

# Decision Making in Lateral Skull Base Surgery

<sup>1</sup>KP Morwani, <sup>1</sup>Narayan Jayashankar, <sup>2</sup>Suresh Sankhla, <sup>1</sup>Rahul Agrawal

<sup>1</sup>Department of ENT and Skull Base Surgery, Dr Balabhai Nanavati Hospital, Mumbai, Maharashtra, India

<sup>2</sup>Department of Neurosurgery, Dr Balabhai Nanavati Hospital, Mumbai, Maharashtra, India

**Correspondence:** Narayan Jayashankar, Department of ENT and Skull Base Surgery, Dr Balabhai Nanavati Hospital, Mumbai Maharashtra, India, e-mail: narayan@narayanj.com

## ABSTRACT

Lateral skull base surgery encompasses a number of lesions and also a variety of approaches to deal with them. Correct understanding of the nature of the lesion as also various patient factors are used to decide on surgical option wherever indicated. The extent of the lesion and also the involvement of structures adjacent to the lesion is discussed with the neuroradiology team, and is very important in deciding the most favorable surgical approach. The subject is explained preoperatively about staging of the procedure, if needed. The principle is to gain maximal exposure of the lesion with good control of the neurovascular structures along the surgical route, so as to minimize morbidity. Correct decision making and good skill help in achieving the best possible results.

**Keywords:** Vestibular schwannoma, Glomus tumors, Petroclival, Facial nerve.

## INTRODUCTION

Selecting the correct approach to access the lesion is of utmost importance to excise the lesion completely. Skull base surgery offers a myriad of approaches and each approach has specific indications. The basic principle in skull base surgery is removal of the bone of the skull base with preservation of the important neurovascular structures. However, removal of certain lesions requires manipulation of these vital neurovascular structures with resultant morbidity—either temporary or permanent, which should be anticipated and explained clearly to the subject preoperatively. This article attempts to explain the thought process involved in decision making of common skull base lesions and does not attempt to cover the entire spectrum of skull base lesions or the approaches involved therein.

## DECISION MAKING IN VESTIBULAR SCHWANNOMA SURGERY

Treatment of vestibular schwannoma depends on a variety of factors, important of which are hearing status, symptoms, size and location of the tumor in relation to the internal auditory meatus, and cerebellopontine angle areas.

A wait and watch approach for vestibular schwannoma can be used if the tumor is intracanalicular, with minimal or very occasional vertigo and fairly good hearing<sup>1</sup> (100% speech discrimination at diagnosis). Such a subject with a good follow-up who is willing to undergo serial MRI scans, an elderly individual or medical conditions rendering the subject unfit for surgery, are candidates for observation. However, it is not always possible to only observe, as significant growth causing symptoms can be encountered over a period of time in this group of subjects necessitating surgery.<sup>2-4</sup>

A symptomatic, tiny vestibular schwannoma located in the internal auditory meatus or with minimal (< 0.5 cm) extension into the cerebellopontine angle with preserved hearing should be removed through a middle cranial fossa approach. This surgery needs to be done meticulously and with minimal manipulation of the facial nerve during tumor removal. The rate of preservation of hearing and facial nerve are very high in good hands. Although retrosigmoid approach is also used by mainly neurosurgeons for these tumors, middle fossa approach is preferred, since the rates of hearing preservation by this approach are higher.<sup>5-7</sup>

A larger vestibular schwannoma which arises from the internal auditory meatus with extension of more than 0.5 cm into the cerebellopontine angle can be removed using either a translabyrinthine or retrosigmoid approach. The guiding factor in selecting the approach is the presence or absence of preoperative serviceable hearing. Serviceable hearing is defined as hearing threshold better than 50 dB and speech discrimination better or equal to 50%. The retrosigmoid approach offers benefit of hearing preservation in cases where the subject has a preoperative serviceable hearing, whereas the translabyrinthine approach basically sacrifices the residual hearing. However, tumor size again plays a significant role in deciding the approach in cases with serviceable hearing. It has been conclusively proved that for tumors above 2.5 cm in extrameatal diameter, the rates of hearing preservation (serviceable hearing) are poor—less than 11.2%,<sup>8,9</sup> if a hearing preservation surgery is attempted. It should be noted here that preservation of hearing does not mean hearing a few sounds with poor discrimination as mentioned very often by surgeons performing the retrosigmoid approach. In fact, in these cases, the sound distortion in the affected ear is so severe that it



