ADVANCES IN LATERAL SKULL BASE AND INFRATEMPORAL FOSSA SURGERY

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Lateral skull base surgery is a highly specialized field which has evolved rapidly over the last two decades. It has widely expanded the horizons of surgical treatment of skull base neoplasms that were previously deemed inoperable. It is a multi-disciplinary specialty, requiring the expertise of neurosurgeons, head and neck surgeons, and neuro-otologists, along with neuroradiologists and interventional radiologists, for the successful treatment of extensive lesions with minimal morbidity. In addition to the extirpative surgery, the reconstruction of the resulting defects by plastic or head and neck reconstructive surgeons has also revolutionized the functional and esthetic outcomes of these elaborate procedures. It is this multi-disciplinary approach which accounts for the current success of lateral skull base surgery. These demanding procedures however should take place only in select centers with expertise available in all of the mentioned disciplines, because a surgeon's inexperience may result in high rates of recurrence of disease and increased morbidity.

SURGICAL ANATOMY

Lateral skull base approaches have been developed primarily to address intracranial diseases involving the middle and posterior cranial fossae and the infratemporal fossa. A thorough knowledge of the anatomy of the region is of paramount importance because of the complex relationship of the various neurovascular structures. It is this understanding of the surgical anatomy that has made possible the numerous modifications and improvisations in the surgical procedures in an attempt to preserve much of the normal structures without compromising access to and excision of the lesion. Anatomy of the temporal bone, clivus and the infratemporal fossa is of prime importance.

When approaching the lateral skull base, dissection of the temporal bone is crucial with identification and preservation of the important cranial nerves, in particular the facial nerve, and the vascular structures (internal carotid artery, jugular bulb and sigmoid sinus) associated with the temporal bone.

The clivus (Figure 1) serves as a critical landmark to determine what types of surgical approaches are required to access the tumor. It is divided into three anatomic zones.[1] The upper clivus is supratentorial, lying above Meckel's cave, and provides access to the midbrain. The middle clivus lies between Meckel's cave and the jugular foramen providing access to the pons and upper medulla. The lower clivus lies between the jugular foramen and the foramen magnum, anterior to the lower medulla and the spino-medullary junction.

Of equal significance to the surgeon is the anatomy of the infratemporal fossa. The lateral approach to the infratemporal fossa depends on the early identification of the facial nerve and the internal carotid artery.[2] The facial nerve exits the temporal bone via the stylomastoid foramen deep to the posterior belly of the digastric muscle, and divides into its terminal branches within the parotid gland.

The internal carotid artery (ICA) ascends deep to the digastric and styloid muscles, entering the carotid siphon medial to the styloid process. This constitutes the post-styloid neurovascular component of the parapharyngeal space (Figure 2). In the petrous portion of the temporal bone, the vertical portion of the ICA at the genu is deep to the Eustachian tube, postero-medial to the glenoid fossa, and infero-medial to the tensor tympani muscle. The mid-portion of the vertical segment is antero-medial to the basal turn of the cochlea. The horizontal portion of the ICA is directed intracranially, from lateral to medial, in an oblique fashion from the genu towards the foramen lacerum.

The glenoid fossa limits the exposure of the infratemporal fossa in lateral approaches. Dissection through the glenoid fossa and its contents facilitates exposure of the vertical intrapetrous segment of the ICA.

