

Paparella: Volume II: Otology and Neuro-Otology

Section 3: Diseases of the Ear

Part 1: General Problems

Chapter 13: Guidelines for Dissection of Temporal Bone

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These general guidelines have been designed for the practical purpose of being read and followed as a dissection proceeds. They are intended to be a dialogue between the "instructor" and the surgeon dissecting the bone. Methods for removing temporal bones are described in Chapter 18, Volume I. In this chapter, aims, checklist, pitfalls, pertinent anatomy, and surgical steps are discussed during the dissection in an attempt to mimic a rational procedure.

We encourage dissection of temporal bones. Such dissection is an essential prerequisite for otologic training in residency programs and for otolaryngologists who wish to practice specific techniques. This practice plus knowledge of anatomy and histopathology is essential for developing rational and not merely imitative means of surgical treatment. There is nothing wrong with imitation, provided that what is being imitated is understood and fully agreed upon.

The procedures described include only those most commonly used in an otologic practice and are based on the utilization of two "wet" temporal bones. The succession of the procedures is organized for better utilization of such bones. A more extensive description, as well as a practical approach to otologic surgery, is included in the *Atlas of Surgical Otology: A Practical Approach*, by M. V. Goycoolea, M. M. Paparella, and R. L. Nissen.

Operations to be Described

Dissection of the first temporal bone:

1. Simple mastoidectomy.
2. Surgery on the endolymphatic sac.
3. Approach through the facial recess (posterior tympanotomy).
4. Cochlear implants (posterior tympanotomy - facial recess approach).
5. Transmastoid decompression of the facial nerve.
6. Surgery on the ear canal and middle ear:
 - a. Canalplasty.
 - b. Underlaid grafting for perforation of the tympanic membrane.
 - c. Ossiculoplasty; procedures on the incus; partial ossicular replacement prostheses (PORP).
7. Intact bridge mastoidectomy.
8. Modified radical mastoidectomy.
9. Radical mastoidectomy.
10. Surgery at the petrous apex.

11. Labyrinthectomy.

Dissection of second temporal bone:

12. Surgery on the ear canal and middle ear.

- a. Canalplasty.
- b. Incisions for pressure-equalizing tubes.
- c. Exploratory tympanotomy.
- d. Stapedectomy.
- e. Malleus-to-oval window prosthesis.
- f. Ossiculoplasty; total ossicular replacement prosthesis (TORP).

13. Cochlear implant (via the approach as in mastoidotomy-tympanotomy).

14. Transcanal labyrinthectomy.

When describing or discussing a dissecting procedure for temporal bone, the following terms will be used:

Superior: toward the temporal bone (cephalad).

Inferior: toward the mastoid tip (caudad).

Anterior: toward the external auditory canal (ventral).

Posterior: away from the external auditory canal (dorsal).

Lateral: toward the mastoid cortex (superficial).

Medial: away from the mastoid cortex (deep).

Simple Mastoidectomy

Aim

Exenterate (remove) all mastoid air cells while maintaining the integrity of the posterior canal.

Checklist

1. Use the microscope at all times.
2. Drill under direct vision, avoiding "holes" (drill evenly).
3. When in doubt, identify landmarks and use a mastoid curet.
4. Develop a step-by-step gradual procedure.
5. Think anatomically and three-dimensionally. Look for structures; do not "find them".
6. Keep anatomic aberrations in mind (high sigmoid sinus, anterior sigmoid sinus, Körner's septum, etc).

Pitfalls

1. Failure to identify the antrum:
 - a. Körner's septum.
 - b. Insufficient thinning of the tegmen and/or posterior osseous canal.
2. Injuring a high sigmoid sinus.

3. Injuring the facial nerve by going:
 - a. Deep to the horizontal semicircular canal.
 - b. Too far anterior in the digastric ridge.
4. Dislocating the incus by drilling blindly into the antral area.

Procedures

Assess External Anatomy

Position the temporal bone in surgical position (simulating its normal anatomic location for surgery). Visualize and study the lateral surface (cortex) in its entirety from the temporal line (linea temporalis) superiorly and to the mastoid tip inferiorly. Identify the posterior aspect of the osseous canal anteriorly. Note the presence of the suprameatal spine (spine of Henle) immediately posterior to the osseous canal. Review the imaginary lines that overlie the mastoid antrum - that is to say, between the temporal line and the spine of Henle (mastoid fossa, Macewen's triangle). Imagine the inner structures of the mastoid cavity in a three-dimensional fashion and trace your surgical plan.

