zero-degree scopes are predominantly used, angled scopes of 30, 45, 60, and even 90 degrees provide the ability to expand operative visualization (Fig. 1.3a–d).

Endoscopes traditionally have provided only a two-dimensional view, and therefore the optics can suffer compared to the 3D view of the operative microscope. While some surgeons may find this to be a tremendous disadvantage, it can be overcome by using the manual movement of the scope and operative instruments to provide a better appreciation of the three-dimensional anatomy. We therefore recommend the scope to be “driven” by a member of the operative team, although some surgeons do have a preference for a mechanical scope holder. More recently, 3D endoscopes have become available, but their widespread use is limited by cost, need for additional equipment (e.g., properly equipped monitors and eyeglasses), and in some cases eye strain.



**Fig. 1.3** (a–d) Sample of the equipment and instrumentation used in the endonasal endoscopic approach, including (a) navigation suction, (b) endoscope with irrigation sheath, (c) straight endonasal instruments, and (d) sinonasal rongeurs

As the endoscope is advanced within the surgical field of the sinonasal cavity, unlike the operative microscope, it becomes imperative to have a mechanism for maintaining visualization and clearing the scope of blood and surgical debris. This can be done with either manual irrigation or a cleaning-irrigation system. The latter typically takes the form of a sheath around the endoscope that is controlled with a foot pedal or hand control. Although we find these systems highly efficient in limiting repeated entrances and exits from the nostril, surgeons who prefer manual irrigation criticize the added bulk and size of the irrigation sheath.

Unlike the bayoneted microscopic transsphenoidal instruments, the operative instruments used in EEA should be straight to avoid conflict with the endoscope (Fig. 1.4a, b). While their shaft is straight, the tips can be fitted with a variety of angled tips and shapes. Additionally, malleable instruments that can be shaped to accommodate the unique needs of each operative pathology are also of tremendous utility.

Hemostatic control can be obtained quickly and efficiently by a surgeon proficient in EEA. Sinonasal venous oozing can be reduced with elevating the head of the bed, preventing hypertension, total intravenous anesthesia, and warm irrigation fluid. Electrocautery is the mainstay of hemostasis with monopolar devices being quite effective. When used for mucosal graft and flap incisions, a fine needlepoint monopolar electrocautery should be used, while broad suction monopolar devices are better for obtaining hemostasis and vascular control within the sinonasal cavity. Bipolar electrocautery has proven more challenging in endonasal surgery; however, a number of devices, both in malleable suction and pistol-grip form, are available. Additional vascular control can be obtained with vascular clips, and



**Fig. 1.4** (a, b) Endonasal instruments with straight shafts, including (a) ring currettes and (b) microdissectors

traditional microaneurysm clips for intracranial use can be placed with specially designed applicators that can also be malleable. In addition to electrocautery, other hemostatic agents useful in EEA are familiar to both neurosurgeons and otolaryngologists. These include flowable hemostatics, oxidized cellulose, thrombin-soaked gelatin sponges, and even bone wax for osseous bleeding.

For soft tissue removal and tumor debulking, tissue debriders developed for rhinologic surgery can be used and are available in both straight and angled forms. For more delicate and intracranial work, ultrasonic aspirators and side-cutting tumor aspiration devices are better utilized. These can be combined with traditional bimanual microsurgical techniques.

For exposure of the osseous cranial base and creating osteotomies, angled self-irrigating drills are available. These have a protective sheath along the drill shaft to prevent thermal injury to nasal structures. We prefer larger (3 or 4 mm) round cutting burrs for removal of sinonasal bone (e.g., sphenoid rostrum, pterygoid base, etc.). When drilling the cranial base or trying to skeletonize the bone surrounding neurovascular structures, diamond burrs are preferred in smaller sizes.

## 1.6 Imaging

To best assess the target pathology, high-quality preoperative imaging is essential for surgical planning and for the purposes of intraoperative neuronavigation. We recommend a thin slice CT with multiplanar reconstructions for analysis of the osseous cranial base and sinonasal anatomy. This demonstrates the degree of aeration of the paranasal sinuses and the osseous integrity of involved structures, location of hyperos-

stosis, evaluation of intersinus septae, and the presence of anatomical variations (e.g., Onodi cells, pneumatized anterior clinoid processes, concha bullosa, etc.). Additionally, CT angiograms can be obtained to clarify the associated vascular anatomy.

