Temporal Bone Dissection

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General Considerations

Introduction

Otologic and neurotologic skull base surgery requires a thorough knowledge of temporal bone anatomy. This familiarity goes well beyond that which can be obtained by reading the pertinent textbooks. A great number of neurologic, vascular, sensory, and supporting structures crowd the ~16 cm³ space within the temporal bone. Ear surgeons must have an understanding of the three-dimensional relationships of what is arguably one of the most complex bony areas of the body. Repetitive laboratory dissection of human temporal bone specimens creates an eye–hand familiarity that is essential for safe operating in the live patient. These skills, obtained in the temporal bone dissection laboratory, are unique and cannot be mastered through substitute educational materials. Moreover, continued reinforcement of these skills is necessary throughout the duration of active surgical practice.

Specimen Handling (Fig. 7.1)

The temporal bone specimen should be trimmed to fit comfortably in the dissection bowl. For example, an excessive amount of squamosa may interfere with secure placement and orientation of the specimen. The anatomical dissection exercises in this manual approach the temporal bone from three sides: mastoid (lateral), middle fossa (superior), and posterior fossa (posterior). Soft tissues should be removed to allow the exposure seen in the illustrations for

Fig. 7.1 Entire temporal bone—soft tissues removed.
each approach. In general, the bone should be mounted in the surgical position to begin the exercise. It may be reoriented as the dissection proceeds for better visualization of deeper areas. It should be remembered that the dissections in this manual are designed to emphasize the identification of anatomical structures and their respective relationships, rather than to illustrate the exact steps of a specific surgical procedures.

**Laboratory Set-up (Fig. 7.2)**

The set-up for temporal bone dissection requires magnification, illumination, a surgical drill, suction and irrigation equipment, and a few otologic instruments. Typically, the temporal bone dissection station should include a dish with screws to immobilize the bone. Visualization is an integral part of temporal bone dissection. A surgical microscope that is illuminated by either a halogen or xenon light source provides magnification and visualization. High-vacuum suction and water irrigation should also be available on a continuous basis to remove the bone fragments from the dissection field. Frequently used instruments are listed below:

- High-speed otologic drill (pneumatic or electric)
- Irrigating suctions
- Otologic suctions (no. 3, 5, 7, 10)
- Hosing for both suction and irrigation
- No. 15 blade scalpel
- Heavy periosteal elevator
- Round knife
- Annulus elevator
- Curved needle
- Microscissors

**Fig. 7.2 Typical surgical set-up.**
Position

The positioning of the surgeon and the bone are critical aspects for temporal bone dissection. The surgeon should be comfortable, seated in a straight-back chair with both feet on the ground under the table on which the dissection is being performed. The temporal bone is positioned in a secure bone holder in the surgical position. This requires the bone to be placed with either the anterior (lateral and posterior approaches) or inferior aspect (superior approach) of the bone facing away from the surgeon. The surgeon’s hands and arms should be able to rest on the table for stability while dissecting. The microscope is suspended from an articulating arm that should enter the field from an anterior or lateral direction. The footpedal for the drill is under the table.

Dissecting Technique

Use of the suction–irrigating equipment requires some practice. The flow of water should be rapid enough to remove the bone dust but not so fast as to obscure visualization. This can usually be accomplished by regulating the flow of water so that the water flows freely when the thumb is off the aspiration hole and is completely aspirated when the thumb is over the hole. During dissection, the suction–irritigator should be positioned so as to allow the water to flow into the area in question but not to obscure visualization.

Use of the high-speed surgical drill also requires practice. Anatomical dissection of the temporal bone structures requires careful identification and preservation. To accomplish this, the surgeon should drill parallel to major structures to avoid transection or inadvertent removal. The largest burrs should be used whenever possible to provide a stable mode of dissection and avoid deep cutting into small unexposed areas. The cutting burrs are fluted, thus providing for aggressive bone removal when needed. When using these burrs, three-sided contact with the bone should be avoided as this may make the drill bite deeply into the bone. The diamond burrs are smoother and thus better for fine, detailed work. Use of the diamond burrs requires prolonged contact with the bone. In the past, drills operated at substantially lower speeds (<15000 rpm). Using those drills, a change in sound and tactile response of the burr touching bone was useful for identifying the proximity to critical structures (i.e., dura and large blood vessels). However, with the new high-speed drills (>20000 rpm), chatter and digging are markedly reduced, although this comes at the expense of sound and tactile feedback.

As in all anatomical dissections, the exercise should follow a step-wise progression from superficial to deep structures. Thus, the topography and soft-tissue details of the temporal bone should be appreciated before the dissection is begun. Upon removing superficial structures, recognize that these are the landmarks to the deeper structures. Frequent appreciation and reflection is necessary to understand this concept.

The Temporal Bone

The temporal bone comprises five distinct sections attached at bony sutures, termed the squamous portion, the mastoid portion, the tympanic portion, the petrous portion, and the zygomatic process.