Initiate Drilling (Use Large Burs, Saucerize)

Starting from the very beginning under the microscope, use a large bur and start saucerizing in an even fashion, beginning at the fossa mastoidea, until air-cells appear. Make a wide cortical removal, including thinning of the posterior canal. In going deeper, keep thinking ahead to your future landmarks, orienting yourself toward the antrum. Your superior limit is the tegmen mastoideum (level of the temporal line), superior to which lies the dura of the middle cranial fossa. The tegmen should be thinned down, being careful to keep it intact. This is important if adequate access to the antrum is intended. The wall of the posterior canal should be thinned down, as well, for the same purpose. Again, drilling should remain even at all times and not straight; it is oriented anteriorly toward the nose of the imaginary patient. Your anterosuperior limit is the root of the zygomatic process; this should be opened without opening the epitympanum.

Identify the Lateral Sinus (Sigmoid Sinus)

In drilling posteriorly, you will encounter the sigmoid sinus (lateral sinus). It is identified in surgery by its bluish color and its smooth bony plate. (In this dissection, you are looking for the smooth bony plate.) The best guides for the sigmoid sinus are these characteristics: (1) change in the sound of the burs, which can be a helpful hint but not at all a guide (visualization far outweighs sensations in surgery on the temporal bone); and (2) it must be kept in mind that the sigmoid sinus does not have a uniform anatomy; it can be high (lateral) or low (medial/deep). The surgeon should be cautious with the use of the drill. Inferiorly, toward the mastoid tip, the air-cells are to be drilled evenly, with the level of drilling superior. Little by little, a typical mastoid kidney-shaped cavity becomes evident.

Identify Körner's Septum and Antrum

In going medially (deeper down), one may occasionally encounter a thick plate of bone that may give the impression of having reached the antrum. That is Körner's septum, a solid plate that represents the fusion of the squamous and petrous portions of the temporal bone. When in doubt, go back to your already identified landmarks and structures, verify your location, imagine the bone in three dimensions, and imagine your suspected area of the antrum. By use of a mastoid curet, curet superiorly and posteriorly until identifying the "true antrum".

The antrum is located posterosuperiorly to the osseous canal. A common error is to go too far below the temporal line because of lack of thinning of the plate. Another important concept is that the antrum is to be reached or entered from above if damage is to be avoided. Once the antrum is identified, avoid uncovering the incus, and identify the horizontal semicircular canal, one of the most important landmarks. At that point, you know that you are definitely in the antrum and that you are superior to the facial nerve. If unable to see the incus, work anteriorly just inferior to the dura of the tegmen; this is the widest distance between the ossicles and the epitympanum.

Identify and Define the Sinodural Angle, Solid Angle, and Facial Nerve

Drill posteriorly, thinning the sigmoid sinus, and between it and the tegmental plate until they meet in a sharp angle (sinodural angle or Citelli's angle). Keep drilling inferiorly toward the mastoid tip, exenterating cells from the area of the digastric ridge. Keep in mind that the facial nerve and its point of exit from the stylomastoid foramen are immediately anterior to the digastric ridge. At this point there remains an intact area in the so-called "hard angle" (area containing the posterior semicircular canal in the plate that overlies the posterior cranial fossa, with an unidentified facial nerve). It is important to remain above the area of the horizontal semicircular canal. The location of the horizontal canal allows exposure of the fossa incudis (and the short process of the incus) laterally and inferiorly to the antrum, of the horizontal canal, of the epitympanum, and of the external genu of the facial nerve located medial to the horizontal semicircular canal.

Using a fenestrometer, measure an imaginary triangle 10 mm from the tip of the short process of the incus or fossa incudis, along the axis of the horizontal semicircular canal (30 degrees from the tegmen). Then measure 12 mm from the fossa incudis at an angle of 45 degrees from the tegmen. This area identifies and isolates the hard angle (containing the posterior semicircular canal). Immediately inferior to it and anterior to the sigmoid (lateral) sinus is the plate of bone that overlies the dura of the posterior cranial fossa, where the endolymphatic sac is located. Identify now Trautmann's triangle, bordered by the lateral sinus (sigmoid sinus), tegmen, and semicircular canals. This triangle identifies the location of the posterior cranial fossa.

