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Transotic Approach to the Cerebellopontine Angle

J. Dale Browne, MD[a,*], Ugo Fisch, MD[b]

[a]Department of Otolaryngology, Wake Forest University School of Medicine, Winston-Salem, NC, USA
[b]Department of Otolaryngology, University of Zurich, Zurich, Switzerland

The development by House in the early 1960s of the translabyrinthine approach to lesions in the cerebellopontine angle revolutionized their treatment. Until the late 1970s, this was the primary approach used in the University of Zurich Department of Otolaryngology for the treatment of acoustic neuromas. At that time, an extension in the degree of temporal bone dissection was introduced to provide improved facial nerve identification and tumor visualization in larger lesions [1]. This new approach featured the complete exenteration of all pneumatic cell tracts of the temporal bone, total removal of the otic capsule with transposition of the facial nerve, and obliteratior of the middle ear cleft. The procedure was described as the *transotic approach* to distinguish it more clearly from the less extensive transcochlear approach introduced by House et al for the resection of skull base tumors [2].

The original transotic approach eliminated many exposure problems encountered with the translabyrinthine procedure, yet introduced a temporary postoperative facial paralysis from transposition of the facial nerve. To address this problem, a modification was developed that involved preservation of the facial nerve within the fallopian canal, thereby eliminating the temporary paralysis of permanent transposition while maintaining improved exposure [3,4]. As a result of the success of this procedure for the removal of larger tumors, the transotic approach has replaced the translabyrinthine approach in the treatment of virtually all acoustic neuromas treated in the Department of Otolaryngology. The purpose of this article is to present a detailed summary of the advantages, disadvantages, and technical aspects of this method as it relates to the surgical therapy of acoustic neuromas.

Surgical technique

The principal objective of the transotic approach is the direct lateral exposure of the cerebellopontine angle via the medial wall of the temporal bone. No cerebellar retraction is required, with the limits of dissection along the medial wall extending from the superior petrosal sinus to the jugular bulb and from the internal carotid artery to the sigmoid sinus. The facial nerve is left undisturbed within the tympanic and mastoid segments of the fallopian canal. The component steps in the transotic approach consist of (1) a subtotal petrosectomy with preservation of the tympanic and mastoid segments of the fallopian canal, (2) total removal of the otic capsule with wide exposure of posterior fossa dura along the medial temporal bone, (3) tumor removal with maximal facial nerve exposure, and (4) dural reconstruction with cavity obliteration.

Subtotal petrosectomy

The foundation of the transotic approach is the successful completion of a subtotal petrosectomy before advancing to otic capsule removal and tumor exposure (Figs. 1, 2, and 3). This involves the obliteration of the eustachian tube isthmus, closure of the external auditory canal, and complete exenteration of all air cell tracts to

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* Corresponding author. Department of Otolaryngology, Wake Forest University Medical School, Medical Center Boulevard, Winston-Salem, NC 27157.

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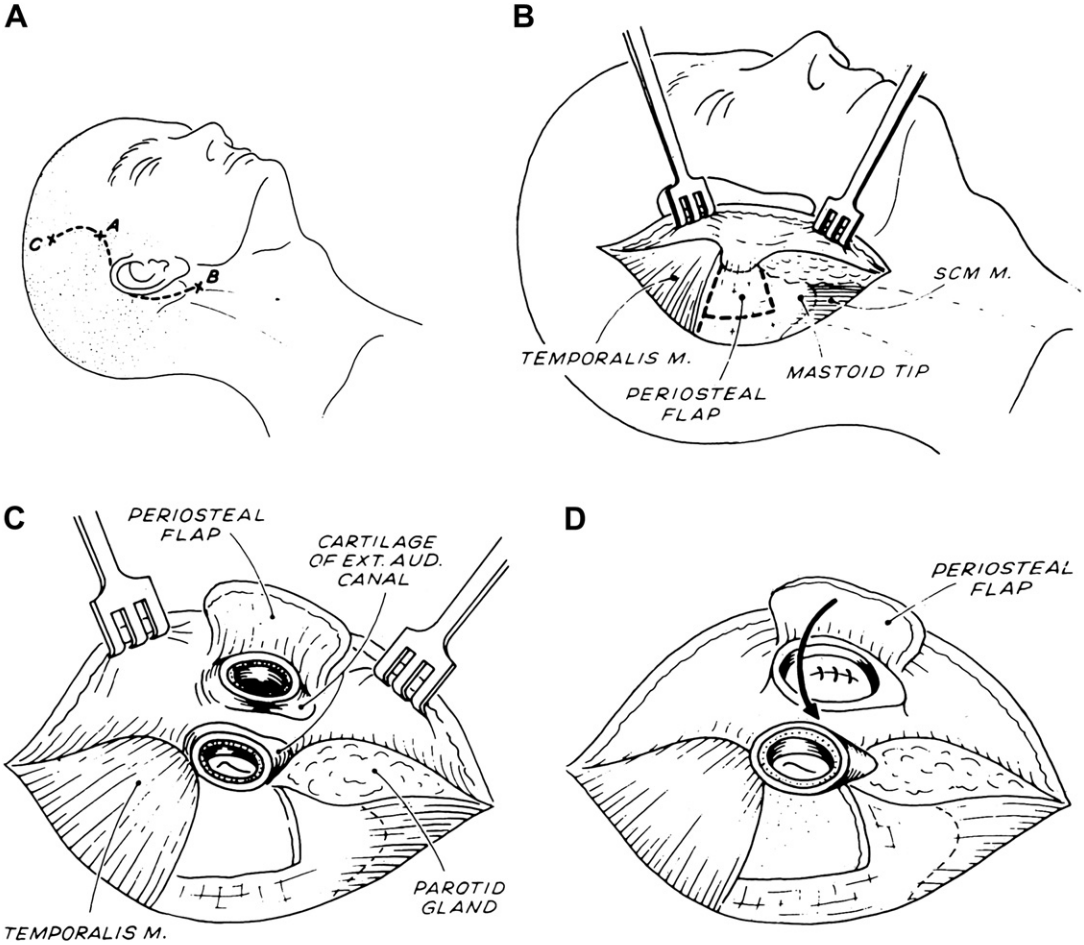

Fig. 1. (*A*) An S-shaped incision is made from the temporal region to 2 cm below the mastoid tip (A-B), with the superior portion (A-C) made at the conclusion of the procedure if needed for the temporalis muscle flap. (*B*) The postauricular skin is anteriorly reflected superficial to the temporalis muscle. An anteriorly based flap is created for mastoid periosteum and soft tissues. (*C*) The external auditory canal is transected at the level of the bony-cartilaginous junction. (*D*) The skin edges of the cartilaginous canal are separated slightly from underlying cartilage, everted laterally, and closed. The preserved periosteal flap is folded over the closed meatus and sutured to the cartilage for a two-layered closure. (*Adapted from* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

include the retrosigmoid, retrofacial, antral, retrolabyrinthine, supralabyrinthine, infralabyrinthine, peritubal, and pericarotid cells. At the end of this initial dissection, the internal carotid artery, jugular bulb, and mastoid segment of the fallopian canal have been skeletonized.

