Chapter 115 – Mastoid Surgery

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Mastoidectomy is one of the most common otologic operations performed today. Indications for mastoidectomy range from eradication of chronic infection or cholesteatoma to approaches for various neurotologic procedures. Mastoidectomy was first described by Louis Petit in the 1700s, although the concept did not gain wider acceptance until espoused by von Troltsch and Schwartze.[1,2] Modifications of the original radical procedure followed. Bondy described a technique in 1910 in which mastoidectomy was performed and the posterior canal wall removed while leaving the pars tensa and ossicular chain intact.[3] This procedure represents the origin of today's modified radical mastoidectomy.

Although the terms canal wall down (CWD) mastoidectomy and modified radical mastoidectomy are sometimes used interchangeably, there are in fact distinctions between these various procedures. In modified radical mastoidectomy, usually reserved for attic cholesteatomas, the mesotympanum is not entered.[4] Removal of the canal wall externalizes the cholesteatoma, and there is no need to elevate a tympanomeatal flap to address disease in the mesotympanum or explore the ossicular chain. When the middle ear is entered, the procedure is referred to as tympanoplasty with CWD mastoidectomy.

In 1958, the canal wall up (CWU) mastoidectomy was popularized by William House.[5] This procedure attempted to avoid the common problems with radical mastoidectomy, such as the lifelong requirement for cleaning, a propensity toward caloric stimulation by cold water or air, and restrictions on water exposure while bathing or swimming. In addition, hearing results improved with this procedure when compared with the standard modified radical mastoidectomy. CWU mastoidectomy has the advantage of preserving the normal anatomy of the ear. Generally, there is no need for maintenance of dry ear precautions. However, the exposure granted by this approach is more restricted, and it is technically more difficult to fully eradicate cholesteatomas. Frequently, a second-look procedure is required to rule out recurrent or residual disease, and recurrent disease is more likely.

Removal of the posterior ear canal affords better exposure that usually allows the cholesteatoma to be addressed at a single stage. It is technically easier to fully eradicate a cholesteatoma and the recurrence rate is lower. Disadvantages of CWD procedures include a more protracted postoperative healing period, the need for indefinite mastoid bowl care, a higher possibility of recurrent otorrhea, poorer hearing results, and a need for restricting water exposure.

The technique of removing and reconstructing the posterior bony canal wall has been espoused by numerous authors over the years.[6–8] This technique theoretically provides the advantage of improved surgical exposure with recurrence rates similar to those with CWD procedures yet avoiding the disadvantages of an open mastoid cavity. McElveen and Chung[8] described en bloc removal of the posterior bony canal wall with an oscillating microsaw. In certain cases this technique allows the surgeon to leave the ossicular chain intact, thereby improving hearing results in comparison with the use of partial or total ossicular reconstruction prostheses. The canal wall is then replaced and secured with bone cement. Dornhoffer[7] advocates removal of the upper one third of the canal wall and reconstructs the defect with cymba cartilage. Gantz and colleagues[6] have further modified the technique to involve obliteration of the mastoid with bone pâté and creation of an attic block with bone chips to isolate the mesotympanum from the attic and mastoid. This is done to reduce the amount of nitrogen-absorbing epithelium to discourage the formation of a retraction pocket. Both authors advocate second-look procedures when the canal wall is reconstructed.

PATIENT SELECTION

Cortical mastoidectomy may be used for the treatment of complicated acute otitis media, chronic otitis media unresponsive to medical management, cholesteatoma, neoplasm of the temporal bone, repair of cerebrospinal fluid (CSF) leaks, and decompression of the facial nerve, as well as for exposure of deeper structures in the temporal bone or posterior fossa (Fig. 115-1). The decision to perform a CWU or CWD procedure must be individualized to each patient. Important factors include the location and extent of cholesteatoma, the presence of defects in the bone of the posterior canal wall, patient compliance, the presence of complications of otitis media or cholesteatoma, the presence of malignancy, the patient's hearing status, and the general medical condition of the patient.

Figure 115-1 **A,** Erythema and fluctuance overlying the right mastoid secondary to a subperiosteal abscess. The patient had a history of having undergone mastoidectomy for chronic otitis media. **B,** Incision and drainage revealed extensive purulent debris. Treatment included antibiotics and revision mastoidectomy.