The facial nerve is identified but not unroofed. We will come back to it further in the dissection. By now the simple mastoidectomy is completed; that is, all air-cells have been removed (except those in the petrous apex). Reidentify all anatomic structures, landmarks, triangles, and angles.

Surgery on the Endolymphatic Sac

Aim

Identify and expose the endolymphatic sac overriding the dura mater of the posterior cranial fossa.

Checklist and Surgical Steps

1. Complete simple mastoidectomy (as previously described).
2. Drill to, but not below, the dome of the horizontal semicircular canal.
3. Identify, preserve, and measure the hard angle containing the posterior semicircular canal.
4. Identify the position of the sigmoid sinus and its relationship to Trautmann's triangle.
5. Decompress the lateral sinus and dissect the infra-labyrinthine cell tract.
6. Incise the endolymphatic sac, probe its lumen, and place Silastic sheeting.

Pitfalls

1. Skeletonizing or damaging the posterior semicircular canal.
2. Insufficient unroofing of the dural plate.
3. Failure to identify the endolymphatic sac and its lumen.
4. Damage to the incus.
5. Debris in the middle ear.
6. Bleeding in the lateral sinus.

Dissection

In surgery on the endolymphatic sac, we advocate a thorough simple mastoidectomy, as described above. The bony plate overlying the dura of the posterior cranial fossa has already been identified. Now redefine Trautmann's triangle, identify the hard bone containing the posterior semicircular canal, measure distances again - 10 mm from the tip of the short process of the incus or fossa incudis, along the axis of the horizontal semicircular canal (30 degrees from the tegmen). The measure 12 mm from the fossa incudis at an angle of 45 degrees from the tegmen.

Drill into the infralabyrinthine cell tract to help expose the location of the sac. Pay special attention to the position of the sigmoid sinus. Occasionally it partially overlies the dural plate, reducing the size of Trautmann's triangle. The plate is thinned down to eggshell thickness, and then it is gently elevated and separated from the underlying dura with a duckbill elevator. The sac is identified as a thickened white area of the dura over the thin surrounding dura. The posterior semicircular canal should *not* be thinned or skeletonized. Drilling is done immediately inferior to this area.

The sac comes toward the dura from the direction of the posterior semicircular canal. If the lateral sinus is in such a position that it tends to cover the dura partially or make its access difficult, first recheck the position of the bone - the "head" might be bent too far

forward. If after repositioning the head the sinus is still prominent, it should be decompressed by removing part of its bony covering facing the dura. Infralabyrinthine cells might have to be drilled (leading toward the jugular bulb). The sac is incised gently with a sickle knife and the lumen probed with a Whirlybird.

A thin piece of Silastic sheeting (0.01 cm) is cut into a T-shape and placed in the lumen. Small pieces of Silastic sheeting are used to separate the dura from the floor of the posterior canal (spacers). A Silastic "apron" is applied and held in place by Gelfoam. At the end of the procedure, a ventilation tube is placed in the tympanic membrane.

Approach Through the Facial Recess (Posterior Tympanotomy)

Aim

Remove air-cells immediately lateral to the facial nerve at the external genu (collection of air-cells in the facial recess).

Checklist

1. Define the landmarks clearly.
2. Thin the posterior wall of the canal.
3. Drill parallel to the fibers of the facial nerve.
4. If the approach is troublesome, combine transmastoid and transcanal visualization.

Pitfalls

1. Damaging the facial nerve.
2. Perforating the bony external ear canal.
3. Perforating the tympanic membrane.
4. Pitfalls of a simple mastoidectomy.

Procedure

Define landmarks. The external genu of the facial nerve is medial and the fossa incudis is superior. Thin the wall of the posterior canal. Identify the facial nerve by its pearly white color underneath the thin layer of bone.

The bone is still thick. Thin it down very carefully by drilling parallel to the direction of the fibers of the facial nerve. Small cutting burs should be used, since the recess is quite small. Inferiorly, identify the chorda tympani as it leaves the facial nerve, taking an anterosuperior direction (it is to be preserved), and then taking a lateral direction toward the annulus.