Otic capsule removal

Exposure of the internal auditory canal contents requires a complete removal of the otic capsule with continued preservation of the fallopian canal as a bridge of bone from the geniculate ganglion to the stylomastoid foramen (Figs. 4 and 5). Posterior exposure is achieved through removal of the semicircular canals and vestibule. The inferior and anterior exposure inherent to this technique follows removal of the cochlea by drilling under and anterior to the fallopian canal bridge. Special care is taken to expose all dura between the jugular bulb, internal carotid artery, and semicanal of the tensor tympani muscle. Before completion of the superior exposure, the remaining bone over the posterior

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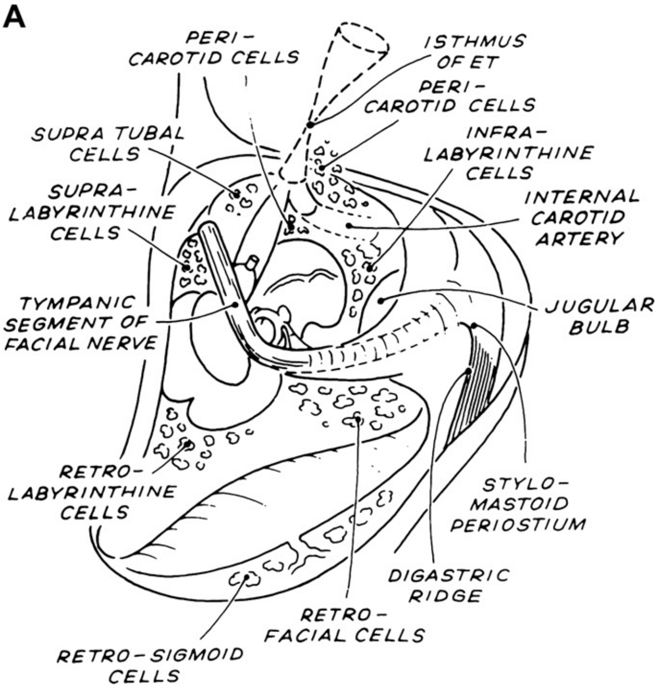
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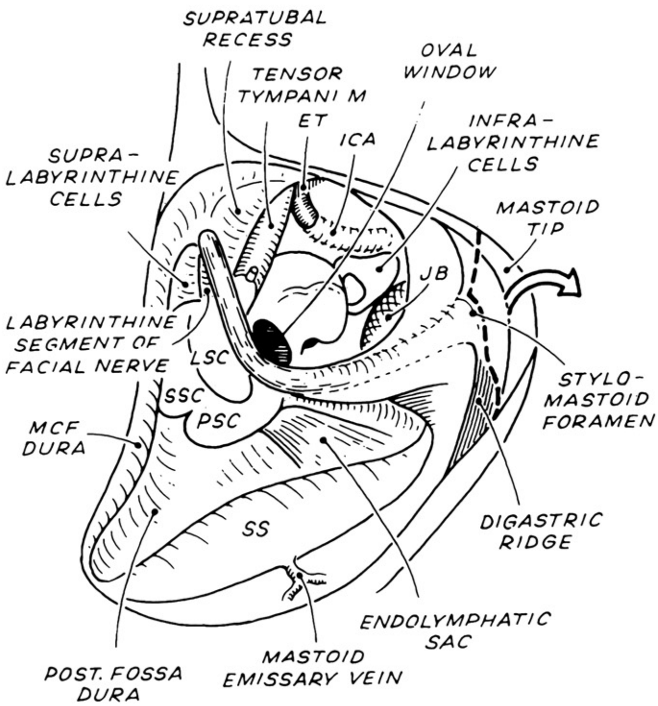
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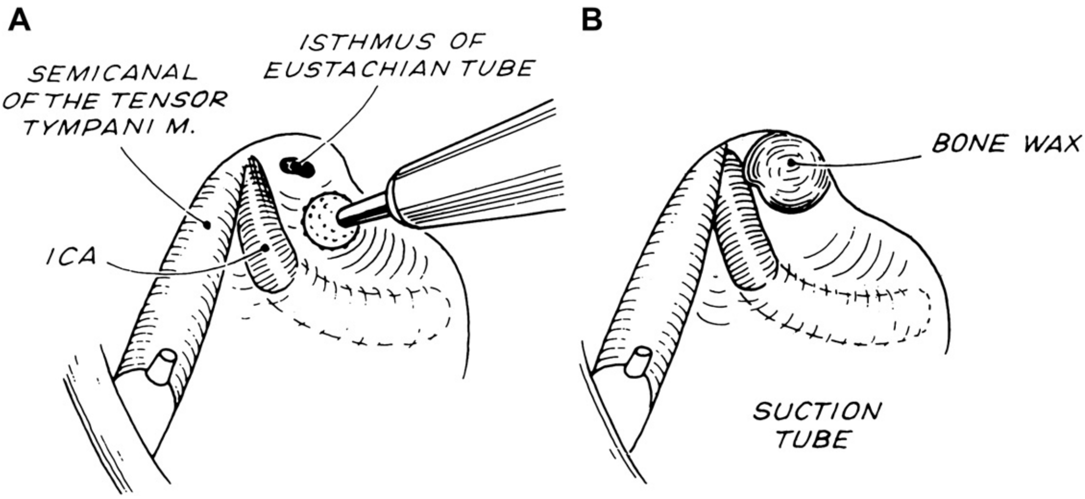

Fig. 3. (*A*) The bony eustachian tube is removed as far as the isthmus with diamond burs, taking care to avoid injury to the carotid artery. (*B*) After bipolar coagulation of the mucosa of the bony-cartilaginous junction, the eustachian tube is obliterated with bone wax. (*Adapted from* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

fossa dura is removed between the superior petrosal sinus, sigmoid sinus, and posterior internal auditory canal.