Fig. 1: Large vestibular schwannoma on right side

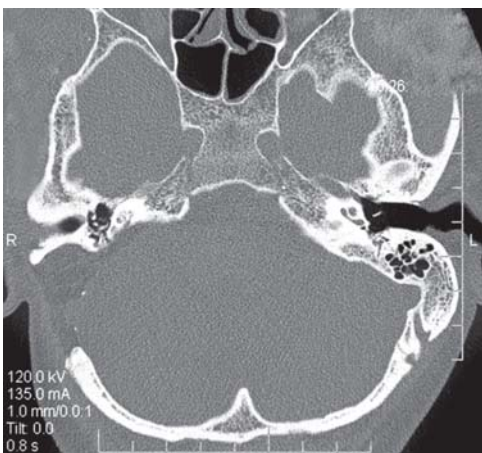


Fig. 2: Postoperative CT scan showing the amount of bone removed in the enlarged translabrynthine approach and the access it offers

affects good speech perception from the normal ear. The hearing results need to be classified as preoperatively or postoperatively based on the AAO-HNS hearing result scale.<sup>10</sup> These factors need to be considered and clearly explained to the subject before attempting hearing preservation surgery for vestibular schwannomas above 2.5 cm in extrameatal diameter.

The enlarged translabrynthine approach is our procedure of choice for removal of large vestibular schwannomas. This essentially includes decompression of the posterior fossa dura including about 2 cm of retrosigmoid dura posteriorly, decompression of the middle fossa dura superiorly, decompression of the jugular bulb inferiorly and drilling 270 to 300 degrees around the internal acoustic meatus towards the prepontine cistern. This offers a very large access for removal of large vestibular schwannomas (Figs 1 and 2). This approach offers the benefit of early

identification of the facial nerve at the lateral end of the internal auditory meatus and also gives better access to tumors involving the lateral end of internal auditory meatus. The enlarged translabrynthine approach offers the added benefit of having the entire course of facial nerve within the surgical field, so that in cases of inadvertent injury, it can be repaired during the primary procedure itself. This can involve end to end anastomosis or interposition nerve grafting between two ends of the nerve. The gain in enlarged translabrynthine approach is regained earlier than the retrosigmoid approach due to the fact that the cerebellum need not be retracted. In case a hematoma ever develops, it seems to be easier to drain it via a translabrynthine as compared to a retrosigmoid route where a swollen cerebellum may be encountered.

### DECISION MAKING IN GLOMUS TUMORS

Glomus tumors are classified according to Fisch classification.<sup>11</sup> Microsurgical extirpation of the disease should be the primary objective to control these tumors.<sup>12</sup> Glomus tympanicum tumors require a transcanal approach and can be removed quite easily. Glomus type B tumors require a transmastoid approach. Glomus type C tumors require infratemporal fossa approaches depending on the extent following the course of the internal carotid from the neck towards the cavernous part. In the class C and D tumors, the subject is preoperatively explained about the possibility of facial nerve paresis (due to rerouting of the facial nerve) which is usually expected to recover in about 70% cases to grade II.

In glomus tumors, age can play a critical role in deciding the modality of treatment. Since, there is always a risk of lower cranial nerve paresis/palsy in removal of class C or D tumors, such extensive surgery is deferred in the older age group (above 65 years) to essentially prevent risk of aspiration and recurrent pneumonia. In case surgery is needed, care is taken to prevent vagal nerve injury with total removal where possible or alternatively a very tiny residue of tumor is left behind over the vagus nerve, if a good dissection plane cannot be obtained. However, in the younger age group, surgery is the treatment of choice inspite of the risk of lower cranial nerve weakness due to easier compensation of function.

Presence or absence of lower cranial palsies preoperatively is also noted as degree of compensation. Those with a fairly good compensation are good candidates for surgery.