On occasion the facial recess is quite small and the procedure is difficult. Rather than insisting on taking unnecessary risks, the recess can be approached via a combined transcanal/transmastoid approach. Once the recess is opened, the landmarks are reidentified: the external genu of the facial nerve medially; the fossa incudis superiorly; the chorda tympani laterally, inferiorly, and posteriorly; and the tympanic membrane anteriorly and

laterally. Now visualize the following structures: horizontal portion of the facial nerve, lenticular process of the incus, incudostapedial joint, capitulum of the stapes, and stapedial tendon. Then visualize the promontory and inferiorly and medially the round window niche.

Cochlear Implant (Facial Recess Approach)

Aim

Place an electrode into the cochlea by sliding it through the round window. We deal here only with intracochlear placement of electrodes and with electrodes placed far inside the cochlea.

Checklist

1. Assure good visualization via an adequate approach through the facial recess.
2. Clearly identify the round window niche and round window membrane.

Pitfalls

1. Pitfalls of the facial recess approach itself.
2. Inadequate visualization of the round window so that the electrode is blocked and incapable of being passed beyond the hook.

Surgical Steps

1. Follow steps as in a simple mastoidectomy and approach through the facial recess.
2. Prepare a seat for the internal receiver.
3. Insert intracochlear electrode.

Procedure

At this point in the dissection, the main drilling for the procedure has been done. It remains to insert the electrode through the round window and drill a seat for the internal receiver posterosuperior to the mastoid cavity. Locate a position for the internal receiver immediately posterior to the posterior limit of the drilled mastoid cavity with its anterior border (that toward the ear canal) no further than where the border of the imaginary pinna (auricle) would be if it were pushed posteriorly - that is, immediately posterior to the posterior border of the pinna. Also, superiorly, the border should not be above the superior border of the pinna.

Drill a seat, using as a guideline the sides of the internal receiver of your practice electrode. If an electrode is not available for practicing, drill a seat to fit a nickel-sized coin. Drilling can be done carefully with a regular bur or it can be done with a butterfly bur or bur specially designed by one of the companies that manufacture cochlear implants. If a screw type of internal receiver is to be used, drill four holes in the corresponding openings of the base of the pedestal. Do so for a depth of 2 mm at the most.

Regardless of the type of internal receiver, drill two small holes with a small bur immediately superior and inferior to the location of the already drilled seat - that is, two holes superiorly and two holes inferiorly. Bring those holes together very carefully. Then pass No. 2-0 silk through those openings, which would theoretically be used to pass over the internal receiver and seat it in place. Do not place the internal receiver at this point in time.

Attention is now turned back to the active electrode. Again visualize the round window niche. If visualization is not adequate, a transcanal approach can be done. Verify the opening of the round window niche. Occasionally it is necessary and/or useful to gently drill the anterior border of the niche. This will provide a slightly larger opening with better visualization and at the same time will provide a "straight shot" at the cochlea, skipping the hooked portion, which is sometimes hard to bypass.

Locate the electrode in the opening of the window and then gently push it in with the help of a blunt pick, wire guide, or one of the special electrode guides provided by the companies that make implants. If there is some resistance, it is likely that you are caught up in the hook. Retract gently and try to rotate the electrode, imagining the direction of the cochlea. On the left, for example, turn gently toward the right (clockwise); for the right ear, turn gently toward the left (counterclockwise). Place the electrode and then secure the internal receiver either with screws or sutures.

Transmastoid Decompression of the Facial Nerve

Checklist and pitfalls are discussed in the text that follows.

Surgical Steps

1. Follow steps as in simple mastoidectomy.
2. Identify the various segments of the facial nerve, skeletonizing the fallopian canal.
3. Fracture and remove any bone covering.
4. Open the sheath of the facial nerve.

Procedure

During the complete simple mastoidectomy, the vertical portion and external genu of the facial nerve have been fairly well delineated. The facial nerve can be divided for practical surgical purposes into three portions: (1) the portion within the internal auditory canal, (2) the tympanic (horizontal/middle ear) portion, and (3) the vertical (mastoid) portion. We deal here with the vertical and horizontal portions in that order.

From the external genu, the nerve proceeds vertically to the stylomastoid foramen at the level of the anterior edge of the digastric ridge. It is important to visualize its anatomy and, if possible, compare it with other bones, since there is considerable variation. The nerve must be lateral to the horizontal canal or may have a posterior projection at the genu, leading itself to potential damage. It is useful to visualize the nerve anterior to the digastric ridge and have an appreciation of how lateral it becomes as it reaches the mastoid tip. In the tympanic or middle ear portion, it appears in the region of the cochleariform process at the geniculate ganglion and then runs posteriorly toward the oval window (stapes) to a point just inferior to

and usually medial (deep) to the horizontal semicircular canal.