Numerous irregularities create the important landmarks on the lateral surface of the temporal bone. As the drilling exercises outlined in the subsequent section illustrate, taking the time to study these landmarks and their relationships to structures on the medial surface of the temporal bone leads to greater facility with bony dissection.
Lateral Dissection

Dissection of the temporal bone from the lateral aspect is the most common approach for the vast majority of otologic procedures. The components of the lateral dissection include:

- Topography
- Cortical mastoidectomy
- Facial recess
- Extended facial recess
- Retrolabyrinthine/infralabyrinthine
- Supralabyrinthine/supracochlear
- Labyrinthectomy
- Internal auditory canal (translabyrinthine)
- Canal wall down mastoidectomy
- Canal wall down with labyrinthectomy
- Canal wall down with internal auditory canal
- Infracoaclear
- Transcochlear

Topography (Fig. 7.3)

The surface landmarks that form the basis for the initial descent into the mastoid include the mastoid tip, the digastric muscle, the spine of Henle, the cribiform area, the temporal line, the external auditory canal (EAC), and the root of the zygoma. To identify these structures,

Fig. 7.3 Complete temporal bone—lateral view. Structures: squamous portion (SQ), mastoid process (M), external auditory canal (EAC), root of zygoma (Z), temporal line (TL), glenoid fossa for the temporomandibular joint (TMJ), styloid process (SP), petrotympanic fissure (PT), petrous apex (PA).
the soft tissues over the bone must be reflected or removed. Roughly, the temporal line lies somewhat below the level of the middle fossa plate (dura) in most bones, and the spine of Henle and the cribiform area approximate the level of the mastoid antrum. The mastoid tip is inferior to the stylomastoid foramen and the digastric muscle approximates the level of the stylomastoid foramen and, thus, the exit of the facial nerve (FN) from the temporal bone.

**Cortical Mastoidectomy (Figs. 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, and 7.10)**

The initial entry into the temporal bone is directed at locating the mastoid antrum. Drilling should begin in the angular region bounded by the temporal line superiorly and the root of the zygoma and the EAC anteriorly. The dissection should continue superiorly and anteriorly until the middle fossa plate is identified and the EAC is thin anteriorly. The middle fossa plate always courses medially to form the roof of the mastoid antrum, thus providing a safe means for identifying this important air cell within the temporal bone. During the initial descent, a wide field of view should be maintained and Koerner’s septum (continuation of tympanomastoid suture) should be identified and removed. Within the antrum, the horizontal semicircular canal (HSCC) and incus buttress should be identified. Finally, progressive anterior drilling in the antrum will uncover the short process of the incus. The posterior and inferior aspects of the mastoid can then be excavated, the sigmoid sinus identified posteriorly, and the sinusoidal angle deepened. The inferior limit of dissection should include the digastric ridge, a fibromuscular impression of the digastric muscle and groove.

(text continues on p. 408)
Fig. 7.5 Cortical mastoidectomy: Thin the external auditory canal and middle fossa plate (mastoid tegmen). **Structures:** external auditory canal (EAC), middle fossa plate (MF), pneumatized root of zygoma (Z), Koerner’s septum (KS).

Fig. 7.6 Cortical mastoidectomy: Open the lateral wall of the mastoid antrum (i.e., Koerner’s septum) and proceed anteriorly until the short process of the incus is visible. **Structures:** posterior wall of external auditory canal (EAC), mastoid antrum (MA), aditus ad antrum (AA), horizontal semicircular canal (HSCC), short process of incus (I), incus buttress (IB), middle fossa plate (MF).
Fig. 7.7 Cortical mastoidectomy: The use of water reflection may help visualization. This image depicts the view of the antrum without the use of water (compare with Fig. 7.8 with water). Structures: posterior wall of external auditory canal (EAC), aditus ad antrum (AA), horizontal semicircular canal (HSCC).

Fig. 7.8 Cortical mastoidectomy: The use of water reflection as shown here may help visualization of the incus (compare with Fig. 7.7 without the use of water). Avoid drilling on the incus (Fig. 7.9). Structures: posterior wall of external auditory canal (EAC), aditus ad antrum (AA), horizontal semicircular canal (HSCC), short process of incus (I), incus buttress (IB), middle fossa plate (MF).
Fig. 7.9 **Cortical mastoidectomy**: Avoid drilling on the incus; see flattened short process. **Structures**: aditus ad antrum (AA), horizontal semicircular canal (HSCC), short process of incus (I), incus buttress (IB).

Fig. 7.10 **Cortical mastoidectomy**: Remove posterior (perisigmoid sinus) and inferior (mastoid tip) cells. **Structures**: posterior wall of external auditory canal (EAC), horizontal semicircular canal (HSCC), sigmoid sinus (SS), sinodural angle (SD), digastric ridge (DR).
The next portion of the dissection should include identification of the facial nerve in the descending (vertical) mastoid segment. This nerve is best identified by first imagining a line that begins just anterior to the inferior portion of the HSCC and travels in an inferior direction toward the digastric ridge. The bone of the EAC is progressively thinned, in a direction parallel to the nerve, until the white sheath is identified through the yellow bone. The nerve will frequently have some minor variation in medial/lateral angulation as it courses inferiorly.

