34 Surgical Refinements to the Translabyrinthine Approach to the Cerebellopontine Angle

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34.1 Introduction

The translabyrinthine approach (TLA) is a lateral approach used for accessing various tumors of the cerebellopontine angle (CPA), most commonly vestibular schwannoma (VS). This approach was first described by Rudolf Panse in 1904 and was first performed for VS in 1911 by Franciscus Hubertus Quix from Utrecht University, the Netherlands. However, due to unsatisfactory results, this approach was criticized by Harvey Cushing and Walter Dandy, two of the pioneers of neurosurgery of that time, and thereafter this approach fell into disrepute.[1] After the advent of microscopes in otology, William House at the House Ear Institute in Los Angeles rediscovered the TLA, marking the beginning of the era of modern skull base microsurgery.[2,3,4,5] Subsequently, there was a developing opinion that while small tumors could be removed through the TLA, larger lesions were best approached through a suboccipital approach as the TLA failed to provide a large surgical field.[6] To overcome this limitation of the TLA, the proponents of this approach enlarged the surgical corridor by additional bone removal over the middle and posterior fossa dura and by the addition of the transapical extensions (where bone is drilled out to various degrees around the internal auditory canal [IAC]), thereby obtaining a wider surgical view and better control over the tumor and surrounding structures. This facilitated removal of even very large tumors with anterior and medial extensions.[1,7,8,9,10] Furthermore, this approach could be combined with other skull base approaches such as the transcochlear approaches described by William House[11] or transotic approaches described by Ugo Fisch[12,13] for additional exposure (Chapter 38).

Over the years, we have introduced some technical modifications to the TLA for very large tumors that have allowed us to reduce the mortality rate to < 1% with minimal morbidity.[14] Identifying the facial nerve by using the ampullary nerve as a landmark rather than the vertical crest (Bill's bar), lowering the high jugular bulb, and extending bone removal around and anterior to the IAC (transapical extension) were the major refinements added to the original technique.

The standard TLA approach is reviewed in detail in Chapter 33. This chapter will discuss the two significant modifications that have been developed at the Gruppo Otologico to the conventional TLA described by House. We refer to these modifications as the enlarged translabyrinthine approach (*ETLA*) and the *ETLA with transapical extension* (*ETLA + TAE*). Both of these approaches will be described and discussed separately. This chapter is based on the experience accumulated in the management of over 3,000 VSs using the TLA performed between 1986 and 2016 at the Gruppo Otologico.

34.2 The Enlarged Translabyrinthine Approach

34.2.1 Rationale

The limited view provided by the classic TLA prevented considering this valuable approach for the removal of large VS, more so in the presence of limiting anatomical obstacles such as a high jugular bulb, an anteriorly placed sigmoid sinus, low middle fossa dura, and a small mastoid cavity.[15]

The purpose of the ETLA approach is the same as with the conventional TLA—i.e., to obtain lateral access to the IAC and the CPA, thereby allowing removal of CPA lesions without cerebellar retraction. In the conventional TLA, a thin shelf of bone is sometimes left over the middle cranial fossa dura, the sigmoid sinus, and the jugular bulb. In the ETLA, bone is removed over these structures to completely expose the middle cranial fossa dura, the posterior fossa dura, sigmoid sinus, retrosigmoid dura, and the jugular bulb along with the contents of the IAC. This allows retraction of structures during surgery, thereby enabling exposure and hence removal of even very large VSs. The advantage in exposure obtained by the enlarged approach when compared to the conventional TLA is shown in ▶ Fig. 34.1. Another difference between the two approaches is that in the enlarged approach, the bone around the IAC is drilled by 270 degrees or more compared to 180 degrees in the conventional approach, providing the surgeon with additional anteromedial exposure (▶ Fig. 34.2).

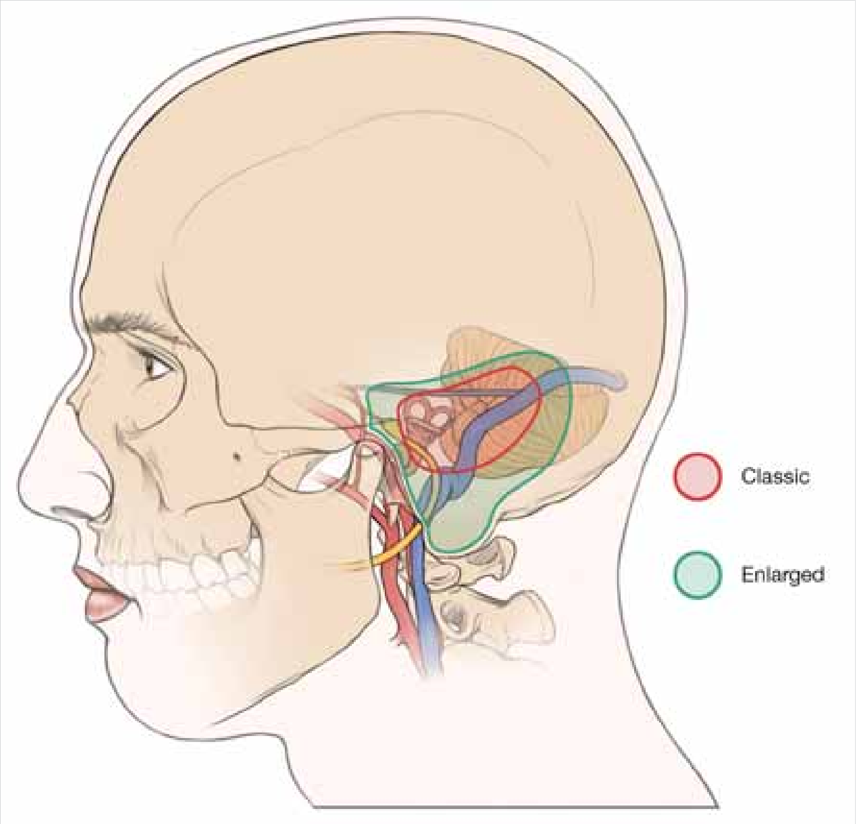

Fig. 34.1 Exposure of the CPA and the surrounding areas obtained by the ETLA is much larger than that obtained by the classic TLA.

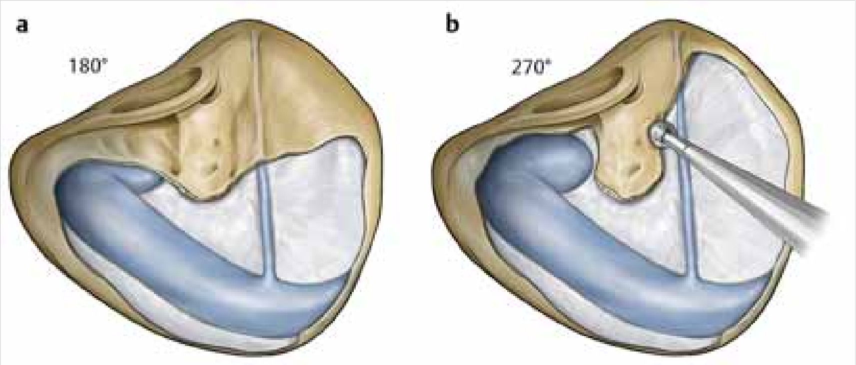

Fig. 34.2 Illustrations showing the difference between the conventional 180-degree exposure **(a)** and the 270-degree exposure **(b)** of the internal auditory canal.

34.2.2 Indications:

- *Tumors of any size with poor preoperative hearing*: This approach is indicated for tumors wherein hearing preservation is not essential due to nonserviceable preoperative hearing. With the wide exposure that this approach provides, the surgeon can focus on disease removal.
- *Large tumors irrespective of preoperative hearing*: While opinions regarding this vary, we feel that the ETLA is indicated in VSs greater than 1.5 cm in diameter in the extracanalicular portion, regardless of the preoperative hearing, since the probability of hearing preservation with gross total resection is low. Very large tumors, even those larger than 4 cm in diameter, can be safely removed by the ETLA.
- *Neurofibromatosis type 2 (NF2) with large tumors*: NF2 commonly presents with bilateral VSs, making hearing preservation or rehabilitation very important. While hearing can be preserved in small tumors by opting for hearing preservation surgeries such as the retrosigmoid or the middle cranial fossa approaches, it is difficult to ensure this in larger tumors.[16] In such a scenario, the ETLA may be used, wherein large tumors can be removed and preservation of the cochlear nerve can be attempted for simultaneous cochlear implantation (CI). Likewise, when it is not possible to preserve the cochlear nerve, an auditory brainstem implant (ABI) can be placed in the same sitting, by this approach.[17]

34.2.3 Contraindications:

- *Only hearing ear*: This procedure is contraindicated in the only hearing ear. However, this has become a relative contraindication currently due to the option of simultaneous ipsilateral CI or ABI, as mentioned above, or a contralateral CI.[18]

- *Ipsilateral chronic otitis media*: This procedure is contraindicated in the presence of active infection. However, the approach can be used in cases of simple tympanic membrane perforation with no active infection, while the external auditory canal is closed as a cul-de-sac. If there is an active infection, a subtotal petrosectomy is performed, with eradication of the infection, obliteration of the cavity with abdominal fat, and closure of the external auditory canal as a cul-de-sac. The ETLA is then performed as a second-stage surgery.

34.2.4 Surgical Technique

Mastoidectomy (Left Ear)

A **C**-shaped postauricular skin incision is placed starting from 2 to 3 cm superior to the attachment of auricle, at the level of the dome of the helix, continuing 4 to 5 cm posterior to the retroauricular sulcus, and ending just below the mastoid tip (▶ Fig. 34.3). The skin flap is reflected anteriorly and maintained in position with fish hooks. The musculoperiosteal layer is incised in a **T**-shaped fashion using cautery (▶ Fig. 34.4) and is elevated. Monopolar cautery is applied to transect the muscles attached to the mastoid tip that helps to raise the flap. Bleeding from the mastoid emissary vein usually occurs at this step and it can be controlled by the use of bone wax. The posterior margins of the musculoperiosteal flaps are sutured to the skin, which helps in achieving hemostasis from the skin incision and at the same time keeps the flaps retracted (▶ Fig. 34.5). We do not recommend the use of the conventional retractors, which limit access and exposure.