Completion of the important superior exposure follows identification of the labyrinthine segment of the facial nerve at the meatal foramen by careful removal of the anterior-superior bone overlying the internal auditory canal. This identification is enhanced through the use of facial nerve monitoring. Subsequently exposure of posterior fossa dura is completed along the superior petrosal sinus and the posterior-superior acoustic porus. The completed exposure is diagrammatically illustrated in Fig. 5.

Tumor removal

Tumor removal begins with separation of the neuroma from the facial nerve at the meatal foramen (Figs. 6, 7, and 8). Working laterally to medially, the intracanalicular portion of the tumor is freed from the facial nerve. As it is separated from the nerve, the tumor is displaced into the space created by removal of the otic capsule. Once the porus is reached, the mobilized portion of tumor can be excised and the remaining intradural tumor debulked by intracapsular removal.

After complete hemostasis, removal of the intradural portion may then proceed with a posterior fossa incision, which begins between the sinodural angle and the posterior edge of the porus and is subsequently extended anteriorly below the porus. By retraction of the dural edges with 4–0 Vicryl sutures, the complete circumference of the tumor can be uncovered. Removal of the neuroma is accomplished by additional intracapsular removal, in conjunction with meticulous dissection of the tumor capsule from feeding vessels and the facial nerve. Identification and

Fig. 2. (*A*) The mastoid cortex is widely exposed. The remaining skin of the external auditory canal is removed, as well as the tympanic membrane, ossicles and posterior canal wall. All pneumatic cell tracts associated with the middle ear are thoroughly removed, the mastoid tip is removed to facilitate cavity obliteration. The tympanic and mastoid segments of the facial nerve are identified, leaving only a thin covering of bone over the nerve. The air cells are removed in the following order: retrosigmoid, retrofacial, retrolabyrinthine, supralabyrinthine, infralabyrinthine, pericarotid, and supratubal. (*B*) The surgical site following removal of all air cell tracts: ET, eustachian tube; ICA, internal carotid artery; JB, jugular bulb; SS, sigmoid sinus; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SSC, superior semicircular canal; MCF Dura, middle cranial fossa dura. All middle ear mucosa has been removed. (*Adapted from* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

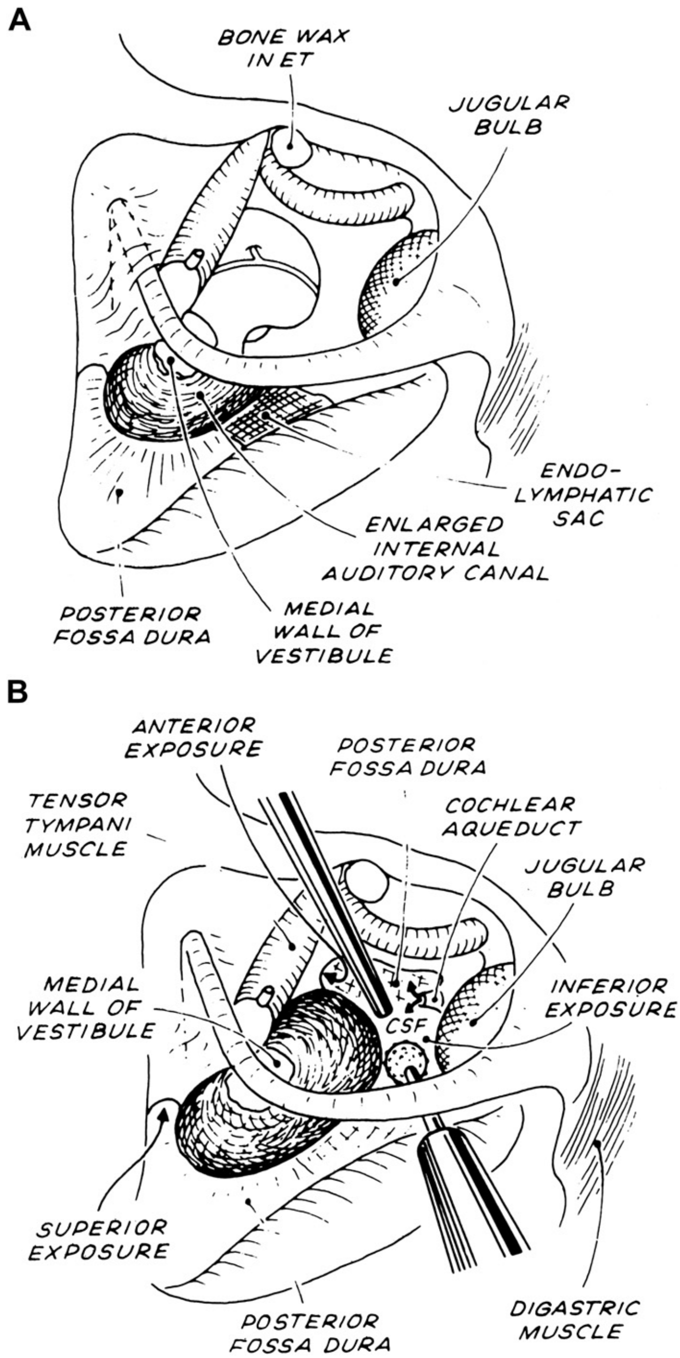

Fig. 4. (*A*) Posterior exposure. As in the translabyrinthine approach, the semicircular canals are removed and vestibule opened. The meatal dura is exposed from the posterior fundus of the canal to the porus. The bone removal is extended interiorly around the enlarged internal auditory canal and under the preserved fallopian canal. The endolymphatic sac is exposed. (*B*) Inferior and anterior exposure. The cochlea is drilled away and the posterior fossa dura is gradually exposed by working under and anterior to the fallopian canal, preserved as a bridge of bone. The dura is exposed between the jugular bulb, internal carotid artery, and the semicanal of the tensor tympani muscle. With this exposure, the cochlear aqueduct is encountered. Arachnoid within the aqueduct may be opened to allow decompression of the posterior fossa before the dura is incised. (*From* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

