



General Principles

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Skull base and AVM surgery continue to challenge the precision, persistence, surgical fitness and ultimately operative talent of the surgeon. I consider the moment of meditation before a challenging operation an important element in surgical preparation. I realize that my faith in God (Hashem/Adonai) plays an important role in my operative success during the life-threatening and transformative moments in surgery. The operating room is the temple where our sacred entity (the patient) is the only center of attention.

Skull base neurosurgery has emerged over the past 25 years as a subspecialty of neurological surgery concerned with surgical management of neoplastic and vascular lesions around the cranial base. Expanded skull

base osteotomies and endoscopic transnasal surgery have revolutionized cranial base surgery and will continue to evolve. Their balance will affect our philosophy for managing complex cranial base tumors.

The skull base with its complex bony anatomy and intricate network of blood vessels and cranial nerves presents a challenging region to fathom and expose at an operation. The space around the skull base is divided into anterior, middle, posterior fossa and parasellar territories. Surgeons operating around the region must possess highly intimate 3-dimensional knowledge of the normal and variant anatomy of the area, as well as alteration of such anatomy by a given pathology.

Extensive and lifelong practice in the microsurgical laboratory, including exercising vascular and neural anastomoses, is an essential precursor to successful skull base microsurgery. *Importantly, advanced apprenticeship under an experienced mentor is crucial to the development of the successful skull base surgeon equipped with unspoken and unwritten microsurgical technical nuances that facilitate favorable outcomes.*

Ultimately, skull base surgery is a *team effort*. In addition to the neurosurgeon, the following team members are critical for operative success: otolaryngologists, plastic and reconstructive surgeons, anesthesiologists, critical care experts, interventional radiologists, oncologists, and rehabilitation experts. Otolaryngologists provide invaluable knowledge of head and neck pathology that is not typically encountered or mastered by neurosurgeons. Plastic and reconstructive surgeons offer consultation regarding closure and reconstruction of skull base defects.

Anesthesiologists and critical care experts contribute knowledge of airway management and perioperative care. Interventional radiologists add their expertise and skill set for management of vascular lesions or tumor embolization to facilitate resection. Oncologists provide appropriate adjuvant therapies for neoplastic lesions, and rehabilitation specialists can outline appropriate regimens for the recovery process often required after surgical treatment of skull base lesions. This teamwork approach brings together a wide range of expertise that benefits patient care and has been

shown to improve patient outcomes.

My Personal Philosophy

Surgery of the cranial base is a complex, technically demanding endeavor requiring above all else experience, preparation, stamina and decisive but serene operator's temperament. The fundamental tenet of skull base surgery is conceived upon the following principle: **Exposure of deep cranial base lesions involves *appropriately extensive* bony resection in order to avoid *any serious* brain retraction or *any aggressive* manipulation of cranial nerves and associated vascular structures, including dural venous sinuses and often under-appreciated veins. This bony resection has to be performed *judiciously and not liberally* or indiscriminately for every patient.**

Appropriate surgical judgment is critical to proceed with an osteotomy *when needed*. The overzealous application of skull base osteotomies with their attended risks has led to dampened enthusiasm about their use in recent years: **"One size does not fit all."** I do not complete an orbitozygomatic osteotomy for every anterior communicating artery aneurysm. Neither do I perform a petrosectomy for every petroclival meningioma. In fact, I rarely use extensive petrosectomies for petroclival lesions such as [epidemoid cysts](#) extending across ventral midline.

Alternatively, the [expanded retrosigmoid](#) and [supracerebellar transtentorial](#) routes offer certain minimally disruptive advantages while maximizing safe gross total tumor resection in appropriately selected patients. Intradural petrous bone drilling also offers tailored operative corridors in select patients.

Of course, extended petrosectomies have a very important and indispensable role in skull base surgery for clearly ventral, mainly clival fibrous meningiomas. ***Every skull base approach has relatively well-defined indications and should not be over-utilized or abandoned only because of one's familiarity or unfamiliarity with other techniques.***