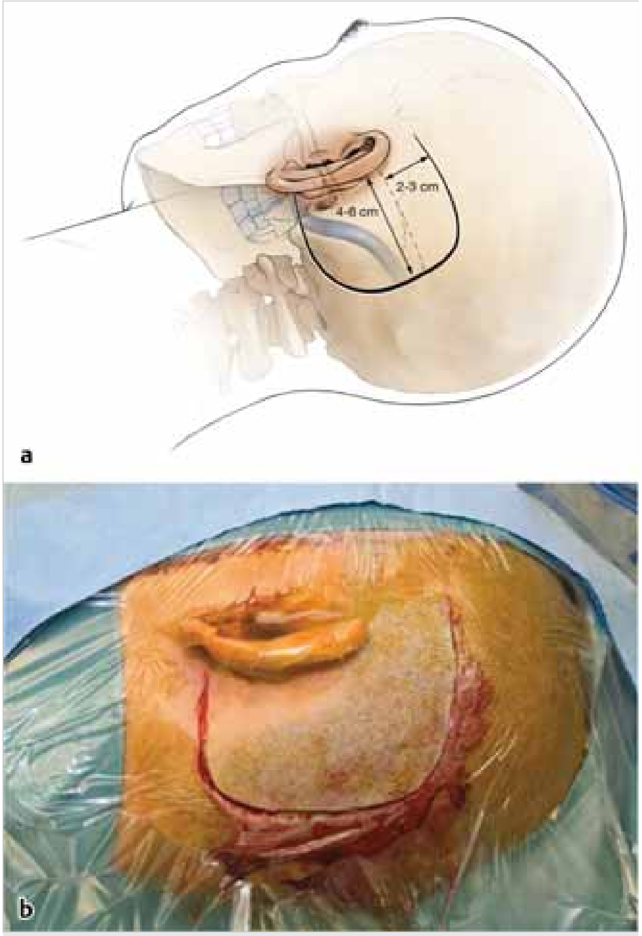

Fig. 34.3 Right postauricular skin incision for the ETLA.

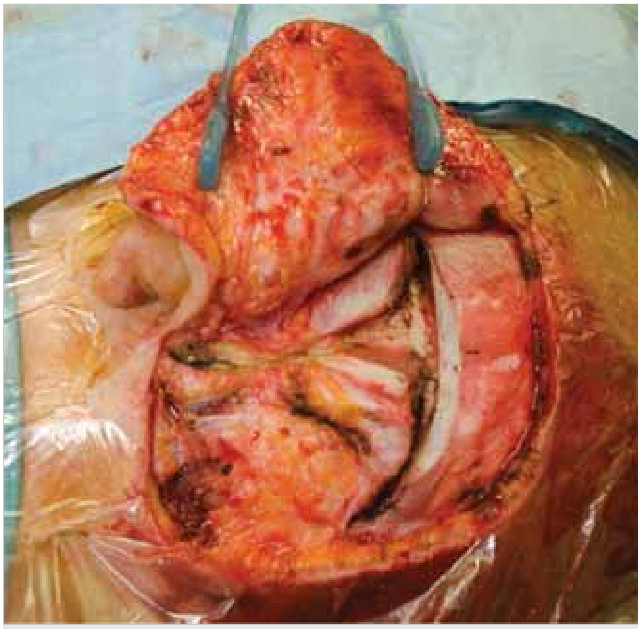

Fig. 34.4 The musculoperiosteal flap is incised using a monopolar diathermy in a "T" fashion. The vertical incision extends up to the mastoid tip.

Fig. 34.5 The musculoperiosteal flaps are held by sutures.

An extended mastoidectomy is then performed. The middle cranial fossa dura and the sigmoid sinus are identified, leaving a thin shell of bone overlying them. Bone 2 to 3 cm posterior to the sigmoid sinus is also drilled using a large cutting burr (▶ Fig. 34.6). The mastoid air cells are exenterated, and the antrum is widely opened. The digastric ridge is identified, the facial nerve is skeletonized, and the retrofacial air cells are drilled out. Using a large diamond burr, the remaining bone covering the middle cranial fossa and the sigmoid sinus as well as the posterior fossa dura posterior to the sinus is further drilled and removed. The sinodural angle must be clearly exposed to know the exact location of the superior petrosal sinus exiting the sigmoid sinus. The sigmoid sinus is followed down to the jugular bulb, and the three semicircular canals are delineated.

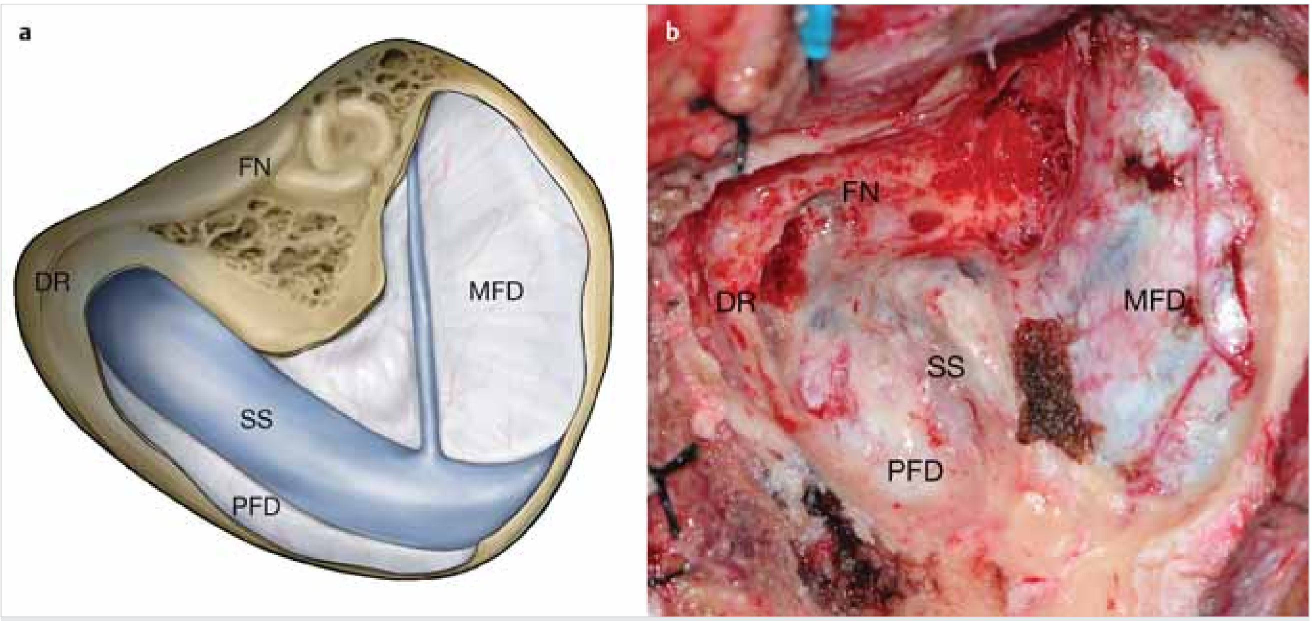

Fig. 34.6 **(a)** Extensive removal of bone over the middle cranial fossa as well as posterior to the sigmoid sinus (SS) is essential in the ETLA. **(b)** Mastoid air cells are well exenterated to demonstrate the labyrinth (L) and the mastoid segment of the facial nerve (FN). An adequate bone exposure will extend to about 3 cm posterior to the sigmoid sinus. DR, digastric ridge; MFD, middle fossa dura; PFD, posterior fossa dura.

Labyrinthectomy, access to the IAC and the CPA. The labyrinthectomy starts by opening the lateral semicircular canal using a medium-sized cutting burr. The posterior semicircular canal is next opened, followed by opening of the superior semicircular canal (▶ Fig. 34.7). The anterior end of the lateral semicircular canal is left in situ to protect the facial nerve lying anteriorly. The last part of bone over the middle cranial fossa dura adjacent to the labyrinth is finally removed using a rongeur after separating the bone from the dura by the use of a freer dissector. The ampullae of the lateral and superior semicircular canals are drilled. However, the anterior part of the ampullae of these two canals should be left to protect the labyrinthine segment of the facial nerve and to serve as a landmark for the superior vestibular nerve.

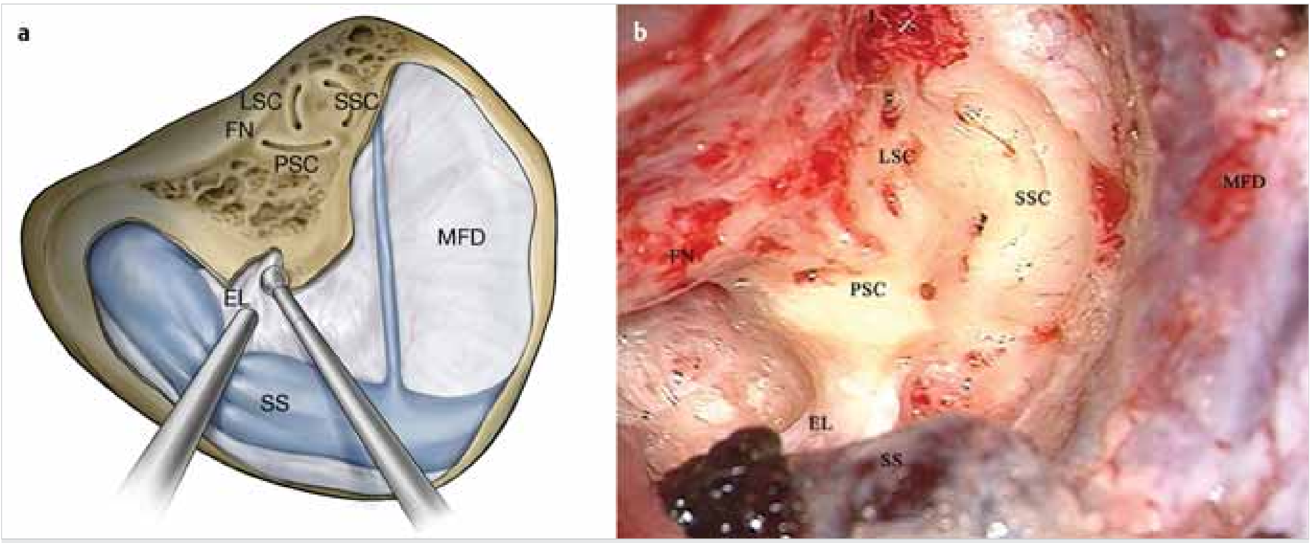

Fig. 34.7 **(a)** Note the suction-irrigator is pushing the sigmoid sinus away from the working burr. **(b)** The three semicircular canals have been opened. Note the endolymphatic duct (EL) extending from the medial surface of the posterior canal (PSC) to the posterior fossa dura (PFD). FN, facial nerve; LSC, lateral semicircular canal; MFD, middle fossa dura; SS, sigmoid sinus; SSC, superior semicircular canal.