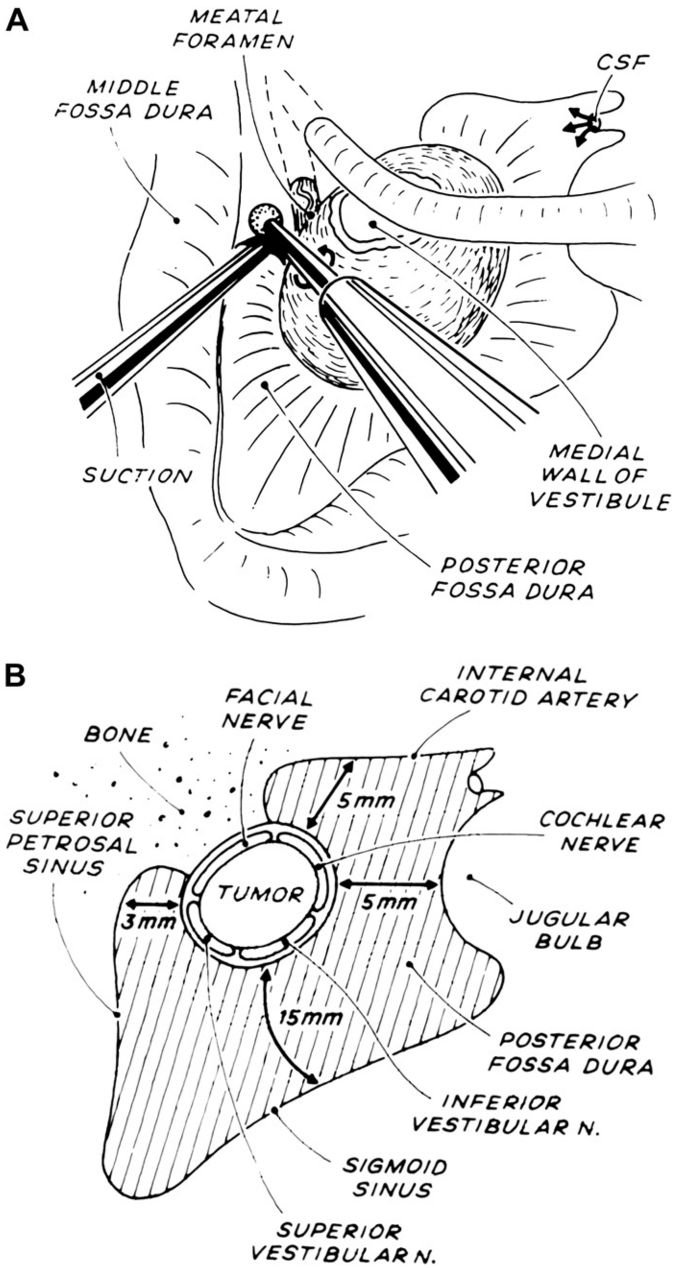

Fig. 5. (*A*) Superior exposure. Identification of the labyrinthine segment of the facial nerve must precede completion of the dural exposure superior to the porus. The nerve is usually 2 mm anterosuperior to the medial wall of the vestibule. Localization of its position is enhanced by the use of the nerve integrity monitor. Following this identification, bone is removed anteriorly along the superior petrosal sinus as far as the meatal foramen. (*B*) Extent of bone removal around the internal auditory canal. For protection of the facial nerve, the anterior-superior wall is left intact. The measurements shown of this maximal exposure represent averages from surgical cases. (*Adapted from* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

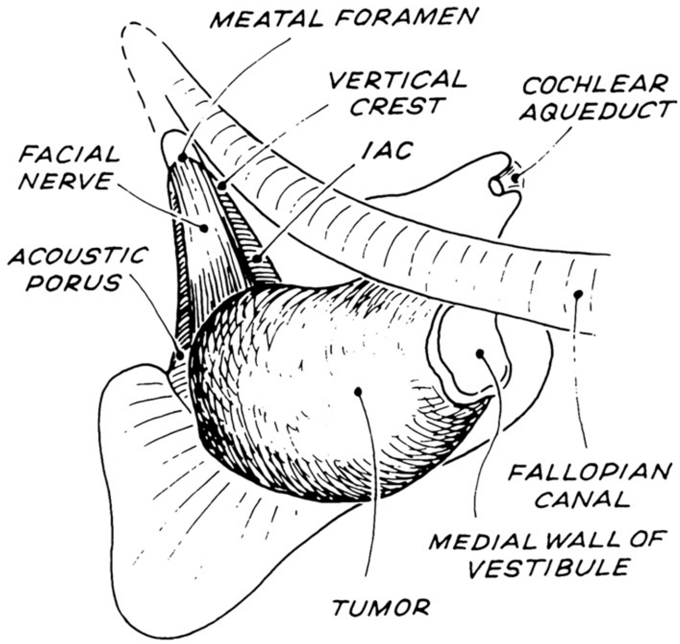

Fig. 6. The facial nerve is identified in the internal auditory canal proximal to the meatal foramen. As the tumor is gently separated from the nerve, it is pushed into the space created by complete otic capsule removal. Once the tumor is mobilized to the porus, the extradural tumor can be amputated and intradural tumor decompressed by intracapsular removal. (*From* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

dissection of a displaced and thinned facial nerve at the porus is facilitated by the additional anterior exposure of its entire intracranial portion used in the transotic approach.

Defect reconstruction and closure

The defect in the posterior fossa dura is reconstructed with a fresh musculofascial graft harvested from the temporalis muscle fixed to the dura using the traction sutures previously placed (Fig. 9). A smaller musculofascial graft and fibrin glue are used to supplement the eustachian tube obliteration. Large strips of abdominal wall fat are then placed over the dural patch, secured under the fallopian canal bridge, fibrin glue applied, and the temporalis muscle transposed. Additional abdominal wall fat is placed under the transposed muscle to increase the pressure on the dural closure slightly. Following a layered skin closure, a pressure dressing is applied and maintained for 5 days.

Discussion

The transotic approach has advantages that are shared with the more posteriorly oriented translabyrinthine procedure. Cerebellar retraction is not necessary, and the surgical orientation is otologically oriented for secure facial nerve identification and reconstruction. Additionally, tumor growth in the lateral internal auditory canal can be dealt with easily because the dissection is initiated laterally.

In the transotic approach, however, the extension of bone removal to include the anterior medial wall of the temporal bone affords the surgeon a superb view of the cerebellopontine angle *anterior* to the tumor (Fig. 10). With this added exposure, the operative field has superior illumination for dissection of tumor from surrounding vessels and facial nerve without increased morbidity or mortality (Table 1). In contrast to the transcochlear approach and its modifications, [2,5] facial nerve transposition is unnecessary because the fallopian canal bridge does not significantly impair exposure. With the entire intracranial segment of the facial nerve visualized before tumor removal, the expeditious separation of nerve from tumor may occur with increased safety to facial function (see Table 1; Tables 2 and 3). If tumor invasion of the facial nerve is significant enough to require segmental