Removal of the canal wall is indicated when it has already been destroyed to a significant degree by disease. Although small dehiscences can be repaired, a large erosion of the posterior canal wall by cholesteatoma is often best dealt with by removing the remaining canal wall. A fistula in the horizontal semicircular canal (HSC) (Fig. 115-2) is often best managed by leaving the skin in situ and externalizing the matrix into a CWD mastoid cavity. However, successful preservation of hearing has been reported with complete removal of the matrix overlying the dehiscence via a CWU technique.[9] Sclerotic mastoids may necessitate the use of a CWD approach (Fig. 115-3). When there is extensive cholesteatoma that would require a second stage in a patient with significant comorbid disease, removal of the canal wall can allow single-stage eradication of the disease. Recurrent cholesteatoma despite multiple attempts at CWU procedures is another indication for CWD mastoidectomy. Some authors would argue that cholesteatoma in an only-hearing ear constitutes an indication for a CWD procedure; however, this depends on the extent of the cholesteatoma and the surgeon's experience. Finally, poor compliance has frequently been cited as an indication for CWD surgery.

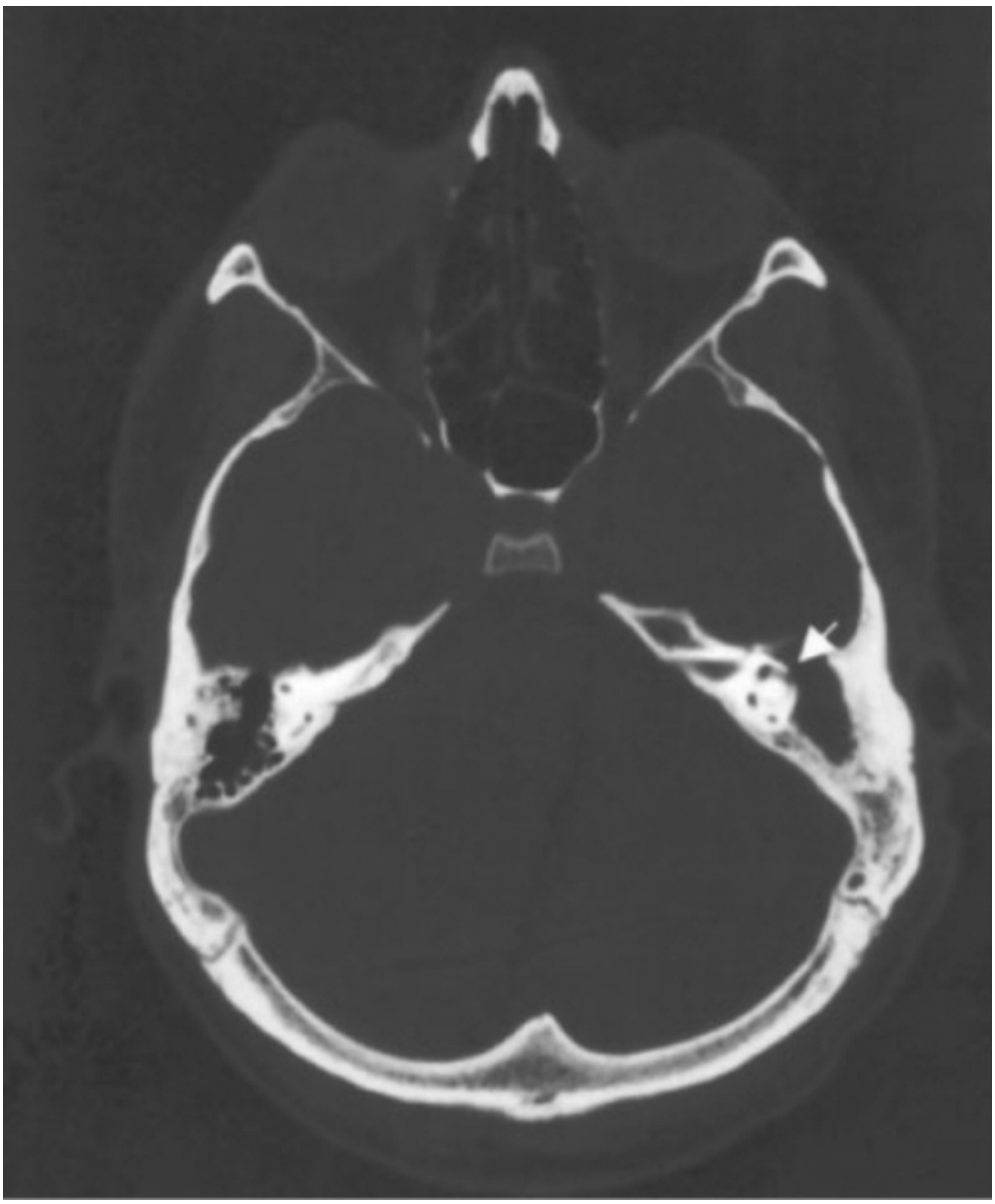

Figure 115-2 Cholesteatoma in the left mastoid with dehiscence of the horizontal semicircular canal *(arrow)*. Matrix was left over the dehiscent area and exteriorized with a canal wall down mastoidectomy.