The vertical portion can be dissected from the level of the fossa incudis or from the digastric ridge. From the ridge it can be followed superiorly to the external genu; however, that is not a reliable landmark. While this approach is perfectly acceptable, we tend to follow nerves peripherally rather than centrally; it seems safer and simpler to us.

Having visualized the genu, the canal is skeletonized all the way down to the stylomastoid foramen. Drilling is done with strokes parallel to the direction of the nerve (superior to inferior, or vice versa). Exposure of the tympanic segment is helped by enlarging the aditus ad antrum. This dissection plus enlargement of the facial recess approach follows visualization anteriorly toward the cochleariform process.

Visualize the portion at the level of the oval window and the pyramidal eminence. This is a very useful image to keep in mind. If necessary for better exposure, adequate visualization can be obtained by a combined approach. Visualize the tympanic portion through the canal.

It is also possible to obtain adequate visualization by removing the incus. Prior to disarticulating it, try to drill under it without damaging or dislocating it. Use the smallest possible burs. Now try to remove and replace the incus. If drilling toward the geniculate ganglion was incomplete, drill now without the incus in place. (The incus should be left in place for use in the next procedure; practice positioning and repositioning the incus, however, to become familiar with its normal anatomical position.) Once the whole facial canal has been thinned to eggshell consistency, fracture it with a pick and lift the bone fragments gently with a Whirlybird *without using the facial nerve as a fulcrum*. The sheath is opened with a sharp sickle knife.

Canalplasty and Surgery on Middle Ear

Canalplasty

Aim

Enlarge the bony canal and visualize the entire fibrous and bony annulus.

Pitfalls

The major pitfalls are drilling the anterior wall excessively and entering the space for the temporomandibular joint.

Procedure

Using a large bur, drill the canal wall evenly until visualization of the entire fibrous annulus is achieved. Do not drill in one spot, but "sweep" the bur gently with even pressure and go one step at a time. (Skin procedures will not be dealt with here, since the skin of a specimen is thick, tight, and difficult to elevate adequately for these purposes.)

Underlaid Graft of the Tympanic Membrane

Aim

Place a graft under the tympanic membrane, covering all edges of the perforation.

Procedure

Visualize the tympanic membrane. Imagine it in four quadrants. Using a straight pick and a sickle knife, make a central perforation. Fill the middle ear's space with Gelfoam. Obtain a piece of fascia (or paper) that exceeds the size of the perforation by at least 30 per cent. Scarify the undersurface of the tympanic membrane around the perforation, using a Hough hoe. Now place the graft over the perforation and position it medially, using the Hough hoe.

Ossiculoplasty (Procedures on the Incus) Aim

Restore continuity of the ossicular chain (in this case, where incudal problems are the cause of the loss).

Procedure

Remove the "graft", the entire tympanic membrane and the Gelfoam filling the cavity. Now visualize the cavity and what is found beneath the various quadrants. Familiarize yourself with the anatomy. Mobilize the temporal bone and learn what areas can be seen best at various angles. Palpate the ossicles with a blunt pick and observe the area of the round window niche, the opening of the eustachian tube, the stapedial tendon, and so on. Compare these views of the middle ear cavity with those in approaches via posterior tympanotomy and transcanal. The incus is already loose.

Clip the distalmost portion of the long process of the incus ("necrosis of the lenticular process"). Since the mastoidectomy has been done, remove a piece of "cortical bone" posterior to the opening of the mastoid cavity. Using a small bur, delineate a square of bone and remove it in toto. Shape this piece of bone in order to restore continuity. Drill a small acetabulum for the head of the stapes and a groove for the remaining long process of the incus.

Remove the whole incus. Restoration of ossicular continuity in this case can be achieved in a number of ways. We use a sculptured incus, sculptured cortical bone, and, if it is available, a partial ossicular replacement prosthesis (PORP). Using the incus, clip the short process of the incus and drill a groove in the remaining long process for fitting over the head of the stapes. Then drill an acetabulum over the remaining body for fitting under the malleus. Now try to sculpt a piece of cortical bone in this same shape. Avoid contact by the incudal shaft with the promontory. If a PORP is available, try a PORP as well.