The vestibule is then opened widely. It is important to avoid drilling the floor of the vestibule in order to avoid inadvertent entry into the IAC. Similarly, drilling the roof of the vestibule may result in injury to the facial nerve, as the nerve runs immediately lateral to the vestibule. The endolymphatic duct is transacted by the use of Beaver knife (▶ Fig. 34.8). This step facilitates the complete drilling of bone overlying the posterior fossa dura and the subsequent dural retraction. The bone left over the posterior and middle fossa is successively drilled out. During this step, the cochlear aqueduct can be identified. This is an important landmark for the glossopharyngeal nerve, which lies immediately inferior to it. In small or medium-sized VSs, opening the cochlear aqueduct allows the cerebrospinal fluid (CSF) to drain. This does not occur in large tumors, because the duct is occluded by the tumor. After a wide exposure of the dura is accomplished, following the posterior fossa dura allows the porus of the IAC to be identified. The ampulla of the superior semicircular canal serves as a landmark for the superior border of the IAC at the fundus. The inferior border of the canal is identified by drilling the retrofacial air cells up to the cochlear aqueduct. Further cautious drilling at the level of the fundus leads to the identification of the horizontal crest as well as the superior ampullary canal. Bone between the superior border of the IAC and the middle fossa dura and between the inferior border of the IAC and the jugular bulb can be further drilled, depending on the size of the tumor. We routinely drill the bone 270 degrees around the IAC (▶ Fig. 34.2).

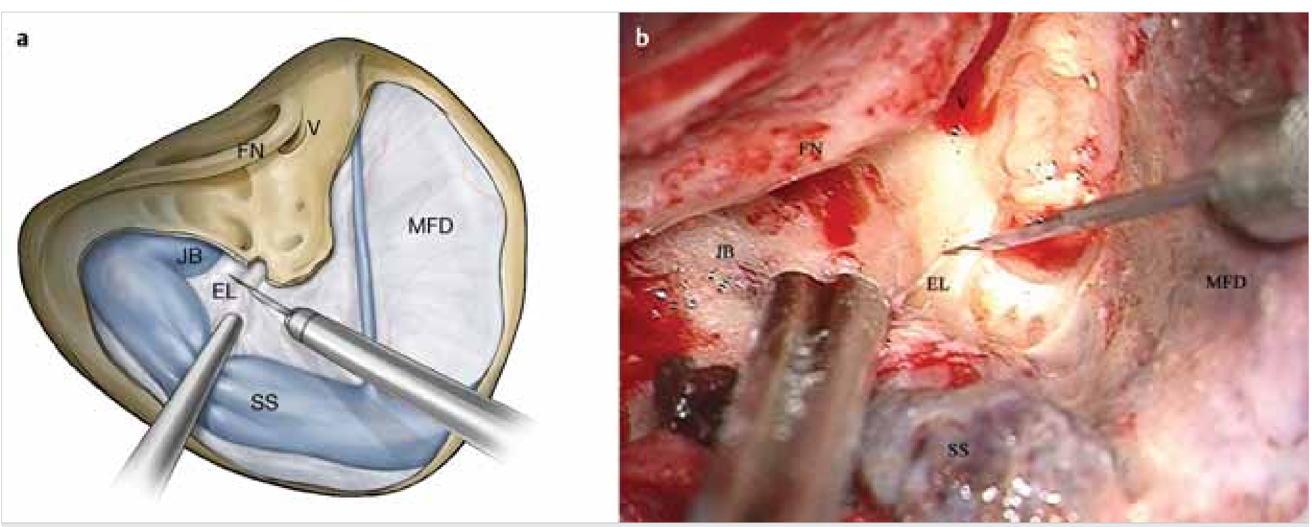

Fig. 34.8 A Beaver knife is used to cut sharply the endolymphatic duct (EL) to allow dural retraction. The semicircular canals have been drilled out and the vestibule (Ve) can be seen. FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; SS, sigmoid sinus.

Identification of the Facial Nerve at the Fundus

The original technique described by House for identifying the facial nerve at the fundus depends on the identification of the vertical crest (Bill's bar). However, we have modified this technique. By drilling inferiorly at the fundus, the inferior vestibular nerve is exposed, while in a more superior plane the horizontal crest is identified, which separates the inferior vestibular nerve from the superior vestibular nerve. The superior vestibular nerve is followed laterally where it leaves the fundus of the IAC. The nerve then lies in a tiny canal that enters the ampulla of the superior semicircular canal as the superior ampullary nerve (▶ Fig. 34.9). The superior ampullary nerve is dissected from its canal using a 90 degrees hook with the tip facing inferiorly (▶ Fig. 34.10a). The superior ampullary nerve is separated from the facial nerve by a vertical crest of bone, called Bill's bar, which protects the facial nerve while this step is being carried out. The hook is moved medially toward the fundus, with subsequent separation and establishment of a good plane of cleavage between the superior vestibular nerve and the anteriorly lying facial nerve. Once the superior ampullary nerve is detached and reflected medially and posteriorly, the facial nerve can be clearly observed (▶ Fig. 34.10b). The relationship between the facial and cochlear nerves and the horizontal and vertical crests is well appreciated. Careful dissection of the superior vestibular nerve continues medially. Often, here, one may encounter adhesive bands between the superior vestibular nerve and the facial nerve (▶ Fig. 34.11), which may bleed on manipulation, thus obscuring the plane of dissection. To control this, a piece of dry Gelfoam is placed on the facial nerve, which also helps to protect the nerve during further dissection. Our technique of identification of the facial nerve by identification of the superior ampullary nerve and the horizontal crest rather than the vertical crest ensures proper identification and hence greater protection to the facial nerve.

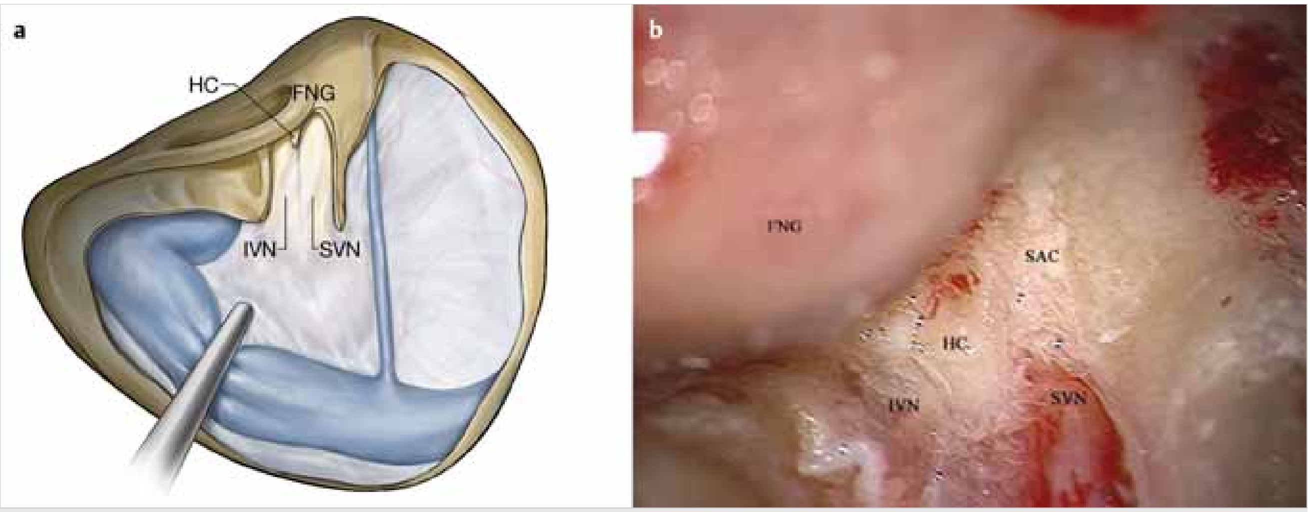

Fig. 34.9 The superior vestibular nerve (SVN) has been followed laterally into the superior ampullary nerve canal (SAC), where the superior ampullary nerve enters the lateral canal ampulla. FNG, facial nerve genu; HC, horizontal crest; I, incus; IVN, inferior vestibular nerve; LCA, ampulla of the lateral semicircular canal; SCA, ampulla of the superior semicircular canal.

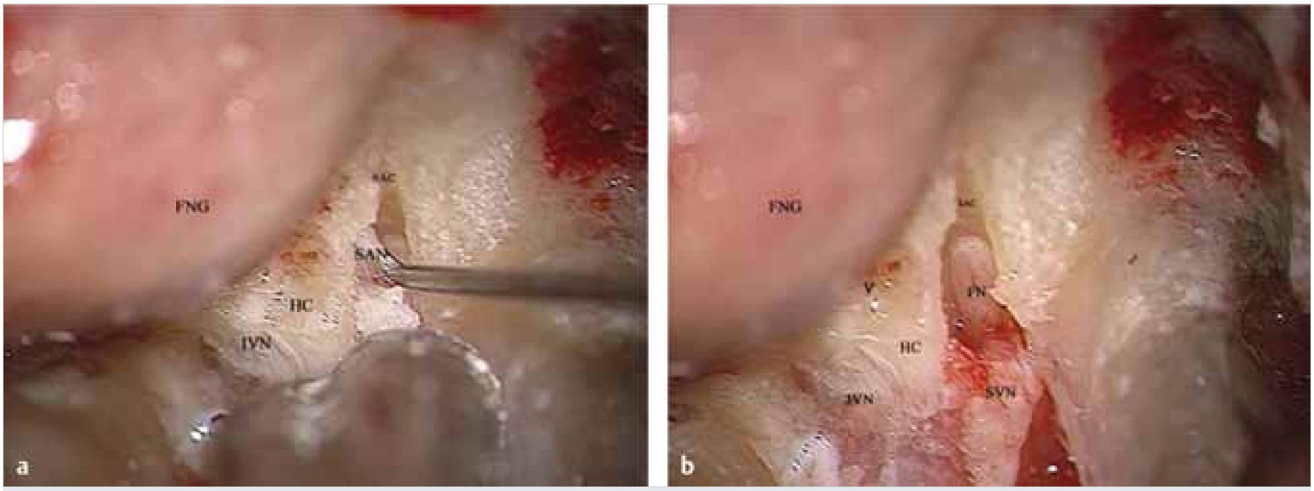

Fig. 34.10 **(a)** A small hook is used carefully to dislodge the superior ampullary nerve (SAN) from the superior ampullary canal (SAC). **(b)** After reflecting the superior vestibular nerve (SVN), the facial nerve (FN) can be seen anteriorly. FNG, facial nerve genu; HC, horizontal crest; I, incus; IVN, inferior vestibular nerve; LCA, ampulla of the lateral semicircular canal; SCA, ampulla of the superior semicircular canal; SVN, superior vestibular nerve; V, vestibule; VC, vertical crest (Bill's bar).