**Facial Recess (Figs. 7.11, 7.12, and 7.13)**

The facial recess (i.e., posterior tympanotomy) is a triangular region bounded by the facial nerve medially, the chorda tympani nerve laterally, and the fossa incudis superiorly. The region of the facial nerve where the chorda tympani nerve fibers exit is referred to as the chorda–facial angle and can be found in a variable location along the mastoid segment. The chorda tympani nerve then courses anteriorly and superiorly in the EAC to enter the middle ear space on the lateral aspect of the facial recess. The facial recess is frequently pneumatized and progressive drilling near the fossa incudis superiorly, within the confines of the chorda tympani and facial nerve, will open the middle ear. In most instances, a small sensory branch of the facial nerve can be identified superior to the chorda tympani nerve takeoff, coursing inferolaterally in the EAC. This nerve lies posterior to the chorda tympani nerve. Through the posterior tympanotomy the following structures should be visualized: stapedius tendon exiting the pyramidal process; long process of the incus; incudostapedial joint; stapes superstructure; round window niche and promontory. The tympanic (i.e., horizontal) segment of the facial nerve should also be identified coursing in an anterior direction superior to the stapes and the cochleariform process. The cochleariform process anchors the tensor tympani tendon medially, as it tracks toward the neck of the malleus. A tangential view through the facial recess and medial to the neck of the malleus can frequently reveal the eustachian tube (ET) opening into the middle ear.

**Extended Facial Recess (Figs. 7.14, 7.15, and 7.16)**

To expose the inferior portion of the middle ear and hypotympanum, the facial recess can be extended inferiorly by transecting the chorda tympani nerve and EAC sensory nerve while progressively drilling on the anterior and lateral sides of the descending segment of the facial nerve. In this maneuver, the tympanic annulus is identified and followed around the inferior part of the tympanic ring. All of the bone inferior to the EAC can be removed.
Fig. 7.12 **Facial recess**: Open facial recess cells (i.e., posterior tympanotomy). **Structures**: mastoid segment facial nerve (FN), chorda tympani (CT), incus buttress (IB), promontory (P), incudostapedial joint (IS), external auditory canal (EAC), stapedius tendon (ST), round window niche (RW).

Fig. 7.13 **Open facial recess**: Higher magnification. **Structures**: mastoid segment facial nerve (FN), tympanic segment of the facial nerve (TFN), chorda tympani (CT), tympanic annulus (TA), incus buttress (IB), external auditory canal (EAC), aditus ad antrum (AA), cochleariform process (CP), horizontal semicircular canal (HSCC).
**Fig. 7.14 Extended facial recess:** Open the facial recess inferiorly by transecting the chorda tympani and following the tympanic annulus to the floor of hypotympanum. **Structures:** tympanic annulus (TA), stylo-mastoid foramen (SF), hypotympanum (H), incus buttress (IB), mastoid segment of the facial nerve (FN), chorda tympani nerve (CT), external auditory canal (EAC), sensory branch of the facial nerve (SB), long process of the incus (I).

**Fig. 7.15 Extended facial recess:** Open extended facial recess with transected chorda tympani nerve. **Structures:** incus buttress (IB), external auditory canal (EAC), horizontal semicircular canal (HSCC), mastoid segment of facial nerve (FN), hypotympanum (H), tympanic annulus (TA).
Fig. 7.16 Retrolabyrinthine/Infralabyrinthine: Skeletonize the posterior semicircular canal and open the cells medial to the facial nerve (i.e., retrofacial cells). **Structures:** posterior semicircular canal (PSCC), sigmoid sinus (SS), jugular bulb (JB), infralabyrinthine region (IL), facial nerve (FN), external auditory canal (EAC), horizontal semicircular canal (HSCC).

The jugular bulb may be encountered during the medial, anterior portion of this dissection as the floor of the posterior middle ear is removed.

**Retrolabyrinthine/Infralabyrinthine (Fig. 7.17)**

The confines of the retrolabyrinthine and infralabyrinthine exposures are delineated by the posterior semicircular canal (PSCC), the jugular bulb, the facial nerve, and the sigmoid sinus (see also Fig. 7.16). The medial limits of the dissection should include skeletonizing the presigmoid, posterior fossa dura as well as identification of the endolymphatic sac. Following cortical mastoidectomy and facial nerve identification, bone in the region anterior to the sigmoid sinus is removed until the midpoint of the PSCC is identified. The plane of the PSCC is at right angles to that of the horizontal canal previously identified. The canal is followed superiorly to the common crus as well as inferiorly to the ampullated end. The inferior excavation requires substantial bone removal medial to the facial nerve and inferior to the PSCC ampulla. As the posterior fossa dura is decompressed, the endolymphatic sac is identified within the bony confines of the vestibular aqueduct as a triangularly shaped, white thickening in the presigmoid dura, with the narrowest point forming the endolymphatic duct, which is directed medially toward the PSCC. The anterior boundary of the retrofacial, infralabyrinthine region is the posterior wall of the jugular bulb. In this exposure, the sigmoid sinus is followed throughout its descent into the retrofacial region, initially coursing anteroinferiorly and then turning superiority at the sigmoid groove to become the jugular bulb. The bulb then makes a sharp angulation inferolaterally into the jugular vein that exits the skull base at the jugular foramen.
Fig. 7.17 Retrolabyrinthine/infralabyrinthine: Identify and decompress the endolymphatic sac and duct (extralabyrinthine portion). Structures: endolymphatic sac (ES) at the tip of the instrument, posterior semicircular canal (PSCC), jugular bulb (JB), infralabyrinthine air cells (IL), facial nerve (FN), external auditory canal (EAC).

