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STATE OF THE ART

# Skull-base surgery – a challenge for rhinology

**Ermil Tomescu MD, PhD,** Professor of Otolaryngology University of Medicine, Cluj -Napoca, Romania

Classic nasal and sinus surgery has been performed without any major changes until the '80s. Surgical access was being limited to anatomical and pathological elements that could have been seen directly, as for the hidden places, their surgical exposure was being necessary. Surpassing these boundaries was being dangerous and there are enough examples of this, culminating with blind curettage of the ethmoid that resulted in numerous and serious accidents.

The introduction of the endoscope in rhinology has produced a revolution, perhaps as large as the introduction of surgical microscope in otology. Diagnosis and surgical possibilities have improved dramatically, the new technique replacing the old ones almost entirely. Functional surgery took the place of radical surgery, especially because of the modern concept of the "ostiomeatal complex" and to the possibility of direct sinusal approach by less invasive surgical methods. Nasal endoscopic surgery was not only limited to treating infectious or inflammatory pathology but also dealt with surgery for epistaxis, malformations and tumors, proving superior even to conventional surgery aided by the surgical microscope.

Skull base approach meant a real challenge for rhinologic surgeons. Endoscopic-assisted skull base surgery (ESB) is now attacking lesions extending from the frontal sinus and the cribriform plate up to the cranio-vertebral joint, and laterally from the orbit to the infratemporal fossa and petrous apex, the latter being known as „expanded endonasal approaches". The endoscope can thereby reach the anterior and middle cranial fossas, as the cerebellar fossa itself.

Performing endoscopic skull base surgery depends on the technical equipment, thorough and accurate knowledge of endoscopic anatomy, the abilities and techniques achieved by the surgeon and his team, the quality of endoscopes and instruments, the access to CT and MRI and, more recently, to image guidance systems.

At its beginnings, endoscopic surgery has been limited to treatment of nasal cavities and paranasal sinuses pathology. The skull base approach began in the '80s with the procedures for closing dural defects and CSF fistulas. Then, the pituitary gland has been approached endonasaly, which has remained an indication of choice. Experience acquired through practice has led to the establishment of the anatomical boundaries within which this type of surgery can be performed, such as the internal carotid artery, the cavernous sinus or the optical nerve, this allowing the surgical tools and those handling them to tempt removing tumors whose extensions have been identified. Also, there have been defined some injuries that can not be solved or are being difficult solved nowadays, such as vascular lesions or extensive dural defects. A problem that has proved to be major is the necessity of closing the surgical cavity and here, the surgeons' imagination and experience has prevailed: they successfully used pedicled flaps, such as septo-nasal, turbinate, pericranial or palatal flaps that can properly obturate the dural defects, preventing serious postoperative complications.

Nasal endoscopic approach of the skull base depends mainly on the location of the tumor, the surgeon's skill and experience, and on the available equipment for surgery. The main approach paths are transfrontal, transcribriform, transplanum, transsellar, transclival and transodontoid/cranio-cervical junction and the lateral ones are orbital, transpterygoid and infratemporal, each of them having its indications, marks, limitations and traps.

The transfrontal route is indicated in approaching the posterior wall and floor of the frontal sinus in case of sinusitis, extended mucoceles, osteomas and in the anterior extension of ethmoidal tumors. The transcribriform path extends from the apophysis of Crista galli to the planum sphenoidale over the ethmoidal roof and provides a passageway for the surgical removal of olfactory groove and ethmoidal tumors. Transplanum approach addresses the upper extensions of pituitary gland tumors, meningiomas or craniopharyngiomas. Pituitary gland tumors can be removed by transsellar approach. Transclival path is indicated for bony lesions of clivus such as chordomas, chondrosarcomas and meningiomas. The most posterior approach, transodontoid and at the level of cranio-cervical junction allows access to the C1 and C2 vertebrae, as well as to foramen magnum. Through this approach one can solve degenerative problems of the cervical spine, malignant tumors and cases of brainstem compression by odontoid apophysis.

The transorbital approach addresses tumors located internal and below the optical nerve (hemangiomas and schwannomas). Infratemporal tumors can be removed by transpterygoid or infratemporal approach.

**Corresponding author:** Ermil Tomescu, Cluj - Napoca, Romania, 4 Clinicilor Str.
email: ermil.tomescu@gmail.com

Endoscopic-assisted skull base surgery represents an interdisciplinary excellence surgery. In order to be practiced, it implies the coexistence of several conditions:

- Specialized instrumentary of very good quality such as: scopes, cameras, long drills, dissecting tools, special forcepses, and, especially for reintervention cases where the anatomical landmarks are being disturbed, an imaging guidance system (navigation) would be helpful.
- Experienced surgical team, consisting of one or two rhinologic surgeons (helps at discussing the encountered problems, in decision taking and in tempering a too enthusiastic surgeon), a neurosurgeon, an anesthesiologist, possibly an ophthalmologist, endocrinologist, medical imaging specialist, pathologist, bacteriologist and others. It is not advised that such procedures would be performed by a solitary surgeon.
- The doctors involved in the surgical act, but especially the first-hand surgeon must have thorough knowledge of endoscopic anatomy, must be able to solve the multiple problems, accidents and complications encountered in this type surgery. Therefore he must be experienced, he must have skilful hands and keen eyes.

The advantages of endoscopic skull base surgery can be summarized as follows: lack of external incisions, reduced surgical trauma, optimal view, better postoperative course, faster recovery, reduced hospital stay and lower costs.

The disadvantages are being represented by the complicated anatomy of the areas, the disruption of the nasal anatomy and physiology (by septum or turbinate resection), a long learning curve and the existence of technology limits.

Actual endoscopes only provide a two-dimensional image. Lack of binocular stereoscopic vision is limiting the perception of depth, the ability to estimate sizes and disturbs the eye-hand coordination. Although not currently available for nasal and skull base endoscopic surgery (because they have exceeding diameters), the rapid development of technology will surely lead to the appearance of high-definition stereo-endoscopes with 3D image. Currently systems for converting the 2D flat images into 3D images exist, but one has to use special glasses (with polarized lens) that make the surgical act more difficult.

The use of rigid endoscopes implies sacrificing the anatomical features encountered on the gateway (septum, turbinate, posterior wall of the maxillary sinus, etc.). The use of flexible endoscopes and instruments would eliminate this shortcoming by offering the possibility to avoid obstacles. Even though they are being used in other specialties (e.g. laparoscopic endoluminal digestive surgery), in our specialty they proved to be too thick to allow the access and the effective handling.

A future technology would be the use of so-called „virtual augmented reality" (AR) combined with the „Image Guidance Systems„. AR systems should provide additional information by superimposing virtual images (obtained by CT or MRI), over the real ones. These systems are considered as an enhanced navigation experience, because the "see-through" effect allows the direct understanding of surgical anatomy under the visible surface and the direct guidance towards the surgical target.

Robotic skull base surgery is still in prospect. The advantages of this surgery consist on the possibility of 3D vision, of both hands use and to a superior manual ability. Unfortunately, the robot arms have now a larger diameter than the cavity areas of the nose, sinuses and skull base would allow.

I am convinced that the future will bring new technological offers that will solve the nowadays problems. Nasal and skull base endoscopic surgery will constantly improve its performance, in the benefit of patients and science. It only remains necessary that the human factor keeps up and learns how to use the wonderful appliances of the future and to know what to ask the engineers in order to maintain the progress and to overcome always the limits of endoscopic surgery.