Intact Bridge Mastoidectomy

Aim

Exteriorize the disease process within the epitympanum, antrum, and mastoid to the meatus. The intact bridge mastoidectomy is a contemporary version of a modified radical mastoidectomy with preservation of the bridge, allowing tympanoplastic repairs.

Checklist and Pitfalls

Enlarge the anterior wall of the canal without opening the temporomandibular joint and visualize the entire fibrous and bony annulus. Incomplete removal of the posterior meatal wall is the major pitfall.

Procedure

These procedures involve removal of the posterior meatal wall. The original Bondy modified radical mastoidectomy implies this concept; however, the cavity of the middle ear is not entered in the Bondy procedure. The intact bridge mastoidectomy and modified radical mastoidectomy imply entering the middle ear.

The "bridge" is the most medial portion of the posterosuperior meatal wall. It is literally the bridge that crosses the attic toward the tegmental area. It has an anterior and posterior buttress. The anterior buttress is the superior portion where the posterior bony canal meets the tegmen. The posterior buttress is the inferior portion where the posterior bony canal meets the floor of the external auditory canal, lateral to the facial nerve.

Drill the anterior wall of the canal, enlarging it until clearly visualizing the entire fibrous and bony annulus without entering the space for the temporomandibular joint. Lower the posterior wall of the canal, leaving the bridge intact. Normally, the facial recess is not drilled open. In this bone, it has already been opened. Visualize the tensor tympanic tendon and section it (this maneuver lateralizes the manubrium). At this point in a clinical case, you would place a tube in the remnant of the tympanic membrane and do an ossiculoplasty, place a graft, and obliterate the aditus with either periosteum or cartilage.

Modified Radical Mastoidectomy

There is little else to do at this point in this regard, with this specimen. For practical purposes, a modified radical mastoidectomy has been done, except that the bridge is still intact. Removing the bridge would complete the modified radical mastoidectomy.

There are two approaches for the modified radical mastoidectomy: the inside-out or atticotomy approach, and the outside-in or atticantrotomy approach. We have done, step by step, an outside-in approach in this bone. In the next bone, which will be used for dissection of the middle ear, the inside-out approach should be done as in a modified radical mastoidectomy. Drilling is started in the epitympanum and followed posteriorly into the antrum. In doing this, the bridge is removed. The antrum is identified, as well as the dome of the horizontal canal. With this landmark under direct vision, mastoidectomy is performed,

and the posterior bony wall is lowered to the level of the facial ridge. This method is easier and safer than the outside-in approach in a sclerotic mastoid.

Radical Mastoidectomy

The aim of a radical mastoidectomy is to create an exteriorized cavity that includes the mastoid, antrum, epitympanum, and mesotympanum, leaving a dry, epithelialized cavity continuous with the external meatus. The procedure involves removal of the malleus and incus, leaving the stapes intact. The mucosa of the middle ear is removed, as well. At this point in this dissection, all that is left to do is removal of the ossicles and mucosa of the middle ear.

Surgery at the Petrous Apex

Aim

Exenterate (remove) air-cells of the petrous apex while maintaining the integrity of the structures of the inner ear.

Procedure

The petrous apex (petrous pyramid) has major groups of air-cells: the anterior and posterior. The posterior group involves cell tracts superior, posterior, and inferior to the semicircular canals; the anterior group involves cell tracts in the medial and superior aspects of the orifice of the eustachian tube, where the carotid artery is located. In order to reach these anterior cell tracts, radical mastoidectomy must be done. There are also hypotympanic air-cells adjacent to the round window niche.

Posterior Cell Tract

For this dissection, skeletonizing of the sigmoid sinus, dura in the posterior fossa, and facial nerve is required. This has already been done. The next step is carefully to skeletonize the semicircular canals. Use small burs (size 3-0 or 4-0).

There are four areas or tracts that should be looked for; they may or may not be present. The first tract is through the arch of the superior semicircular canal. The second tract is anterosuperior to the semicircular canal, leading into the supracochlear air-cells. Visualize this tract and its relationship to the facial nerve. The third tract is posterior to the superior canal and runs between the tegmen mastoideum and common crus of the membranous labyrinth toward the internal auditory canal. Do not expose the common crus - this is to be done later. At this time a better visualization of this anatomic relationship will be obtained. The fourth tract, or retro-labyrinthine cell tract, is inferior to the posterior semicircular canal, medial to the vertical segment of the facial nerve, and superior to the jugular bulb.

