Advantages and Limitations of Endoscopic Endonasal Approaches to the Skull Base

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Key words
- Endoscopic endonasal approaches
- Endoscopy
- Microscopy
- Skull base

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
EEA: Endoscopic endonasal approach
ICA: Internal carotid artery
LOS: Length of stay
QOL: Quality of life

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Citation: World Neurosurg. (2014) 82, 6S:S12-S21.
http://dx.doi.org/10.1016/j.wneu.2014.07.022

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

1878-8750/$ - see front matter

■ BACKGROUND: **The anatomy of the skull base is extremely complex with an abundance of critical neurovascular bundles and their corresponding foramina as well as the insertions and origins of multiple masticatory and craniocervical muscles. These anatomic intricacies increase the difficulty of surgery within this area.**

■ METHODS: **Advantages and disadvantages of endoscopic endonasal approaches (EEAs) based on the authors' sequential learning and experience are described.**

■ RESULTS: **EEAs offer the advantages of using preexistent air spaces that enable accessing various areas of the skull base, while avoiding external incisions or scars and obviating the need for the translocation of the maxillofacial skeleton. In addition, EEAs are well suited to preserve neurologic, visual, and masticatory functions as well as cosmesis. However, the sinonasal corridor must be expanded and optimized to access the skull base adequately, facilitate the reconstruction of the surgical defect, avoid sinonasal complications, and minimize sequelae. Important considerations can limit or indicate the approach, such as the nature of the pathology, including location, diagnosis, and vascularity; patient characteristics, including age and medical comorbidities; surgeon attributes, including training, experience, and expertise; the resultant need to reconstruct large skull base defects and feasible alternatives to do so; and institutional resources, including adjunctive services, an intensive care unit, and operating room equipment.**

■ CONCLUSIONS: **EEAs are important techniques in contemporary skull base surgery. Understanding the indications for and limitations of these approaches help to maximize outcomes.**

INTRODUCTION

The skull base is one of the most complex anatomic locations in the human body. It acts as a relay station for cranial nerves. The cervicocranial vasculature serves as the origin or insertion of all masticatory and craniocervical muscles and acts as the suspension system for the upper aerodigestive tract. Surgery of the skull base is intrinsically challenging. A review of the literature reveals a wealth of wide and minimal access surgeries including external, microscopic, and endoscopic approaches to the skull base. An ideal approach, regardless of the anatomic route and visualization device, should provide adequate exposure of the target lesion and facilitate complete resection, debulking, or repair. The approach should also allow the possibility to broaden the exposure to account for unanticipated extension of the resection margins and to enable the identification and protection of important neurovascular structures. Endoscopic endonasal approaches (EEAs) offer most, if not all, of these characteristics in well-selected patients.

Expansion of the clinical indications for EEAs has produced a paradigm shift in the surgical management of skull base lesions. Anatomy-based surgical modules, in the sagittal and coronal planes, allow surgical access to the entire ventral skull base (28, 29). Modules in the sagittal plane provide exposure of median structures extending from the frontal sinus to the second cervical vertebra (6). Coronal plane modules provide access to the paramedian skull base extending laterally to the midroof of the orbit, the floor of the middle cranial fossa, and the jugular foramen. EEAs continue to evolve, led by the expanding experience of surgeons and advances in technology, to provide the most direct access to the anterior cranial base (including the sella, cribriform plate, planum sphenoidale, and suprasellar cistern) and the clivus and posterior fossa, Meckel cave and medial middle cranial fossa, pterygopalatine fossa, and adjacent paramedian skull base locations.

EEAs comprise 2 important concepts: bilateral nasal access to allow for a 2-surgeon, 4-hand technique and customized removal of bone to create a wide surgical corridor that aids visualization and instrumentation. Important considerations can limit or indicate the approach, such as the nature of the pathology (i.e., location, diagnosis, vascularity), patient characteristics (i.e., age, medical comorbidities), surgeon attributes (i.e., training, experience, expertise), the resultant need to reconstruct large skull base defects and feasible alternatives to do so, and institutional resources (i.e., adjunctive services, intensive care unit, operating room equipment).

In this article, we discuss the advantages and limitations of EEAs. It is not our intention to compare EEAs directly with other available approaches. In our practice, EEAs are among many techniques in our armamentarium. We see open and minimal access techniques as complementary. Similarly, our surgical paradigm has been reproduced around the world yielding similar outcomes; however, an extensive review of the literature is beyond the scope of this article. Our discussion and criteria for EEAs are presented in the context of our long-term experience with these techniques.