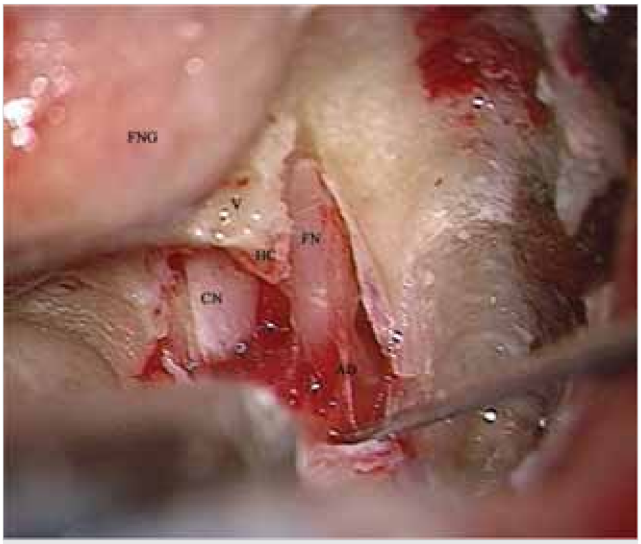

Fig. 34.11 While the dissection of the vestibular nerves is further progressed medially, adhesions (AD) between the facial nerve (FN) and the vestibular nerves start to be encountered. CN, cochlear nerve; FNG, facial nerve genu; HC, horizontal crest; I, incus; IVN, inferior vestibular nerve; LCA, ampulla of the lateral semicircular canal; SAN, superior ampullary nerve; SCA, ampulla of the superior semicircular canal; SVN, superior vestibular nerve; V, vestibule; VC, vertical crest (Bill's bar).

Opening the Dura

Before opening the dura of the posterior fossa, the lines of incision are coagulated with a bipolar cautery. Careful coagulation over the dural surface leads to its retraction, thus providing wider access. In ▶ Fig. 34.12, the dotted red line represents the dural incision. Using the neurosurgical scissors, a small snip is made just anterior to the sigmoid sinus and immediately inferior to its junction with the superior petrosal sinus and the dura is opened. Once sufficient opening of the dura has been achieved, Merocel is inserted and slipped further in to protect the underlying structures while the dural incision is being completed. The superior dural incision runs parallel and just inferior to the superior petrosal sinus up to the limit of bony drilling. The inferior incision starts just in front of the distal part of the sigmoid sinus, and follows the sinus and jugular bulb course to the porus, where it joins the superior incision.

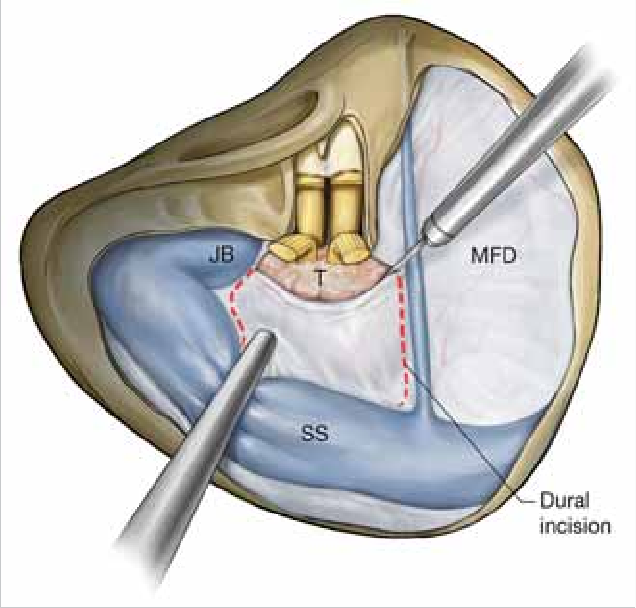

Fig. 34.12 Bipolar coagulation of the posterior fossa dura is done before incision of the dura. The dashed lines indicate the outlines of the dural incision. D, dura; JB, jugular bulb; PFD, posterior fossa dura; SS, sigmoid sinus.

Bloodless Techniques for Tumor Removal

After the dura has been opened, the tumor in the CPA can be visualized, and the arachnoid of the lateral cistern is identified and opened. This allows CSF to drain out, leading to relaxation of cerebellum, which results in an increased working space. In the case of a large tumor, it is difficult to achieve this due to compression of the cistern by the tumor (▶ Fig. 34.13). In large tumors, they may be debulked at the center to reduce their size. Intracapsular debulking is performed by using microscissors and bipolar coagulation. It is extremely important to find the plane of cleavage that lies between the arachnoid adherent to the tumor capsule and the arachnoid surrounding the other structures in the CPA. Once this plane of cleavage has been obtained, Gelfoam is placed on this plane to prevent blood from entering the CPA (▶ Fig. 34.14). The outer surface of the tumor is coagulated using a bipolar. Using this maneuver in all the directions, the tumor retracts and comes separated from the surrounding structures.

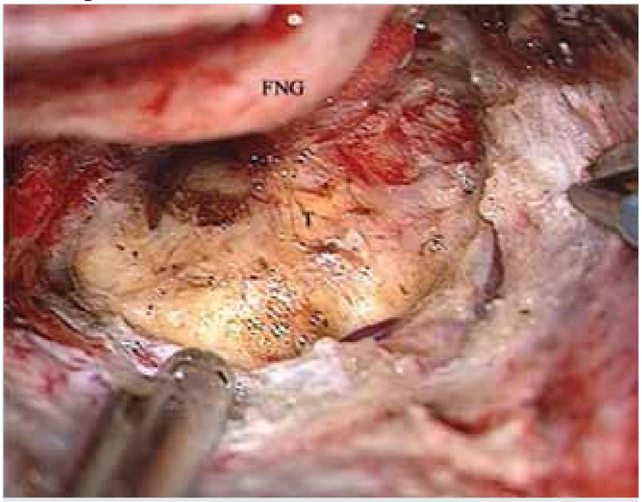

Fig. 34.13 After opening in the dura, the tumor (T) can be seen filling the cerebellopontine angle. FNG, facial nerve genu.

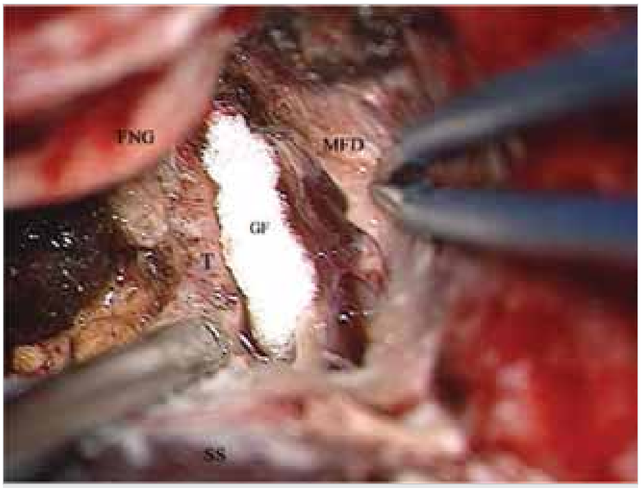

Fig. 34.14 After coagulating the arachnoid at the superior surface of the tumor (T), a plane of cleavage is looked for. A large piece of Gelfoam (GF) is used to fill the gap around the tumor (T) to prevent blood from filling the CPA. FNG, facial nerve genu; MFD, middle fossa dura; SS, sigmoid sinus.

The superior surface of the tumor is dissected (▶ Fig. 34.15). The trigeminal nerve is frequently found adherent to the tumor. The tumor surface is repeatedly coagulated and incised, thereby reducing the size of the tumor. The posterior aspect is further dissected and the interface between the tumor and the brainstem can be perceived. Tumor is then dissected from the facial nerve. Since the plane of cleavage between the tumor and the facial nerve has already been established at the fundus of the IAC, dissection proceeds in a lateral to medial direction. Localization of the facial nerve at the porus is achieved by following it from the fundus (▶ Fig. 34.16). Care should be taken not to force any traction on the facial nerve while carrying out the dissection. At the level of the porus, the facial nerve is usually adherent to the tumor and frequently becomes thin and splayed, thereby becoming vulnerable. Very gentle manipulation is necessary in this step (▶ Fig. 34.17). The facial nerve at the level of the brainstem is then identified and the last part of the tumor is carefully dissected from the facial nerve and the brainstem. It is important to neither coagulate nor apply traction to these important structures (▶ Fig. 34.18). The integrity of the facial nerve is determined using the facial nerve stimulator at the root exit zone. The anesthetist raises the blood pressure, and a Valsalva maneuver is performed to evaluate for bleeding points. Meticulous hemostasis is achieved.

Fig. 34.15 The outer surface of the tumor is coagulated from all directions to achieve adequate tumor retraction from surrounding tissues. FNG, facial nerve genu; MFD, middle fossa dura; SS, sigmoid sinus; T, tumor; Tent, tentorium.