Anterior Cell Tract

A radical mastoidectomy has already been done. The tegmen should be skeletonized and the anterior wall should be thinned; both of these have already been performed as well.

These cells are in the "peritubal" and carotid areas in the bony wall just medial to the orifice of the eustachian tube anterior to the promontory. The cells are in close association with the tegmen mastoideum. Because of this close association, dissection must be very careful. We prefer to use small currets at this level.

Labyrinthectomy (Transmastoid Labyrinthine Dissection)

Aim

Completely remove the semicircular canals and soft tissue of the vestibule.

Checklist

1. The sinodural angle has to be completely thinned for adequate exposure of the vestibule.
2. The tegmen has to be thinned for adequate visualization of the superior aspect of the semicircular canals.

Procedure

The three semicircular canals are skeletonized until the membranous labyrinth is identified through the bone as a thin blue line. The relationship of the facial nerve to the horizontal semicircular canal is noted. Fenestrate the horizontal canal. Unroof the posterior and anterior portions of the superior semicircular canal. Follow the superior semicircular canal until it reaches the common crus with the posterior semicircular canal. The arcuate artery penetrates the hard labyrinth in the center of the arch of the superior semicircular canal. Go back to the superior semicircular canal, identify the superior vestibular nerve, and follow it into the internal auditory meatus.

Visualize the common crus. Now identify the endolymphatic duct as it enters the posterosuperior end of the vestibule. Verify its presence and its direction toward the endolymphatic sac. This is a useful anatomic relationship to keep in mind, since this area is not visualized in procedures done to enhance the endolymphatic sac. Bone is now removed from the floor of the vestibule where the inferior vestibular nerve is encountered.

Follow the common crus anteriorly into the vestibule. Open it widely and try to identify the membrane of the utricle and saccule. Get a feel for the relationship and distance between the footplate, saccule, and utricle. Just skeletonize the round window, because two additional observations can still be made in this area. First, at the inferior margin of the round window, drill carefully and identify the singular nerve. Second, drill the area now and identify the hook of the basal turn of the cochlea. This is an area where cochlear electrodes can encounter an obstruction when sliding into the cochlea. Visualize its anatomy and get an idea of the direction in which the electrode should be pointed and the amount and area of bone removal that should be drilled to bypass the hook.

Middle Ear Dissection

Procedure

This section is started with a new wet bone. Skin procedures will not be dealt with, because the skin of the specimen is thick and tight and difficult to elevate adequately for these purposes. Identify the walls of the ear canal. Visualize the tympanic membrane. Imagine it in four quadrants. Make an opening in the anterosuperior, anteroinferior, posteroinferior, and posterosuperior quadrants. Now elevate the tympanic membrane gently and identify areas and structures underneath your four openings. Visualize what is found beneath the opening in the posterosuperior quadrant.

Now bend the tympanic membrane forward. If it is too brittle, remove it. Visualize the middle ear. Palpate the ossicles, Jacobson's nerve, the area of the round window niche, and the opening of the eustachian tube, and identify the tensor tympani.

Remove the skin, leaving the annulus intact. Identify the tympanosquamous suture superiorly and the tympanomastoid suture posteriorly. Between the sutures is the vascular strip. Identify the anterior wall and carefully drill the anterior bony overhang without entering the temporomandibular joint's space. Enlarge the cavity until the entire annulus of the tympanic membrane is clearly visualized.

Now, by means of a large stapedial curet, curet the scutum from superior to inferior, thus avoiding injury to the ossicles. Visualize the stapedius tendon. Make sure that it is well in sight. At this point you are ready for a stapedectomy. Instead of sectioning the stapedius tendon (although this can be done, as well), try to lift it with the incudostapedial joint knife, along with its periosteum, leaving it attached to the periosteum of the long process of the incus. This is not a simple procedure.

Using the incudostapedial joint knife, separate the joint very gently. By means of a straight pick, fracture the footplate right in the middle. Mobilize the stapes, using superior-to-inferior and inferior-to-superior movements. Remove it, hooking the joint knife to the area immediately inferior to the capitulum. The remaining portions of the footplate are lifted gently with a Hough hoe.

