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Microsurgical Anatomy of Acoustic Neuroma

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Acoustic neuromas, as they expand, may involve a majority of the cranial nerves, cerebellar arteries, and parts of the brain stem. On the lateral side, in the meatus, they commonly expand by enlarging the meatus and may infrequently erode into the vestibule and cochlea. On the medial side, they compress the pons, medulla, and cerebellum. An understanding of microsurgical anatomy is especially important in preserving the facial and adjacent cranial nerves, which are the neural structures at greatest risk during acoustic neuroma removal. A widely accepted operative precept is that a nerve involved by tumor should be identified proximal or distal to the tumor, where its displacement and distortion are the least, before the tumor is removed from the involved segment of nerve. Considerable attention has been directed to the early identification of the facial nerve distal to the tumor at the lateral part of the internal acoustic canal, whether the operative route be through the middle fossa, labyrinth, or posterior meatal lip. Less attention has been directed to identification at the brain stem on the medial side of the tumor. These anatomic considerations are divided into sections dealing with the relationships at the lateral end of the tumor in the meatus and those on the medial end of the tumor at the brain stem.

Meatal relationships

The nerves in the lateral part of the internal acoustic meatus are the facial, the cochlear, and the inferior and superior vestibular nerves (Fig. 1). The position of the nerves is most constant in the lateral portion of the meatus, which is divided into a superior and an inferior portion by a horizontal ridge, called either the *transverse* or *the falciform crest*. The facial and the superior vestibular nerves are superior to the crest. The facial nerve is anterior to the superior vestibular nerve and is separated from it at the lateral end of the meatus by a vertical ridge of bone, called the *vertical crest*. The vertical crest is also called *Bill's bar* in recognition of William House's role in focusing on the importance of this crest in identifying the facial nerve in the lateral end of the canal [6]. The cochlear and inferior vestibular nerves run below the transverse crest with the cochlear nerve being located anteriorly. Thus the lateral meatus can be considered to be divided into four portions, with the facial nerve being anterior-superior; the cochlear nerve, anterior-inferior; the superior vestibular nerve, posterior-superior; and the inferior vestibular nerve, posterior-inferior.

The anatomy of the region offers the opportunity for three basic approaches to the tumor in the meatus and cerebellopontine angle. One is directed through the middle cranial fossa and the roof of the meatus. Another is directed through the labyrinth and posterior surface of the temporal bone. The third is directed through the posterior cranial fossa and posterior meatal lip. The anatomy presented by all three approaches is reviewed here.

Middle fossa approach

In the middle fossa approach, the meatus is approached from above, through a temporal craniotomy located anterior to the ear and above the zygoma (Figs. 2 and 3) [2,11]. The dura under the temporal lobe is elevated from the floor of the

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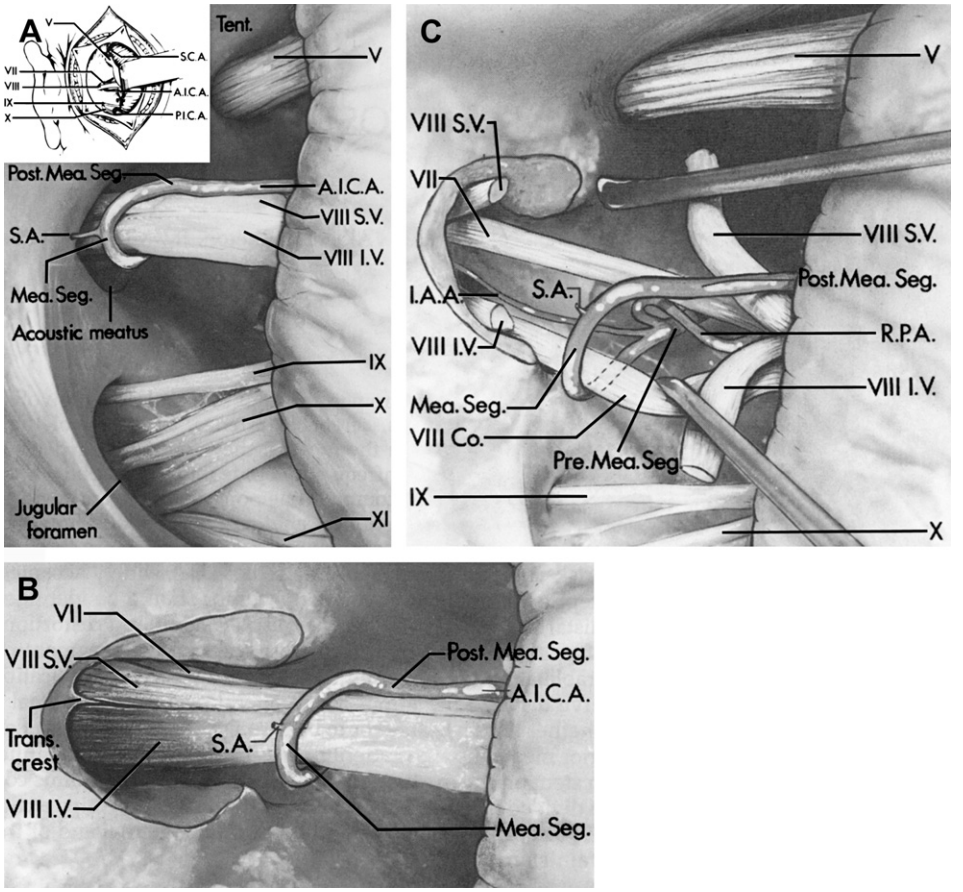


Fig. 1. Posterior view into the left cerebellopontine angle and internal acoustic meatus. Insert shows the orientation. (*A*) The tentorium (Tent.) is above the trigeminal nerve (V). The facial and vestibulocochlear nerves enter the internal acoustic meatus. The posterior surface of the vestibulocochlear nerve is formed by the inferior (VIII I.V.) and superior vestibular (VIII S.V.) nerves. The glossopharyngeal (IX), vagus (X), and spinal accessory nerves (XI) enter the jugular foramen. The premeatal segment of the anterior inferior cerebellar artery (A.I.C.A.) is not visible because it is anterior to the nerves. The meatal segment (Mea. Seg.) passes posterior to the nerves and gives rise to the subarcuate artery (S.A.). The postmeatal segment (Post. Mea. Seg.) passes above the nerves. The insert shows the superior cerebellar artery (S.C.A.) above the trigeminal nerve, and the posterior inferior cerebellar artery (P.I.C.A.) below the glossopharyngeal nerve. (*B*) The posterior wall of the internal acoustic canal has been removed. The facial nerve (VII) is anterior to the superior vestibular nerve. The subarcuate artery had to be divided to gain access to the posterior wall of the acoustic canal. The transverse crest (Trans. Crest) separates the superior and inferior vestibular nerves at the lateral end of the canal. (*C*) The superior and inferior vestibular nerves have been divided to expose the facial and cochlear nerves (VIII Co.). The premeatal segment (Pre. Mea. Seg.) gives origin to the internal auditory (I.A.A.) and recurrent perforating (R.P.A.) arteries. The initial segment of the recurrent perforating artery loops toward the meatus before turning medially to reach the side of the brainstem. (*From* Martin RG, Grant JL, Peace D, et al. Microsurgical relationships of the anterior inferior cerebellar artery and the facial-vestibuloco-chlear nerve complex. Neurosurgery 1980;6:483–507; with permission.)

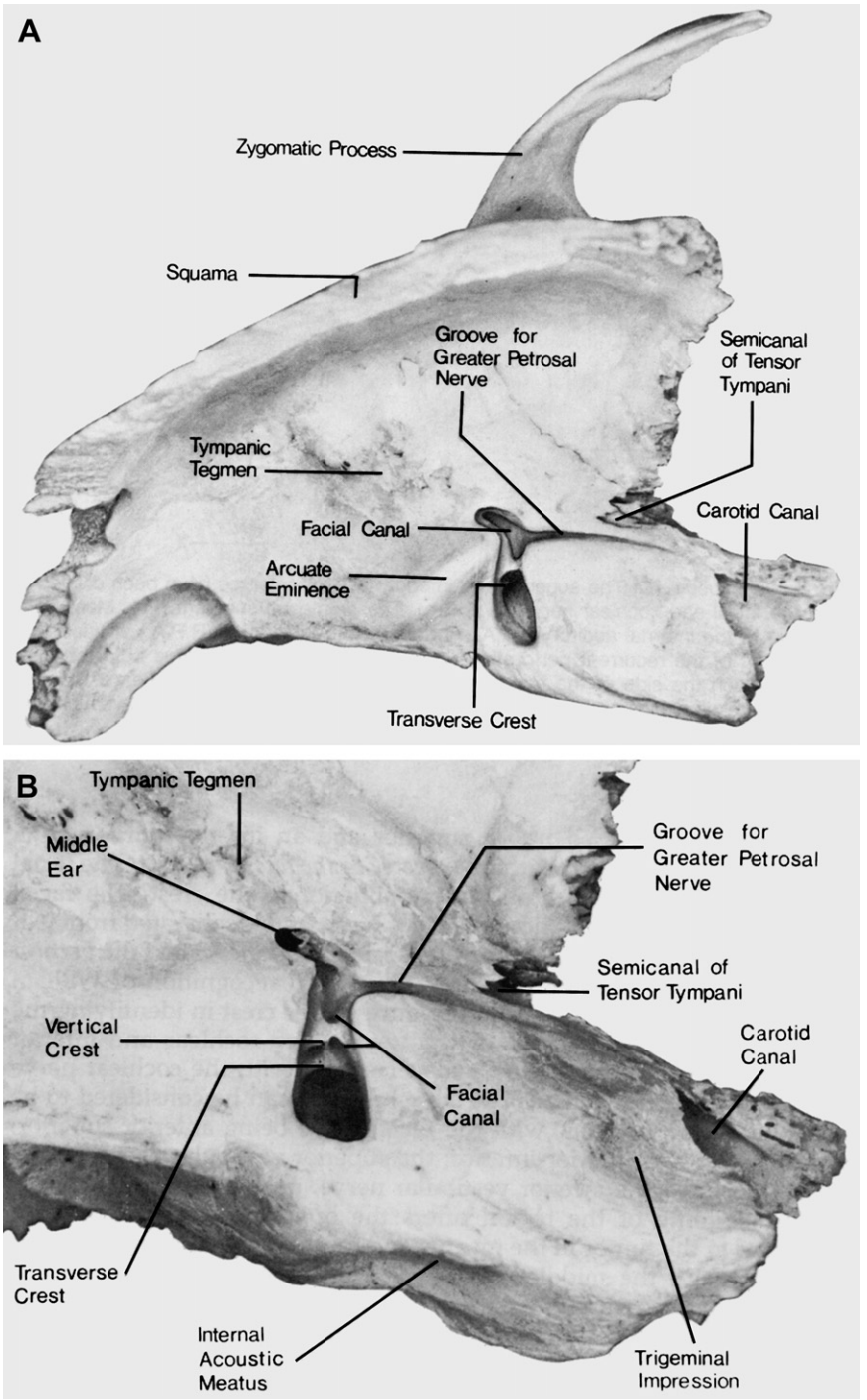
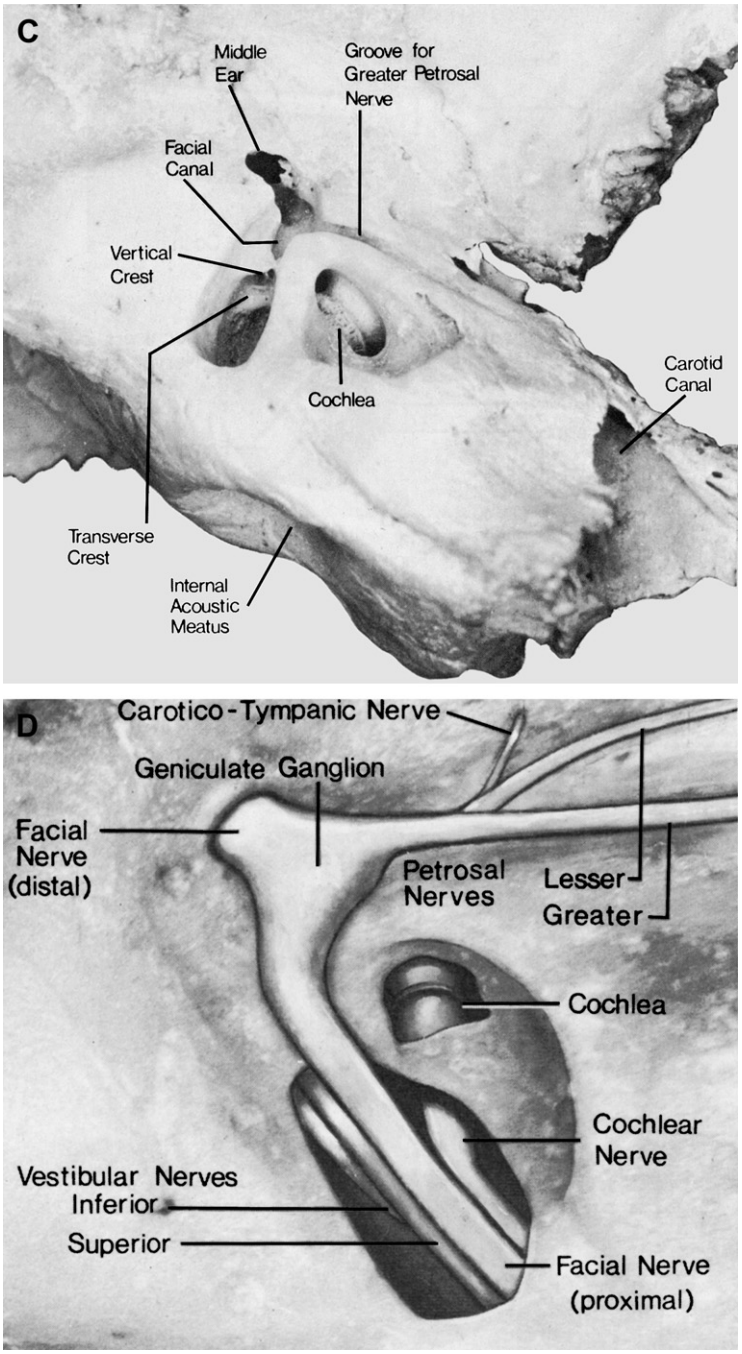


Fig. 2. Middle fossa approach to internal acoustic meatus. (*A*) Superior view of left temporal bone. Facial canal exposed proximal and distal to junction with canal of greater petrosal nerve. Internal auditory meatus unroofed. (*B*) Enlarged view. Vertical and transverse crests exposed at lateral end of internal auditory meatus. (*C*) Cochlea exposed in angle between the groove for the greater petrosal nerve and labyrinthine part of the facial canal. (*D*) Specimen with nerves intact. Dura and bone above facial canal and internal acoustic meatus removed. Cochlear nerve exposed medial to geniculate ganglion. (*E*) Three semicircular canals, nerves in meatus, and carotid artery exposed. (*From* Pait TG, Harris FS, Paullus WS, et al. Microsurgical anatomy and dissection of the temporal bone. Surg Neurol 1977;8:363–91; with permission.)