Fig. 7.18 Supralabyrinthine/supra-cochlear: Open cells bounded by the following: superior semicircular canal, middle fossa plate (i.e., tegmen tympani), tympanic segment facial nerve. Structures: superior semicircular canal (SSCC), middle fossa plate (MF), mastoid segment facial nerve (FN), posterior semicircular canal (PSCC), incus buttress (IB).
Supralabyrinthine/Supracochlear (Fig. 7.18)

The supralabyrinthine region is exposed by first identifying the SSCC from the ampullated end to the common crus. The middle fossa plate is the superior boundary and the tympanic segment of the facial nerve forms the inferior border. The posterior border is the ampulla of the superior semicircular canal. Occasionally, the incus may need to be removed to open this relatively small region. An air cell tract in this region may communicate with cells above the IAC and within the petrous apex.

Labyrinthectomy (Figs. 7.19, 7.20)

The translabyrinthine exposure requires removal of all three semicircular canals (i.e., a labyrinthectomy) in a systematic fashion to identify the vestibule of the inner ear. As the vestibule occupies the space adjacent to the lateral end of the IAC, this is a critical landmark for progressive dissection toward the internal acoustic meatus.

Removal of the superior side of the HSCC lumen is typically the initial step of the labyrinthectomy. Respecting the anterior-inferior wall of this canal ensures protection of the facial nerve in the region of the second genu and tympanic segment. Next, the posterior and superior canals should be skeletonized and opened. For the superior canal, the anterior wall of the ampulla should be preserved, as this will avoid injury to the labyrinthine segment of the facial nerve. Likewise, removal of the ampulla of the PSCC should be performed cautiously as the mastoid segment of the facial nerve courses just laterally.

Following removal of the semicircular canals, the contents of the vestibule and ampullae should be examined. The medial wall of the vestibule has two distinct depressions: the

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Fig. 7.19 Labyrinthectomy: Open the semicircular canal lumina. Structures: horizontal (HSCC), posterior (PSCC), and superior (SSCC) semicircular canals and ampullated ends (see later), subarcuate artery (SA), endolymphatic duct (ED), mastoid segment of the facial nerve (FN).
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Fig. 7.20 Labyrinthectomy: Opening the inner ear. Structures: vestibule (V) (spherical [SR] and elliptical [ER] recesses), intralabyrinthine endolymphatic duct (ED), ampullae of the horizontal (AH), posterior (AP), and superior (AS) semicircular canals, facial nerve (FN), middle fossa (MF), superior semicircular canal (SSCC).

anterior-inferior spherical recess for the saccule, and the posterior-superior elliptical recess for the utricle. The endolymphatic duct should also be seen entering the medial wall of the vestibule just medial to the common crus remnant at the utriculoendolymphatic valve.

Internal Auditory Canal (Translabyrinthine) (Figs. 7.21, 7.22)

The internal auditory canal (IAC) approach requires removal of the bone medial to the vestibule of the inner ear down to the level of the posterior fossa dura. As drilling proceeds, the endolymphatic duct will need to be transected. The IAC penetrates the posterior fossa dura in a medial-to-lateral direction, in line with the EAC. The superior limit of the IAC is defined by both the subarcuate artery and the ampullated end of the SSCC. The inferior limit of the IAC is defined by the cochlear aqueduct medially and the PSCC ampulla laterally. The medial extent of the dissection should be carried along the posterior fossa dura until the internal acoustic meatus (i.e., porus acusticus) is identified. The canal should be skeletonized for about $270^\circ$ in an extradural fashion, from the internal acoustic meatus to the lateral end of the canal. The fundus of the IAC should be carefully dissected to identify the transverse crest on its posterior aspect and the vertical crest (i.e., Bill’s bar) on its superior side. The transverse crest separates the superior and inferior vestibular nerves. The vertical crest separates the superior vestibular nerve posteriorly from the facial nerve anteriorly. It is important to recognize that as the facial nerve leaves the lateral end of the IAC at the meatal foramen, it courses superiorly and anteriorly, along the labyrinthine segment, to reach the geniculate ganglion. Following the completion of the drilling, the dura of the canal should be opened and the four nerves (superior and inferior vestibular, facial, and cochlear nerves) appreciated.
Fig. 7.21 **Internal auditory canal**: Skeletonize the internal auditory canal. **Structures:** internal auditory canal (IAC) dura, cochlear aqueduct (CAQ), vestibule (V), middle fossa dura (MF), jugular bulb (JB), facial nerve (FN).