Using the wire-bending die, 0.005 stainless steel, and Gelfoam make a prosthesis as described. Place it over the long process of the incus and gently crimp it - not too tightly, not too loosely - allowing some mobility in it, since excessive tightness may result in necrosis of the long process of the incus. Using 0.6 mm Teflon strips (or similar material), make your own piston prosthesis as described. Practice with measuring rod and measure the distance from the long process of the incus to the oval window. Cut the piston slightly larger than needed, to start with, and appreciate its position in the area of the oval window, and the potential damage that a longer prosthesis can cause. Then cut it to the right length and compare.

Now remove the incus. Try to make a longer prosthesis of stainless wire and Gelfoam for a malleus-to-oval window prosthesis. Use the incus to make a strut for use between malleus and stapes. Section the short process of the incus and drill an acetabulum over the

body in order for the strut to fit under the malleus. Use a small graft to cover the oval window.

At this point, using a curet or very small bur, curet or drill the attic in order to do an atticotomy. Use a Whirlybird to probe the antrum.

Cochlear Implant (via the Approach as in Mastoidotomy-Tympanotomy)

Aim

To place an electrode into the cochlea by sliding it through the round window.

Checklist and Surgical Steps

1. Achieve good visualization of the middle ear and round window niche via an endaural approach (Lempert I incision).
2. Perform atticotomy.
3. Remove the incus.
4. Expose the mastoid cortex and drill a mastoidotomy (Lempert I incision).
5. Perform a small postauricular incision and drill a seat for the internal receiver.
6. Tunnel the electrode from the postauricular incision to the mastoidotomy into the antrum, middle ear, and round window niche.
7. Secure the internal receiver in place.

Procedure

This procedure implies an endaural approach, exposing both the middle ear and mastoid cortex. Once the round window niche is clearly exposed and defined, an atticotomy is done and the incus is removed. A small mastoidotomy is performed. This opening will allow passage of the electrode into the middle ear through the antrum. The receiver is placed as in the approach for a posterior tympanotomy; however, only a small postauricular incision is needed, and the electrode is tunneled anteriorly towards the mastoidotomy.

As this is a dissection of temporal bone, what can be tried is to place the receiver during a mastoidotomy and to pass the electrode through the antrum and into the round window. The incus has to be removed (in this case it has already been removed). In the mastoidotomy an opening is made in the mastoid fossa without doing a complete cortical mastoidotomy. The bone is drilled in the direction of the antrum by visualizing the attic area by direct view into the middle ear. In order to obtain a good idea of location of the antrum, a Whirlybird can be used for direct probing. Even if a mastoidotomy is not precisely a cortical mastoidectomy, the opening should be big enough, and not a dangerous, blind, small opening. The mastoidotomy itself is a useful exploratory tool for the antrum when blockage is suspected and/or improved aeration of the middle ear is desired. Insertion of the electrode via the round window is the same as in the approach in a posterior tympanotomy, in the sliding of the electrode through the opening into the cochlea.

Transcanal Labyrinthectomy

Procedure

Visualize the middle ear cavity. Identify the oval and round windows, promontory, and facial nerve. The purpose of this procedure is to destroy the labyrinth. The stapedial footplate has been removed, and the vestibule containing the saccule and utricle is exposed. By use of a hook or Hough hoe, the saccule can be destroyed. Using this same route, the ampulla of the superior semicircular canal can be reached above and in front; that of the posterior canal below and behind; and that of the lateral canal inferiorly beneath the facial nerve.

In this process, the utricle is destroyed as well. It is important to stay within bony confines and destroy only the "membranous labyrinth". Immediately inferior to the vestibule is the internal auditory canal, and the bony plate is quite thin. The facial nerve can also be injured. For completion, drill the promontory and join the oval and round windows, exposing the beginning of the basal turn of the cochlea.

Additional drilling can be done at this point for purposes of orientation to cochlear anatomy. Placing an electrode via the basal turn can give the surgeon a better idea of electrode placement and its anatomic location. Also, at this point, an "inside-out" modified radical mastoidectomy can be performed following directions as described in the section "Modified Radical Mastoidectomy" in this chapter. After this procedure, there will still be the possibility of repeating some of the operative procedures done with the first wet bone.