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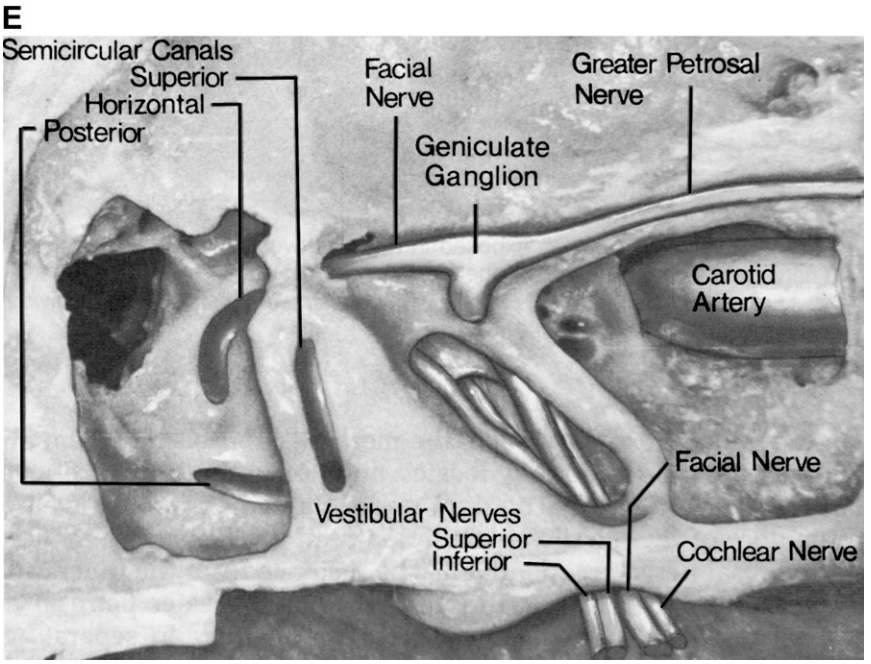


Fig. 2 (*continued*)

middle cranial fossa until the arcuate eminence and greater petrosal nerve are identified. The distance from the inner table of the skull to the facial hiatus, through which the greater petrosal nerve passes, ranges from 1.3 to 2.3 cm (average 1.7 cm) [17]. In separating the dura from the floor of the middle fossa, one should remember that bone may be absent over all or part of the geniculate ganglion. In a previous study of 100 temporal bones, we found that all or part of the geniculate ganglion and genu of the facial nerve was exposed in the floor of the middle fossa in 15 bones (15%) [19]. In 15 other specimens, the geniculate ganglion was completely covered, but there was no bone extending over the greater petrosal nerve. The greatest length of greater petrosal nerve covered by bone was 6 mm. More than 50% of the specimens had less than 2.5 mm of greater petrosal nerve covered.

It is also important to remember that the petrous segment of the carotid artery may be exposed without a covering of bone in the floor of the middle fossa deep to the greater petrosal nerve. In a previous study, we found that a 7-mm length of petrous carotid artery may be exposed without a bony covering in the area below where the greater petrosal nerve passes below the lateral margin of the trigeminal ganglion [5,12]. The foramen spinosum and middle meningeal artery and the foramen ovale and 3rd trigeminal division are situated at the anterior margin of the extradural exposure. The extradural exposure can usually be completed without obliterating the middle meningeal artery at the foramen spinosum. The tensor tympany muscle and eustachian tube, although not exposed in this approach, are located beneath the floor of the middle fossa roughly parallel to and in front of the horizontal portion of the petrous carotid (see Fig. 3).

In completing the middle fossa approach, bone is removed over the greater petrosal nerve to expose the geniculate ganglion and genu of the facial nerve. From here the labyrinthine portion of the facial nerve is followed to the lateral end of the internal auditory canal by removing bone. The lateral part of the bone removal is limited posteriorly by the superior semicircular canal, which is located a few millimeters behind and is oriented parallel to the labyrinthine segment of the facial nerve. The anterior edge of the exposure is limited by the cochlea, which sits only a few millimeters anterior to the site of bone removal in the angle between the labyrinthine portion of the facial nerve and the greater petrosal nerve. It is important that the cochlea and semicircular

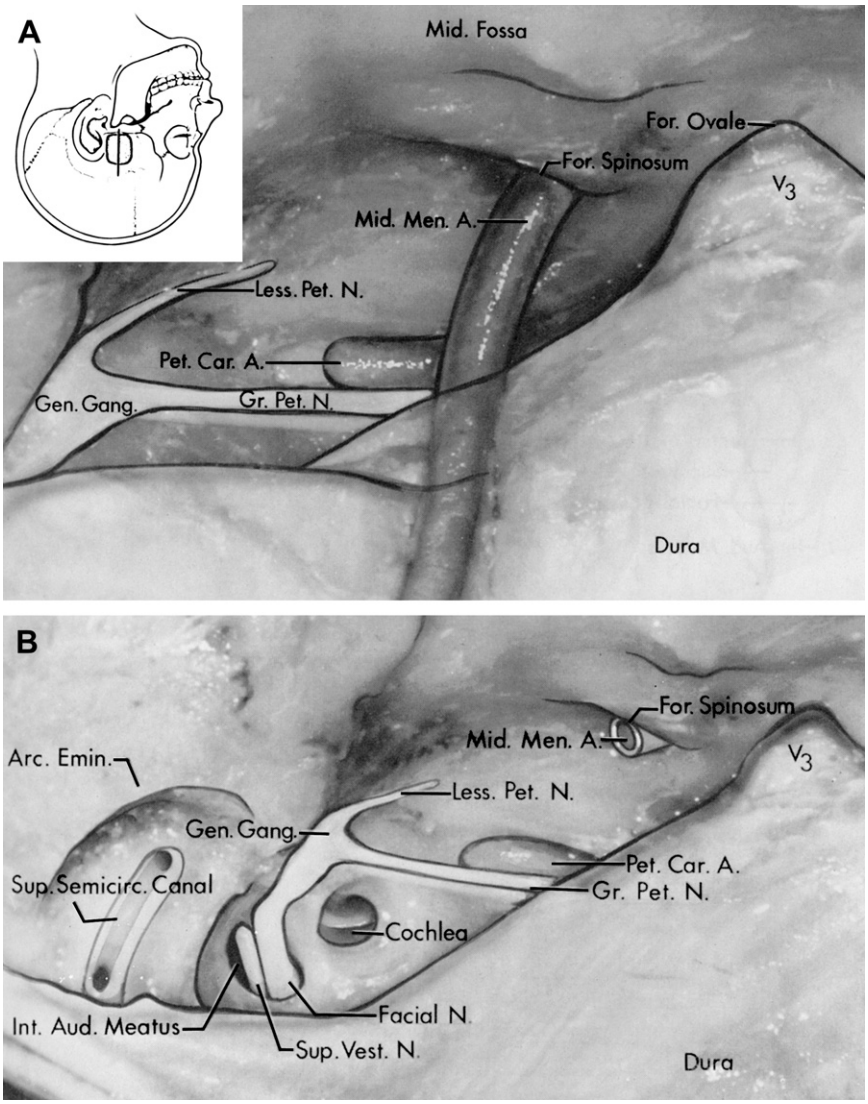


Fig. 3. Anatomy of middle fossa approach to the internal acoustic meatus. (*A*) The insert of the upper left shows the site of the scalp incision (*straight line*) and the site of the craniectomy (*stippled area*). The dura has been elevated on the floor of the middle cranial fossa (Mid. Fossa). In this case, the bone was absent over the geniculate ganglion (Gen. Gang.) and the petrous segment of the carotid artery (Pet. Car. A.) and both were exposed in the floor of the middle fossa. The dura has been elevated from the floor of the middle cranial fossa to expose the middle meningeal artery (Mid. Men. A.) at the foramen spinosum (For. Spinosum), and the third trigeminal division (V3) at the foramen ovale (For. Ovale). The geniculate ganglion is exposed by identifying the greater petrosal nerve and following it to the geniculate ganglion. The lesser petrosal nerve (Less Pet. N.) is also in the exposure. (*B*) The middle meningeal artery was divided at the foramen spinosum and bone was removed over the internal auditory meatus (Int. Aud. Meatus) to expose the superior vestibular (Sup. Vest. N.) and facial nerves (Facial N). Bone has been removed to expose the cochlea in the angle between the greater petrosal nerve and labyrinthine segment of the facial nerve. The superior semicircular canal (Sup. Semicirc. Canal) lies behind the superior vestibular nerve in the area deep to the arcuate eminence (Arc. Emin.). (*C*) The dura has been elevated to expose the gasserian ganglion (Gass. Gang.). The greater petrosal nerve courses above the petrous segment of the carotid artery. Bone has been removed in the floor of the middle fossa to expose the tensor tympany muscle (Tens. Tymp. M.) and eustachian tube (Eust. Tube). The superior vestibular and facial nerves are separated at the lateral end of the meatus by the vertical crest (Vert. Crest—Bill's Bar). (*D*) The facial and cochlear nerves (Cochlear N.) are in the anterior half and the superior and inferior vestibular nerves (Inf. Vest. N.) are in the posterior half of the meatus. The superior vestibular and facial nerves are separted from the inferior vestibular and cochlear nerves by the transverse crest (Trans. Crest). The cochlea sets in the angle between the facial and greater petrosal nerve.

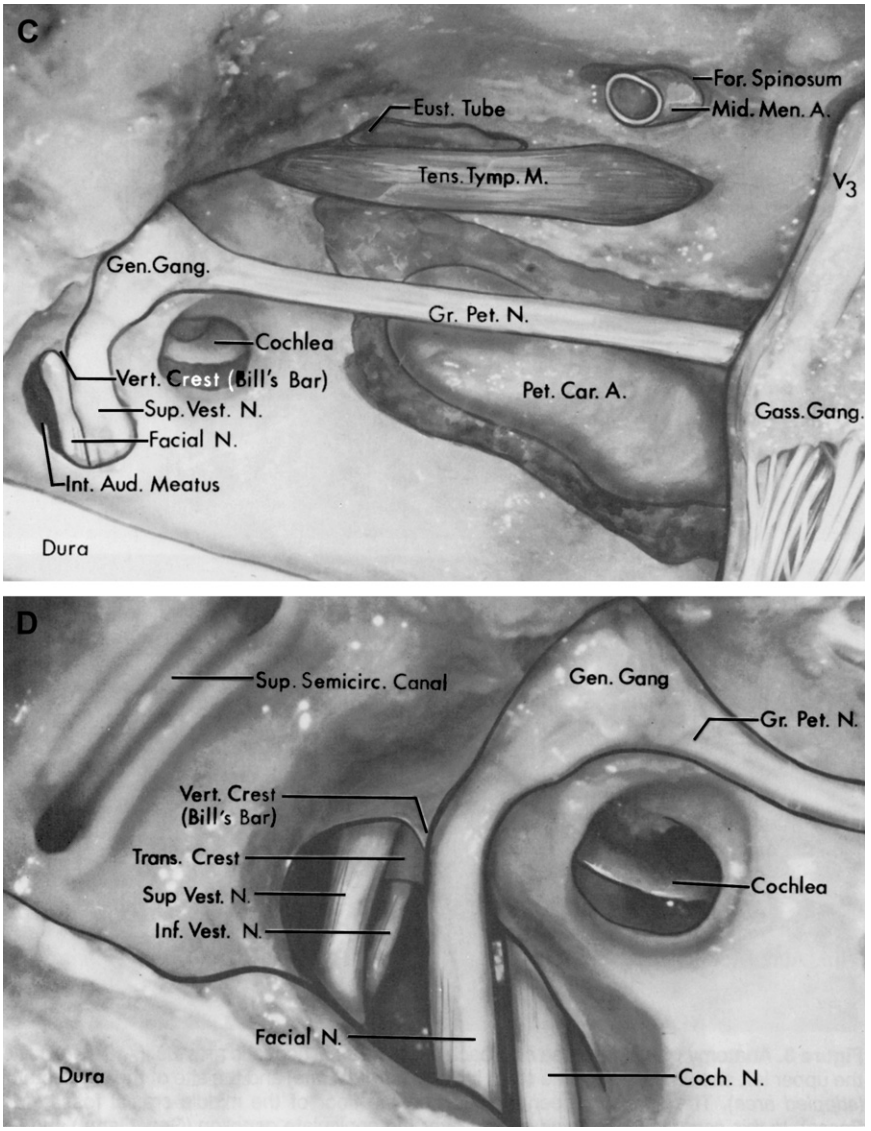


Fig. 3 (*continued*)

canals not be damaged in this approach because it is used only for removing small tumors in which there is an opportunity to preserve hearing. The vertical crest, which is identified at the upper edge of the lateral end of the internal acoustic canal, provides a valuable landmark for identifying the facial nerve. In the final stage of bone removal, the upper wall of the internal auditory canal is removed to expose the dura lining the entire superior surface of the internal auditory canal from the vertical crest to the porus acusticus.

Translabyrinthine approach

In the translabyrinthine approach, the meatus and cerebellopontine angle are approached through a mastoidectomy and labyrinthectomy (Figs. 4 and 5) [6,11]. There are two goals of bone removal in this approach: (1) to remove enough bone to be able to identify the nerves lateral to the tumor as they course through the internal auditory canal and by the transverse and vertical crests and (2) to expose the dura on the posterior