Assessment of preoperative hearing is always performed for whatever class the tumors belong to. In all classes of tumors, the extent of tumor invasion of the auditory apparatus will determine preoperatively the chances of retaining good hearing. Hearing preservation is attempted,

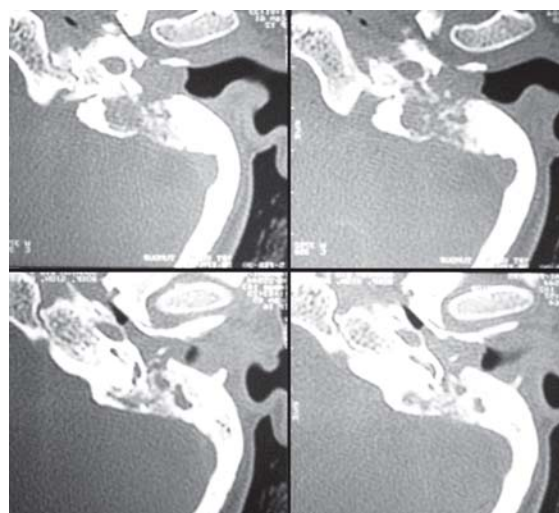
if possible, in all ears and especially important in class A and B tumors. However, complete removal of the glomus tumor at the first sitting itself is the goal (excluding tumors with gross intradural extension) even at the expense of sacrificing hearing, if needed. In class C tumors, a cul-de-sac closure of the external auditory canal is performed and this is explained to the subject preoperatively.

Imaging plays perhaps the most important part in surgery for glomus. We perform high resolution CT scan of the temporal areas and also of the neck. This gives us valuable information about the extent of the lesion and its relation to the internal carotid artery. As mentioned earlier, the involvement of cochlea or labyrinth and intradural involvement can be determined preoperatively. We base the classification as the approach primarily based on the CT scan findings (Figs 3 to 5).

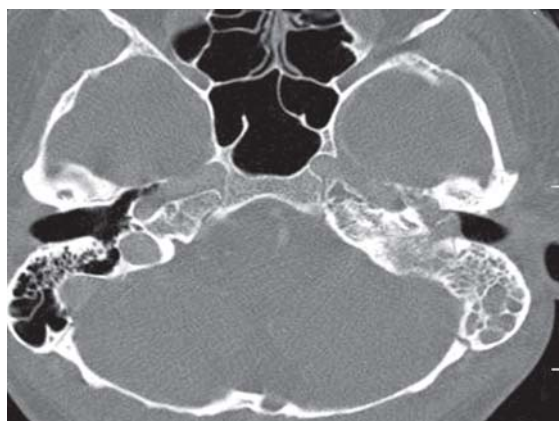
Magnetic resonance imaging provides adjunctive information regarding the tumor extension. It especially helps in differentiating dural involvement, if any doubts exist about whether the tumor is just adherent to dura or has any intradural extension. It also determines the relationship of the tumor to various intracranial structures in cases of intradural extension. MRI can also indicate extent of involvement of jugular bulb and vein, since normal flow voids get altered. Only in cases of extensive involvement of internal carotid artery, a carotid angiogram is additionally performed as a balloon occlusion test to assess the blood flow in the opposite internal carotid artery as the cerebral perfusion. In our series though, we have not had any case where this was necessary, as we have yet not encountered a case where internal carotid needed to be excised. It may be prudent to add here that tumor usually involves the carotid periosteum and this can be easily lifted off the internal carotid artery without injuring the artery, itself. We additionally, can mobilize the internal carotid artery, so that drilling towards the petrous apex can be achieved where desired.

Embolization of glomus tumors preoperatively is performed only for tumors of class C or D, and is preferably performed 48 to 72 hours prior to the surgery for optimum effect (Figs 6 and 7). Although we prefer embolization routinely, all subjects in India cannot afford embolization and in these cases the external carotid artery is temporarily ligated just above the carotid bulb only at the time of tumor excision. This has been found to decrease blood loss significantly in our series.