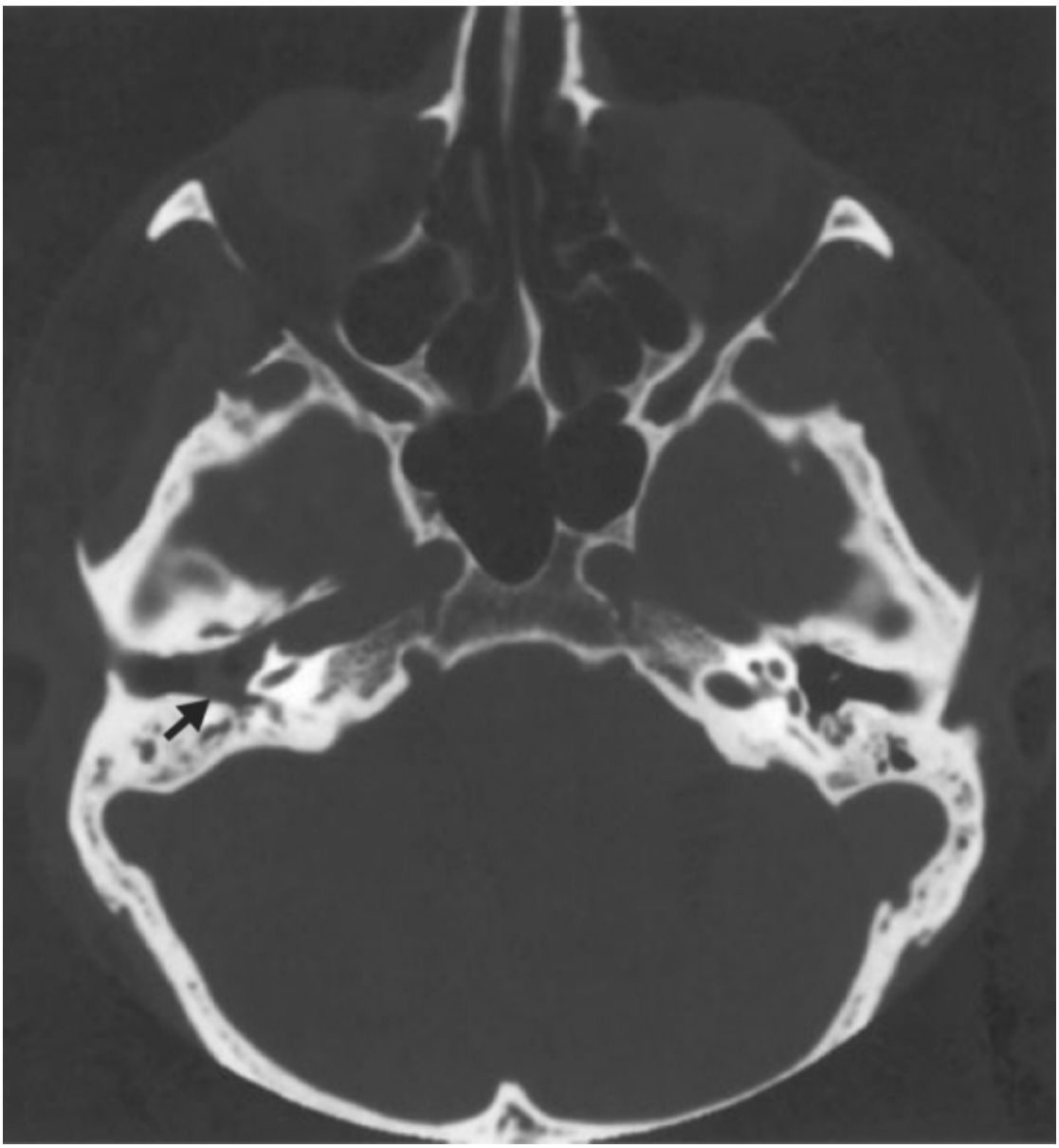

Figure 115-3 Cholesteatoma *(arrow)* in a right contracted mastoid cavity. A canal wall down mastoidectomy was planned from the outset.