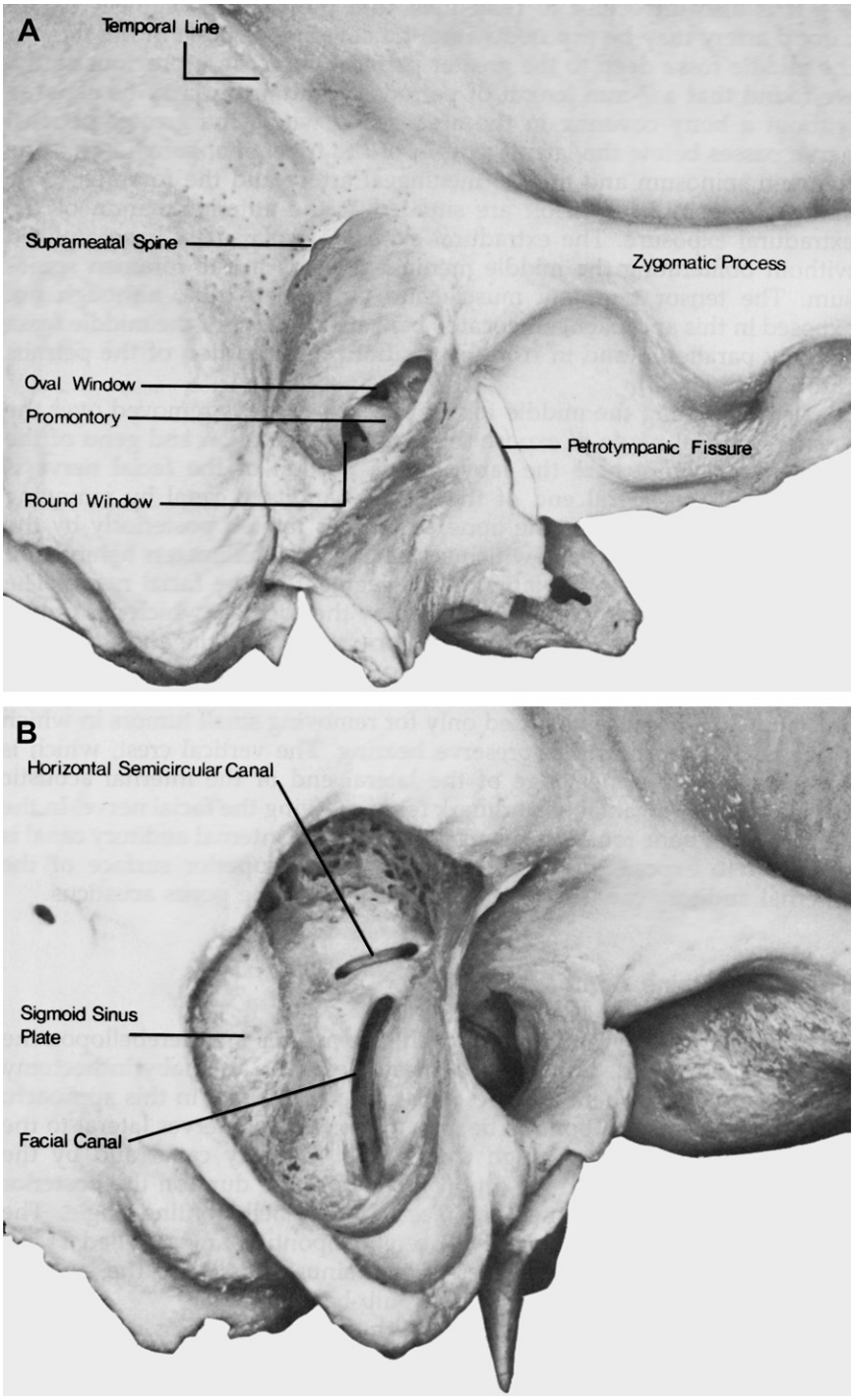
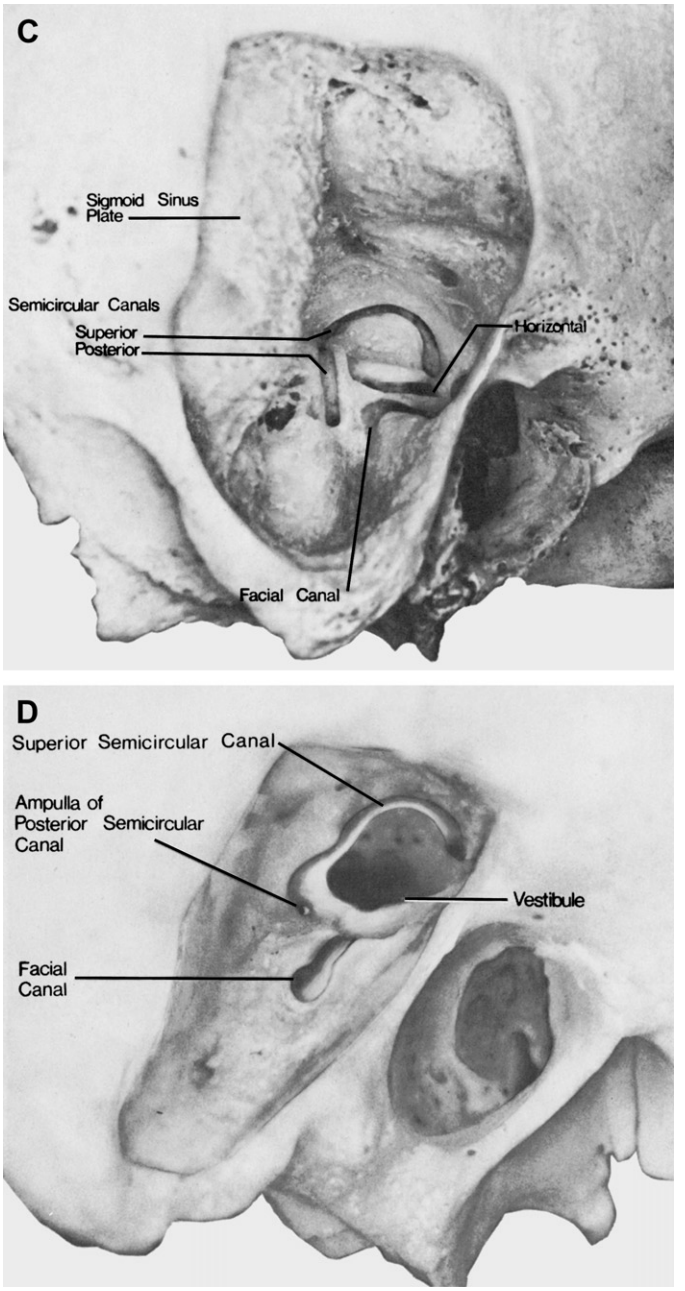


Fig. 4. (*A*) Translabyrinthine approach to the internal acoustic meatus. Lateral view of right temporal bone showing external acoustic meatus, oval and round windows and promontory. (*B*) Sigmoid sinus plate, facial canal and semicircular horizontal canal exposed. (*C*) Three semicircular canals and the facial canal exposed. (*D*) Canals removed to open into vestibule. (*E*) Specimen with nerves intact. Upper part of internal acoustic meatus exposed by drilling through the vestibule and ampulla of posterior canal. (*From* Pait TG, Harris FS, Paullus WS, et al. Microsurgical anatomy and dissection of the temporal bone. Surg Neurol 1977;8:363–91; with permission.)



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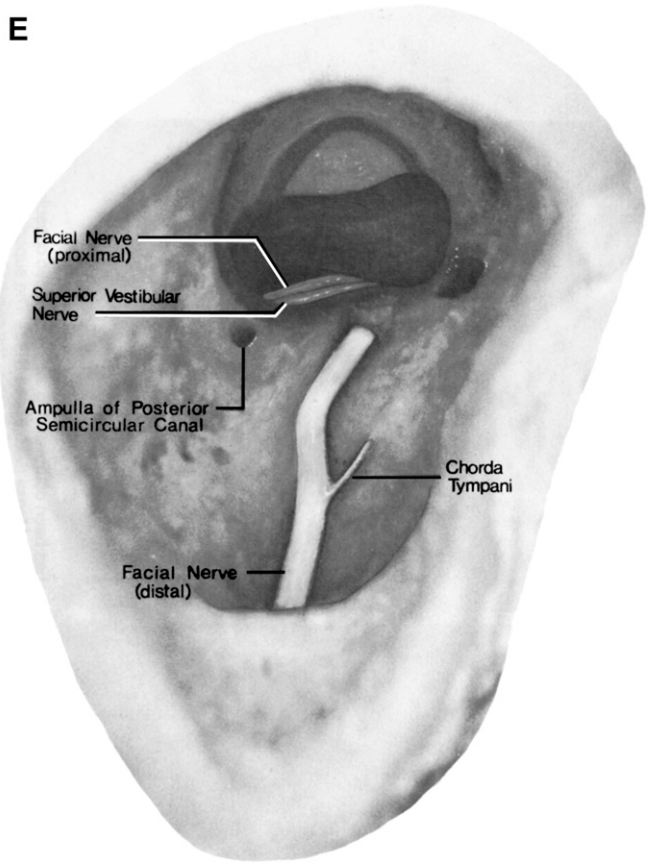


Fig. 4 (*continued*)

face of the temporal bone that faces the cerebellopontine angle. The triangular patch of dura facing the cerebellopontine angle, called *Trautman's triangle,* extends from the sigmoid sinus laterally to the superior petrosal sinus above and the jugular bulb below.

In the translabyrinthine exposure, the mastoid cortex is opened, and the exposure is directed through the triangular gateway between the facial nerve anteriorly, the sigmoid sinus posteriorly, and floor of the middle fossa above. Bone is removed to skeletonize the dura covering the sigmoid sinus; middle fossa; facial nerve; the angle between the sigmoid sinus and middle fossa dura, called the *sinodural angle;* and the upper surface of the jugular bulb. The mastoidectomy is carried down to the horizontal semicircular canal, which provides the landmark for identifying the other canals and the facial nerve.

The labyrinthectomy portion of the procedure involves removing the semicircular canals and vestibule to expose the dura lining the internal auditory canal. In the process of removing the semicircular canals, the dura of the middle fossa above the internal acoustic meatus is skeletonized, and the dura on the posterior fossa plate behind the canal is exposed. After opening and removing the canals, the vestibule is opened and removed, and the dura lining the posterior half of the internal auditory canal is exposed. Care is required to avoid injury to the facial nerve as it courses below the horizontal canal and the ampullae of the posterior canal and around the superolateral margin of the vestibule. Further bone removal at the lateral end of the meatus exposes the transverse and vertical and facial nerves. In removing bone behind the internal acoustic meatus, it is important to remember that the jugular bulb may bulge upward behind the posterior semicircular canal or internal auditory meatus. The vestibular aqueduct and endolymphatic sac are opened and removed as bone is

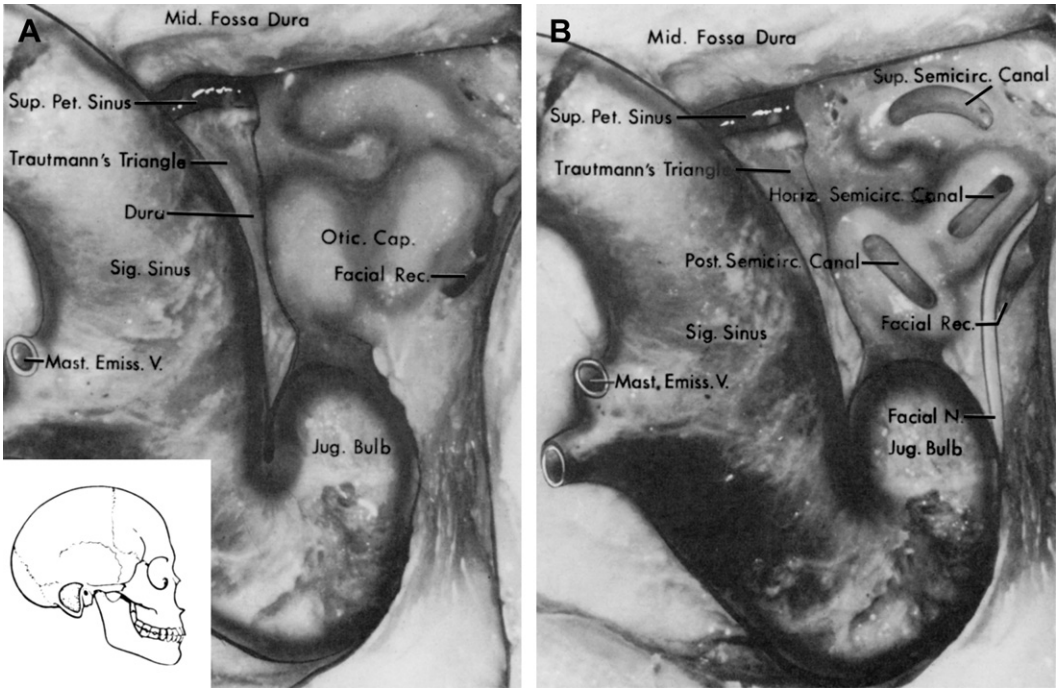
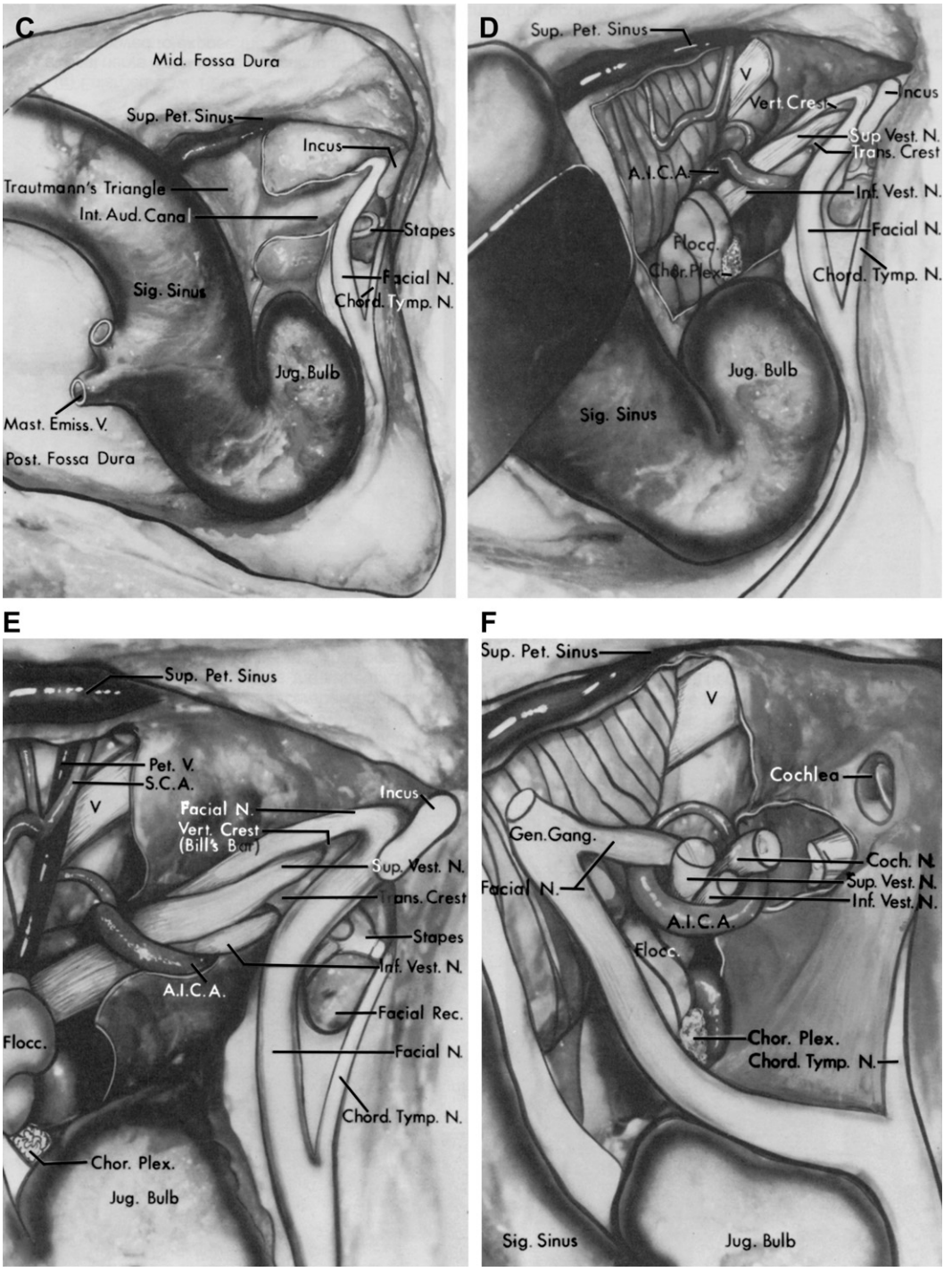


Fig. 5. (*A*) Translabyrinthine and transcochlear exposure. A mastoidectomy has been completed to expose the otic capsule (Otic Cap.), the sigmoid sinus (Sig. Sinus), jugular bulb (Jug. Bulb) and the dura lining the floor of the middle cranial fossa (Mid. Fossa Dura). The superior petrosal sinus (Sup. Pet. Sinus) extends medially from the sinodural angle. Trautman's triangle is the triangular portion of dura that faces the cerebellopontine angle. This triangle is located between the superior petrosal sinus above, the sigmoid sinus laterally, and the jugular bulb below. Mastoid emissary veins (Mast. Emiss. V.) join the sigmoid sinus. The facial recess (Facial Rec.) is located in front of the facial nerve. (*B*) Additional bone has been removed to expose the horizontal (Horiz. Semicirc. Canal), posterior (Post. Semicirc. Canal), and superior semicircular canals (Sup. Semicirc Canal). The facial nerve passes below the horizontal canal. (*C*) The semicircular canals and vestibule have been removed to expose the dura lining the internal auditory canal (Int. Aud. Canal). The chorda tympany (Chor. Tymp. N.) arises from the facial nerve. The posterior fossa dura (Post. Fossa Dura) is behind the sigmoid sinus. (*D*) The dura lining the internal auditory canal and facing the cerebellopontine angle has been removed to expose the trigeminal (V), facial, and vestibulocochlear nerves. The transverse crest (Trans. Crest) separates the superior (Sup. Vest. N.) and inferior vestibular nerves (Inf. Vest. N.). The vertical crest (Vert. Crest) separates the facial and superior vestibular nerves. The flocculus (Flocc.) is behind the vestibulocochlear nerve. Choroid plexus (Chor. Plex) protrudes from the foramen of Luschka. The anterior inferior cerebellar artery (A.I.C.A.) courses around the facial and vestibulocochlear nerves. The superior cerebellar artery (S.C.A.) courses above the trigeminal nerve. (*E*) Enlarged view. Petrosal veins (Pet. V.) join the superior petrosal sinus. (*F*) The facial nerve has been transposed posteriorly after dividing the greater petrosal nerve distal to the geniculate ganglion. The superior and inferior vestibular and cochlear nerves (Coch. N.) have been divided. Additional bone has been removed to expose the cochlea. The distal segment of the cochlear nerve penetrates the lateral end of the meatus to enter the cochlea. (*G*) The bone surrounding the cochlea has been removed to complete the transcochlear exposure. The bone removal extends to the lateral margin of the clivus and the inferior petrosal sinus (Inf. Pet. Sinus). The abducens nerve (VI) ascends beside the basilar artery (Bas. A.). The glossopharyngeal (IX) and vagus (X) nerves are in the lower margin of the exposure behind the vertebral artery (Vert. A.). (*H*) Another dissection. The jugular bulb has been removed to expose the glossopharyngeal, vagus, and accessory (XI) nerves as they course through the medial side of the jugular foramen. The internal carotid artery (Car. A.) and eustachian tube (Eust. Tube) are in the anterior part of the exposure.



