Minimally Invasive Approaches to the Anterior Skull Base

Michael E. Ivan, MD[a,b], Arman Jahangiri, BS[a,b], Ivan H. El-Sayed, MD[b,c], Manish K. Aghi, MD, PhD[a,b,*]

KEYWORDS

• Minimally invasive surgery • Endoscopy • Skull base malignancy • Anterior craniofacial

KEY POINTS

- The advantages of minimally invasive endoscopic approaches to the skull base are: (1) devascularization of the skull base blood supply before tumor resection, (2) avoidance of brain manipulation and retraction, (3) protecting the vascular supply of the optic apparatus as the tumor is approached from below by maintaining arachnoid planes, and (4) providing a better cosmetic result.
- Limitations of minimally invasive approaches include: (1) instrumentation that may be associated with greater application of force on surrounding structures than when using microinstruments; (2) difficulty accessing large tumors with significant lateral extension; (3) difficulty resecting the entire dural attachment, potentially limiting gross total resections; (4) difficulty with resection of tumor that completely encase vascular structures; and (5) lack of three-dimensional visualization.
- Selection of the appropriate minimally invasive approach depends on identification of the appropriate entry point and surgical corridor.
- Through careful surgical planning to avoid complications and select appropriate patients, minimally invasive techniques can be used to improve the function and prognosis of patients with skull base malignancies.

Videos of "Exposure of and removal of anterior skull base dura" and "Anterior skull base closure" accompany this article. at http://www.neurosurgery.theclinics.com/

INTRODUCTION

Minimally invasive approaches in neurosurgery have been a recent, yet rapidly growing area that is becoming a more accepted and valuable tool in the neurosurgeon's armamentarium. This area continues to rapidly expand because of continual developments in technique and equipment, most specifically endoscopy. As with any new field, these minimally invasive approaches are not always intuitive and require additional training and time to develop the needed skills. Once acquired, however, minimally invasive approaches have been shown to decrease morbidity and speed recovery in patients while providing similar extent of resection.

This article reviews the tenets of the minimally invasive approaches to the anterior skull base in neurosurgery and discusses the history of this technique, advantages and disadvantages, the corridors and pathways of the approaches, the equipment and operating room setup, perioperative care, and complication avoidance.

HISTORY

Skull base surgery has been founded on the ideals of finding the most direct access to skull based

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[a] Department of Neurological Surgery, University of California San Francisco, 505 Parnassus Avenue, CA 94143-0112, USA; [b] Center for Minimally Invasive Skull Base Surgery, University of California San Francisco, 505 Parnassus Avenue, CA 94143-0112, USA; [c] Department of Otolaryngology–Head and Neck Surgery, University of California San Francisco, 505 Parnassus Avenue, CA 94143-0112, USA

* Corresponding author. 505 Parnassus Avenue, M-774, Box 0112, San Francisco, CA 94143-0112.

E-mail address: aghim@neurosurg.ucsf.edu

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lesions with the least amount of risk and brain manipulation. The first attempts at anterior skull based surgery were likely performed by the ancient Egyptians as evidence by intranasal dissection found in their remains.[1] However, not until 1894 was the transphenoidal approach first discussed when David Giordano performed an anatomical study via a transfacial transphenoidal exposure to gain access to the sella turcia.[2] Then in 1907, the first transphenoidal resection of a pituitary tumor was performed by Hermann Schloffer in Austria.[3] Theodor Kocher and Oskar Hirsh further modified the procedure by developing submucosal removal of the septum and an endonasal transseptal transphenoidal procedure that then set the stage for Harvey Cushing to later improve.[3–5] Harvey Cushing, who completed more than 231 pituitary surgeries via a sublabial transphenoidal approach, had an astonishingly low mortality rate of 5.6% during his career.[5] At the same time, the mortality rates of larger open transfrontal surgeries to access the anterior skull base were also decreasing and ultimately equaled that of the more difficult transphenoidal approach. Therefore popularity for these challenging minimally invasive approaches declined until the inventions of the intraoperative radiofluoroscopy and the operating microscope in the 1950's-1960's.[3,6] Jules Hardy, who was responsible for the first use of the operating microscope during the transphenoidal approach, spread the teaching of this approach throughout North America. He was responsible for the development of many of the micro-instruments used in transphenoidal surgery.[3] With continued advancements in technology and technique, the methods that Hardy developed continue to improve and have resulted in minimally invasive procedures of the anterior skull base becoming accepted as an effective and safe procedure.

The first neurosurgical endoscopic surgery was performed in 1910 by Lespinasse. Lespinasse, who practiced urology, performed choroid plexus coagulation via a burr hole in two children with hydrocephalus. In 1923, the neurosurgeons, William Mixter and Walter Dandy, performed the first endoscopic third ventriculoscopy; however, this procedure was severely limited by poor visualization.[7,8] The use of endoscopy in neurosurgery was not well accepted until improvements were made in the endoscopes and additional supportive equipment, as well as in the understanding of the surrounding microanatomy. The return of endoscopy in neurosurgery did not occur until the late twentieth century. Gerard Guiot, in 1963, was likely the first neurosurgeon to apply the endoscope to transsphenoidal surgery. He soon abandoned its use, however, due to poor visualization and light compared with the operative microscope.[8,9] Then in the 1990s, endoscopy increased independently with otorhinolaryngologists operating on the paranasal sinuses for the treatment of inflammatory sinonasal disorders.[10] Then, with the collaboration of these two disciplines, there began a new era in surgical technique with the use of the endoscopy. With the addition of angled lens, surgeons were now able to see areas that were previously unreachable with such small exposure. In 1992, Jankowski and colleagues[11] and, in 1995, Sethi and Pillay[12] (otorhinolaryngologists and neurosurgeons) reported the use of the endonasal endoscopy transsphenoidal technique that relied solely on the use of the endoscope for complete visualization during surgery. With improved lighting, optics, and high-definition imaging, expanded endoscopic techniques have become routine in the management of complex sinonasal and anterior skull base surgery and have also spread to spinal surgery, peripheral nerve surgery, craniosynostosis correction, aneurysm clipping, and accessing of ventricular masses.

Management of anterior skull base lesions endoscopically advanced significantly with the advent of two-surgeon expanded endonasal approaches.[13] In this set up, two surgeons work in tandem to using a four-handed technique to maintain surgical visualization while dissecting with two instruments. At the skull base, an otorhinolaryngologist and neurosurgeon work to dissect tumor from the dura and anterior cranial fossa. Adequate closure of the skull-base defects with the pedicle axial vascularized nasoseptal flap (NSF) has reduced the cerebral spinal fluid (CSF)-leak rate and allowed rapid expansion of endonasal techniques.[14] With advances in minimally invasive techniques continuing to develop, surgeons can customize an approach for each patient and their disease to allow for the safest and most effective treatment.

Keyhole Surgery

The supraorbital craniotomy offers a window to the inferior frontal lobe, to the circle of Willis, and dissection of the sylvian fissure without the need of brain retraction.[15,16] In 1912, McArthur[17] reported trephination following incision over the eyebrow. In 1913, Frazier[18] described the supraorbital approach to treat a pituitary adenoma in the anterior fossa. In 1984, Jane and colleagues[19] used the supraorbital approach to treat orbital tumors, anterior communicating artery aneurysms, pituitary adenomas, craniopharyngiomas, and parasellar or olfactory groove meningiomas. With the advent of neuronavigation and improved microsurgical instrumentation in the 1990s, the supraorbital keyhole