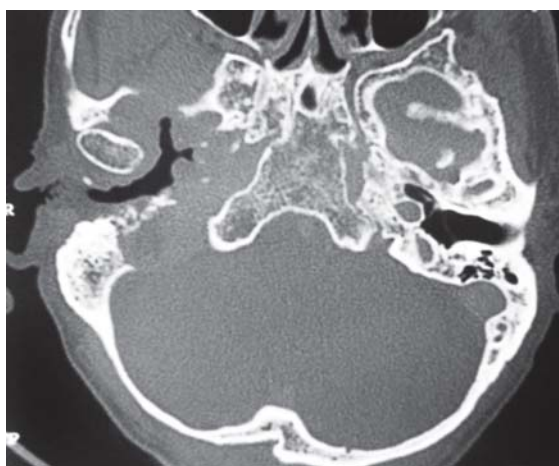
The decision for single stage or two stage resection in class D tumors is based on the extent of intradural extension. It is preferable to do intradural extensions in two stages to prevent the risk of CSF leak. However, very small, i.e. less than 1 cm intradural extension are removed in a single stage (Fig. 8). The dural defect needs to be plugged securely with fat (Fig. 9), so as to completely obliterate the surgical cavity.



**Fig. 3:** Left sided glomus jugulare class C2 involving the jugular foramen and the ascending vertical course of internal carotid artery



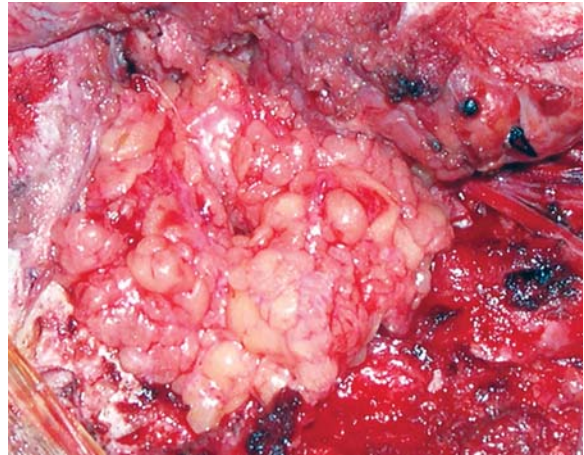
**Fig. 4:** Left sided glomus jugulare class C3 involving the genu and extending partially to the horizontal portion of internal carotid artery along its petrous course



**Fig. 5:** Right sided glomus jugulare class C4 involving the internal carotid artery up to the intracavernous course



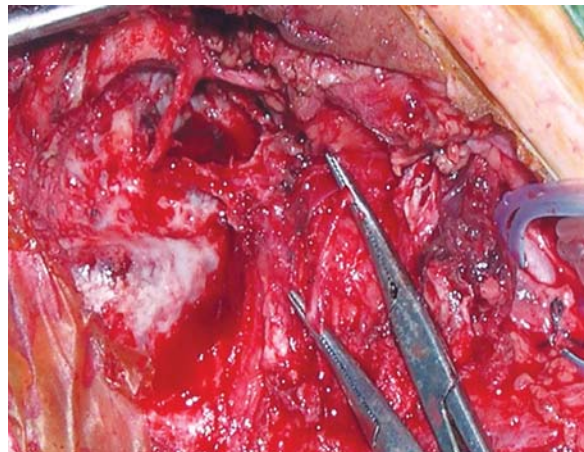
**Fig. 6:** Pre-embolization arteriogram



**Fig. 9:** Fat used to seal the dural defect, so as to completely obliterate the surgical cavity



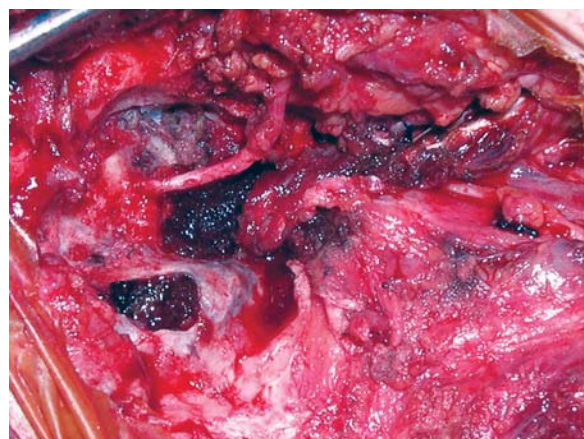
**Fig. 7:** Post-embolization arteriogram showing decreased tumor blush



**Fig. 10:** Mobilization of only the vertical intratemporal portion of facial nerve from second genu to the parotid division (right side)