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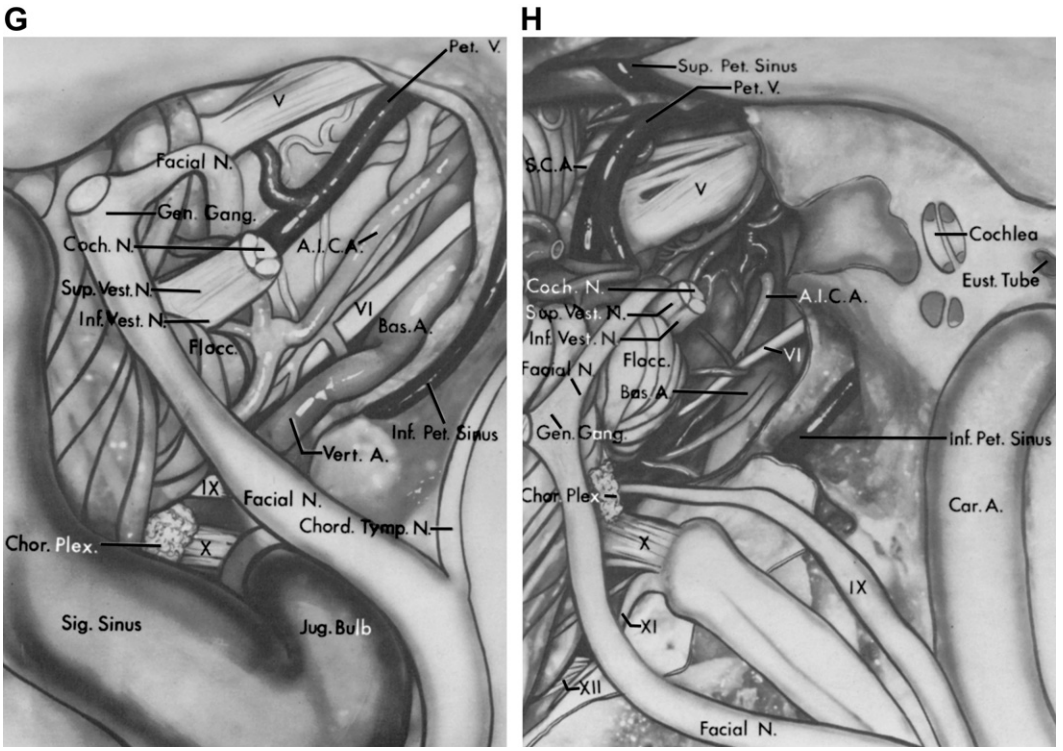


Fig. 5 (*continued*)

removed between the meatus and the jugular bulb. The cochlear cana-liculus is seen deep to the vestibular aqueduct as bone is removed in the area between the meatus and the jugular bulb. The lower end of the cochlear canaliculus is situated just above the area where the glosso-pha-ryngeal nerve enters the medial side of the jugular foramen.

The subarcuate artery, or the anterior-inferior cerebellar artery, may be encountered in the dura of Trautman's triangle. Commonly the subarcuate artery, which arises from the anterior-inferior cerebellar artery, passes through the dura on the upper posterior wall of the meatus as a fine stem, but, on occasion, the subarcuate artery along with its origin from the anterior-inferior cerebellar artery may be incorporated into the dura and dip into the subarcuate fossa, on the posterior face of the temporal bone.

Retrosigmoid approach

The retrosigmoid approach to the meatus is directed through a cranial opening situated just behind the sigmoid sinus and down the plane between the posterior face of the temporal bone and the anterior surface of the cerebellum (Fig. 6) [13,14,15]. In removing the posterior meatal wall, it is often necessary to sacrifice the subarcuate artery because it passes through the dura on the posterior meatal wall to reach the subarcuate fossa [8]. This artery usually has a sufficiently long stem that its obliteration does not risk damage to the anterior-inferior cerebellar artery from which it arises. In a few cases, however, the subarcuate artery and the segment of the anterior-inferior cerebellar arteries from which it arises are incorporated into the dura covering the subarcuate fossa. In this situation, the dura and artery have to be separated together from the posterior meatal lip in preparation for opening the meatus from posteriorly.

The posterior wall of the internal auditory canal may be removed before opening the arachnoid membrane around the tumor. The preservation of the arachnoid membrane that lies posterior to an acoustic neuroma during the removal of the posterior meatal wall with a drill prevents bone dust from entering the subarachnoid space. The posterior semicircular canal and its common crus

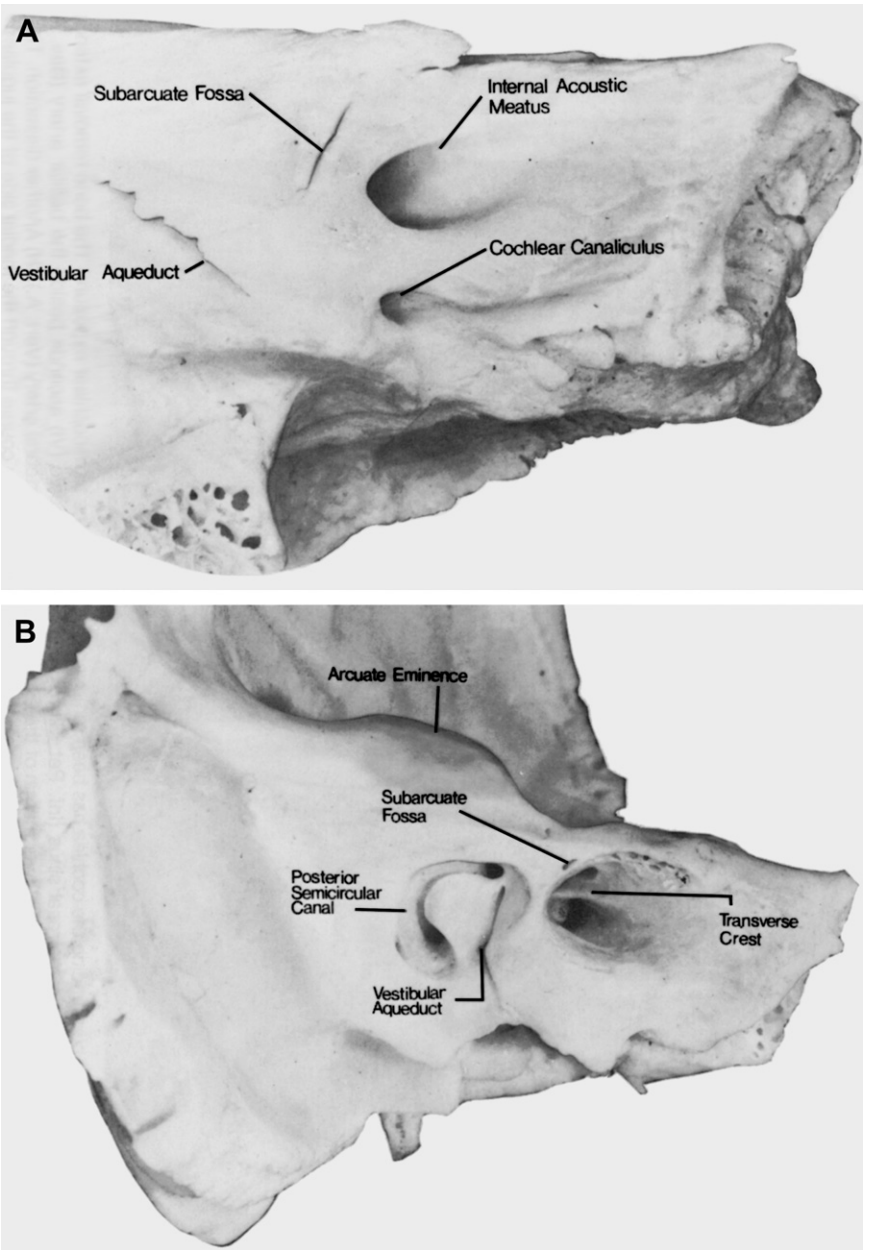


Fig. 6. Posterior fossa approach to internal acoustic meatus. (*A*) Posterior view of left temporal bone showing the subarcuate fossa, vestibular aqueduct, and cochlear canaliculus. (*B*) Bone removed to expose anteromedial part of transverse crest, vestibular aqueduct, and posterior semicircular canal. (*C*) Relationship of the three semicircular canals to the internal acoustic meatus. Horizontal canal exposed by removing bone anterior to posterior canal and lateral to superior canal. (*D*) Bone removed to show the lateral end of internal acoustic meatus. Transverse crest separates facial canal and superior vestibular area from cochlear and inferior vestibular areas. The vertical crest (Bill's bar) separates the facial canal and the superior vestibular area. (*E*) Enlarged view of the lateral end of canal. (*F*) Temporal bone with$_{v}$ nerves preserved. Posterior wall of internal auditory meatus removed to expose the nerves. (*G*) Bone removed lateral to the internal auditory canal to expose the posterior and superior semicircular canals. (*From* Pait TG, Harris FS, Paullus WS, et al. Microsurgical anatomy and dissection of the temporal bone. Surg Neurol 1977;8:363–91; with permission.)

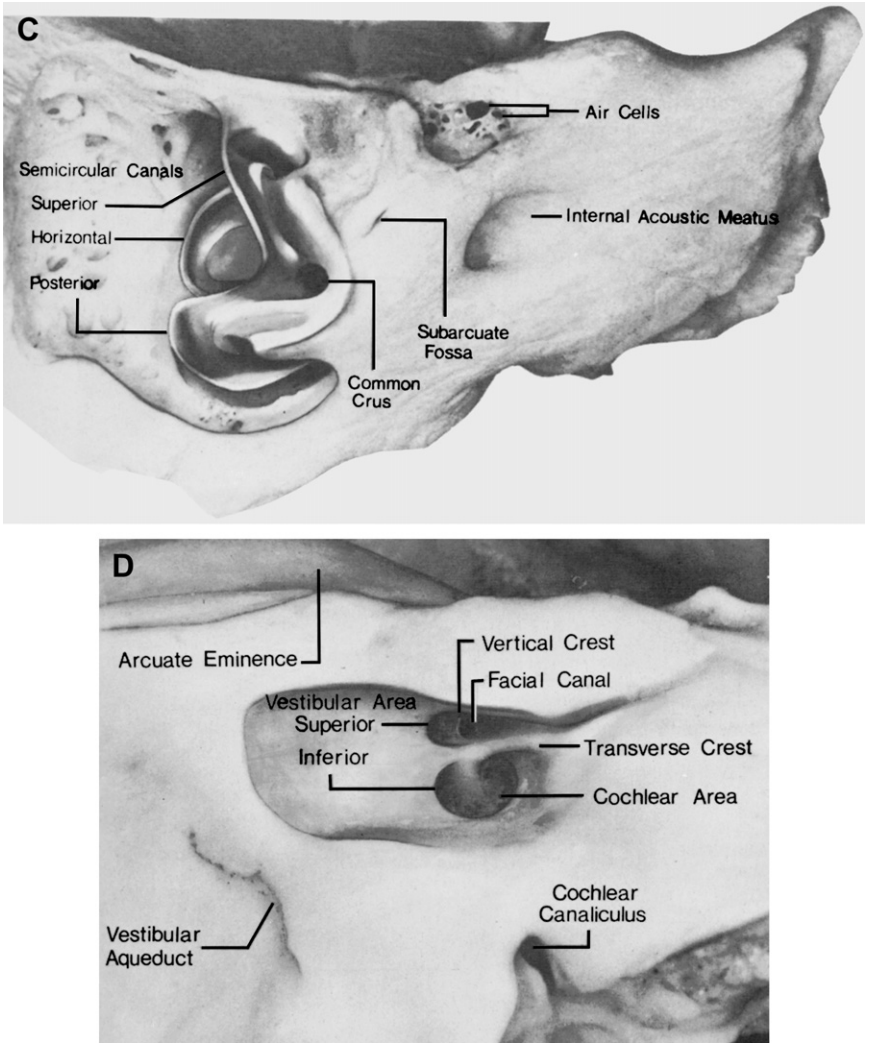


Fig. 6 (*continued*)

with the superior canal, both of which are situated just lateral to the posterior meatal lip, should be preserved in exposing the meatal contents if there is the possibility of preserving hearing because hearing will be lost if they are damaged. Care is also required to avoid injury to the vestibular aqueduct, which is situated inferolateral to the meatal lip and the endolymphatic sac, which expands under the dura on the posterior surface of the temporal bone inferolateral to the posterior meatal lip. The endolymphatic sac may be entered in removing the dura from the posterior meatal lip. There is little danger of encountering the cochlear canaliculus, which has a more anterior course below the internal auditory canal. An anomaly that may block access to the posterior meatal lip is an unusually high projection of the jugular bulb. Mastoid air cells are commonly encountered in the posterior meatal lip.