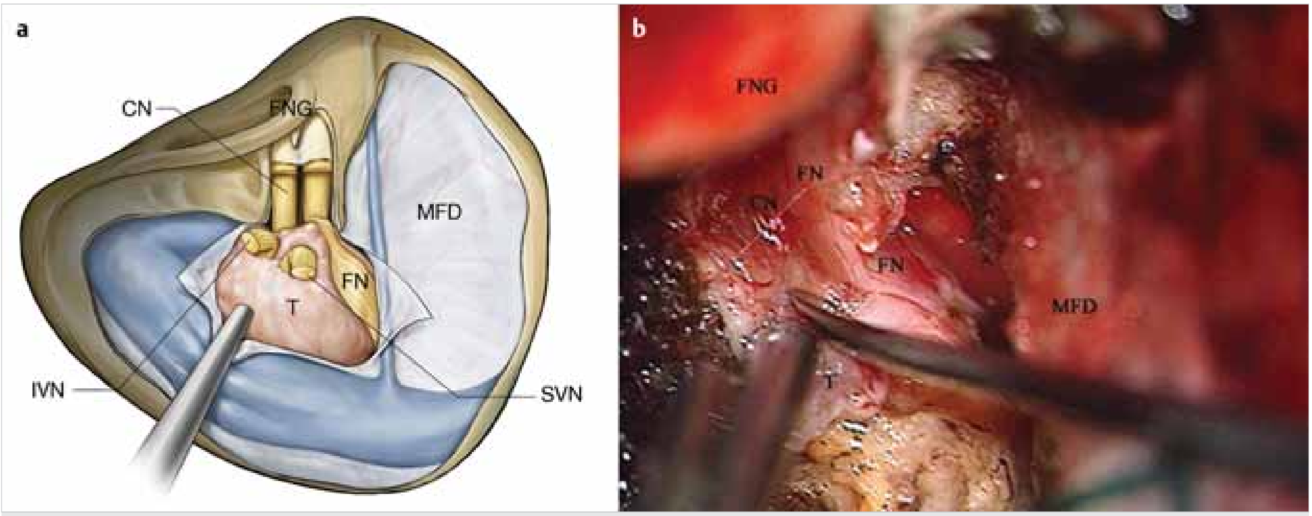

Fig. 34.16 The facial nerve (FN) can be followed from within the internal auditory canal, and it can be seen angulating anteriorly over the porus and lying adherent to the anterior surface of the tumor (T). The identification in this area where the nerve is usually adherent to the surrounding structures can be achieved with the help of transapical extension. CN, cochlear nerve; FNG, facial nerve genu; MFD, middle fossa dura; SS, sigmoid sinus; V, trigeminal nerve; VNs, superior and inferior vestibular nerves.

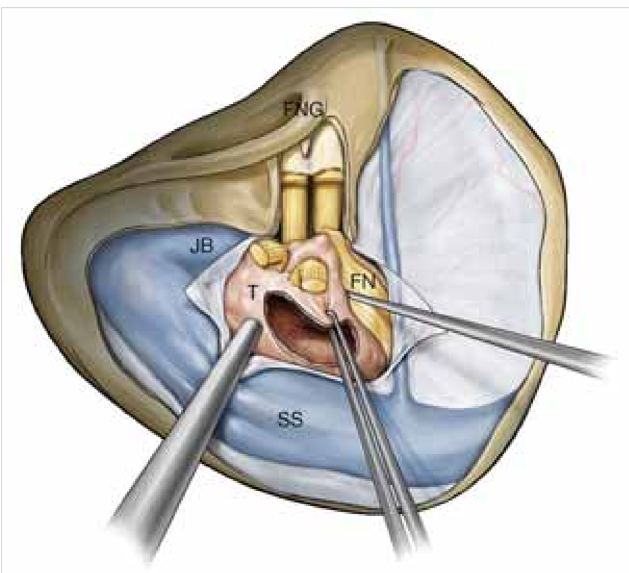

Fig. 34.17 After reducing the core and the walls of the tumor, dissection of the facial nerve is continued. Very delicate maneuvers are made in this area. FNG, facial nerve genu; MFD, middle fossa dura; SS, sigmoid sinus; T, tumor.

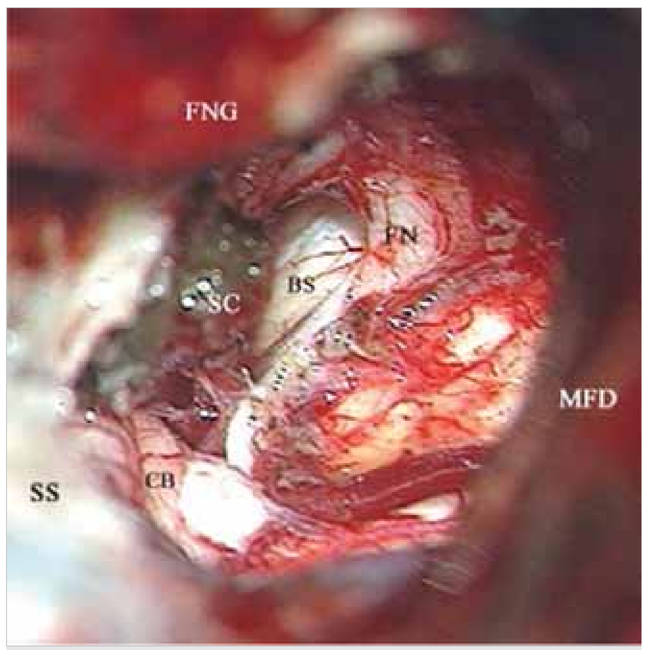

Fig. 34.18 CPA after total tumor removal. Note the integrity of the facial nerve (FN) together with its vasculature. BS, brainstem; CB, cerebellum; FNG, facial nerve genu; MFD, middle fossa dura; SC, Surgicel; SS, sigmoid sinus.

Closure

All the air cells, especially the retrofacial cells, should be observed to see if they have communication with the tympanic cavity. If so, these cells are obliterated with bone wax to avoid CSF leak postoperatively. After the incus is disarticulated and removed, the aditus is obliterated with periosteum. Abdominal fat which has been harvested is sliced into several long, thin strips, and these strips are placed inside the CPA. The musculo-periosteal layer is closed using 1–0 Vicryl (▶ Fig. 34.19). This is followed by closure of the subcutaneous tissue and skin. A pressure dressing is applied. Using this approach, our group has experienced less than a 1% rate of postoperative CSF leak.

Fig. 34.19 **(a)** In a pneumatized temporal bone, cells superiorly and inferiorly to the internal auditory canal are obliterated with bone wax. BW, bone wax; FN, facial nerve; IAC, internal auditory canal; JB, jugular bulb; SS, sigmoid sinus. **(b)** Abdominal fat is used to close the CPA and the bony defect. **(c)** The musculoperiosteal layer is approximated using 1–0 Vicryl. After the musculoperiosteal layer is closed tightly, the skin flap is replaced and sutured.

In our experience with the ETLA, tumors of very large sizes in the CPA can be safely removed. Wide removal of bone from the middle fossa dura, as well as extensive drilling of bone between it and the IAC, provides excellent control of the upper pole of the tumor and the trigeminal nerve area. Uncovering the sigmoid sinus and bone 2 to 3 cm posterior to it, and extensive bone removal creating a deep trough inferior to the IAC, obviates the need for a suboccipital or transotic approach, and provides good control of the anterior pole of the tumor up to the lateral aspect of the prepontine cistern. In addition, extensive removal of bone between the IAC and the jugular bulb allows good visualization of the lower tumor pole. Tumors up to 6 cm in extrameatal diameter have been safely removed using this approach (▶ Fig. 34.20).

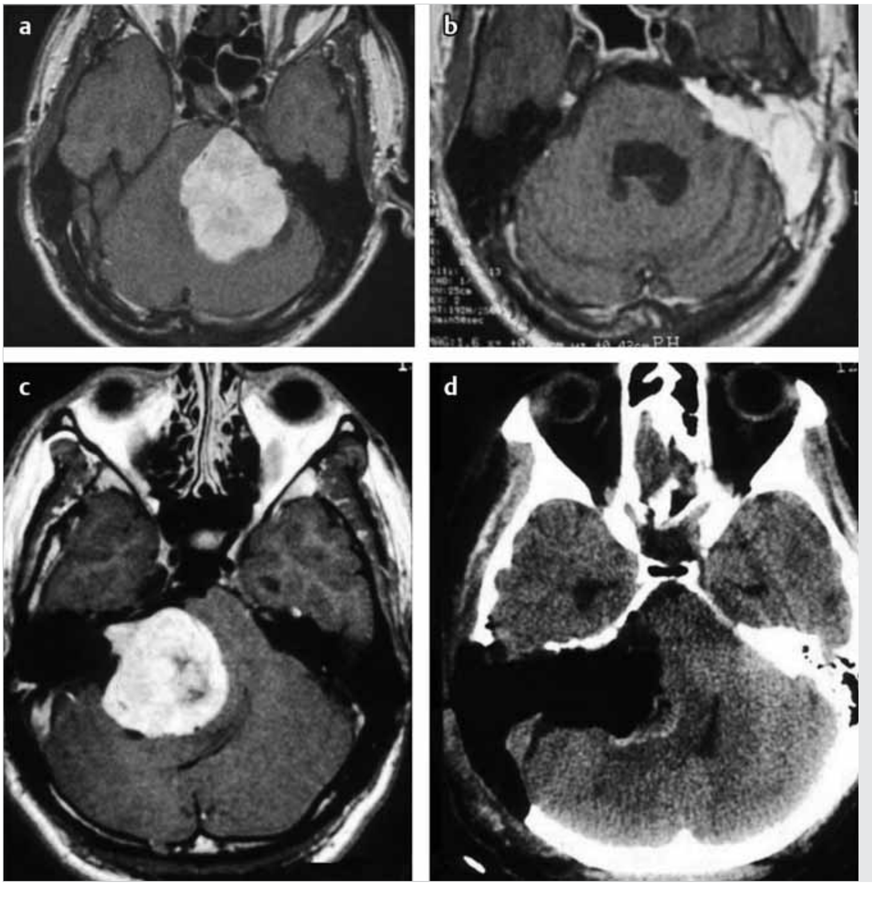

Fig. 34.20 Preoperative **(a)** and 1-week postoperative **(b)** MRI scan of a large tumor which was removed totally with the ETLA. Preoperative **(c)** and 1-year postoperative **(d)** scans of another patient with a similarly large tumor excised using a similar approach. Note that fat is inserted up to the petrous apex.