Fig. 7.22 **Internal auditory canal**: Opening of the internal auditory canal dura and exposure of structures within the canal. **Structures:** internal auditory canal (IAC), open middle fossa dura (MF), jugular bulb (JB), facial nerve (FN), superior vestibular nerve (SVN), inferior vestibular nerve (IVN), transverse crest of the internal auditory canal (TC), vertical crest (VC), porus acusticus (PA).
Canal Wall Down (Figs. 7.23, 7.24, 7.25, 7.26, 7.27, and 7.28)

The canal wall down procedure can be performed at the initial stages of mastoidectomy (e.g., for either chronic ear surgery or cholesteatoma removal) or as an adjunct to skull base exposure in the jugular foramen and transcoclear exposures. Drilling should commence at the lateral-most aspect of the EAC in a direction parallel to the facial nerve. As the canal wall is removed medially, the relationship to the chorda tympani nerve should be appreciated. The incus will need to be removed (if still present). Once the canal wall has been removed to the level of the antrum and facial recess, an anterior spike (i.e., scutum) and posterior spike (i.e., inferior EAC ridge) will remain. The anterior spike should be removed up to a point that is flush with the anterior EAC wall. This will require removing the malleus and anterior extension of the chorda tympani nerve. The relationship of the tympanic annulus, cochleariform process, supratubal recess, and eustachian tube should be appreciated. The chorda tympani nerve exiting the temporal bone through the chordae anterius (i.e., canal of Huguier) should also be appreciated. The posterior spike should be removed down to the facial nerve inferomedially and the floor of the EAC anteriorly. The chorda tympani nerve will be sacrificed.

Infracochlear (Fig. 7.29)

When the canal wall down procedure is performed in combination with the retrolabyrinthine and translabyrinthine exposures, the floor of the EAC should be removed to expose the floor of the hypotympanum and the apex of the jugular bulb (anterior to the facial nerve).

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**Fig. 7.24 Canal wall down mastoidectomy:** Remove the tympanic membrane, malleus, and incus. **Structures:** eustachian tube (ET), promontory (P), Jacobson's (i.e., tympanic) nerve and plexus (JN), round window niche (RW), stapes (S), oval window (OW), pyramidal process (PP), tympanic facial nerve (FN), cochleariform process (CP), cog (C), supratubal recess (SR), tensor tympani semicanal (TT), stapedius tendon (ST).

**Fig. 7.25 Canal wall down with labyrinthectomy:** Opening the superior semicircular canal. **Structures:** semicircular canals (horizontal [HSCC], superior [SSCC], posterior [PSCC]), perilabyrinthine air cells (PAC), vestibular aqueduct (VA), jugular bulb (JB), promontory (P), facial nerve (FN), subarcuate artery (SA).
Fig. 7.26 Canal wall down with labyrinthectomy: View the vestibule. Structures: vestibule (V), vestibular aqueduct (VA) with endolymphatic duct, ampullated end (AS) of the superior (SSCC) semicircular canal, spherical recess (SR) for the saccule, elliptical recess (ER) for the utricle, facial nerve (FN).

Fig. 7.27 Canal wall down with internal auditory canal: Skeletonizing the internal auditory canal. Structures: internal auditory canal (IAC), jugular bulb (JB), eustachian tube orifice (ET), perilabyrinthine air cells (PAC).
Fig. 7.28 Canal wall down with internal auditory canal: Opening the internal auditory canal. Structures: superior (SVN) and inferior (IVN) vestibular nerves, labyrinthine segment of the facial nerve (FN), transverse crest of the internal auditory canal (TC), promontory (P), eustachian tube (ET).

Fig. 7.29 Infracochlear: Remove the floor of the external auditory canal, skeletonize the carotid artery and jugular bulb. Structures: jugular bulb (JB), mastoid segment of facial nerve (FN), basal turn of cochlea (CO), vertical carotid artery (CA), infracochlear air cell tract (IC), eustachian tube (ET), cochleariform process (CP).
The tympanic (i.e., Jacobson’s) nerve should be seen crossing the promontory, and is followed proximally into the tympanic canaliculus inferiorly. Further bone removal anterior to the jugular bulb should begin to uncover the vertical segment of the carotid artery. The close relationship of the carotid artery to the basal turn of the cochlea and eustachian tube should be appreciated. The jugular bulb should be opened and the opening(s) of the inferior petrosal sinus viewed. The pars nervosa sits between the jugular bulb and the carotid artery medially. Air cells inferior to the cochlea may be present that extend anteriorly into the petrous apex.