After removing the posterior wall of the meatus, the dura lining the meatus is opened to expose its contents. The facial nerve is identified near the origin of the facial canal at the anterior-superior quadrant of the meatus rather than in a more medial location, where the direction of displacement is variable. It is easy to expose the

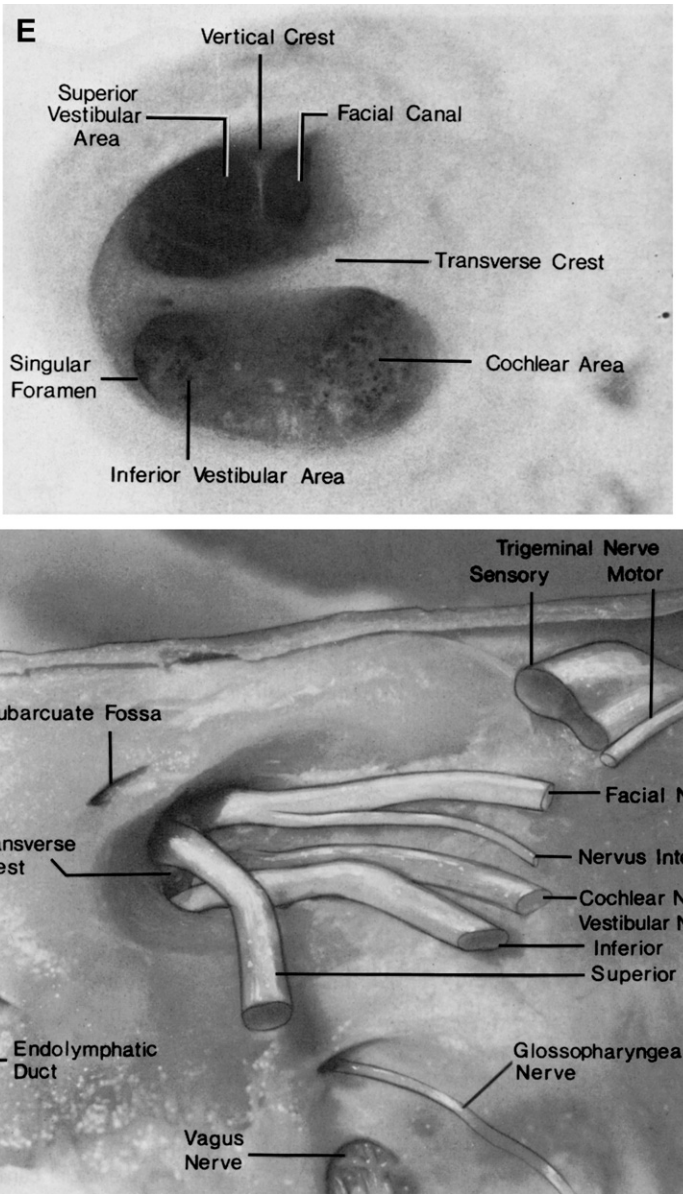


Fig. 6 (*continued*)

vestibule if the tumor extends into the vestibule by drilling along the posterior and superior semicircular canals.

Nervus intermedius

The filaments of the nervus intermedius are also stretched around an acoustic neuroma (Fig. 7). The nervus intermedius is usually described as a component of the facial nerve. Relatively little note has been taken of the fact that it may be closely bound to the vestibulocochlear nerve for a variable distance before it enters the brain stem and that in the cerebellopontine angle it may consist of as many as four rootlets. In previous studies, we found that the nervus intermedius is divisible into three parts: (1) a proximal segment that adheres closely to

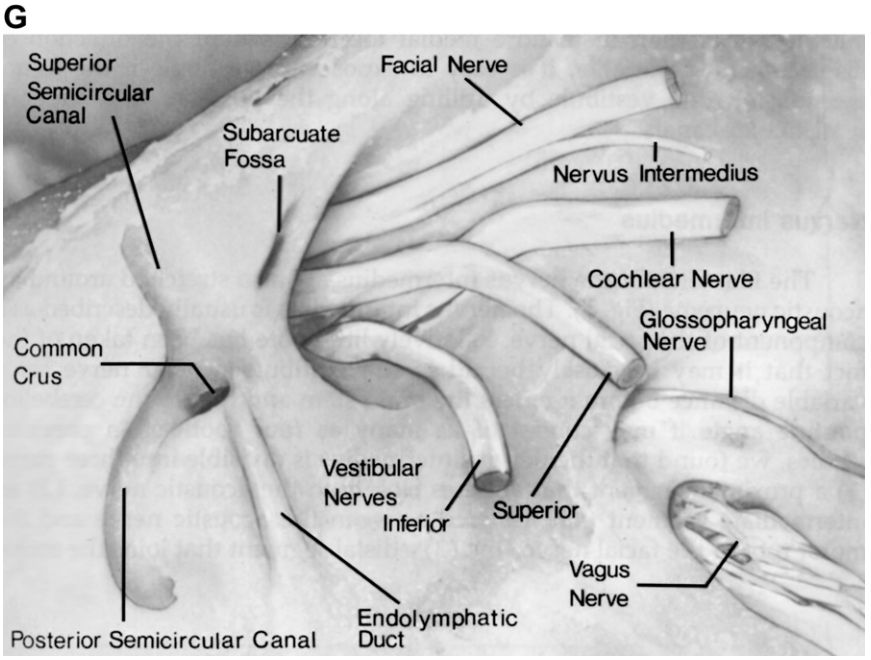


Fig. 6 (*continued*)

the acoustic nerve, (2) an intermediate segment that lies free between the acoustic nerve and the motor root of the facial nerve, and (3) a distal segment that joins the motor root to form the facial nerve [18]. Twenty-two percent of the nerves were adherent to the acoustic nerve for 14 mm or more (the entire course of the nerve in the posterior cranial fossa) and could be found as separate structures only after opening the internal acoustic meatus (see Fig. 7). In most instances, the nerve was a single trunk, but in some cases it was composed of as many as four rootlets. A single large root most frequently arose at the brain stem anterior to the superior vestibular nerve and, in the meatus, lay anterior to the superior vestibular nerve. When multiple rootlets are present, they may arise along the whole anterior surface of the acoustic nerve; however, they usually converge immediately proximal to the junction with the facial motor root to form a single bundle that lies anterior to the superior vestibular nerve.

Brain stem relationships

There is a consistent set of neural, arterial, and venous relationships at the brain stem that facilitate identification of the nerves on the medial side of the tumor [16].

Neural relationships

The neural structures most intimately related to the medial side of an acoustic neuroma are the pons, medulla, and cerebellum (Figs. 8 and 9). The landmarks on these structures that are helpful in guiding the surgeon to the junction of the facial nerve with the brain stem are the pontome-dullary sulcus; the junction of the glossopharyngeal, vagus, and accessory nerves with the medulla; the foramen of Luschka and its choroid plexus; and the flocculus.

Pontomedullary sulcus

The facial nerve arises from the brain stem near the lateral end of the pontomedullary sulcus. This sulcus extends along the junction of the pons and the medulla and ends immediately in front of the foramen of Luschka and the lateral recess of the 4th ventricle (see Fig. 8). The facial nerve arises in the pontomedullary sulcus 1 to 2 mm anterior to the point at which the vestibulocochlear nerve joins the brain stem at the lateral end of the sulcus. The interval between the vestibulocochlear and facial nerves is greatest at the level of

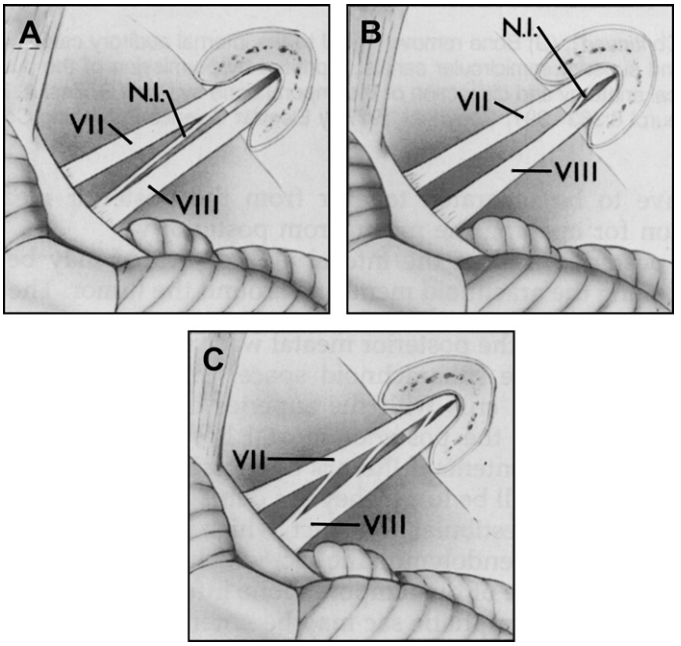
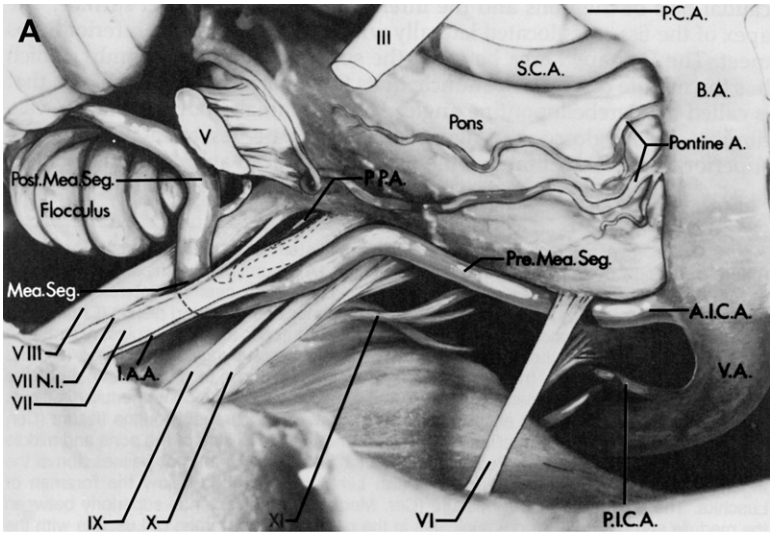
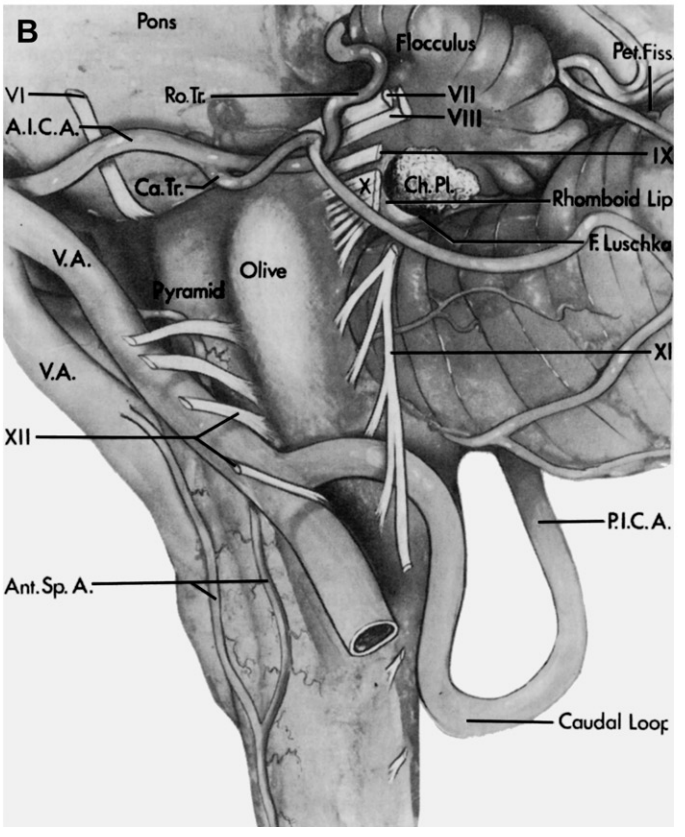
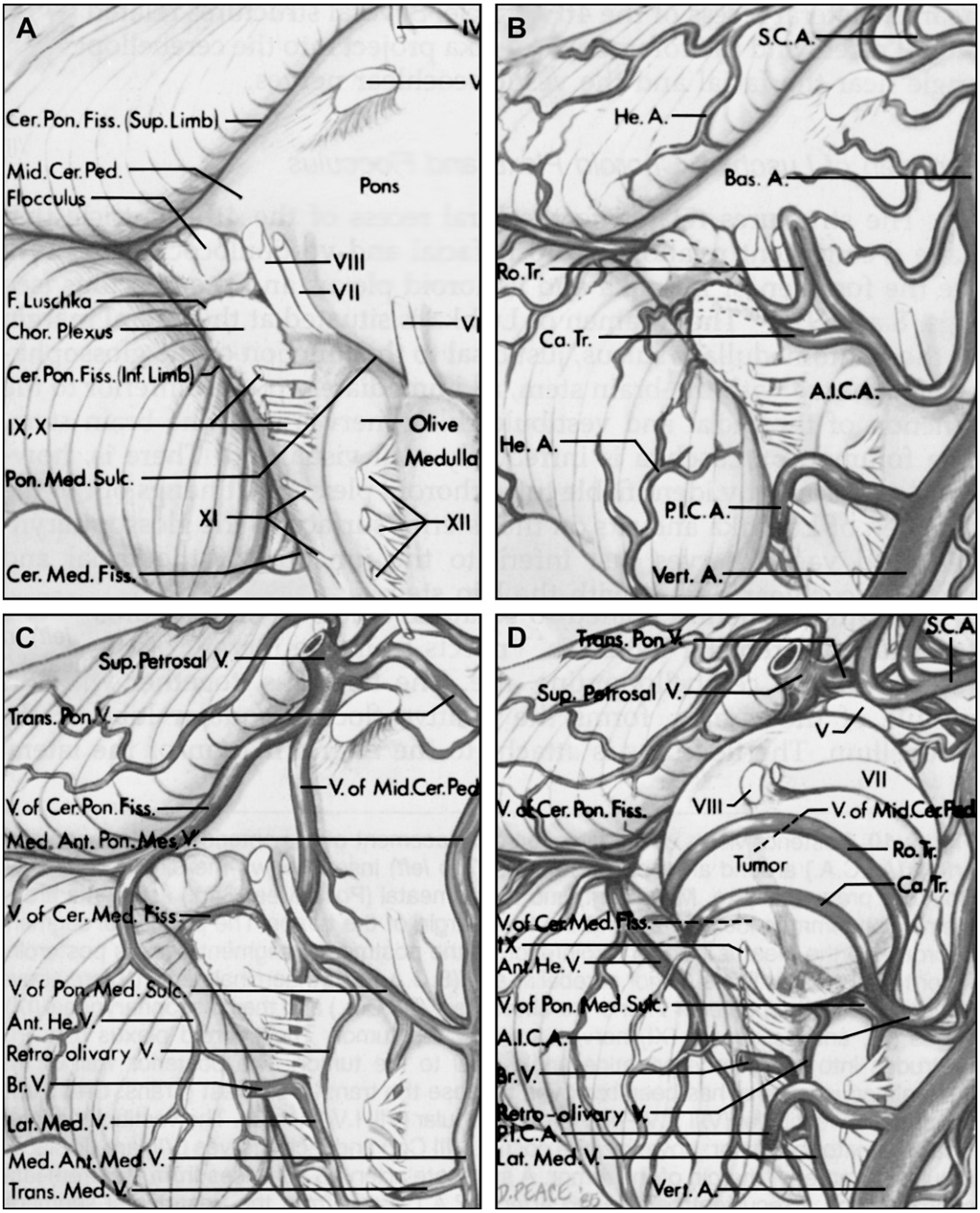


Fig. 7. View of cerebellopontine angle from above to show relationship of nervus intermedius to seventh (VII) and eighth (VIII) nerves. (*A*) Most common relationship. Nervus intermedius (N.I.) is joined to ventral surface of eighth nerve for a few millimeters adjacent to brain stem, then has a free segment in the cerebellopontine angle in its course to join the facial motor root. (*B*) Pattern present in 20% of nerves studied; free segment is entirely in meatus. (*C*) Nervus intermedius consists of three free segments. Two are in cerebellopontine angle, and one is in meatus. Nervus intermedius in A could be exposed in cerebellopontine angle without drilling off posterior lip of meatus. In B, it could not be found in the angle but only in the meatus.