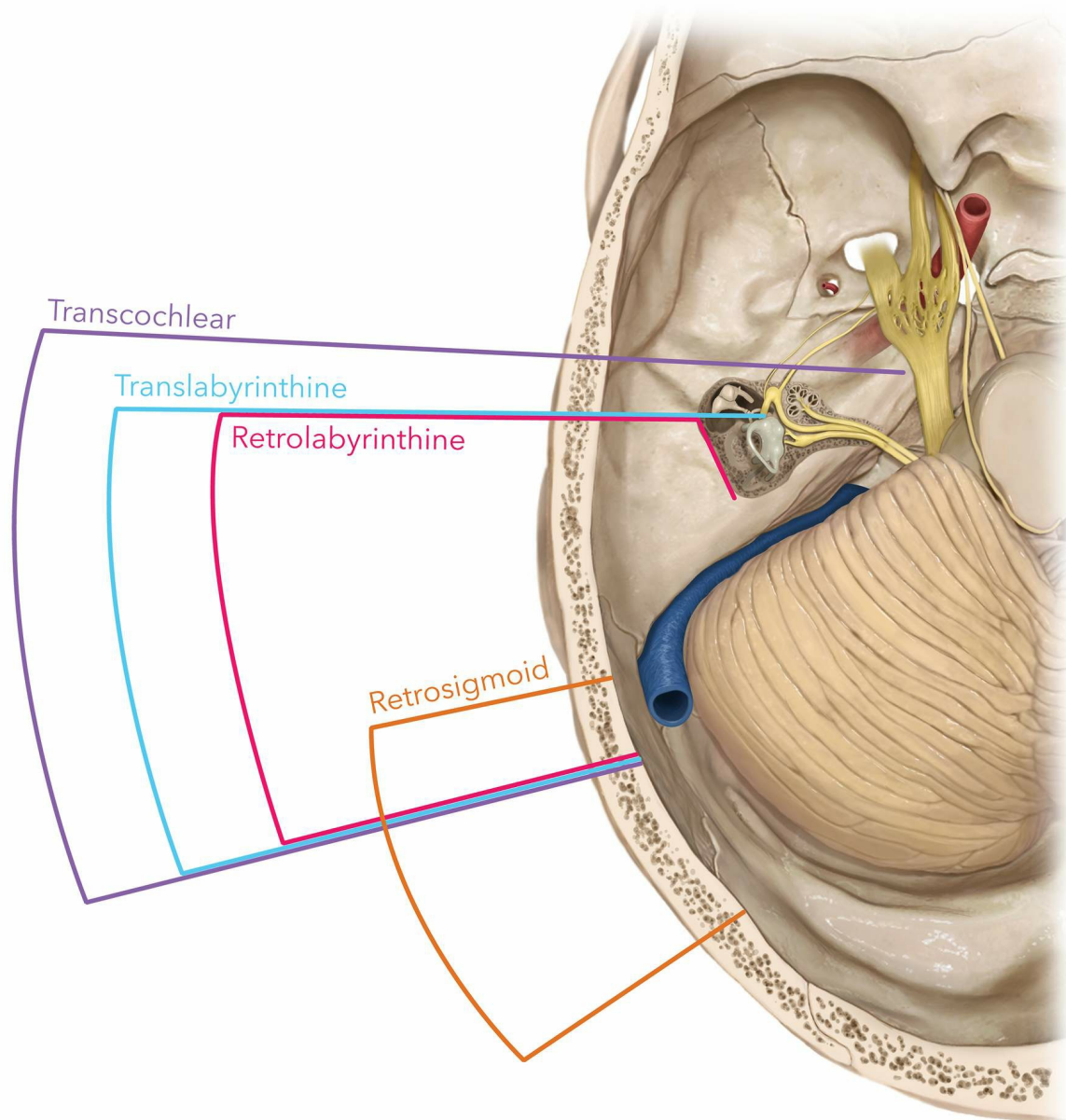


Figure 1: The progressive level of ventrolateral and ventral brainstem exposure via more radical transpetrosal osteotomies is illustrated. The retrolabyrinthine, translabyrinthine, and transcochlear routes each afford a less obstructed view of the anterior brainstem but also carry higher complication rates and extended operative times as compared to the retrosigmoid approach. Surgeons often do not consider the longer operative sessions and their more invasive nature as factors in the long-term quality of life of the patient.