PREOPERATIVE EVALUATION

Before surgery, patients should undergo routine audiometry, in addition to imaging studies as indicated. It is never advisable to operate on an ear in which hearing status is unknown. Preoperative audiometry will also allow the surgeon to determine whether the better- or worse-hearing ear is being operated on, which can affect the operative strategy. Additionally, the surgeon should note the presence and degree of any conductive hearing loss, whose source should be sought at the time of surgery.

Imaging studies are not mandatory before simple mastoidectomy, but high-resolution computed tomography (CT) allows assessment of the size and degree of pneumatization of the mastoid cavity, as well as the position of the tegmen mastoideum and sigmoid sinus. In addition, one should evaluate for dehiscence of the tegmen, facial nerve, or HSC. CT of the temporal bone is usually performed before cochlear implantation to assess the cochlea for congenital abnormality or ossification.

Barring extenuating circumstances such as severe comorbid conditions, mastoidectomy is performed under general anesthesia. Long-acting muscle relaxants should be avoided to allow monitoring or electrical stimulation of the facial nerve. Nerve monitoring is not essential for initial mastoidectomy, and disposable nerve stimulator units can be used if an unanticipated need arises. Formal nerve monitoring should be available for patients undergoing mastoidectomy in the setting of congenital ear anomalies, cochlear implantation, and revision mastoid surgery. Although electrophysiologic nerve monitoring is not a substitute for solid understanding of the course of the facial nerve through the temporal bone, it is a useful tool, particularly when an unanticipated anomaly is encountered. It is

our practice to monitor the facial nerve for all mastoidectomies. Even though this may not represent the current standard of care, regular use of the nerve monitoring unit ensures familiarity with the equipment when the need arises and makes sense from a medicolegal standpoint as well.

Although evidence supporting the perioperative administration of antibiotics to patients undergoing mastoidectomy is limited, we routinely administer one dose preoperatively (generally 2 g of cefazolin). This may serve to reduce the incidence of postoperative wound infection in a contaminated ear inasmuch as most chronically draining ears harbor polymicrobial infections. A special note should also be made regarding preparation for revision mastoidectomy. Regardless of whether the patient has previously been operated on by the same or another surgeon, the operative report should be reviewed to allow the surgeon to anticipate potential pitfalls such as a dehiscent tegmen or facial nerve. It is generally advisable to use facial nerve monitoring in all revision surgery because the potential for dehiscence is greater in this group of patients. A preoperative CT scan is also recommended to delineate changes related to the previous surgery. The revision ear must be approached with caution because of the obliteration of normal landmarks.

SURGICAL APPROACH

The patient is positioned supine on the operating table, usually with the head at the foot of the bed to allow the surgeon's knees to fit under the table. The head is turned toward the side away from the operated ear, while taking care to ensure that the contralateral auricle is not being compressed. A small amount of hair in the postauricular region is shaved to keep the operating field free of hair. The patient's remaining hair is then secured with tape to keep it out of the field. The postauricular crease is cleaned with alcohol and injected with lidocaine with epinephrine. If a facial nerve monitor is to be used, the electrodes are placed at this time. The patient should be secured to the table with straps because rotating the bed will be necessary during the procedure. Bed controls may be retained by the anesthesiologist or may be wrapped in sterile plastic and placed on the bed for the surgeon to control. The operating table is turned either 90 or 180 degrees, depending on the surgeon's preference.

The operative field is then prepared with povidone-iodine (Betadine) and the ear canal is flooded with preparative solution. Drapes are applied as the individual surgeon prefers; it is common to use a drape with a plastic bag attached to collect irrigation fluid and prevent it from running onto the floor or the surgeon's lap. Suction and irrigation tubing is set up, the drill is connected to the motor and foot pedal, and the instrument table and operating microscope are brought into position. Before the start of the procedure, the surgeon should ensure that the microscope is properly balanced and that the correct lens (usually 225 to 300 mm) is attached.

The external auditory canal (EAC) and tympanic membrane (TM) are examined under the operating microscope. Cerumen or debris in the EAC is removed while taking care to not cause bleeding.