34.2.5 Pearls

- Completely uncovering the middle fossa dura, posterior fossa dura, sigmoid sinus, and the retrosigmoid area is the most important aspect of the ETLA. Uncovering the above-mentioned structures allows retraction and hence better visualization of all aspects of the tumor.
- The facial nerve lies immediately lateral to the vestibule. Utmost care should be taken not to injure the nerve during drilling to open the vestibule.
- The IAC should be uncovered over 270 to 310 degrees in the ETLA, creating two troughs—inferior and superior to the IAC. Sufficient removal of bone superior to the IAC is essential in order to control the area of the trigeminal nerve. Failure to do so leads to incomplete control of the superior pole of the tumor and of Dandy's vein.
- The fundus of the IAC is approached by first identifying the inferior vestibular nerve and the horizontal crest instead of the vertical crest (Bill's bar) as in the conventional TLA (▶ Fig. 34.21). Then, the superior vestibular nerve is identified and the drilling is continued laterally until the ampullary nerve is identified. Once the ampullary nerve is identified at the level of the fundus, it is dissected out and the vertical crest (Bill's bar) is identified medial to it. The facial nerve is then identified medial to the Bill's bar.
- Facial nerve monitoring is helpful during tumor dissection. A train response given by the monitor indicates possible trauma to the facial nerve.
- It is important to maintain a bloodless surgical field in order to clearly visualize all vital anatomy at all times. This is ensured by dissecting the cleavage plane between the tumor surface and the arachnoid and by bipolar coagulation of the veins and small arteries on the tumor surface. Once a plane is identified, Merocel is inserted between the tumor and the arachnoid. Dissection proceeds with bipolar dissection of the tumor.
- During closure, long strips of abdominal fat are used to obliterate the CPA along with the bony defect. This is more effective in preventing CSF leakage than using the fat to obliterate the bone defect alone.
- Tumors up to 6 cm in extrameatal diameter can be safely removed using this approach.

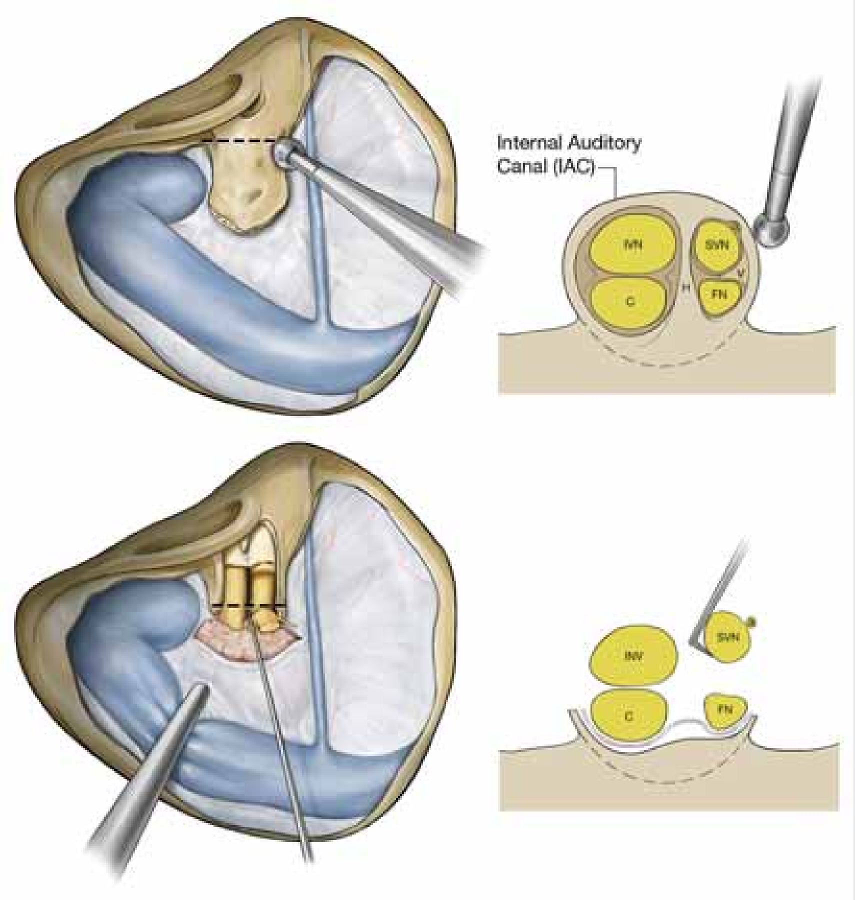

Fig. 34.21 **(a)** In our technique, we first identify the superior ampullary nerve (a) and then look for the facial nerve (FN) after dissecting out along the superior vestibular nerve (Vs). **(b)** In the conventional technique described by House, the vertical crest (Bill's bar) is identified by drilling behind the superior vestibular nerve (Vs).

34.2.6 Pitfalls

- The use of self-retaining retractors for the skin and subcutaneous tissue is not recommended. Retractors impede surgical access, leading to narrow working angle and deeper surgical field.
- Central debulking is important in dealing with a big tumor. Care should be taken while debulking soft or cystic tumors, so as not to penetrate the anterior or medial walls of the tumor capsule and injure the adjacent structures, particularly the facial nerve and the brainstem.
- In small tumors, the anterior inferior cerebellar artery (AICA) can be found looping around the tumor. It can also commonly

traverse between the facial nerve and the vestibulocochlear nerves.

- Toward the end of surgery, care should be taken while removing the incus to avoid fracturing the footplate, since this can create a communication between the CPA and the middle ear, with subsequent postoperative CSF leakage. We prefer periosteum to fat for the closure of the attic because it is easier to manipulate and provides a better, longer lasting seal.

34.3 Enlarged TLA with Transapical Extension

34.3.1 Rationale

The enlarged TLA with transapical extension (ETLA+TAE) approach is an anteromedial extension of the ETLA, in which the IAC is drilled up to 320 degrees (type I) or 360 degrees (type II) of its circumference of the IAC (▶ Fig. 34.22). This extension helps expose the anterior, superior, and medial aspects of large tumors of the CPA.

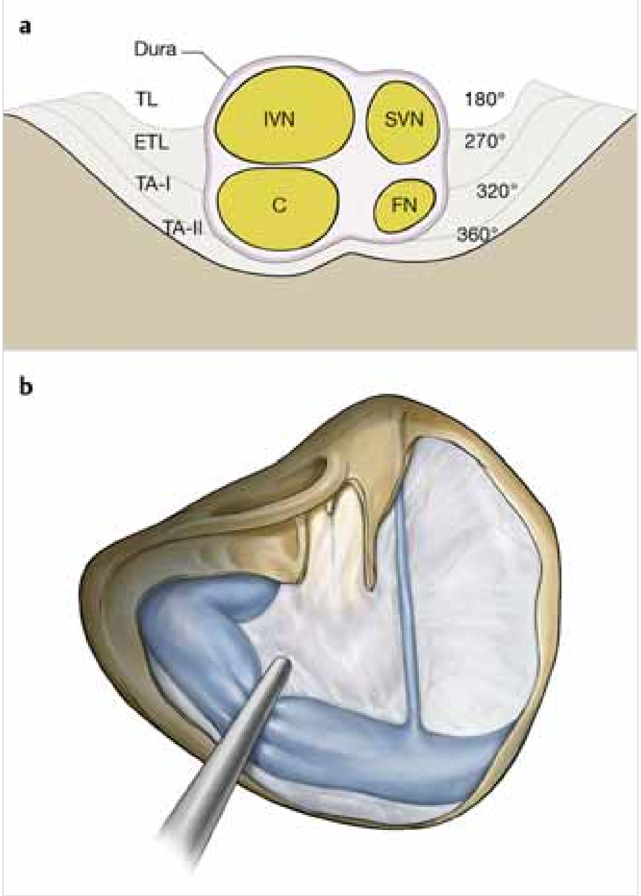

Fig. 34.22 **(a)** Amount of bone removal around the internal auditory canal in the different variations of the TLA. **(b)** The dashed line demonstrates the working area for extended bone removal. Note the fifth and sixth cranial nerves can be exposed and managed effectively. AICA, anterior inferior cerebellar artery; BA, basilar artery; V, trigeminal nerve; VI, abducens nerve.

34.3.2 Indications

This approach is indicated for large CPA tumors or tumors with marked anterior extension, wherein hearing preservation is not intended. This includes large or giant VSs with anterior extension into the prepontine cistern and large meningioma of the posterior surface of the temporal bone centered on the IAC with significant anterior extension. It is also indicated in smaller tumors when marked anterior extension is present.

34.3.3 Limitations

Though this approach provides access to the prepontine cistern, it is difficult to remove tumors involving the petroclival region, such as meningiomas, wherein the modified transcochlear approach is more suitable.

34.3.4 Surgical Technique

The ETLA is performed as previously described. The IAC is identified and uncovered and bone is drilled out for 270 degrees around the canal, as previously described. Further drilling is carried superior and inferior to the IAC toward the petrous apex as required (▶ Fig. 34.23a). In the type I approach, up to 320-degree exposure around the IAC is achieved (▶ Fig. 34.23b) leaving behind a thin segment of bone anteriorly. In the type II approach, 360 degrees of the IAC circumference is exposed (▶ Fig. 34.23c). The contents of the IAC are pushed inferiorly to allow for drilling of the anterior wall of the canal (▶ Fig. 34.24). Care should be taken to avoid injury to the superior petrosal sinus. The dura is opened as previously described.

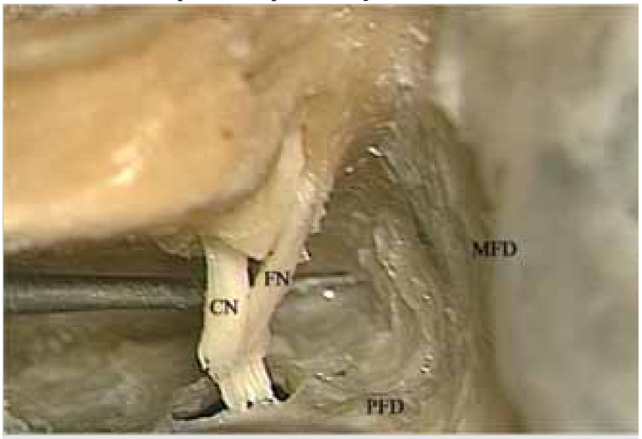

Fig. 34.23 Extended TLA **(a)** with TAE type I **(b)** and type II **(c)**. AW, anterior wall; BB, Bill's bar; CN, cochlear nerve; FN, facial nerve; HC, horizontal crest; IAC, internal auditory canal; MFD, middle fossa dura; PFD, posterior fossa dura.