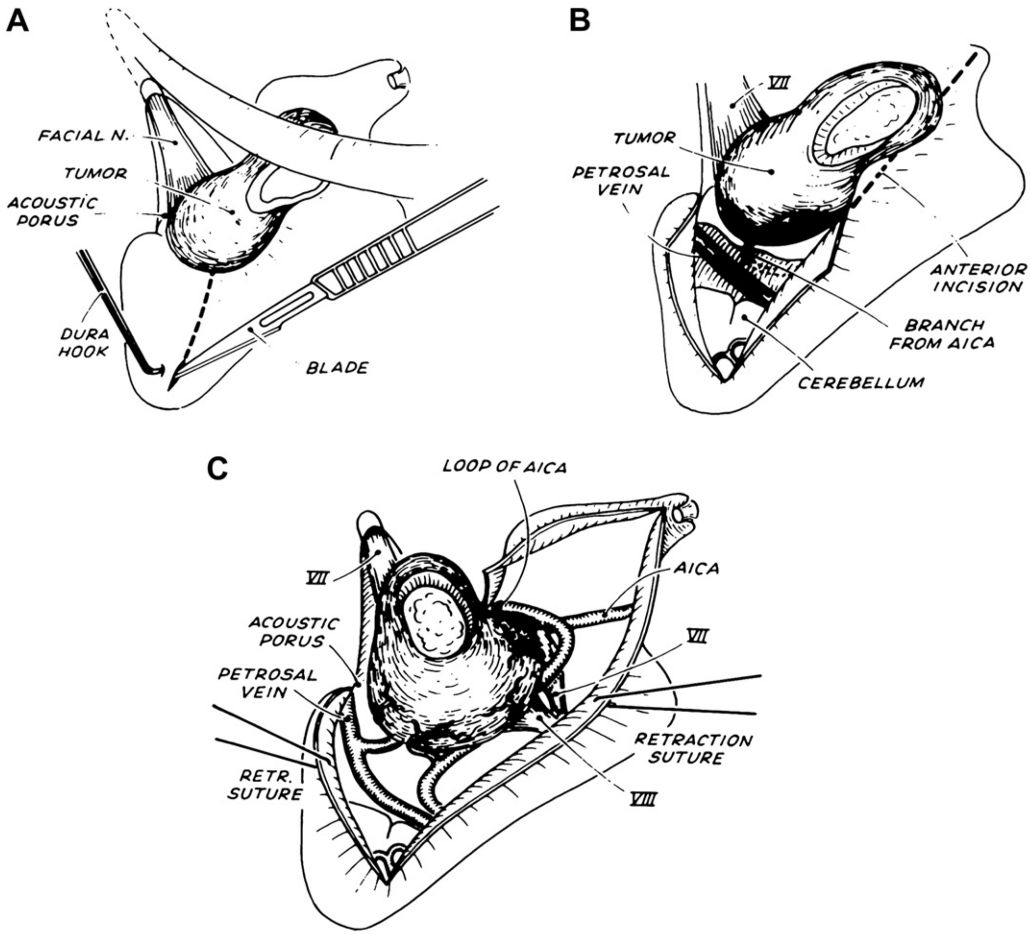

Fig. 7. (*A*) Once all bone removal is completed and hemostasis achieved, the posterior fossa dura is incised between the sinodural angle and posterior edge of the porus. (*B*) The incision is extended below and anterior to the porus, taking care to look for AICA or other vessels beneath the dura before cutting. (The bony fallopian canal bridge has been omitted for ease of illustration.) (*C*) The superior and inferior dural flaps are retracted with 4-0 Vicryl sutures. The posterior and inferior tumor margins are well seen, as well as the anteriorly displaced facial nerve. (Bony fallopian canal bridge omitted.) (*Adapted from* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

resection, exposure is optimal for graft placement (Fig. 11). The cervical portion of the skin incision may be easily extended to facilitate a hypoglossal-facial anastomosis at the conclusion of tumor resection if there is no useful proximal facial nerve stump.

Postoperative cerebrospinal fluid leaks continue to plague other approaches to the cerebellopontine angle (Table 4), with various techniques introduced for the prevention of this complication [6–9]. In contrast, the use of the transotic approach at the University of Zurich has avoided this problem with a high degree of consistency (see Table 1). Additionally an important improvement has been the elimination of *delayed* cerebrospinal fluid leaks in our series that occasionally presented with meningitis several years after the original translabyrinthine surgery.

The technical basis for this improved rate of dural closure begins with the initial subtotal petrosectomy. Inherent in this portion of the procedure is the meticulous obliteration of the eustachian tube orifice, preceded by the removal of all middle ear mucosa and pneumatic cells connecting with the middle ear space. Removal of all middle ear mucosa with fat obliteration of the middle ear

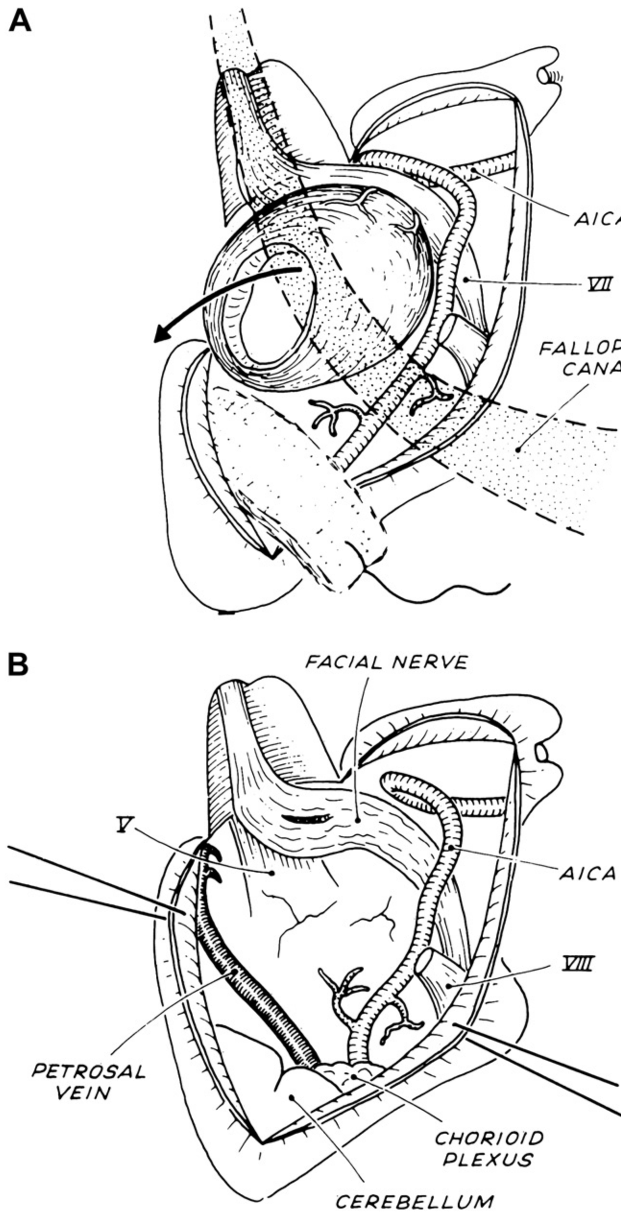

Fig. 8. (*A*) The separation of tumor from intracranial facial nerve is expeditious because of the visualization of its complete intracranial portion. Direct vision anterior to the tumor is advantageous because the anteriorly displaced facial nerve is frequently spread paper thin and nearly transparent. (*B*) Following complete tumor removal, the intracranial facial nerve is well visualized and accessible to grafting if necessary. (Bony fallopian canal omitted.) (*From* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