Four-Quadrant Injection

If a tympanomeatal flap is to be elevated in conjunction with the mastoidectomy, injection of lidocaine with epinephrine is performed at the bony-cartilaginous junction. The location of this junction can be estimated by the medial-most aspect of the hair-bearing canal skin. A 1.5-inch, 25-gauge needle with the bevel aimed toward the bone is used to inject the four quadrants of the canal. Light pressure is applied with the speculum to create a cushion into which the local anesthetic is injected and to direct the anesthetic medially. The correct plane for injection offers a moderate amount of resistance. The bony canal should be monitored to ensure that the skin of the EAC has blanched down to the TM without blebs.

Establishing a Vascular Strip

If a tympanomeatal flap is to be elevated in conjunction with the mastoidectomy, a vascular strip is established via an endaural approach at this point. The canal incision can be fashioned in an H shape (Fig. 115-4). Alternatively, the vascular strip (the lateral aspect of the “H”) can be defined at this point and the tympanomeatal flap (medial aspect of the “H”) deferred until exposure of the canal is established via the postauricular incision. The superior (12 o'clock) incision is placed in line with the lateral process of the malleus. The superior and inferior incisions are established with a flap knife or Beaver blade. They are connected approximately halfway between the annulus and the bony-cartilaginous junction with an angled Beaver blade or a round knife. A cotton ball soaked in topical adrenaline may be inserted into the EAC for additional hemostasis if necessary. Alternatively, the canal incisions can be fashionedvia the postauricular incision. In this case it is useful to have cotton or Gelfoam in the medial ear canal to provide resistance and protect the anterior canal. A no. 11 blade is useful for this approach.