**Transcochlear (Figs. 7.30, 7.31, and 7.32)**

Removal of the cochlea should proceed in a systematic fashion, first removing the promontory extension (lip) over the round window, opening the round window membrane, and visualizing the scala tympani. Intracochlearly, the basilar membrane (superiorly) should be visualized through the cochleostomy. The basal turn of the cochlea should be opened in an anterior direction. Drilling of the superior aspect of the promontory should uncover the scala vestibuli and apical turns. The orientation of the cochlea and its relationship to the cochleariform process (CP), geniculate ganglion, and labyrinthine and tympanic segments of the facial nerve should be examined. The osseous spiral lamina, modiolus, basilar membrane, scala tympani, and scala vestibuli can also be seen. The bone overlying the semicanal of the tensor tympani muscle is then opened and the muscle followed anteriorly. The greater superficial petrosal nerve (GSPN) should also be identified as it leaves the geniculate ganglion in an anterior direction. The stapes can be removed and the vestibule opened anteriorly. Finally, the remaining cochlea should be removed medially to the level of the IAC posteriorly and to the posterior fossa dura anteriorly. The relationship of the cochlea to the genu of the petrous carotid artery may be appreciated at this point. Next, the anterior petrous apex should be excavated. The dura of the middle and posterior fossa should be completely

**Fig. 7.30 Transcochlear:** Remove the mastoid segment of the facial nerve and dissect the cochlea. **Structures:** basal (BC) and apical (AC) turns of cochlea, scala tympani (SCT), scala vestibuli (SCV), basilar membrane (BM), modiolus (MO), osseous spiral lamina (OSL), cochlear nerve (CN), cochleariform process (CP), petrous apex (PA).
Fig. 7.31 Transcochlear: Dissection of the superior petrous apex. **Structures:** genu and horizontal segment of carotid artery (CA), cut tympanic facial nerve (FN), geniculate ganglion (GG; facial nerve), greater superficial petrosal nerve (GSPN), petrous apex (PA).

Fig. 7.32 Transcochlear: Dissection of the inferior petrous apex and jugular foramen. **Structures:** vertical carotid artery (CA), jugular bulb (JB), pars nervosa (PN) containing cranial nerves IX–XI, eustachian tube (ET), inferior petrosal sinus (IPS), internal auditory canal (IAC).
uncovered, revealing the course of both the superior and inferior petrosal sinuses. The sixth cranial nerve may be seen in the most apical portion of the dissection traveling through the petrosphenoid ligament (i.e., Dorello’s canal).

**Superior Exposure**

The components of the superior exposure include:
- Surface topography
- Internal auditory canal
- Inner ear
- Middle ear
- Petrous apex

**Surface Topography (Fig. 7.33)**

Elevation of the middle fossa dura to the superior petrosal sinus reveals the key landmarks of the superior surface of the temporal bone. More than any other approach, the middle fossa dissection requires identification of these landmarks that lead the surgeon to the structures of interest beneath. The critical landmarks of the superior surface of the temporal bone include the following: foramen spinosum (containing the middle meningeal artery); GSPN; tegmen tympani; arcuate eminence of the SSCC; and petrous ridge on which the superior petrosal sinus resides. The most strategic relationship is the 120° angle formed between the GSPN and the arcuate eminence. Beneath the midpoint of this angle (60° posterior to the GSPN and 60° anterior to the arcuate eminence) lies the IAC.

*Fig. 7.33 Surface topography. Structures: foramen spinosum (FS), greater superficial petrosal nerve (GSPN), arcuate eminence (AE), superior petrosal sinus (SPS) on the petrous ridge.*
**Internal Auditory Canal (Figs. 7.34, 7.35, and 7.36)**

There are several techniques for identifying the IAC from the middle fossa approach. One route is simply to bisect the 120° angle between the GSPN and the arcuate eminence, and begin drilling in an inferior direction near the petrous ridge. The arcuate eminence should be drilled until the superior semicircular canal (SSCC) has been identified, but not opened (i.e., blue-lined). If only one of the two critical landmarks can be identified, the IAC can be located by using the angular relationships as described above. The superior, medial, anterior aspect of the temporal bone can be considered a safe area (Kawase’s area [K]) to begin drilling since it generally contains either bone marrow or pneumatized spaces. A second route to the IAC involves the retrograde dissection of the GSPN to the geniculate ganglion (facial nerve). The labyrinthine segment of the facial nerve can be uncovered inferomedially, just posterior to the cochlea, as it travels from the fundus of the IAC.

Once the IAC is located, enough bone should be removed to uncover the entire superior surface of the canal. The vertical crest (i.e., Bill’s bar) should be identified at the lateral end of the IAC. The facial nerve can then be decompressed throughout the labyrinthine segment to the geniculate ganglion. The entire geniculate ganglion should be decompressed to visualize its size and relationship to surrounding structures. The dural covering of the IAC should then be incised in a longitudinal fashion to expose the facial, cochlear, and vestibular nerves.