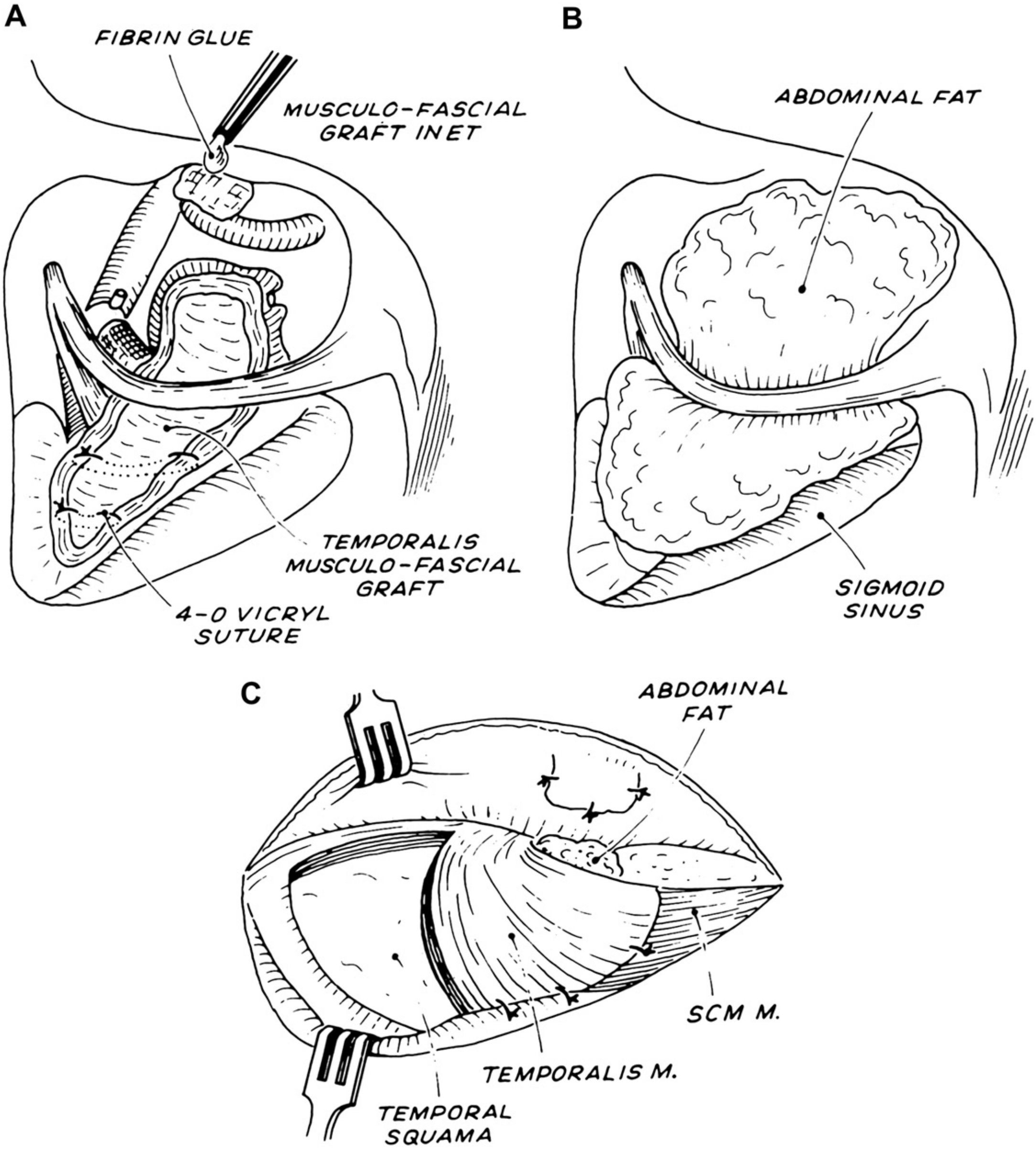

Fig. 9. (*A*) Posterior fossa dura is reconstructed using a musculofascial graft taken from the temporalis muscle, the graft is placed under the dura and fixed by using the previously placed 4-0 Vicryl traction sutures. A small musculofascial graft is also used to supplement the eustachian tube orifice. Fibrin glue is used to stabilize both grafts. (*B*) Large strips of abdominal fat pulled under the bony fallopian canal bridge are used to provide added pressure to keep the musculofascial graft against the dura. (*C*) The skin incision is extended superiorly for exposure of the temporalis muscle (A-C in Fig. 1 *A*). The posterior two thirds of the muscle are mobilized, rotated inferiorly, and sutured to the sternocleidomastoid (SCM) and tissues of the posterior occiput. Additional adipose tissue is then placed under the muscle and fibrin glue injected around the grafts. The subcutaneous tissue and skin are closed in iayers. The wound is drained with a suction drain that is removed as soon as a pressure dressing is placed. (*From* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