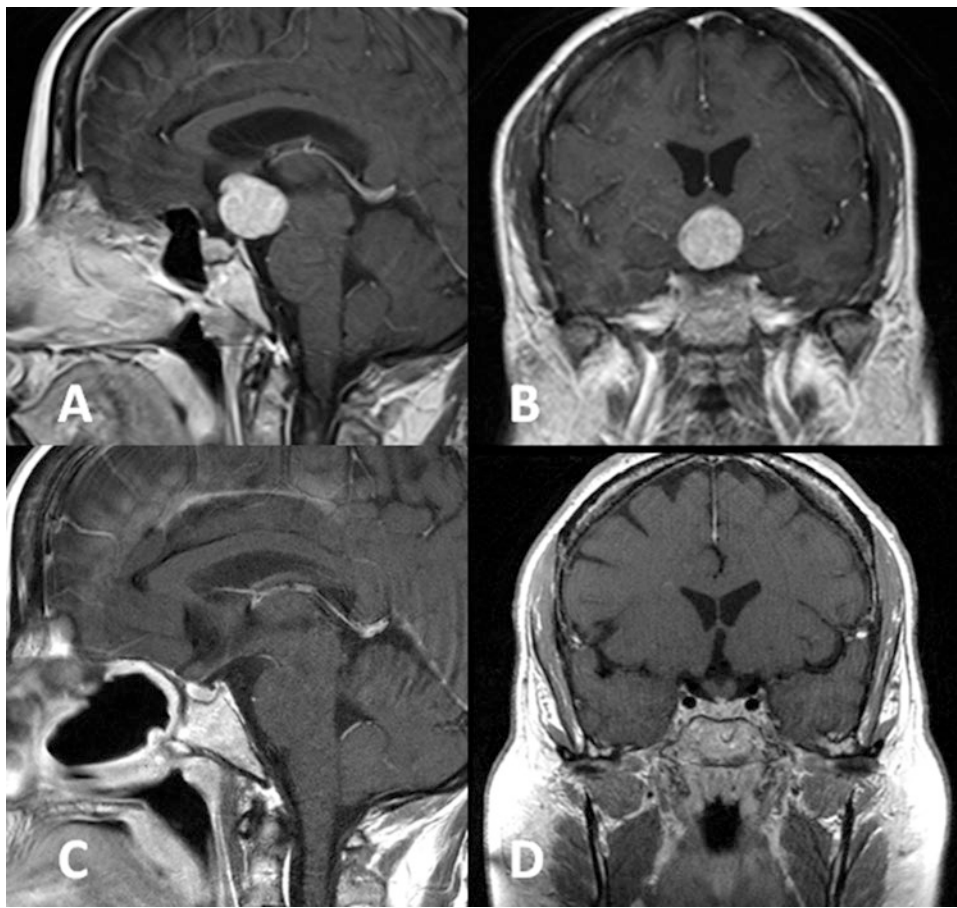
High-field MRI is helpful to distinguish soft tissue and neurovascular structures (Figs. 1.5a–d and 1.6a–d). The interface between neural structures and pathology can be reviewed through the multiple MRI sequences. Any vascular abnormalities evident on CTA or MRA sequences can be further evaluated with digital subtraction angiography (DSA). The latter also provides the ability for embolization of a vascular lesion or tumor, when necessary.

## 1.7 Intraoperative Monitoring

When traversing the cranial base and managing the associated pathology and intracranial anatomy, multiple neurovascular structures may be at risk. Overall the rates of vascular injury and postoperative cranial neuropathies are relatively low, but these can be devastating complications. Any potential measures to further mitigate these risks should be utilized. Although standard transsphenoidal transsellar approaches may not require intraoperative monitoring, it is typically useful for all extended approaches and for any lesion extending intracranially beyond the sella and diaphragm sella.

Global cortical monitoring with electroencephalography (EEG), somatosensory evoked potentials (SSEPs), and transcranial electrical motor evoked potentials (MEPs) provides critical information when the internal carotid arteries or their branches are at risk. When addressing pathology within

**Fig. 1.5** (a–d) Suprasellar craniopharyngioma resected through an endoscopic endonasal approach. Preoperative (a) sagittal and (b) coronal MRI. Postoperative (c) sagittal and (d) coronal MRI



the posterior fossa or craniocervical junction through translival approaches, brainstem ischemia can be detected with brainstem auditory evoked potentials (BAEPs). Cranial nerve monitoring can be performed through electromyography (EMG), which may either be spontaneous or triggered with a hand-held probe. Triggered EMG of extraocular muscles of the eye is very useful when performing significant work within the cavernous sinus.

## 1.8 Navigation

The endoscope provides excellent visualization of the sinonasal cavity and the cranial base, but image guidance can be an invaluable tool for endonasal surgery. It decreases surgical disorientation, optimizes outcomes, and lowers complications rates. Currently available navigation systems function via either optical or electromagnetic technology, and our preference is for an optical system that does not require head fixation for the reasons previously mentioned. While we advocate for the routine use of navigation to maximize familiarity with its use and to serve as a teaching

tool for trainees, it is especially helpful in a number of scenarios:

- Presellar or conchal-type sphenoid sinuses and other anatomic variations
- When the normal anatomy has been distorted by the pathology
- Approaching an intracranial lesion
- Recurrent surgery

## 1.9 Conclusion

The endoscopic endonasal approach affords significant advantages including direct access to pathology, reduced postoperative pain, lower incidence of complications, and quicker patient recovery. As its use has extended beyond the more familiar transsphenoidal approach to sellar pathology, it is critical that the endonasal cranial base surgeon has full knowledge of all of the principles of endoscopic surgery. This will permit optimal outcomes while minimizing complications.

**Fig. 1.6** (a–d) Olfactory groove meningioma resected through an endoscopic endonasal approach. Preoperative (a) sagittal and (b) coronal MRI. Postoperative (c) sagittal and (d) coronal MRI