Fig. 8. (*A*) Anterosuperior view of the right cerebellopontine angle. The right anterior inferior cerebellar artery (A.I.C.A.) arises from the basilar artery (B.A.), courses below the abducens nerve (VI), and passes between the nervus intermedius (VII N.I.) and the facial nerve (VII) anteriorly, and the vestibulocochlear nerve (VIII) posteriorly. The premeatal segment (Pre. Mea. Seg.) of the anterior inferior cerebellar artery passes below the abducens nerve. The meatal segment (Mea. Seg.) passes between the vestibulocochlear nerve and the nervus intermedius, and the postmeatal segment (Post. Mea. Seg.) passes above the flocculus. A recurrent perforating (R.P.A.) and an internal auditory artery (I.A.A.) arise from the meatal segment. Pontine arteries (Pontine A.) arise from the right side of the basilar artery. The oculomotor (III) and trochlear (IV) nerves are above and the trigeminal (V) nerve is below the superior cerebellar artery (S.C.A.). The right posterior inferior cerebellar artery (P.I.C.A.) arises from the right vertebral artery (V.A.) and courses by the glossopharyngeal (IX), vagus (X), accessory (XI) and hypoglossal (XII) nerves. The posterior cerebral artery (P.C.A.) is at the upper margin of the exposure. (*B*) Anterolateral view of the brain stem. A line drawn along the origin of the glossopharyngeal, vagus, and accessory nerves along the postolivary sulcus will pass through the site at which the facial nerve exits the brain stem. The facial nerve usually exits the brain stem 2 to 3 mm rostral to where the glossopharyngeal nerve enters the brain stem. The rootlets of the hypoglossal nerves arise along the preolivary sulcus. The glossopharyngeal and vagus nerves course anterior to the lateral recess of the fourth ventricle and the choroid plexus (Ch. PI.) protruding from the foramen of Luschka (F. Luschka). The facial vestibulocochlear nerves arise above the glossopharyngeal nerve near the peduncle of the flocculus. The anterior inferior cerebellar artery gives rise to a rostral (Ro. Tr.) and a caudal (Ca. Tr.) trunk. The rostral trunk courses above the flocculus to reach the petrosal fissure (Pet. Fiss.). The caudal trunk passes interiorly. The anterior spinal arteries (Ant. Sp. A) arise from the vertebral arteries. (*A from* Martin RG, Grant JL, Peace DA, et al. Microsurgical relationships of the anterior inferior cerebellar artery and the facial-vestibulocochlear nerve complex. Neurosurgery 1980;6:438–507; with permission. *B from* Lister JR, Rhoton AL Jr, Matsushima T, et al. Microsurgical anatomy of the posterior inferior cerebellar artery. Neurosurgery 1982;10:170–99; with permission.)


A
P.C.A.
III
S.C.A.
B.A.
Pons
V
Pontine A.
Post. Mea. Seg.
Flocculus
P.P.A.
Pre. Mea. Seg.
Mea. Seg.
A.I.C.A.
VIII
VII N.I.
VII
I.A.A.
V.A.
IX
X
XI
VI
P.I.C.A.


B
Pons
Flocculus
Pet. Fiss.
VI
Ro. Tr.
VII
VIII
A.I.C.A.
IX
Ca. Tr.
X
Ch. Pl.
Rhomboid Lip
F. Luschka
V.A.
Olive
Pyramid
XI
V.A.
XII
P.I.C.A.
Ant. Sp. A.
Caudal Loop


A
IV
V
Cer. Pon. Fiss. (Sup. Limb)
Mid. Cer. Ped.
Flocculus
Pons
VIII
VII
F. Luschka
Chor. Plexus
VI
Cer. Pon. Fiss. (Inf. Limb)
IX, X
Olive
Medulla
Pon. Med. Sulc.
XI
XII
Cer. Med. Fiss.
B
S.C.A.
He. A.
Bas. A.
Ro. Tr.
Ca. Tr.
A.I.C.A.
He. A.
P.I.C.A.
Vert. A.
C
Sup. Petrosal V.
Trans. Pon. V.
V. of Mid. Cer. Ped.
V. of Cer. Pon. Fiss.
Med. Ant. Pon. Mes. V.
V. of Cer. Med. Fiss.
V. of Pon. Med. Sulc.
Ant. He. V.
Retro-olivary V.
Br. V.
Lat. Med. V.
Med. Ant. Med. V.
Trans. Med. V.
D
Trans. Pon. V.
S.C.A.
Sup. Petrosal V.
V
VII
VIII
V. of Cer. Pon. Fiss.
V. of Mid. Cer. Ped.
Tumor
Ro. Tr.
Ca. Tr.
V. of Cer. Med. Fiss.
IX
Ant. He. V.
V. of Pon. Med. Sulc.
A.I.C.A.
Br. V.
Retro-olivary V.
P.I.C.A.
Lat. Med. V.
Vert. A.
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the pontomedullary sulcus and decreases as these nerves approach the meatus.

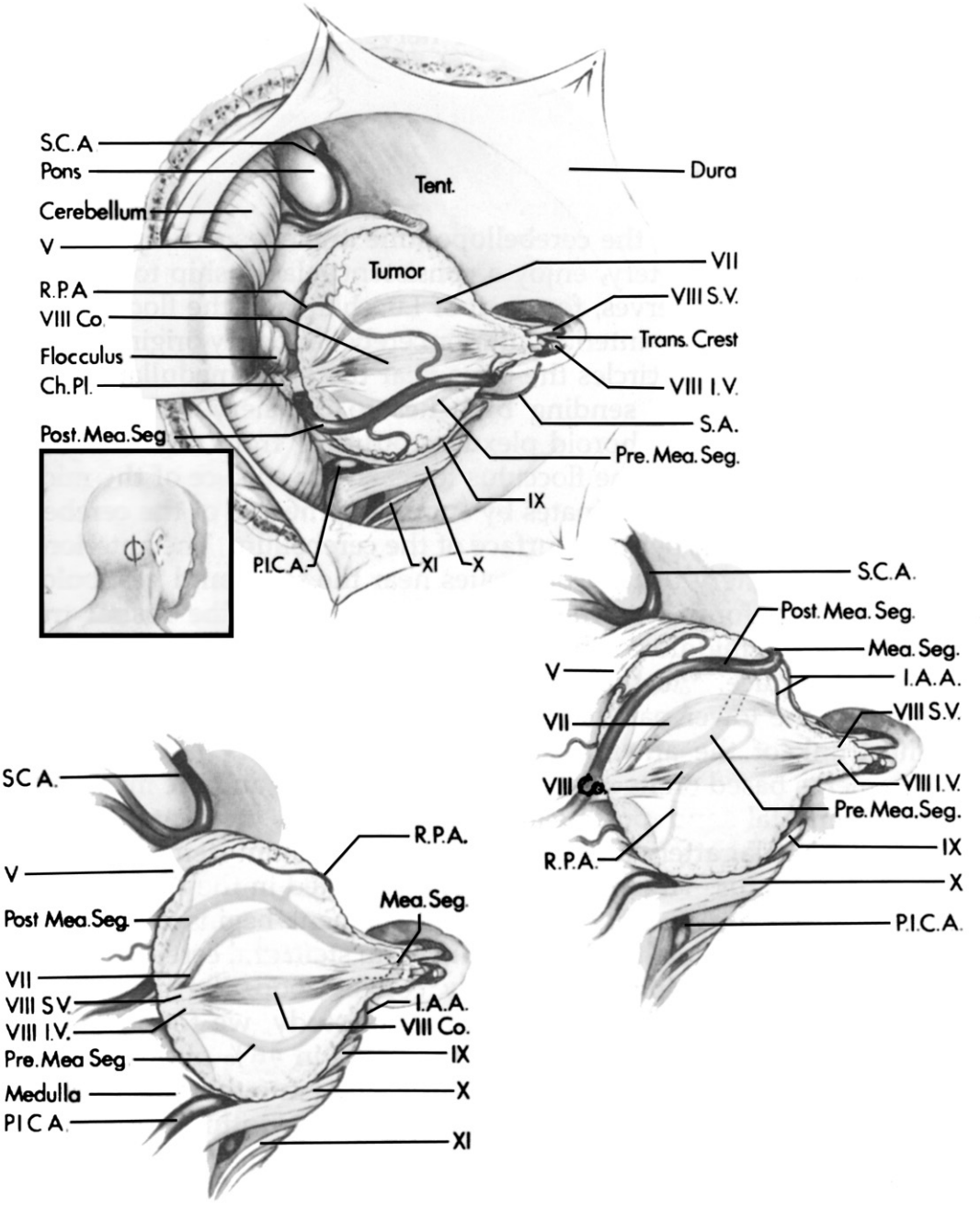
Glossopharyngeal, vagus, and accessory nerves

The facial nerve enjoys a consistent relationship to the junction of the glossopharyngeal, vagus, and accessory nerves with the lateral side of the medulla (see Figs. 8 and 9). The facial nerve arises 2 to 3 mm above the most rostral rootlet contributing to these nerves. A helpful way of visualizing the point where the facial nerve exits from the brain stem, even when displaced by tumor, is to project an imaginary line along the medullary junction of the rootlets forming the glossopharyngeal, vagal, and accessory nerves, upward through the pontomedullary junction. This line, at a point 2 to 3 mm above the junction of the glossopharyngeal nerve with the medulla, passes through the pontomedullary junction at the site where the facial nerve exits from the brain stem. The glossopharyngeal and vagus nerves are seen and should be carefully protected below the lower margin of the tumor in both the translabyrinthine and the retrosig-moid approaches.

Cerebellar–brain stem fissures

Acoustic neuromas are closely related to the cerebellopontine and cerebellomedullary fissures, the clefts formed by the folding of the cerebellum around the pons and medulla (see Fig. 9) [10].

Fig. 9. Neurovascular relationships on the brain stem side of an acoustic neuroma. Anterolateral view of the right cerebellopontine angle. (*A*) Neural relationships. The facial (VII) and vestibulocochlear (VIII) nerves arise from the brain stem near the lateral end of the pontomedullary sulcus (Pon. Med. Sulc), anterior-superior to the choroid plexus (Chor. Plex.) protruding from the foramen of Luschka (F. Luschka), anterior to the flocculus, rostral to a line drawn along the junction of the rootlets of the glossopharyngeal (IX), vagus (X), and accessory (XI) nerves with the brain stem, and slightly posterior to the rostral pole of the inferior olive. The abducent nerve (VI) arises in the medial part of the pontomedullary sulcus. The hypoglossal rootlets (XII) arise anterior to the olive. The cerebellopontine fissure (Cer. Pon. Fiss) formed by the cerebellum wrapping around the lateral side of the pons and middle cerebellar peduncle (Mid. Cer. Ped) has a superior limb (Sup. Limb) that passes above the trigeminal nerve (V), and an inferior limb (Inf. Limb) that extends below the foramen of Luschka. The cerebellomedullary fissure (Cer. Med. Fiss.) that extends superiorly between the medulla and cerebellum communicates in the region of the foramen of Luschka with the cerebellopontine fissure. The trochlear nerve (IV) is above the trigeminal nerve. (*B*) Arterial relationships. The anterior inferior cerebellar artery (A.I.C.A.) arises from the basilar artery (Bas. A.) and divides into rostral (Ro. Tr.) and caudal (Ca. Tr.) trunks. The rostral trunk, which is usually the larger of the two trunks, courses below the facial and vestibulocochlear nerves, and then above the flocculus to reach the surface of the middle cerebellar peduncle. The posterior inferior cerebellar artery (P.I.C.A.) arises from the vertebral artery (Vert. A.) and passes first between the hypoglossal rootlets, and then between the vagus and accessory nerves on its way to the cerebellar hemisphere. The superior cerebellar artery (S.C.A.) passes above the trigeminal nerve. The cerebellar arteries give rise to hemispheric branches (He. A.). (*C*) Venous relationships. The veins that converge on the junction of the facial and vestibulocochlear nerves with the brain stem are the veins of the pontomedullary sulcus (V. of Pon. Med. Sulc), cerebellomedullary fissure (V. of Cer. Med. Fiss), middle cerebellar peduncle (V. of Mid. Cer. Ped.) and the retro-olivary (Retro-olivary V.) and lateral medullary veins (Lat. Med. V.). The vein of the cerebellopontine fissure (V. of Cer. Pon. Fiss.) that passes above the flocculus on the middle cerebellar peduncle is formed by the anterior hemispheric veins (Ant. He. V.) that arise on the cerebellum. Transverse pontine (Trans. Pon. V.) and transverse medullary (Trans. Med. V.) veins cross the pons and medulla. The median anterior medullary (Med. Ant. Med. V.) and median anterior pontomesencephalic veins (Med. Ant. Pon. Mes. V.) ascend on the anterior surface of the medulla and pons. The veins of the middle cerebellar peduncle and the cerebellopontine fissure and a transverse pontine vein join to form a superior petrosal vein (Sup. Pet. V.) that empties into the superior petrosal sinus. A bridging vein (Br. V.) passes below the vagal rootlets toward the jugular foramen. (*D*) Neurovascular relationships of an acoustic neuroma. The tumor arises from the vestibulocochlear nerve and displaces the facial nerve anteriorly, the trigeminal nerve superiorly, and the vagus and glossopharyngeal nerves inferiorly. The facial nerve, although displaced by the tumor, enters the brain stem along the lateral margin of the pontomedullary sulcus, rostral to the glossopharyngeal and vagus nerves, anterior to the flocculus, and rostral to the choroid plexus protruding from the foramen of Luschka. The rostral trunk of the anterior inferior cerebellar artery, after passing below the tumor, returns to the surface of the middle cerebellar peduncle above the flocculus. The veins displaced around the medial side of the tumor are the veins of the middle cerebellar peduncle, cerebellomedullary fissure, cerebellopontine fissure, and pontomedullary sulcus and the retro-olivary and lateral medullary veins. (*From* Rhoton AL Jr. Microsurgical anatomy of the brain stem surface facing an acoustic neuroma. Surg Neurol 1986;25:326–39; with permission.)


S.C.A
Pons
Cerebellum
V
R.P.A
VIII Co.
Flocculus
Ch.Pl.
Post.Mea.Seg
P.I.C.A.
Tent.
Tumor
Dura
VII
VIII S.V.
Trans. Crest
VIII I.V.
S.A.
Pre. Mea. Seg.
IX
XI
X
S.C.A.
Post. Mea. Seg.
Mea. Seg.
I.A.A.
V
VII
VIII S.V.
VIII Co.
VIII I.V.
Pre. Mea. Seg.
R.P.A.
IX
X
P.I.C.A.
SC A.
R.P.A.
V
Mea. Seg.
Post Mea. Seg.
VII
VIII S.V.
I.A.A.
VIII I.V.
VIII Co.
Pre. Mea Seg
IX
Medulla
X
PI C A.
XI

The cerebellopontine fissure is a V-shaped fissure formed by the folding of the petrosal surface of the cerebellum around the lateral side of the pons and middle cerebellar peduncle. The petrosal surface is the cerebellar surface that faces the posterior surface of the petrous bone and is the cerebellar surface compressed by an acoustic neuroma. The cerebellopontine fissure has a superior limb situated between the rostral half of the pons and the superior part of the petrosal surface and an inferior limb located between the caudal half of the pons and the inferior part of the petrosal surface. The apex of the fissure is located laterally where the superior and inferior limbs meet. The V-shaped area between the superior and inferior limbs, which has the middle cerebellar peduncle in its floor, corresponds to the area that is called the cerebellopontine angle. The trigeminal, abducent, facial, ves-tibulocochlear, glossopharyngeal, and vagus nerves arise between the superior and inferior limbs of the fissure. The facial and vestibulocochlear nerves arise just anterior to the inferior limb of the fissure and just below the middle cerebellar peduncle. The trigeminal nerve arises near the superior limb of the fissure.