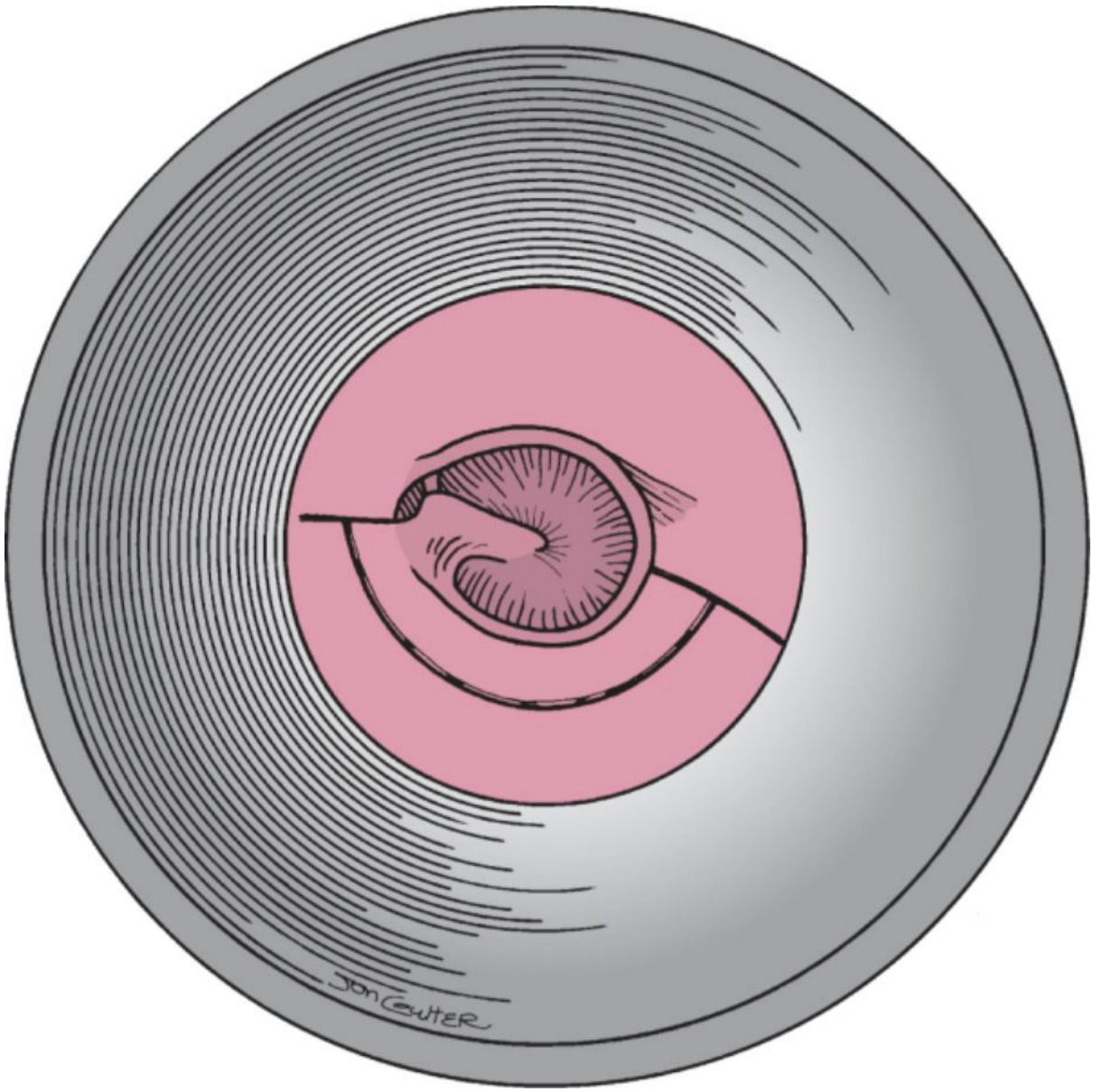

Figure 115-4 Skin flaps within the external auditory canal. An H-shaped skin incision creates a laterally based vascular strip-type flap and a medially based tympanomeatal flap.

Planning the Postauricular Incision

The microscope is moved aside and a postauricular incision is made with a no. 15 blade. The incision extends from just superior and posterior to the root of the helix down to the mastoid tip (Fig. 115-5). The incision should be placed several millimeters behind the postauricular sulcus. When the mastoidectomy is performed for access to deeper structures, a more posterior incision is made to provide better exposure of the sigmoid sinus and posterior fossa (Fig. 115-6). In young children without a well-developed mastoid tip, the inferior aspect of the incision is more posterior and is not carried down as far to avoid injuring the facial nerve (Fig. 115-7). The incision is carried down to the level of the loose areolar tissue overlying the temporalis fascia (Fig. 115-8). Identification of this plane is facilitated by pulling laterally on the auricle as the incision is made. Once the correct plane has been entered, the knife blade is turned flat and dissection is carried anteriorly toward the posterior EAC while taking care to not enter the EAC at this point. Temporalis fascia may now be harvested if TM grafting is anticipated. The inferior-most aspect of the fascia harvest site should be placed at least one centimeter above the linea temporalis. Preserving the fascia at the linea temporalis allows more solid closure of the superior periosteal incision.