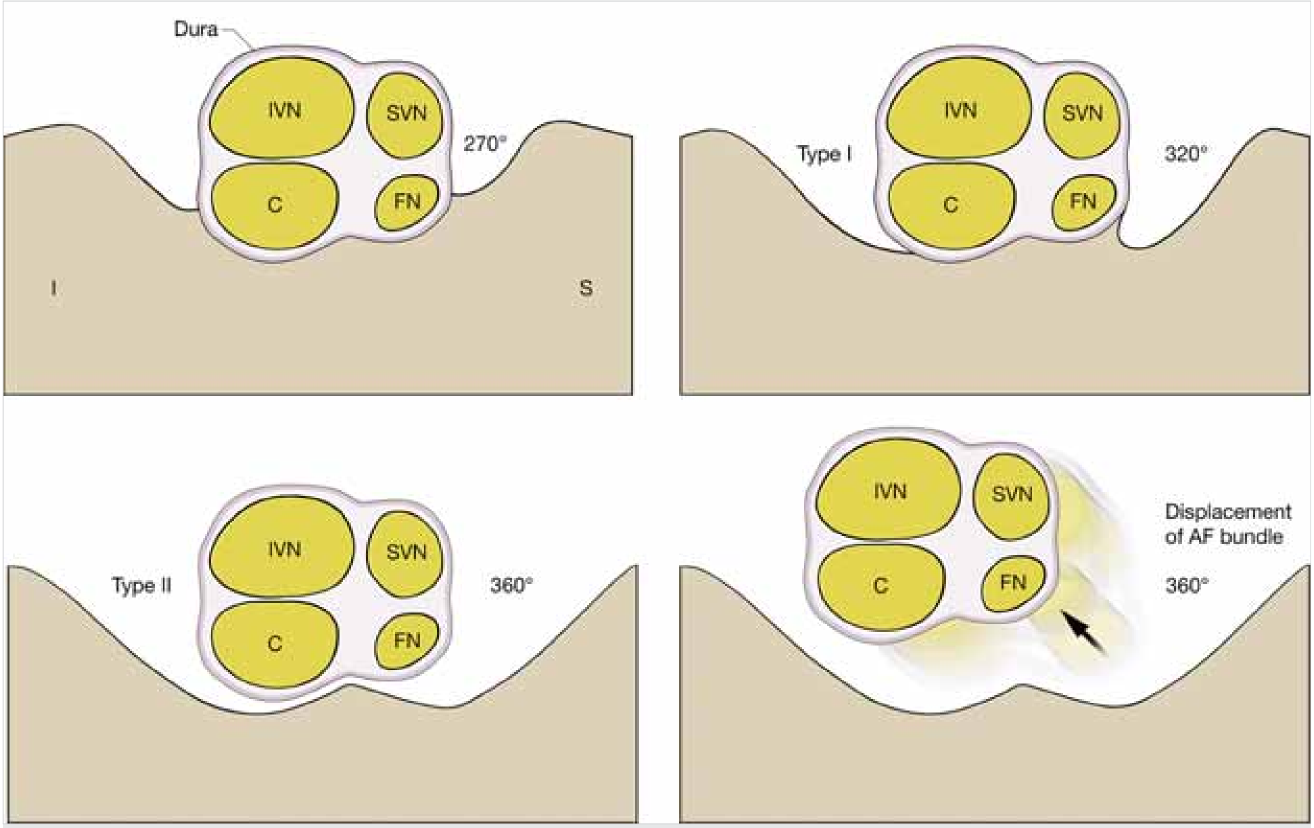

Fig. 34.24 Cross-sectional images of the internal auditory canal as seen in the ETLA exposure (270 degrees), type I (300–320 degrees), and type II TAE (360 degrees). The contents of the internal auditory canal can be moved inferiorly. I, inferior; S, superior.

34.3.5 Pearls

- In the case of tumors extending far anteromedially, the facial nerve is markedly displaced anteriorly. The transapical extension provides enhanced visualization of the nerve.
- In the case of giant tumors causing high intracranial pressure, the dura usually bulges, hindering access. In such cases, the tumor is first debulked from inside and after this the dura is opened to allow drainage of the CSF, which leads to drop in pressure and retraction of intracranial contents.
- After introducing this approach, we have abandoned the transotic approach for removal of anteriorly located tumors limiting its use only in the case of tumors with cochlear invasion, vertical internal carotid artery involvement, or in case with very high jugular bulb and/or very advanced sigmoid sinus.

34.3.6 Pitfalls

- The facial nerve is at risk while performing the transapical drilling. Hence, a diamond burr must be used and extreme care must be taken to avoid injuring the nerve. A useful trick is to place the suction-irrigator between the drill and the nerve to afford protection.
- Care must be taken to avoid injuring the superior petrosal sinus while drilling the petrous apex superior to the IAC.

34.3.7 Difficult Situations and Special Considerations in the ETLA

Despite this being a safe surgery, one can nevertheless encounter difficult situations and complications. These problems may arise either during the approach or during removal of tumor and may be due to anatomical variants, mishaps during surgery, or tumor characteristics.

High Jugular Bulb

A high jugular bulb is encountered in about 25% of cases (▶ Fig. 34.25). This may obstruct the view of the area around the lower cranial nerves. In such cases, the following steps may be followed. After the dome of the jugular bulb is completely exposed (▶ Fig. 34.26), it is gently dissected along with the periosteal layer from its wall, taking care to avoid injury to the thin bulb wall (▶ Fig. 34.27). Then the dome of the jugular bulb is pressed downward using a large piece of Surgicel and tucked in place between the bulb and the surrounding bone. Surgicel helps to control the minor bleeding that may occur during this step. A piece of bone wax is then placed over the Surgicel to keep the bulb in place and prevent entanglement of Surgicel with the burr during further drilling (▶ Fig. 34.28). By adequate inferior displacement of the jugular bulb, drilling can be safely carried out and additional surrounding bone can be removed to achieve additional exposure.

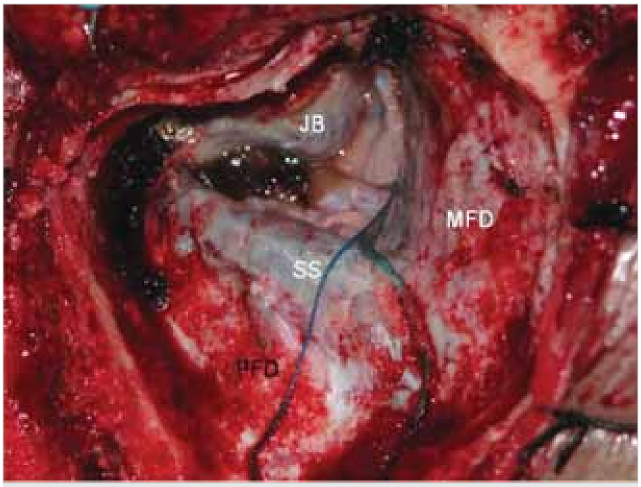

Fig. 34.25 A case of an extremely high jugular bulb that reaches the level of the labyrinth. JB, jugular bulb; MFD: middle fossa dura; PFD, posterior fossa dura; SS, sigmoid sinus.

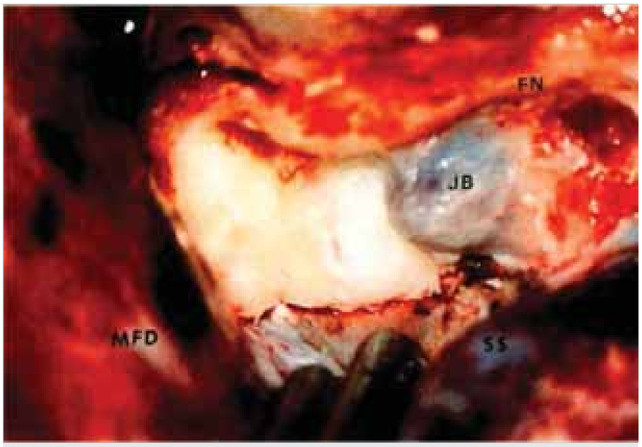

Fig. 34.26 The high bulb is uncovered. FN, facial nerve; JB, jugular bulb; MFD, middle fossa dura; SS, sigmoid sinus.

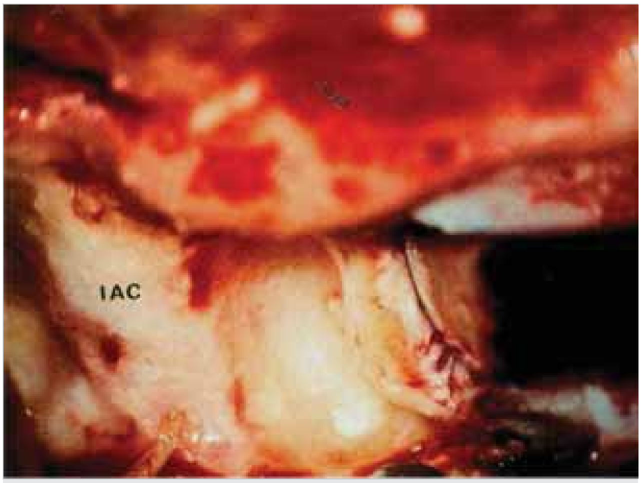

Fig. 34.27 The bulb is dissected using a large freer elevator. IAC, internal auditory canal.

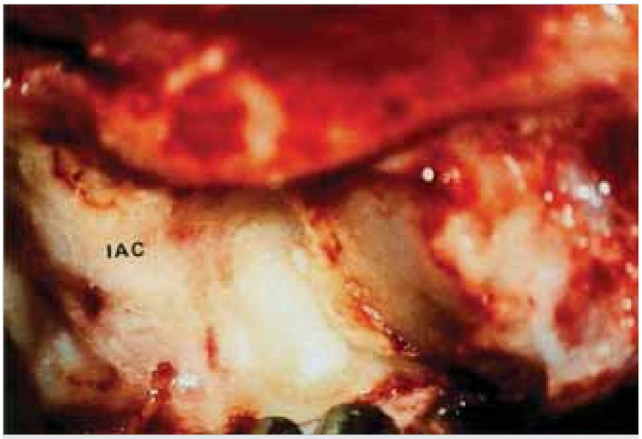

Fig. 34.28 The bulb is kept in place using Surgical and bone wax. IAC, internal auditory canal.