The cerebellomedullary fissure, the cleft between the cerebellum and medulla that extends upward between the cerebellar tonsil and the medulla, communicates with the inferior limb of the cerebellopontine fissure near the lateral recess of the 4th ventricle. Several structures related to the lateral recess and the foramen of Luschka project into the cerebellopontine angle near the facial and the vestibulocochlear nerves.

Foramen of luschka, choroid plexus, and flocculus

The structures related to the lateral recess of the 4th ventricle that have a consistent relationship to the facial and vestibulocochlear nerves are the foramen of Luschka and its choroid plexus and the flocculus (see Figs. 8 and 9) [3,10]. The foramen of Luschka is situated at the lateral margin of the pontomedullary sulcus, just dorsal to the junction of the glossopha-ryngeal nerve with the brain stem, and immediately posteroinferior to the junction of the facial and vestibulocochlear nerves with the brain stem. The foramen of Luschka is infrequently well visualized. There is, however, a consistently identifiable tuft of choroid plexus that hangs out of the foramen of Luschka and sits on the posterior surface of the glossopharyn-geal and vagus nerves just inferior to the junction of the facial and vestibulocochlear nerves with the brain stem.

Another structure related to the lateral recess is the flocculus. It is a fan-shaped cerebellar lobule that projects from the margin of the lateral recess into the cerebellopontine angle. The flocculus, together with the nodule of the vermis, forms the primitive flocculonodular lobe of the cerebellum. The flocculus is attached to the rostral margin of the lateral recess and foramen of Luschka. The flocculus is continuous medially with the inferior medullary velum, a butterfly-shaped sheet of neural tissue that forms on the surface of the nodule and sweeps laterally above the tonsil to form part of the inferior half of the roof of the 4th ventricle. The lateral part of the inferior medullary velum narrows to a smaller

Fig. 10. Posterior views of the direction of displacement of the anterior inferior cerebellar artery (A.I.C.A.) around an acoustic neuroma. (*Top left*) Insert shows the direction of view. Both the premeatal (Pre. Mea. Seg.) and the postmeatal (Post. Mea. Seg.) segments are in their most common location around the lower margin of the tumor. The premeatal segment approaches the meatus from anteroinferior, and the postmeatal segment passes posteroinferior to the tumor. The superior cerebellar artery (S.C.A.) and trigeminal nerve (V) are above the tumor, and the posterior inferior cerebellar artery (P.I.C.A.) and the glossopharyngeal (IX), vagus (X), and accessory (XI) nerves are below the tumor. The choroid plexus (Ch. PI.) protrudes into the cerebellopontine angle medial to the tumor. The posterior wall of the internal acoustic canal has been removed to expose the transverse crest (Trans. Crest) and the superior vestibular (VIII S.V.) and inferior vestibular (VIII I.V.) nerves. The vestibular nerves disappear into the tumor; however, the cochlear (VIII Co.) and facial nerves (VII) are displaced around the anterior margin of the tumor. A subarcuate artery (S.A.) arises from the premeatal segment, and a recurrent perforating artery (R.P.A.) arises from the postmeatal segment. (*Center right*) A less common pattern of displacement of the anterior inferior cerebellar artery in which the premeatal and postmeatal segments are above the tumor. The internal auditory arteries (I.A.A.) arise from the meatal segment (Mea. Seg.). (*Bottom left*) Both the premeatal and the postmeatal segments are displaced anterior to the tumor. This occurs if the anterior inferior cerebellar artery courses between the vestibulocochlear and facial nerves. The tumor arises in the vestibular nerves, and the tumor growth displaces both the premeatal and the postmeatal segments anteriorly. (*From* Martin RG, Grant JL, Peace D, et al. Microsurgical relationships of the anterior inferior cerebellar artery and the facial-vestibulocochlear nerve complex. Neurosurgery 1980;6:483–507; with permission.)

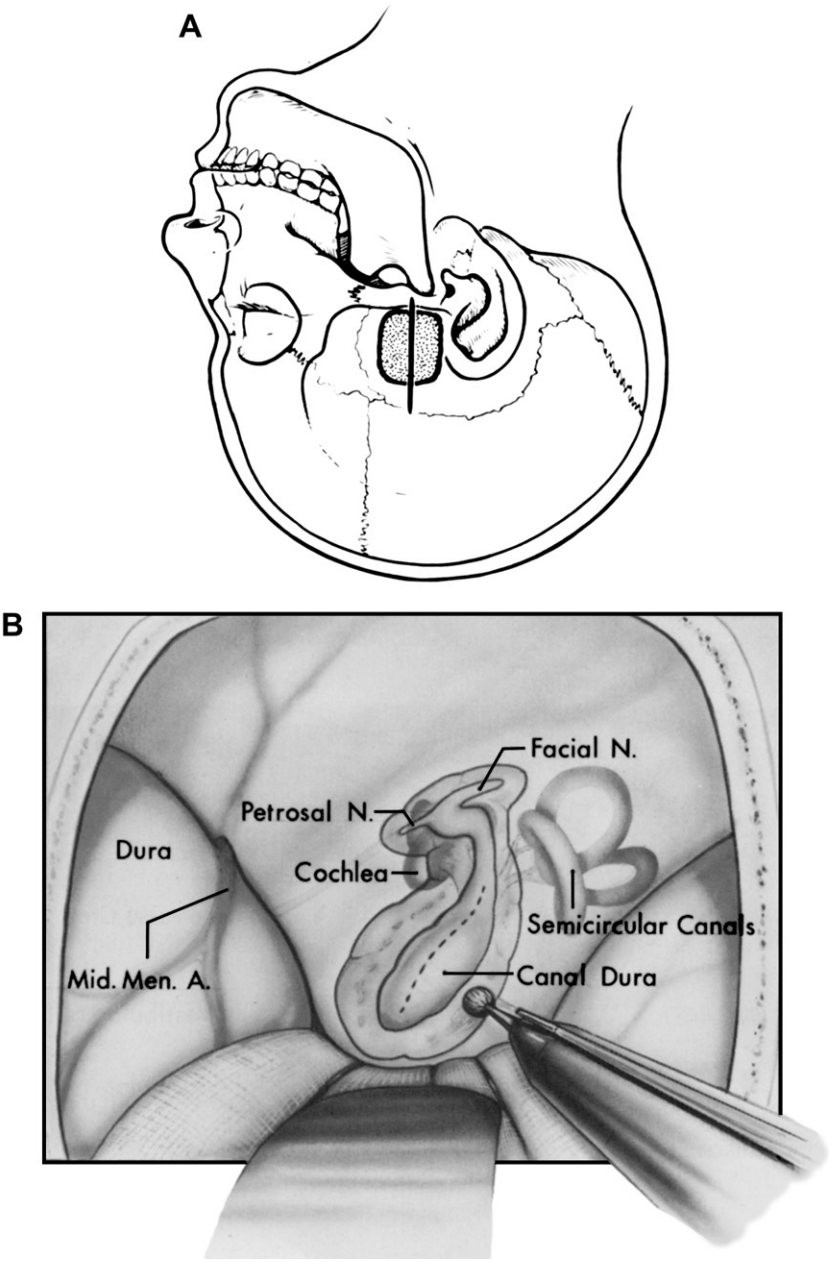


Fig. 11. Middle fossa approach for removing a small acoustic neuroma. (*A*) Left side. The vertical skin incision is located anterior to the ear and the craniotomy is situated with its base on the floor of the middle cranial fossa (*stippled area*). (*B*) The dura is elevated from the floor of the middle cranial fossa to identify the greater petrosal nerve (Petrosal N.). The middle meningeal artery (Mid. Men. A.) courses on the dura. Bone is removed over the greater petrosal nerve (Petrosal N.) to expose the facial nerve (Facial N.) which is followed proximally by removing bone to expose the superior wall of the internal auditory canal. Extreme care must be taken to avoid injuring the semicircular canals located in the bone at the posterior margin of the exposure and the cochlea situated in the bone just anterior and deep to the facial nerve. (*C*) Enlarged view of the area of bone removal. The dura has been opened to expose the tumor in the internal auditory canal. (Int. Auditory Canal). The tumor arises in the superior vestibular nerve (Sup. Vestibular N.) and displaces the facial nerve anteriorly. (*D*) The superior vestibular nerve has been divided above the transverse crest and elevated with the tumor. The superior vestibular nerve is being divided medial to the tumor. The facial, cochlear (Cochlear N.) and inferior vestibular (Inf. Vestibular N.) nerves are preserved.

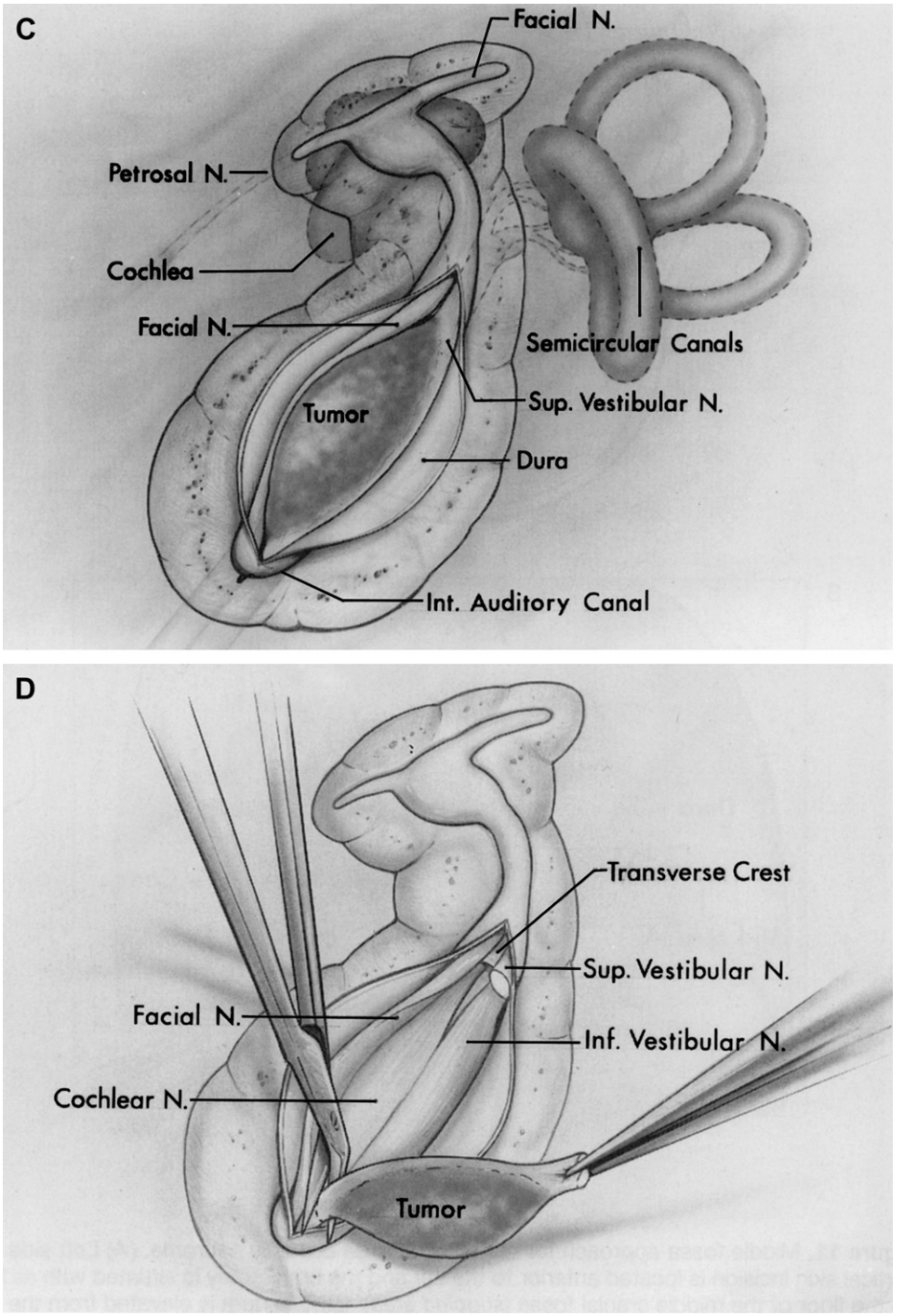
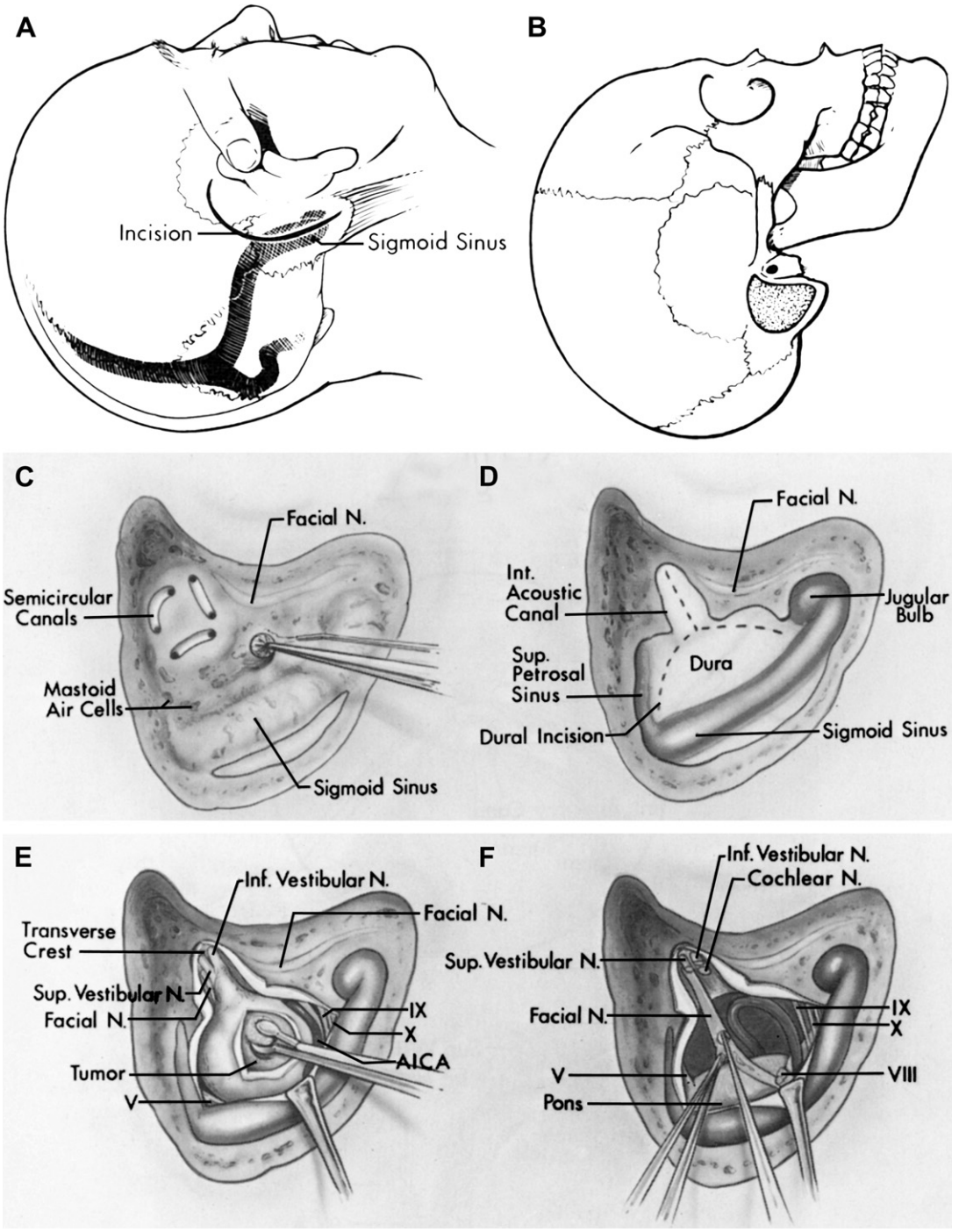


Fig. 11 (*continued*)


A
Incision
Sigmoid Sinus
B
C
Facial N.
Semicircular Canals
Mastoid Air Cells
Sigmoid Sinus
D
Facial N.
Int. Acoustic Canal
Jugular Bulb
Sup. Petrosal Sinus
Dura
Dural Incision
Sigmoid Sinus
E
Inf. Vestibular N.
Facial N.
Transverse Crest
Sup. Vestibular N.
Facial N.
IX
X
AICA
Tumor
V
F
Inf. Vestibular N.
Cochlear N.
Sup. Vestibular N.
Facial N.
IX
X
V
VIII
Pons

bundle, the peduncle of the flocculus, which fuses to the rostral margin of the lateral recess and foramen of Luschka. The flocculus projects from the peduncle of the flocculus into the cerebellopontine angle just posterior to where the facial and vestibulocochlear nerves join the pontomedullary sulcus.