I prefer using the operating microscope's mouthswitch to maintain a focused image within the narrow and deep operative corridors of the skull base exposures. This preference allows bimanual dynamic retraction using the hand held suction device and the dissector or bipolar forceps to expose only part of the pathology at one time and protects the patient's

brain from retraction injury. I have learned to do more through less disruptive operative corridors. **Flexible operative angles, rather than generous operative space, have determined my limits of required exposure.**

Endoscopy is an indispensable tool in the armamentarium of the skull base surgeon. Mastery of endonasal techniques requires a distinct understanding of skull base anatomy. As compared to transcranial approaches with their *inside-out* anatomy, the endonasal routes demand a mastery of the relevant *outside-in* anatomy. Every skull base surgeon should be an expert in both transcranial and endoscopic transnasal techniques to aptly serve the patient. **I do not believe in any concept that creates a distinction between the “transcranial” and “endoscopic” skull base surgeon.**

Preoperative Evaluation

Comprehensive evaluation of every patient is essential for developing an appropriate management plan for cranial base lesions. This begins with a thorough history to document the progression of symptoms as well as the physiologic condition of the patient. The specific requirements of a patient’s job, whether or not the patient cares for others, and the patient’s participation in beloved hobbies may influence the surgical decision-making process.

Documentation of physical and neurological examination will serve as baseline assessments. Preoperative imaging is important and should be tailored to the lesion, but will commonly include some combination of MRI, CT, and/or CT or catheter angiography. Embolization of highly vascular neoplastic lesions should be considered. If sacrifice of the ipsilateral internal carotid artery (ICA) is contemplated, a balloon occlusion test is performed to evaluate the tolerance to temporary ICA occlusion to perform revascularization and not necessarily the feasibility of definitive Hunterian ligation.

Depending on the location of the lesion, neuro-ophthalmologic, audiometric, and endocrinologic assessments are indicated, and if there is

any concern for a malignant neoplasm, a metastatic work-up should be undertaken. **All parasellar lesions should be further evaluated via a complete endocrine work-up since prolactinomas may rarely mimic other tumors and present as an unusual parasellar mass based away from the midline.**

Lastly, all concomitant medical comorbidities should be investigated and maximally controlled to minimize the likelihood of perioperative complications. Once all of the relevant information is assimilated, the patient and his or her family should be counseled regarding the expected untreated natural course of the underlying pathology, and consideration should be given to conservative management or stereotactic radiosurgery. A well-informed and prepared patient often recovers more efficiently during the postoperative period.

If surgery is indicated, the goals and details of the operation, the expected postoperative course, and the possible complications should be discussed at length. Once the patient is fully informed, the exact surgical plan can be drafted.

Operative Care

Surgical intervention for skull base lesions should be characterized first and foremost by meticulous planning and should take into account the individual anatomical traits of each patient, the location and characteristics of the given lesion as seen through multiple imaging modalities, and the surgeon's comfort level with various approaches.

Surgical approaches to the cranial base offer various working angles or distances associated with corresponding degrees of dissection freedom, characterized by diverse extents of bony resection (osteotomy). This osteotomy increases intradural working angles, minimizes brain retraction, and provides spacious operative corridors for maneuvering microsurgical instruments.

An adequately planned approach takes into account normal 3-dimensional anatomical correlations and the pathologic deformation of these normal

structures by the underlying lesion. **The desired approach should provide adequate exposure to maximally preserve function and normal anatomy while accomplishing the surgical goals efficiently.**

Reconstruction of the bony defect and closure should be considered during preoperative planning stage so that necessary provisions can be made prior to surgery, minimizing the risk of a postoperative CSF leak and wound breakdown. This planning may include preparation of vascularized tissue flaps during the exposure, fat or fascial graft from a distant anatomical site, and/or consultation with a plastic surgeon colleague for transfer of a vascularized free tissue flap. The exposure should be conducted with the plans for closure in mind.

In addition to the details of the operative intervention, preoperative planning should account for the patient's physiological function. Anesthetic management should maintain perioperative hemodynamic stability, reduce intracranial pressure, and allow for neurophysiological monitoring of the brain and cranial nerve function.

If cerebrovascular injury is likely or if long periods of temporary vascular occlusion is necessary, preparations should be made for brain protection including mild hypothermia and barbiturate coma, and blood products should be readily available. Preemptive revascularization of the corresponding cerebral territories should be devised.

Skull base operations are often long in duration so overinfusion of crystalloid fluids should be avoided. Placement of a lumbar drain for intra- and postoperative CSF drainage assists with brain relaxation during surgery and prevents the risk of CSF leak after surgery. I use lumbar drain generously and any other tool available to minimize brain retraction.

If postoperative airway protection is likely to be a long term problem, a tracheostomy can be performed. Following surgery, patients should be managed in an ICU setting for at least 48 hours, longer if necessary. Aggressive management of cardiopulmonary function, fluid and electrolyte balance is essential for rapid recovery.