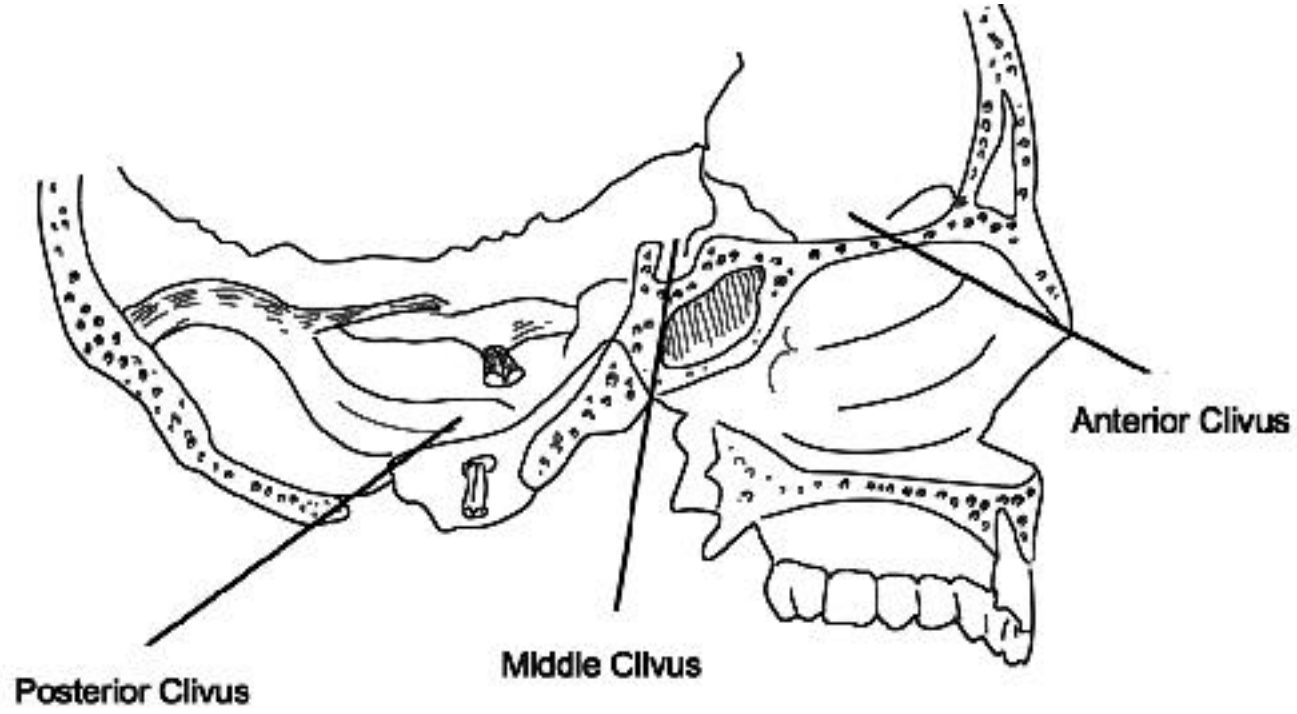

Figure 1. The clivus serves as a critical landmark. (Courtesy: Mr. Aslam Bashir)

MANAGEMENT OF THE INTERNAL CAROTID ARTERY

Management of the ICA in skull base surgery often differentiates between surgical success and failure with significant neurologic sequelae. Unselected transection or sacrifice of the ICA has been associated with almost 50% mortality and 26% incidence of cerebral infarction in survivors.[3] Four-vessel arteriography with venous phase is essential preoperatively to determine the need of ICA control either preoperatively or intraoperatively. Preoperative stent insertion may be done to maintain vascular flow and remove the disease from the ICA. In case of ICA resection, evaluation of cerebral blood flow is also required. A number of modalities are available with varying results. A preoperative or intraoperative ballon test occlusion with EEG monitoring can be done. However, the sensitivity of around 50% and the intrinsic risk of stroke with the test occlusion has limited the use of this test at many centers. Other newer techniques include functional MRI, PET scan, SPECT scan, and xenon-CT blood flow mapping - all of which have shown promising results.[3,4]

SURGICAL APPROACHES

The fundamental goal of all these lateral skull base techniques is to provide necessary access to the disease process at the skull base and intracranially, with minimal brain retraction. With equal importance now being imparted to the preservation of function and esthetics, it is this attempt to preserve normal unaffected structures that differentiates current surgical techniques from previous counterparts. Lateral craniofacial approaches to the skull base and the infratemporal fossa can be divided into two categories - those that remain extracranial and those that necessitate access intracranially to remove disease.

The lateral approach can be accomplished by various routes including the postauricular infratemporal fossa approach,[5] the preauricular infratemporal approach,[6] or the transparotid or extended rhytidectomy approaches.[7]

With the presence of extensive intracranial disease into the middle cranial fossa, a number of approaches can be incorporated: the frontotemporal orbitozygomatic, petrosal, middle fossa, transpetrosal, retrolabyrinthine, translabyrinthine, transotic, transcochlear, total petrosectomy, and retrosigmoid approach. Details of these intracranial approaches are beyond the scope of this review. In practical terms, extensive disease requires a combination of several of these approaches.[8]

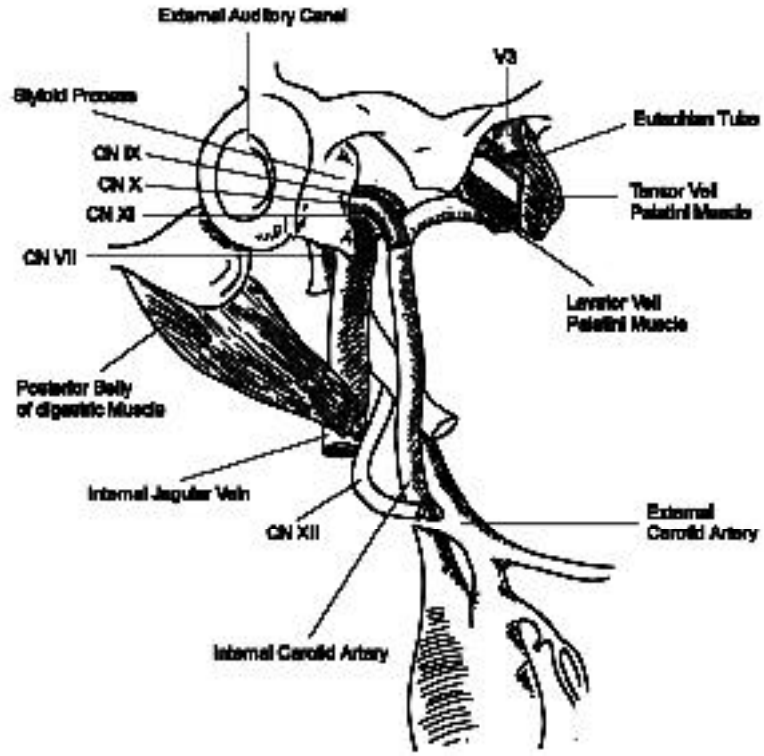

Figure 2. Neurovascular components of the lateral skull base and infratemporal fossa. (Courtesy: Mr. Aslam Bashir)