Anterior Sigmoid Sinus and Bleeding from the Sigmoid Sinus and Jugular Bulb

In the case of a forward-lying or a prominent sigmoid, it is imperative to preoperatively assess the contralateral venous drainage. If the drainage is insufficient, then working on the dominant sigmoid may be dangerous and even life threatening. One must consider avoiding surgery if possible, or if it has to be performed, it must be done so with extreme caution so as to not damage the dominant sinus. In cases with a very anterior sigmoid sinus, the retrosigmoid corridor may be particularly spacious.

Removal of bone over the sigmoid and 2 to 3 cm posterior to it over the posterior fossa dura enables the surgeon to compress any forward-lying sigmoid posteriorly. In a very prominent sigmoid, the posterior canal wall and the hypotympanic bone can be drilled out, followed by a blind sac closure, to gain additional space. It is best to place cotton patties on the sigmoid to protect it from the friction and heat of the instruments working over it. Small tears on the sigmoid can be controlled using bipolar coagulation. The bipolar is switched to a low setting, the edges of the tear are approximated with the bipolar tips (as if being welded), and coagulation is carried out under continuous suction irrigation. If bleeding cannot be stopped with bipolar, it can be controlled by extraluminal placement of a large piece of Gelfoam or Surgicel supported by neurosurgical Cottonoids. Large tears can be closed by suturing a free muscle graft to close the tear. Despite all these, if the bleeding is still not controlled, ligation of sigmoid sinus and internal jugular vein is the last option. This has never occurred in our practice. Bleeding from the superior petrosal sinus can be managed easily by coagulation or intraluminal packing. However, bleeding from the jugular bulb may be more challenging. Significant bleeding usually ensues after injury to the jugular bulb. Bipolar coagulation must not be attempted here, as it leads to further tearing of the very thin bulb wall and risks lower cranial nerve injury. Bleeding is best controlled by a large piece of Surgicel placed over the bulb and held in place with bone wax or Cottonoids.

Position of the Facial Nerve in Relation to the Tumor

Both the literature and our own experience indicate that by far the commonest location of the facial nerve in relation to the tumor is the anteroinferior surface of the tumor capsule. The facial nerve can be found in this position in almost 70% of cases. In 15% of cases, the facial nerve can be found adjacent to the anterosuperior surface and in another 10% it can be found adjacent to the superior surface. In the remaining 5%, the facial nerve lies on the posterior surface (▶ Fig. 34.29). There are three sites where the facial nerve must be identified during surgery: fundus, porus, and at the level of origin of the nerve at the brainstem. The facial nerve is fairly consistent at two of these sites: the fundus of the IAC and its origin at the level of the brainstem when compared with the porus. It is prudent to identify the nerve at the fundus first, followed by the porus and the brainstem. At the porus, the tumor may cause an acute change in the thickness and direction of the nerve due to compression and adherence of the nerve to tumor (▶ Fig. 34.30). After the visual identification of the nerve, the facial nerve stimulator must be used for confirmation. Since the facial nerve in the CPA lacks the thick perineural and fibrous sheaths covering the facial nerve more distally, the lowest intensity of stimulation is used for identification.

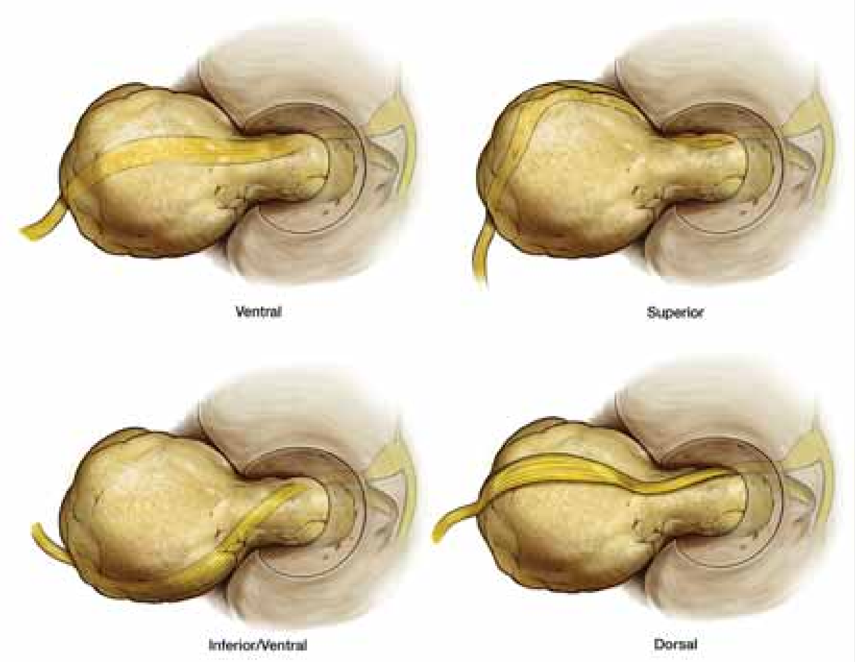

Fig. 34.29 The possible locations of the facial nerve (FN) in relation to the tumor. ant, anterior; CN, cochlear nerve; post, posterior; sup, superior.

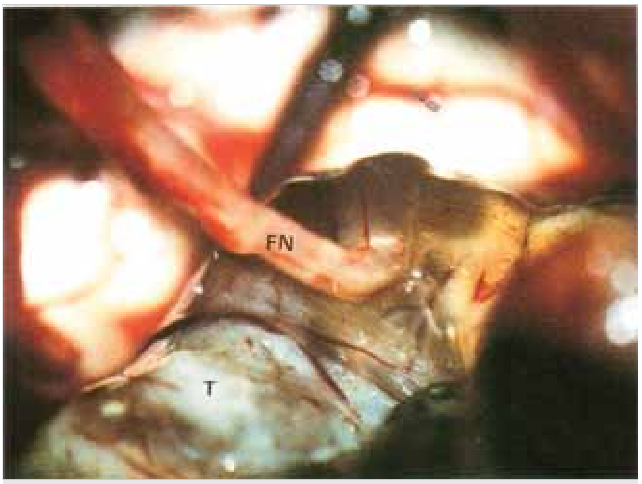

Fig. 34.30 The position of the facial nerve (FN) at the porus of the internal auditory canal is less stable. An acute change of direction on the anterior surface of the tumor is observed.

Anterior Inferior Cerebellar Artery

Usually, large tumors tend to displace the AICA toward the inferior pole of the tumor. In some cases, the AICA may be displaced posteriorly or laterally. Rarely but more importantly, the vessel can be encountered just under the posterior fossa dura, where it is vulnerable to injury during dural incision. When the AICA is intimately in contact with the tumor, the artery is separated from the tumor by coagulating the small branches arising from the artery feeding the tumor.

Petrosal (Dandy's) Vein

Significant bleeding can arise due to injury of the petrosal vein (s). The vein can be protected during dissection of the upper pole of the tumor by keeping the arachnoid over the vein undisturbed. If bleeding does occur, it can be stopped using bipolar coagulation. Generally, no hazardous effects result from occlusion of this vein.

Tumors Associated with Arachnoid Cysts

Extratumoral arachnoid cysts result in the enclosure of arachnoid folds during tumor growth and they can often grow to a large size. Before tumor removal, the cyst is evacuated, if possible, to facilitate brain relaxation and tumor removal. An extratumoral arachnoid cyst must be differentiated from a macrocystic tumor with a thin wall. Generally, the thickness of the wall and enhancement on magnetic resonance imaging (MRI) help distinguish these two entities. The arachnoid cyst can be marsupialized, while a cystic tumor wall should be removed to prevent recurrence.

Cystic, Heterogeneous, and Irregular Tumors

Cystic tumors (▶ Fig. 34.31) are difficult to dissect due to the fact that these tumors are usually adherent to the surrounding nerves and brainstem. This also leaves the facial nerve at considerable risk. At times, it is advisable to leave behind the capsule on the facial nerve and the brainstem. VSs that are heterogeneous in appearance and/or irregular in shape are usually indicative of their fast-growing nature (▶ Fig. 34.32). Such tumors are also adherent to the surrounding structures, posing the same problems of risk of facial nerve injury.

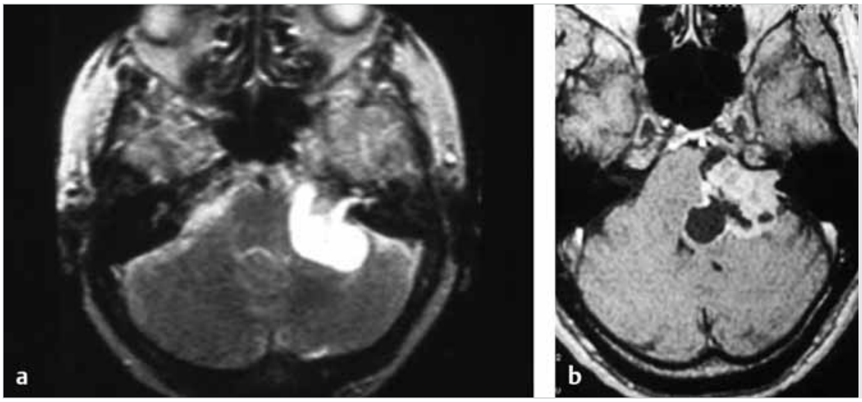

Fig. 34.31 MRI of a cystic VS. **(a)** The T2-weighted image does not show the characteristics of the tumor. **(b)** However, T1 with Gd enhancement can clearly demonstrate the tumor capsule and cystic components.

Fig. 34.32 MRI of a heterogeneous VS. This tumor is extensive and extends to the prepontine region. Planes of cleavage are not identifiable, inferring adherence to the brainstem and cerebellum (*arrowheads*).

Tumor Resection after Prior Radiation Failure

In recent times, radiotherapy has emerged as a primary treatment option for VS. Surgical removal of irradiated tumors is more difficult than primary tumor resection. Usually, the arachnoid–tumor plane is nonexistent and the tumor is more adherent to the surrounding structures than nonirradiated tumors. The tumor is also usually more fibrous and firmer, making the dissection difficult. Chapter 44 reviews the topic of microsurgery after radiosurgery in greater detail.

34.4 Conclusion

The ETLA is a safe approach that provides excellent exposure for even very large tumors. The distinct advantages provided by the ETLAs are: the absence of cerebellar retraction, excellent exposure of the IAC and the CPA, extradural drilling, and reduced incidence of postoperative CSF leaks. The ETLA and the ETLA+TAE have further increased the indications of the approach and help tackled large, giant, and anteromedially located tumors more effectively. Difficult anatomical and tumor-related situations can also be managed effectively with the ETLA.

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