Mobilization should occur as early as possible and deep vein thrombosis (DVT) prophylaxis should be instituted until the patient is adequately ambulating. Patients with the longest postoperative hospital course are often those with major neurological deficits and/or lower cranial nerve palsies requiring tracheostomy and gastrostomy. These patients should have aggressive skin and limb care to prevent decubitus ulcers, and early rehabilitative intervention to regain as much function as possible.

Skull base Surgery: Personal Reflections and Lessons

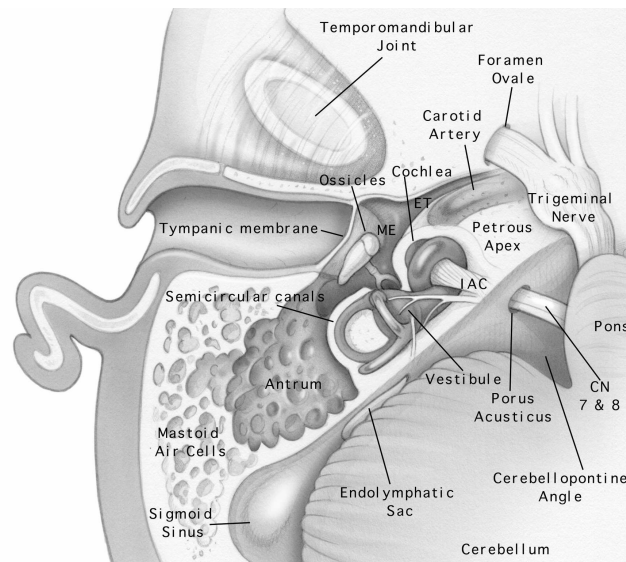
Learned

- 1. Respect normal tissues without exception: Avoid venous sacrifice and minimize the use of fixed retractors. The special "gentle touch" for tissue handling is a must. No one can teach you surgical finesse.*
- 2. The selected operative corridor should a) protect normal cerebrovascular structures while minimizing brain retraction or transgression, b) advance working angles at the potential cost of increasing working distance and c) allow gross total resection of the lesion most efficiently.*
- 3. Respect the arachnoid membranes and use them to your advantage. Use sharp dissection and gently peel the encasing arachnoid sheaths to mobilize cranial nerves away from the tumor capsule. Blunt and blind dissection leads to regrettable outcomes.*
- 4. The first time is the best time for achieving cure. During microdissection, be patient when you need to and accelerate when allowed by the momentous operative encounters. Let the normal tissues and pathology guide you rather and do not force your operative agenda. Remain flexible and alter your plan based on your intraoperative findings to protect perforating vessels and other vital cerebrovascular structures.*
- 5. Surgical intelligence is difficult to define, but it is the ability to monitor one's own operative maneuvers, to discriminate between different operative strategies for safe and efficient handling of the lesion, and to use momentous intraoperative findings to guide the overall plan.*
- 6. Learn from your and others mistakes. The more you operate, the worse complications you will have. Remember and move on. Preserve your*

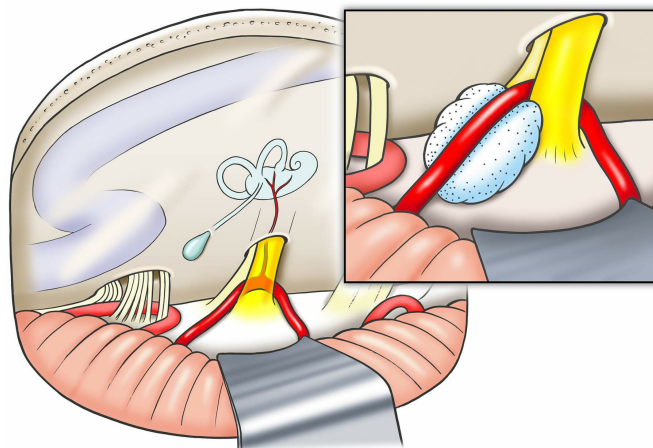
confidence in the face of disappointment. Remain humble and always listen to others' experiences, even your residents. Their questions bring a new perspective to the operation.

7. *Microsurgery is a passion, not a job and not a hobby but a journey of agony and ecstasy. It disappoints you but your successes will carry you along.*
8. *Most importantly, do "the best anyone can" rather than "the best you can" for every patient. You owe it to them. The patient's interest is the only and the most important interest.*

For an overview of the cranial base surgical anatomy, please refer to the Jackler Atlas by clicking on the image below:



For additional illustrations of cranial base surgery vascular considerations, please refer to the Jackler Atlas by clicking on the image below:



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