EXTRACRANIAL SKULL BASE APPROACHES

Postauricular Infratemporal Fossa Approach

The lateral techniques by Fisch,[1,9] involve an infratemporal fossa approach to tumors of the temporal bones and lateral skull base. Three basic approaches have been described by Fisch. The type A approach is most commonly used for glomus tumors, extensive cholesteotomas, and carcinomas extending into the region. The approach involves a complete or radical mastoidectomy, anterior transposition of the facial nerve, exploration of the infratemporal fossa, and cervical dissection to gain access to the neurovascular bundle at the base of the skull.

The type B approach is optimal for exposure of the petrous apex, clivus, and the superior infratemporal fossa. The type C is an anterior extension of the type B, exposing the nasopharynx, pterygomaxillary fossa, parasellar region, and the paranasal sinuses.

These techniques, however, result in conductive hearing loss, facial nerve palsy and significant temporomandibular joint dysfunction. They involve permanent closure of the external auditory canal, permanent rerouting of the facial nerve, and dislocation of the temporomandibular joint anteriorly in order to expose the vertical segment of the internal carotid artery.

Proponents of these elaborate exposures[10] feel that any less aggressive approach which does not allow control of the area of the lesion or of the ICA produces more recurrences. In younger patients especially, conservative approach should be avoided and removal of the disease in total should be the ultimate goal to avoid spread of the disease to areas where it may become difficult to manage. The reported incidence of temporary facial nerve paralysis at one year ranges from 51% to 95%.[10] These authors also maintain that dissection of the lower cranial nerves at the jugular foramen invariably results in their complete paralysis with the risk of residual disease medial to the jugular foramen, hence it is not advisable to attempt preservation of these nerves when involved with tumor.

Rehabilitative procedures such as gold weight eyelid implants for facial paralysis, palatal prosthesis or palatal flaps for velopharyngeal insufficiency from glossopharyngeal and vagus paralysis, and silastic medialization thyroplasty for vocal fold paralysis are now considered standard of care for these deficits and can be performed at the time of the original procedure. This helps tremendously with post-operative rehabilitation,

resumption of oral alimentation, and avoidance of complications such as corneal ulcerations, aspiration pneumonias, and dysphagia. Similarly, problems with malocclusion and trismus after temporomandibular joint disarticulation are significantly reduced with improved plating systems, maxillomandibular fixation, and oral rehabilitation.

Preauricular Infratemporal Fossa Approach

In recent years, the Fisch type B and C approaches have been replaced by preauricular approaches which do not require removal of the external auditory canal or entrance to the middle ear space, hence preserving auditory function. Additonally, the facial nerve is not transposed, which at times may limit the extent of upper cervical dissection. In the author's experience the temporal portion of the facial nerve can be skeletonized without translocation, and the extratemporal facial nerve can be stretched anteriorly with the parotid tissue maintaining its integrity. The temporomandibular joint can then be dislocated and through a transglenoid approach in which the vertical segment of the ICA is exposed along its entire length up to the horizontal segment. There is minimal to no weakness of the facial nerve in the immediate post-operative period and complete recovery has been seen in all patients by the fourth month.

The main advantage of the preauricular approach is avoidance of subtotal petrosectomy and hence conductive hearing loss; its main disadvantage is limited exposure to the temporal bone and posterior cranial fossa. Alternatively, complete exposure of the lateral skull base and infratemporal fossa can be achieved by a multidirectional approach which includes transmastoid, infralabyrinthine, retrosigmoid, transcondylar, and transjugular exposure without rerouting of the facial nerve.[11]

Rhytidectomy Approach

This approach can either be extended to access the lateral skull base and the infratemporal fossa, or it may be limited to the infratemporal fossa alone. It is perhaps the least debilitating of all and is therefore preferred for limited disease to the infratemporal fossa and for mostly benign pathology. Benign tumors of the greater wing of the sphenoid and infratemporal fossa, such as meningionas, fibromas, neuromas or angiofibromas, may be resected with ease. It is dependent on the close association of facial nerve, parotid gland and facial muscles, and involves elevating these units as a block. In this way the tedious dissection of facial nerve and its branches is avoided. Furthermore, traction injury to the facial nerve is minimized.[7]

SUMMARY

The field of skull base surgery has advanced considerably with greater emphasis on preservation of normal structures and maintenance of function, without compromising complete removal of the disease. It is now possible to achieve greater exposure with minimal brain retraction and minimal cranial neuropathies and vascular injuries. These advances have been made possible by the extensive work of multiple investigators (several of whom have been cited in this article), whose accomplishments have helped clarify the extremely complex area of lateral skull base surgery to the point that it is no longer a mystery. This is the prime example of a multi-disciplinary specialty that draws on various distinct areas of expertise, and must be attempted by only those with considerable knowledge and experience in this area.

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