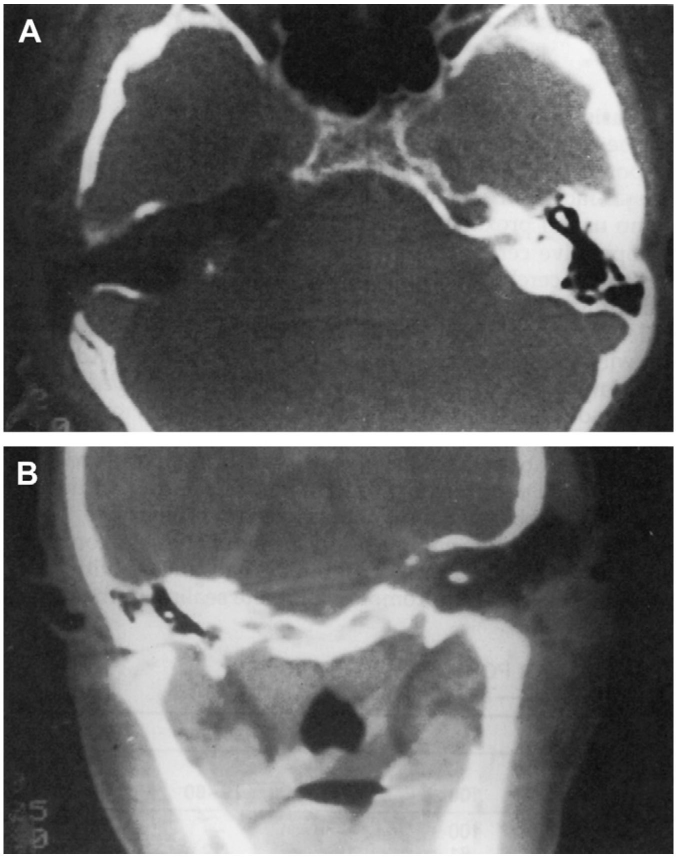

Fig. 10. Postoperative computed tomography scan following a transotic approach to the cerebellopontine angle for tumor removal. Note the wide exposure and bony defect created in the medial temporal bone. (*A*) Axial view. (*B*) Coronal view.

Table 1
Postoperative complications of surgical approaches*

Complication	Transotic (n = 147)(%)	Translabyrinthine (n = 114)(%)
Mortality	1	1
CSF leak		
Immediate	3	15
Requiring wound revision	1	7
Delayed (4–8 yr postoperatively)	0	5
Requiring wound revision†	0	5†
Meningitis	1	5
Facial function (2 yr postoperatively)		
Grades I,II	85	65
Paresis	13	31
Paralysis	2	4

* 1–2.5 cm diameter acoustic neuromas.

† Three patients presented with meningitis over 4 years following surgery.

Table 2
Two-year postoperative facial function—transotic approach

	Percent recovery					
Tumor Size (cm)	n	100	99–80	79–60	59–40	39–0
1–1.4	14	100	—	—	—	—
1.5–2.5*	52	61	19	12	4	4
Total	66	70	15	9	3	3

* No differences noted in facial function following removal of tumors 1.5–1.9 cm versus 2–2.5 cm.

cleft promotes complete sealing of the dural closure without the potential development of mucosal cysts [10]. The closure of the eustachian tube eliminates an important conduit for cerebrospinal fluid contamination; exenteration of all air cells removes occult tracts that may lead to postoperative cerebrospinal fluid leakage. Additionally, the bony fallopian canal bridge and temporalis muscle flap provide a stable means to apply constant pressure on the musculofascial dural patch.

In the Department of Otolaryngology at the University of Zurich, safety of tumor removal with preservation of facial function is paramount in the rationale of the surgical approach. A middle fossa approach is used for the treatment of intracanalicular tumors up to 8 mm in size in patients with usable hearing in the involved ear. The suboccipital approach has not been used for hearing conservation procedures owing to their generally unpredictable, low success rates at the possible expense of incomplete tumor removal [11,12]. Therefore larger tumors up to 2.5 cm are excised using the transotic approach in all patients with usable contralateral auditory function. Tumors that are believed to be adherent to the brain stem or larger than 2.5 cm are generally removed through the suboccipital approach. Additionally, the presence of unresolved otitis media or mastoiditis is a contraindication to the use of the transotic technique.

Table 3
Results of intracranial grafting

			Facial function	
Surgical approach	n	Mean follow-up (yr)	Percentage	Grade
Transotic	8	4	66	III
Translabyrinthine	2	11	63	III

The transotic approach to the cerebellopontine angle is a procedure that rewards the extra work required for full otic capsule removal with an excellent view of the anterior cerebellopontine angle. The additional 11/2 to 2 hours required beyond a translabyrinthine technique for this bone work is easily compensated by less time necessary for tumor removal (40 to 60 minutes). With this exposure, straightforward separation of tumor from intracranial contents can proceed expeditiously with emphasis on facial nerve preservation. The benefits of this technique are seen in the preservation of normal facial function (grade I) in all patients with tumors less than 1.5 cm in diameter and in 61% of those with larger lesions (see Table 2). Although the major utilization of a transotic procedure has been in removal of acoustic neuromas, other useful applications have been in the surgical treatment of meningiomas, hemangiomas, arachnoid cysts, and mucosal cysts invading the internal auditory canal.

Summary

The transotic approach to the cerebellopontine angle for resection of tumors invading the internal auditory canal provides superior illumination and exposure for optimal preservation of facial nerve function. Separation of facial nerve from tumor is enhanced with an anterior exposure that allows visualization of the intracranial segment of the nerve before tumor removal without significantly increasing total operative time. Facial nerve grafting or hypoglossal-facial anastomosis may be incorporated into the procedure at the time of tumor resection using the transotic approach. When combined with a musculofascial patch secured to the dural defect, the initial subtotal petrosectomy with eustachian tube and middle ear cleft obliteration generally avoids the complication of an immediate or delayed postoperative