**Inner Ear (Figs. 7.37, 7.38)**

The inner ear should be dissected from the superior approach. The SSCC can be opened to the ampullated end, anteriorly and medially. The vestibule can then be entered and its relationship

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**Fig. 7.34** Internal auditory canal: Approaching the internal auditory canal. **Structures:** superior petrosal sinus (SPS), Kawase’s (K) area (medial, anterior petrous apex), blue-lined superior semicircular canal (SSCC), greater superficial petrosal nerve (GSPN).
Fig. 7.35 Internal auditory canal: Skeletonizing the internal auditory canal. Structures: internal acoustico-cus meatus (i.e., porous acousticus [IAM]), superior internal auditory canal (IAC) dura, blue-lined superior semicircular canal (SSCC), greater superficial petrosal nerve (GSPN).

Fig. 7.36 Internal auditory canal: Decompressing the labyrinthine segment of the facial nerve. Structures: labyrinthine segment of the facial nerve (FN), geniculate ganglion (GG; facial nerve), greater superficial petrosal nerve (GSPN), cochlea (CO), vertical crest (VC) of the fundus of the internal auditory canal.
Fig. 7.37 **Inner ear**: Opening the vestibular labyrinth and the internal auditory canal dura. **Structures:** facial nerve with meatal segment (FN), vertical crest (VC), superior vestibular nerve (SVN), vestibule (V), superior semicircular canal (SSCC) with ampulla (A), subarcuate artery (SA).

Fig. 7.38 **Inner ear**: Dissecting the cochlear duct. **Structures:** transposed facial nerve (FN), apical (AC) turns of the cochlea, basilar membrane (BM), modiolus (MO), scala tympani (SCT) scala vestibuli (SCV), cochlear nerve (CN).
to the fundus of the IAC examined. Next, the cochlea should be identified anterior to the lateral end of the IAC. The close proximity of the cochlea to the labyrinthine segment of the facial nerve should be appreciated. After mobilizing the facial nerve, the cochlea can be carefully dissected under high magnification to visualize the scala tympani, scala vestibuli, basilar membrane, osseous spiral lamina, modiolus, and lateral aspect of the cochlear nerve.

**Middle Ear (Fig. 7.39)**

The middle ear can be opened from the superior approach. First, that portion of middle fossa floor (i.e., tegmen tympani) lateral to the geniculate ganglion, cochlea, and vestibule is opened to expose the epitympanum and middle ear below. From this perspective, the ossicles (malleus, incus, stapes), tensor tympani, cochleariform process, and tympanic segment of the facial nerve are seen. Continued dissection anteriorly will expose the bony eustachian tube, protympanum, and semicanal of the tensor tympani muscle. Exposure of these structures may require transection of the GSPN.

**Petrous Apex (Figs. 7.40, 7.41, and 7.42)**

The petrous apex is the next area of dissection. Anterior to the IAC, a relatively safe dissection area known as Kawase’s triangle is bounded by the carotid artery inferolaterally, the medial surface of the temporal bone and posterior fossa dura medially, the cistern of the trigeminal ganglion (i.e., Meckel’s cave) anteriorly, and the cochlea and internal auditory canal posteriorly. The dissection commences anterior to the cochlea, medial to the bony

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**Fig. 7.39 Middle ear:** Removing tegmen tympani. **Structures:** malleus (M), incus (I), semicanal of the tensor tympani muscle (TT), tensor tympani tendon (TTT), cochleariform process (CP), tympanic segment of the facial nerve (FN), geniculate ganglion (GG; facial nerve), eustachian tube (ET), medial surface of tympanic membrane (TM).
Fig. 7.40 Petrous apex: Exposing the carotid artery. Structures: eustachian tube (ET), tensor tympani muscle (TT), carotid artery (CA), cochlea (CO), Kawase’s area (K), geniculate ganglion (GG; facial nerve).

Fig. 7.41 Jugular foramen: Remove the internal auditory canal. Structures: tympanic membrane (TM), carotid artery (CA), jugular bulb (JB).
Fig. 7.42 Pars nervosa: Dissecting the jugular foramen. Structures: jugular bulb (JB) opened anterior and posterior to the pars nervosa (PN) with cranial nerves IX–XI, carotid artery (CA).

eustachian tube, and anterior to the IAC. The carotid artery and its bony covering may be absent on occasion. The entire horizontal (petrous) segment of this important artery should be dissected. The superior medial wall of the eustachian tube contains the semicanal of the tensor tympani (TT) muscle. The relationship of the carotid artery, tensor tympani, and eustachian tube should be studied. With a full cut temporal bone specimen, Meckel’s cave and the trigeminal nerve can be identified.