Arterial relationships

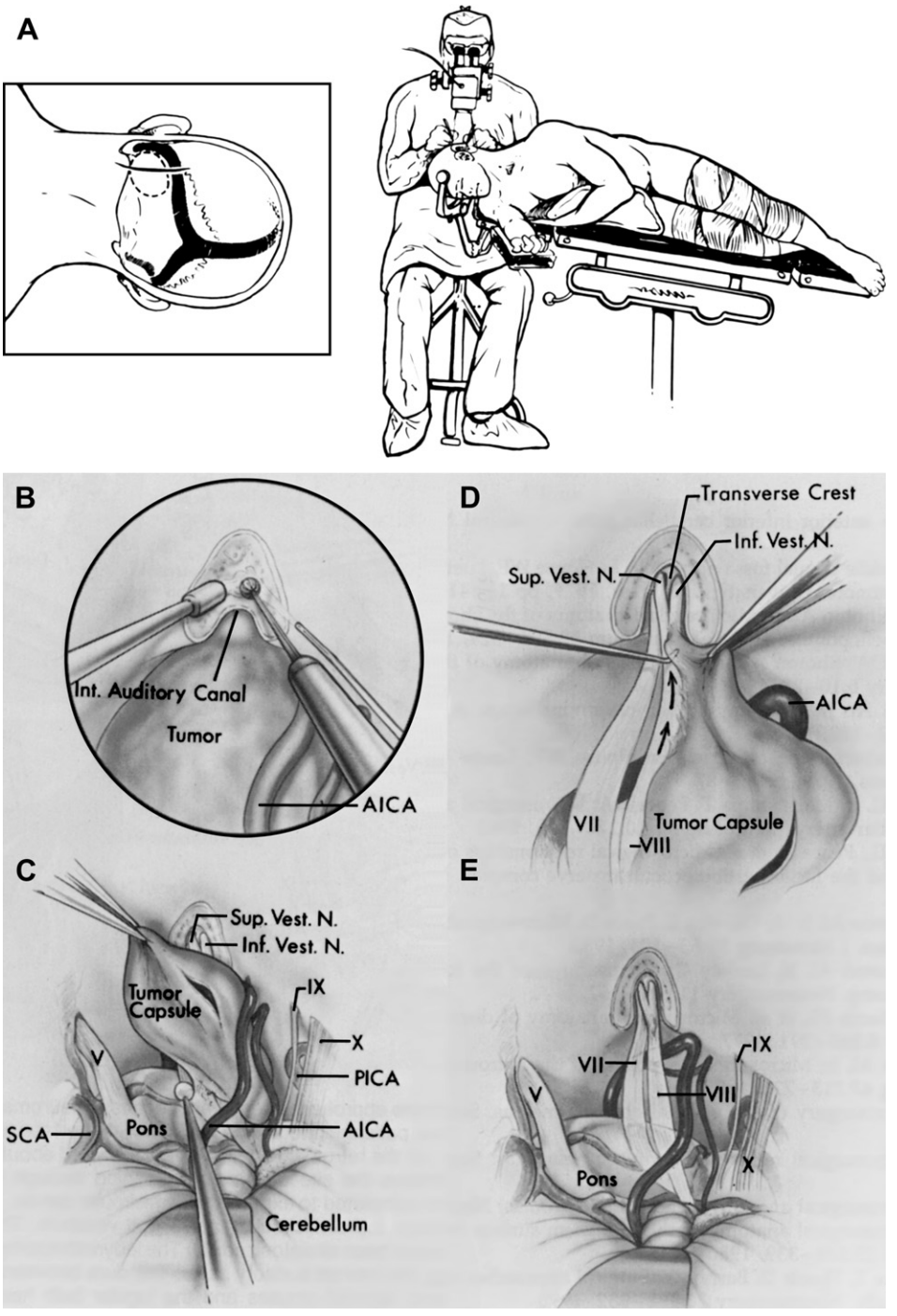
The arteries crossing the cerebellopontine angle, especially the anterior-inferior cerebellar artery, enjoy a consistent relationship to the facial and vestibulocochlear nerves, foramen of Luschka, and the flocculus (see Figs. 1, 8, 9,10) [1,4,7,8]. The anterior-inferior cerebellar artery originates from the basilar artery and encircles the pons near the pontomedullary sulcus. After coursing near and sending branches to the nerves entering the acoustic meatus and the choroid plexus protruding from the foramen of Luschka, it passes around the flocculus to reach the surface of the middle cerebellar peduncle and terminates by supplying the lips of the cerebellopontine fissure and the petrosal surface of the cerebellum. The anterior-inferior cerebellar artery usually bifurcates near the facial and vestibulocochlear nerves to form a rostral and a caudal trunk. The rostral trunk courses along the middle cerebellar peduncle to supply the upper part of the petrosal surface, and the caudal trunk passes near the lateral recess and supplies the lower part of the petrosal surface.

The trunk of the anterior-inferior cerebellar artery is divided into three segments based on its relationship to the nerves and the meatus: the premeatal, meatal, and postmeatal segments. The premeatal segment begins at the basilar artery and courses around the brain stem to reach the region of the meatus. The meatal segment is located in the vicinity of the internal acoustic meatus. The postmeatal segment begins distal to the nerves and courses medially to supply the brain stem and cerebellum. This meatal segment often forms a laterally convex loop, the meatal loop, directed toward or into the meatus. In a prior study, we found that the meatal segment was located medial to the porus in 46% of 50 cases and formed a loop that reached the porus or protruded into the canal in 54% [8]. In opening the meatus by the middle fossa, translabyrinthine, or posterior approach, care is needed to avoid injury to the meatal segment if it is located at or protrudes through the porus.

In most cases, the anterior-inferior cerebellar artery passes below the facial and vestibulocochlear nerves as it encircles the brain stem, but it may also pass above or between these nerves in its course around the brain stem (see Fig. 8). In the most common case, in which the artery passes below the nerves, the tumor would displace the artery inferiorly (see Fig. 10). If it courses between the facial and vestibulocochlear nerves, a tumor arising in the latter nerve displaces the artery forward. Tumor growth would displace the artery superiorly if it passes above the nerves.

The branches of the anterior-inferior cerebellar artery that arise near the facial and vestibulocochlear nerves are the labyrinthine (internal auditory) arteries, which supply the facial and vestibulocochlear nerves and adjacent structures; the recurrent perforating arteries, which may initially pass toward the meatus but subsequently

Fig. 12. Translabyrinthine approach to removal of acoustic neuromas. (*A*) Right side. The operation is done with the patient in the supine position with the face turned toward the side opposite the tumor. Site of the retromastoid skin incision located about 2 cm behind the ear. (*B*) The stippled area shows the site of the bony opening through the mastoid. (*C*) The mastoidectomy has been completed to expose the semicircular canals. The bone removal will be carried medially through the semicircular canals and vestibule. The sigmoid sinus and facial nerves (Facial N.) have been skeletonized. (*D*) The labyrinthectomy has been completed to expose the dura lining the internal auditory canal. The dura between the superior petrosai (Sup. Petrosai Sinus) and sigmoid sinuses and the jugular bulb has been exposed. The interrupted lines show the site of the dural opening. (*E*) The intracapsular contents of the tumor are being removed. The superior (Sup. Vestibular N.) and inferior vestibular (Inf. Vestibular N.) nerves are seen lateral to the tumor where they are separated by the transverse crest. The anterior inferior cerebellar artery (A.I.C.A.) courses around the lower margin of the tumor. The facial nerve is anterior to the tumor. The trigeminal nerve (V) is above and the glossopharyngeal (IX) and vagus nerves (X) are below the tumor. (*F*) The final fragments of tumor are being removed from the surface of the facial nerve. The superior and inferior vestibular and cochlear nerves (Cochlear N.) have been removed along with the tumor. The central stump of the eighth nerve (VIII) is exposed at the brain stem.


A
B
Int. Auditory Canal
Tumor
AICA
C
Sup. Vest. N.
Inf. Vest. N.
Tumor Capsule
IX
X
V
PICA
SCA
Pons
AICA
Cerebellum
D
Transverse Crest
Inf. Vest. N.
Sup. Vest. N.
AICA
VII
Tumor Capsule
VIII
E
VII
IX
V
VIII
Pons
X

turn medially and supply the brain stem; and the subarcuate artery, which enters the subarcuate fossa. The subarcuate artery usually ends in the bone below the superior canal, but it may infrequently supply the distal territory of the labyrinthine arteries.

The superior cerebellar artery, which is separated from the tumor by the trigeminal nerve, is displaced rostrally by the tumor, and the posterior-inferior cerebellar artery is displaced caudally with the glossopharyngeal and vagus nerves by the tumor.

Venous relationships

The veins on the side of the brain stem that have a predictable relationship to the facial and vestibulocochlear nerves are those draining the petrosal surface of the cerebellum, the pons and medulla, and the cerebellopontine and cerebellomedullary fissures (see Fig. 9) [9,10]. The identification of any of these veins during removal of the tumor makes it easier to identify the site of the junction of the facial and vestibulocochlear nerves with the brain stem. These veins on the medial side of the tumor are the vein of the pontomedullary sulcus, which courses transversely in the pontomedullary sulcus; the lateral medullary vein, which courses longitudinally, along the line of origin of the rootlets of the glossopharyn-geal, vagus, and accessory nerves; the vein of the cerebellomedullary fissure, which passes dorsal or ventral to the flocculus before joining the other veins in the cerebellopontine angle; the vein of the middle cerebellar peduncle, which is formed by the union of the lateral medullary vein and the vein of the pontomedullary sulcus and ascends on the middle cerebellar peduncle to join the vein of the cerebellopontine fissure; and the vein of the cerebellopontine fissure, which is formed by the union of the veins that arise on the petrosal surface of the cerebellum and converge on the apex of the cerebellopontine fissure. All of these veins course near the lateral recess and the junction of the facial and vestibulocochlear nerves with the brain stem (see Fig. 9).

The veins surrounding an acoustic neuroma terminate by forming bridging veins, called *petrosal veins*, which empty into the superior petrosal sinus (see Figs. 5 and 9). These veins, which cross the cerebellopontine angle to reach the superior petrosal sinus, are the ones most frequently occluded in the course of operations in the cerebellopontine angle. Bridging veins are more frequently exposed and sacrificed in the rostral part of the cerebellopontine angle during operations near the trigeminal nerve than during operations near the nerves entering the internal acoustic meatus. The exposure of an acoustic neuroma in the central part of the cerebellopontine angle near the lateral recess can usually be completed without sacrificing a bridging vein. If a vein is obliterated during acoustic tumor removal, it is usually one of the superior petrosal veins, which is sacrificed near the superior pole of the tumor during the later stages of the removal of a large tumor. Small acoustic neuromas are usually removed without sacrificing a petrosal vein. The largest vein encountered around the superior pole of an acoustic neuroma is the vein of the cerebellopontine fissure, which passes from the petrosal surface of the cerebellum above the facial and vestibulocochlear nerves to join other tributaries of the superior petrosal sinus.

Fig. 13. Retrosigmoid approach for removal of an acoustic neuromas. (*A*) Right side. The patient is positioned in the three-quarter prone position with the surgeon behind the head. The insert (*left*) shows the site of the scalp incision (*continuous line*) and the bony opening (*interrupted line*). (*B*) The posterior wall of the internal auditory canal is removed. The anterior inferior cerebellar artery (A.I.C.A.) courses around the lower margin of the tumor. (*C*) The intracapsular contents of the tumor have been removed. The capsule of the tumor is being separated from the pons and the posterior surface of the facial (VII) and vestibulocochlear nerves. The superior (Sup. Vest. N.) and inferior vestibular nerves (Inf. Vest. N.) are seen at the lateral end of the internal auditory canal. The trigeminal nerve (V) and superior cerebellar artery (S.C.A.) are above the tumor and the glossopharyngeal (IX) and vagus (X) nerves and the posterior inferior cerebellar artery (PICA) are below the tumor. (*D*) The dissection along the eighth nerve (VIII) is done in a medial to lateral direction (*arrows*) in order to avoid tearing the tiny filaments of the nerve in the lateral end of the canal where they pass through the lamina cribrosa. The transverse crest separates the superior and inferior vestibular nerves in the lateral end of the canal. (*E*) Cerebellopontine angle and internal auditory canal after tumor removal with the facial and cochlear nerves preserved.

Summary

Because acoustic neuromas most frequently arise in the posteriorly placed vestibular nerves, they usually displace the facial and cochlear nerves anteriorly (Figs. 11, 12, and 13). The facial nerve is stretched around the anterior half of the tumor capsule. Variability in the direction of growth of the tumor arising from the vestibular nerves may result in the facial nerve being displaced, not only directly anteriorly, but also anterior-superiorly or anterior-inferiorly. The nerve is infrequently found on the posterior surface of the tumor. Because the facial nerve always enters the facial canal at the anterior-superior quadrant of the lateral margin of the meatus, it is usually easiest to locate it here, rather than at a more medial location where the degree of displacement of the nerve is more variable. The cochlear nerve also lies anterior to the vestibular nerve and is most frequently stretched around the anterior half of the tumor. The strokes of the fine dissecting instruments used in removing the tumor should be directed along the vestibulocochlear nerve from medial to lateral rather than from lateral to medial because traction medially may tear the tiny filaments of the cochlear nerve at the site where these filaments penetrate the lateral end of the meatus to enter the cochlea.

The landmarks that are helpful in identifying the facial and vestibulocochlear nerves at the brain stem on the medial side of the tumor have been reviewed. These nerves, although distorted by tumor, can usually be identified on the brain stem side of the tumor at the lateral end of the pontomedullary sulcus, just rostral to the glossopharyngeal nerve and just anterior-superior to the foramen of Luschka, flocculus, and choroid plexus protruding from the foramen of Luschka. After the facial and vestibulocochlear nerves are identified on the medial and lateral sides of the tumor, the final remnants of the tumor are separated from the intervening segment of the nerves.

In the three approaches to the meatus and cerebellopontine angle—retrosigmoid, translabyrinthine, and middle fossa—a communication may be established between the subarachnoid space and the mastoid air cells that requires careful closure to prevent a cerebrospinal fluid leak.

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