**Fig. 8:** Glomus tumor excised completely with single-stage excision of a small intradural extension (dural defect)

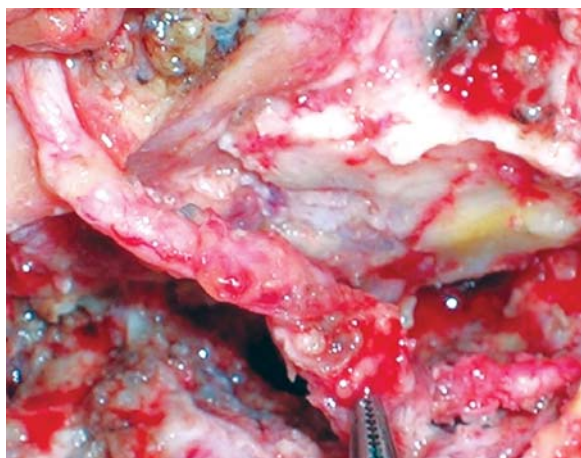


**Fig. 11:** Facial nerve integrity maintained and reposed at the end of surgery (right side)

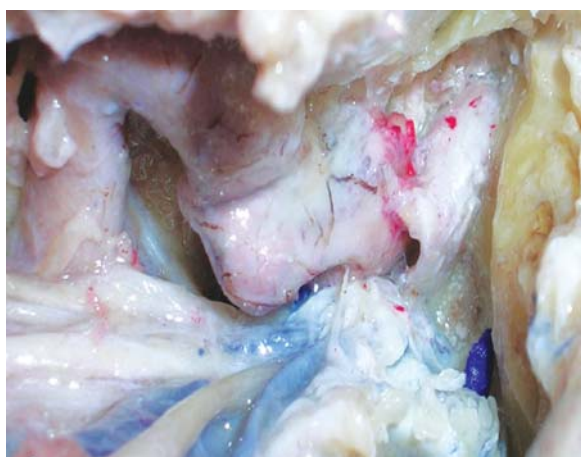
It may be mentioned here that some centers are managing the intracranial extensions in a single stage.<sup>13</sup>

Intraoperatively, facial nerve needs to be transposed anteriorly to gain effective access to the jugular foramen.

However, we do know limited transposition of the facial nerve where feasible. To achieve this, facial nerve is decompressed from geniculate ganglion to the stylomastoid foramen and the extratemporal portion of the facial nerve



**Fig. 12:** Anterior transposition of facial nerve (left side)



**Fig. 13:** Carotid periosteum can be lifted off as a separate layer if infiltrated with tumor

in parotid is liberated to include the upper and lower divisions. Care must be taken to retain enough periosteum around the nerve at the stylomastoid foramen. Having done this, the facial nerve is then lifted off the fallopian canal in its vertical segment in some class C1 tumors (Figs 10 and 11) or if needed the entire segment including the tympanic segment and geniculate ganglion is lifted off in class C2 tumors and beyond, and transposed anteriorly (Fig. 12). Of course, this decision is taken intraoperatively without compromising tumor excision and without putting the facial nerve at grave risk of injury due to limited mobilization. If the facial nerve is involved with the tumor, it is prudent to excise the segment of involved nerve and to place an interposition nerve graft between healthy cut ends of the nerve. Usually, greater auricular or sural nerve grafts are preferred.

If any doubt exists about tumor infiltration of the carotid periosteum, the periosteum is dissected off from the internal carotid and excised (Fig. 13). The internal jugular vein along with lateral wall of the jugular bulb is excised and surgically

packed into the openings of the inferior petrosal veins. Spongy bone after tumor excision also needs to be drilled off till healthy bone is visualized to give optimal results.

Use of gamma knife radiosurgery for glomus tumors is highly objectionable. Although there are reports suggesting use of radiosurgery,<sup>14</sup> they lack long-term follow-up and do not clearly mention recurrence rates and further control of recurrences following use of gamma knife. For recurrences, we in fact advise infratemporal fossa A approach<sup>15</sup> with anterior transposition of the facial nerve, excision of the complete lesion together with the lateral wall of the jugular bulb and sigmoid sinus, correct management of the internal carotid artery and drilling of the spongy bone under the lesion to prevent further recurrences and achieve long-term good control. The only instance where gamma knife radiosurgery may be justified in our view is when a tumor residue is left adjoining the cavernous sinus.