**Posterior Exposure**

The components of the posterior exposure include:

- Surface topography
- Internal auditory canal
- Endolymphatic system and inner ear
- Jugular foramen

**Surface Topography (Fig. 7.43)**

The posterior surface of the temporal bone offers a direct view of the porus acusticus and foramina for the lower cranial nerves. It is recommended that the anatomical specimen be approached from the suboccipital surgical orientation with the sigmoid sinus located posteriorly and parallel to the plane of the laboratory table. In this position, the surface topography includes the following: petrous ridge; superior and inferior petrosal sinuses; cistern of the trigeminal ganglion (i.e., Meckel’s cave); internal acoustic meatus; jugular bulb with the
Fig. 7.43 Surface topography (high power): Structures: superior petrosal sinus (SPS), internal acoustic meatus with cranial nerves VII–VIII, jugular foramen with cranial nerves IX–XI, endolymphatic sac (ES), operculum (O) of the vestibular aqueduct.

pars nervosa; endolymphatic sac; and operculum. An intact specimen should have visible portions of cranial nerves V, VI, and VII–XI.

Internal Auditory Canal (Figs. 7.44, 7.45)

In a manner similar to the middle fossa dissection, the posterior fossa dissection initially focuses on exposing the IAC. The internal acoustic meatus is located medial and superior to the jugular foramen, the endolymphatic sac, and the endolymphatic duct. Drilling commences from the lip of the meatus in a medial-to-lateral direction, uncovering the dura of the IAC along its posterior aspect. In the surgical position, exposure of the IAC fundus and the transverse crest (which separates the superior and inferior vestibular nerves) almost always requires traversing the common crus of the SSCC and PSSC. The IAC should be widely decompressed medially, avoiding the inner ear. Further lateral drilling then should ensue to appreciate the structures of the lateral end of the IAC and the inner ear.

The dura overlying the posterior aspect of the IAC should then be removed to reveal the cranial nerves. From this approach, the superior and inferior vestibular nerves, and possibly the singular nerve (i.e., posterior canal ampullary nerve), are encountered first since they occupy the posterior compartment of the IAC. The facial nerve is visible in the anterior (deep) and superior aspect of the IAC. Retraction of the vestibular nerves in the superior direction will reveal the cochlear nerve within the anteroinferior compartment of the IAC. The cochlear nerve is best seen after removal of the vestibular nerves, which follows later in the dissection. The bony landmarks at the fundus of the IAC again include the vertical and transverse crests.
**Fig. 7.44 Internal auditory canal:** Skeletonizing the internal auditory canal. **Structures:** posterior internal auditory canal (IAC) dura, internal auditory meatus (IAM).

**Fig. 7.45 Internal auditory canal:** Opening the internal auditory canal dura. **Structures:** facial nerve (FN), superior (SVN) and inferior (IVN) vestibular nerves, singular nerve (SN) branch of inferior vestibular nerve, transverse crest (TC); the vertical crest cannot be seen in this particular view.
Endolymphatic System and Inner Ear (Figs. 7.46 to 7.48)

The endolymphatic sac can now be traced along the posterior face of the temporal bone into the operculum of the vestibular aqueduct. In this region, the sac consolidates into a duct-like structure and turns sharply in an anterolateral direction toward the medial wall of the vestibule. The SCC and PSCC can be opened at their respective ampullated ends by following the superior vestibular and singular nerves, respectively. The vestibule can be opened further to expose the medial surface of the stapes footplate.

Removing the vestibular nerves reveals the cochlear nerve, which can be traced to its entry into the modiolus of the cochlea. The cochlea can be opened for inspection of its contents, including the scala tympani, the scala vestibuli, the basilar membrane, the osseous spiral lamina, and the modiolus. Inferior dissection parallel to the floor of the IAC will reveal the cochlear aqueduct.

Jugular Foramen (Fig. 7.49)

Dissection should then proceed from the inferior aspect of the IAC to the jugular bulb and pars nervosa. For this dissection, the bone between the jugular bulb and the IAC floor can be removed to visualize the pars nervosa. The carotid artery is identified deep to the cochlea and anterior to the jugular bulb.

The jugular foramen can be dissected further to clearly identify the pars nervosa, containing cranial nerves IX–XI, between the carotid artery and jugular bulb. The jugular bulb should be opened to identify the multiple opening of the inferior petrosal sinus on its anterior wall.

Fig. 7.46 Endolymphatic system and inner ear: Localizing the endolymphatic duct and vestibule. Structures: endolymphatic sac (ES) and duct (ED), internal auditory canal (IAC), superior semicircular canal (SSCC), blue-lined posterior semicircular canal (PSCC), common crus (CC).
**Fig. 7.47 Inner ear:** Opening the SSCC and PSCC. **Structures:** ampullae (A) of superior (SSCC) and posterior (PSCC) semicircular canals, common crus (CC) of SSCC and PSCC, vestibule (V), medial surface of stapes footplate (SFP).

**Fig. 7.48 Inner ear:** Exposing the cochlear nerve and opening the cochlea. **Structures:** cochlear nerve (CN), cochlea (CO), cochlear aqueduct (CAQ), facial nerve (FN), cranial nerves IX–XI.
Fig. 7.49 Jugular foramen: Dissecting the jugular foramen and carotid artery. Structures: pars nervosa (PN) with cranial nerves IX-XI, jugular bulb (JB), carotid artery (CA), cochlear aqueduct (CAQ).