ADVANTAGES OF EEAS

Technique

We advocate a 2-surgeon, 2-nostril, 4-hands technique for all EEAs. The presence of a co-surgeon expedites the surgery and increases efficiency and safety. One surgeon focuses in the operative field, while the other surveys a more global perspective; 2 surgeons provide each other continuous feedback and "second opinions" that improve intraoperative decision making and problem solving and modulate individual enthusiasm (5, 48). The roles of the co-surgeons can be reversed according to expertise and experience, providing enhanced productivity and helping to combat fatigue.

Technology

Advances in optics, improvements in the resolution of endoscopic cameras and video monitors, and computer-assisted navigation have significantly enhanced the potential for the resection of various cranial base lesions using minimal access surgery. Rod-lens rigid endoscopy provides superior magnification and distal illumination and visualization (of the surgical target) and offers the possibility of using angled lenses (0, 30, 45, and 70 degrees) to look "around corners" (2, 5, 25, 51).

The field of view provided by the microscope is hindered by all proximal structures in its line of sight. Endoscopic visualization is not hampered this way because the endoscope can be advanced past these structures, or angled lenses can be used to look around them (Figure 1). Rod-lens rigid endoscopy provides a panoramic view that affords cephalad and lateral visualization superior to that of the tunnel vision provided by a microscope (Figures 2 and 3). This panoramic view eliminates the need for "blind" grasping or curettage of tumor, diminishing the risk of neurovascular injury, incomplete removal of tumor, or inadequate reconstruction of a dural defect (15). Rod-lens endoscopy optimizes visual inspection and provides a superior view of the surgical field, such as the planum sphenoidale, sella, and suprasellar space. These fields are better visualized and controlled via EEAs than with traditional microscopic approaches (25, 51). An EEA provides unhindered access to the median corridor that is flanked by cranial nerves and internal carotid arteries (ICAs); it is ideal to manage pathologies that are medial or anterior to these critical structures, avoiding manipulation of the cranial nerves and dissection of critical vessels.

Outcomes

Use of preexistent air spaces confers additional advantages, including lack of incisions (i.e., no potential for unsightly scars), lack of maxillofacial osteotomies (i.e., no deformities or change in appearance), decreased trauma to normal soft tissue and bone leading to faster recovery time, improved visualization, and increased access in select lesions. Avoidance of facial incisions and scars, osteotomies, and bone grafting through use of an EEA becomes even more important in pediatric patients, who could experience abnormal craniofacial growth because of the disruption of midface growth centers (48). In patients with malignant tumors needing postoperative adjuvant therapy, chemotherapy or radiotherapy can start earlier because there is less need for the healing of external incisions. Of great relevance, endoscopic endonasal skull base surgery offers a caudal approach to the ventral skull base that involves minimal brain and cranial nerve manipulation. These benefits potentially can translate into improved outcomes, fewer complications, shorter hospitalization, and lower cost (27).

The incidence of complications associated with EEAs compares favorably with external or microscopic approaches. The most common complication is a postoperative cerebrospinal fluid (CSF) leak. However, the incidence of CSF leak has decreased significantly (<5%) with the adoption of vascularized tissue flaps for reconstruction of EEA-related defects. Other complications include transient neurologic deficits (2.5%), permanent neurologic deficits (1.8%), intracranial infection (1.6%), systemic complications (2.1%), and death (0.9%) (27).

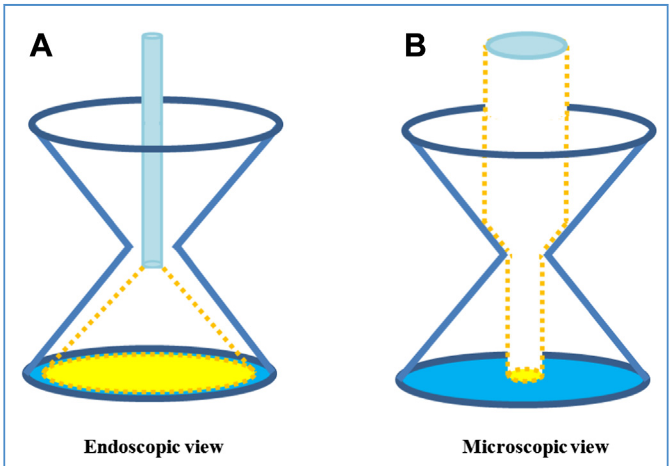

Figure 1. (**A** and **B**) Diagrammatic comparison of endoscopic and microscopic fields of illumination and visualization.