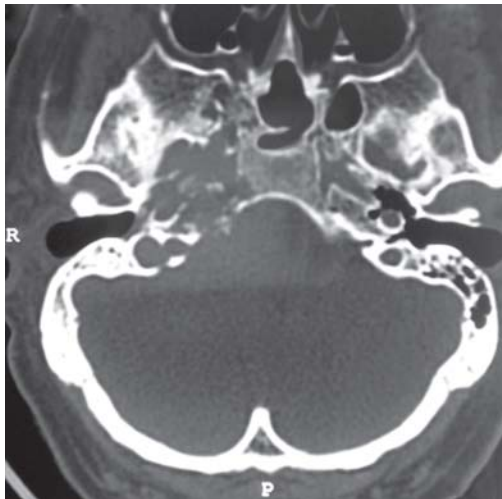
### DECISION MAKING IN PETROUS AND PETROCLIVAL LESIONS

High-resolution CT scan and MRI help to determine not only the extent but also the nature of the pathology in the petrous apex,<sup>18</sup> which has an important bearing on the treatment option.

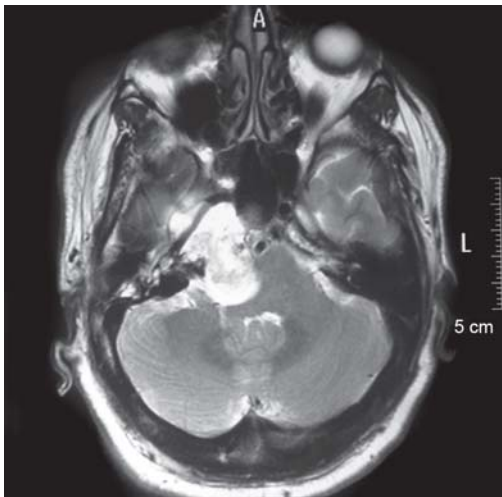
Petrous apex cyst, cholesterol granuloma and mucocele can be removed by infracochlear, infralabyrinthine or trans-sphenoidal approaches. The main aim is to establish good drainage of the lesion into the middle ear or the nasal cavity without compromising the hearing. However, these lesions need to be operated on only if symptomatic. We prefer the transcanal approach between the cochlea, internal carotid artery and the jugular bulb.<sup>16</sup> This provides a direct route to the petrous apex and the lesion is effectively drained close to the eustachian tube. Possibility of vascular injury is remote in good hands and if occurs can be easily treated with surgical applied pressure to the injured area. Bleeding from the jugular bulb is adequately controlled by this, however, an injury to the internal carotid may need definite treatment of the internal carotid bleed.

Cholesteatomas and other solid lesions of the petrous bone are to be removed completely and the approach depends on various factors. Hearing and involvement of cranial nerves need to be assessed preoperatively. The commonly used approaches to large petrous apex lesions are the transcoclear and infratemporal fossa approaches.

The modified transcoclear A approach is used for extensive petrous apex lesions with inner ear and facial nerve compromise, like petrous bone cholesteatoma, extensive acoustic neuroma with petrous bone invasion, meningiomas of the petrous/petroclival areas, chordomas and chondrosarcomas. In this approach, the facial nerve needs to be rerouted posteriorly. This approach offers excellent



**Fig. 14A:** CT scan showing extensive destruction of the petrous apex on right side



**Fig. 14B:** MRI showing the lesion (chondrosarcoma) at the petrous apex, which requires a modified transcochlear B approach

control of both, extradural and intradural lesions of the petrous and petroclival areas. The postoperative facial nerve function in posterior rerouting is poorer as compared to anterior rerouting.<sup>17</sup>

In cases of petrous lesions encasing the internal carotid artery, modified transcochlear approach A can be combined with infratemporal fossa B or C approaches—this forms the modified transcochlear B approach (Figs 14A and B). Similarly, petroclival lesions with supratentorial extension can be approached via a modified transcochlear C approach where the tentorium is excised to convert the supratentorial and infratentorial compartments into a single compartment. Lesions of the middle or lower petroclival area extending towards the foramen magnum can be approached via a modified transcochlear D approach. Hence, knowledge of anatomy of the petrous bone helps in combining approaches to access the lesion widely.

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