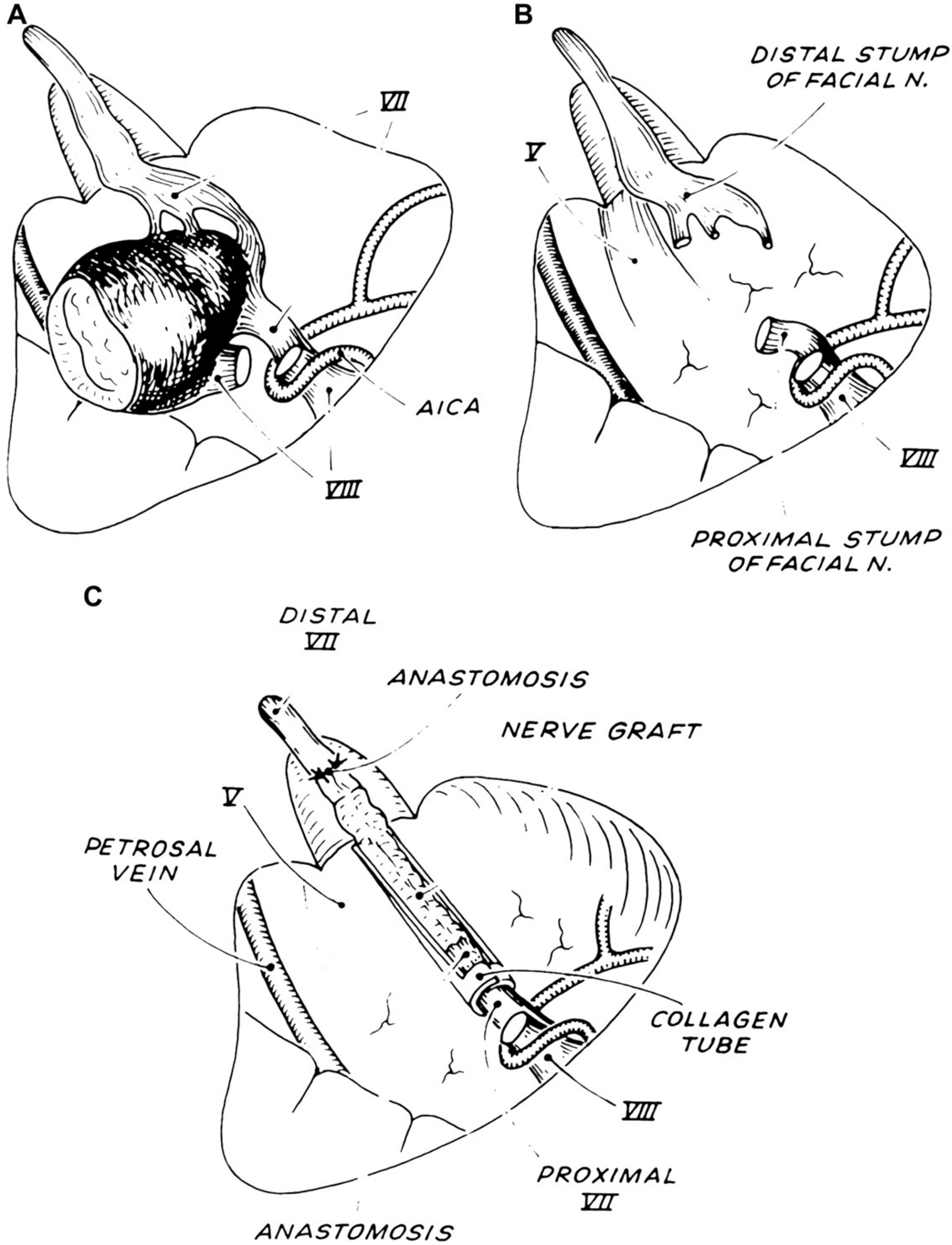

Fig. 11. (*A–B*) In some cases, a plane of dissection between facial nerve and tumor can not be easily developed. In these instances, a portion of nerve is resected if there is persistent tumor or loss of function in residual nerve. (*C*) The transotic approach provides excellent exposure for freshening nerve stumps and graft anastomosis. (*Adapted from* Fisch U, Mattox D. Microsurgery of the Skull Base. Stuttgart, Germany, Georg Thieme Verlag; 1988; with permission.)

Table 4
Postoperative cerebrospinal fluid leaks in literature

Series (yr)	Total no of series patients	Patients with postoperative cerebrospinal fluid leak (%)		
		Translabyrinthine	Combined	Suboccipital
Bryce, et al [6] (1991)	319	11	29	10
Robson, et al [13] (1989)	98	—	—	17
Hardy, et al [14] (1989)	100	13	—	—
Glasscock, et al [15] (1986)	616	11	25	27
Harner, et al [16] (1985)	162	—	—	12
Tos and Tomsen [17] (1985)	200	10	—	—
Gardner, et al [18] (1983)	105	9	22	—

cerebrospinal fluid leak. The transotic approach is indicated for tumors up to 2.5 cm in size that are not adherent to the brain stem.

References

[1] Jenkins HA, Fisch U. The transotic approach to resection of difficult acoustic tumors of the cerebellopontine angle. Am J Otol 1980;2:70–6.
[2] House WF, Hitselberger WE. The transcochlear approach to the skull base. Arch Oto laryngol 1976;102:334–42.
[3] Fisch U, Mattox D. The transotic approach to the cerebellopontine angle. In: Microsurgery of the Skull Base. New York: Thieme; 1988.
[4] Gantz BJ, Fisch U. Modified transotic approach to the cerebellopontine angle. Arch Otolaryngol 1983; 109:252–6.
[5] Horn KL, Hankinson HL, Erasmus MD, et al. The modified transcochlear approach to the cerebellopontine angle. Otolaryngol Head Neck Surg 1991; 104:37–41.
[6] Bryce GE, Nedzelski JM, Rowed DW, et al. Cerebrospinal fluid leaks and meningitis in acoustic neuroma surgery. Otolaryngol Head Neck Surg 1991; 104:81–7.
[7] House JL, Hitselberger WE, House WF. Wound closure and cerebrospinal fluid leak after translabyrinthine surgery. Am J Otol 1982;4:126–8.
[8] Myerhoff WL, Pollack KJ, Roland PS, et al. Modified Rambo meatoplasty in translabyrinthine tumor removal. Otolaryngol Head Neck Surg 1991;104:100–2.
[9] Sataloff RT, Myers DL. Techniques for decreasing the incidence of cerebrospinal fluid leaks following translabyrinthine surgery. Am J Otol 1987;8:73–4.
[10] Pollak A, Wolfensberger M, Fisch U. Obliteration of the eustachian tube and middle ear cleft in humans—a histopathological study. In: Proceedings of the Conference on the Eustachian Tube and Middle Ear Diseases. Kugler and Ghedini; 1991 (in press).
[11] Neely JG. Is it possible to totally resect an acoustic neuroma and conserve hearing? Otolaryngol Head Neck Surg 1984;92:162–7.
[12] Wiet RJ, Kazan RP, Raslan W, et al. Complications with the approach to acoustic tumor surgery. Ann Otol Rhinol Laryngol 1986;95:28–31.
[13] Robson AK, Clarke PM, Dilkes M, et al. Transmastoid extracranial repair of CSF leaks following acoustic neuroma resection. J Laryngol Otol 1989; 103:842–4.
[14] Hardy DG, MacFarlane R, Baguley D, et al. Surgery for acoustic neuroma. J Neurosurg 1989; 71:799–804.
[15] Glasscock ME, Kveton JF, Jackson CG, et al. A systematic approach to the surgical management of acoustic neuroma. Laryngoscope 1986;96:1088–94.
[16] Harner SG, Ebersold MJ. Management of acoustic neuromas, 1978–1983. J Neurosurg 1985;63:175–9.
[17] Tos M, Thomsen J. Cerebrospinal fluid leak after translabyrinthine surgery for acoustic neuroma. Laryngoscope 1985;95:351–4.
[18] Gardner G, Robertson JH, Clark WC, et al. Acoustic tumor management—combined approach with the CO_2 laser. Am J Otol 1983;5:87–108.