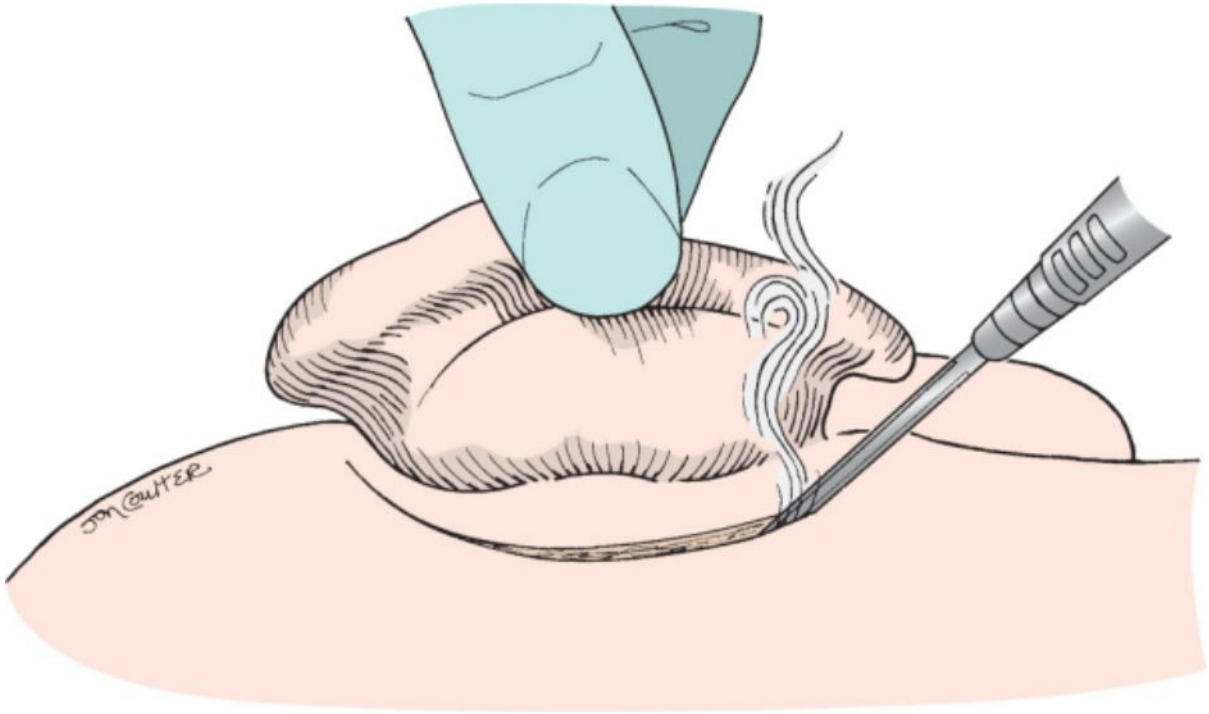

Figure 115-5 Postauricular skin incision used in adults.

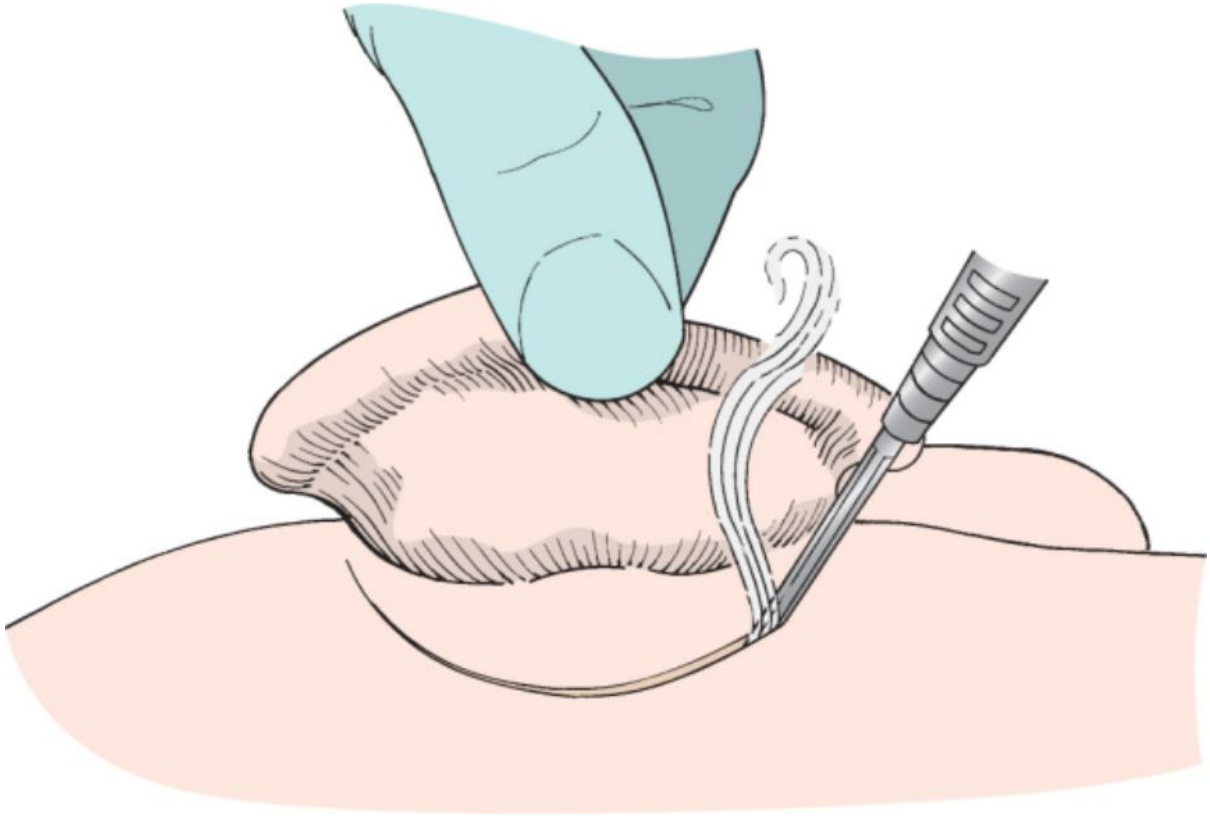

Figure 115-6 Skin incision used for transmastoid neurotologic surgery.

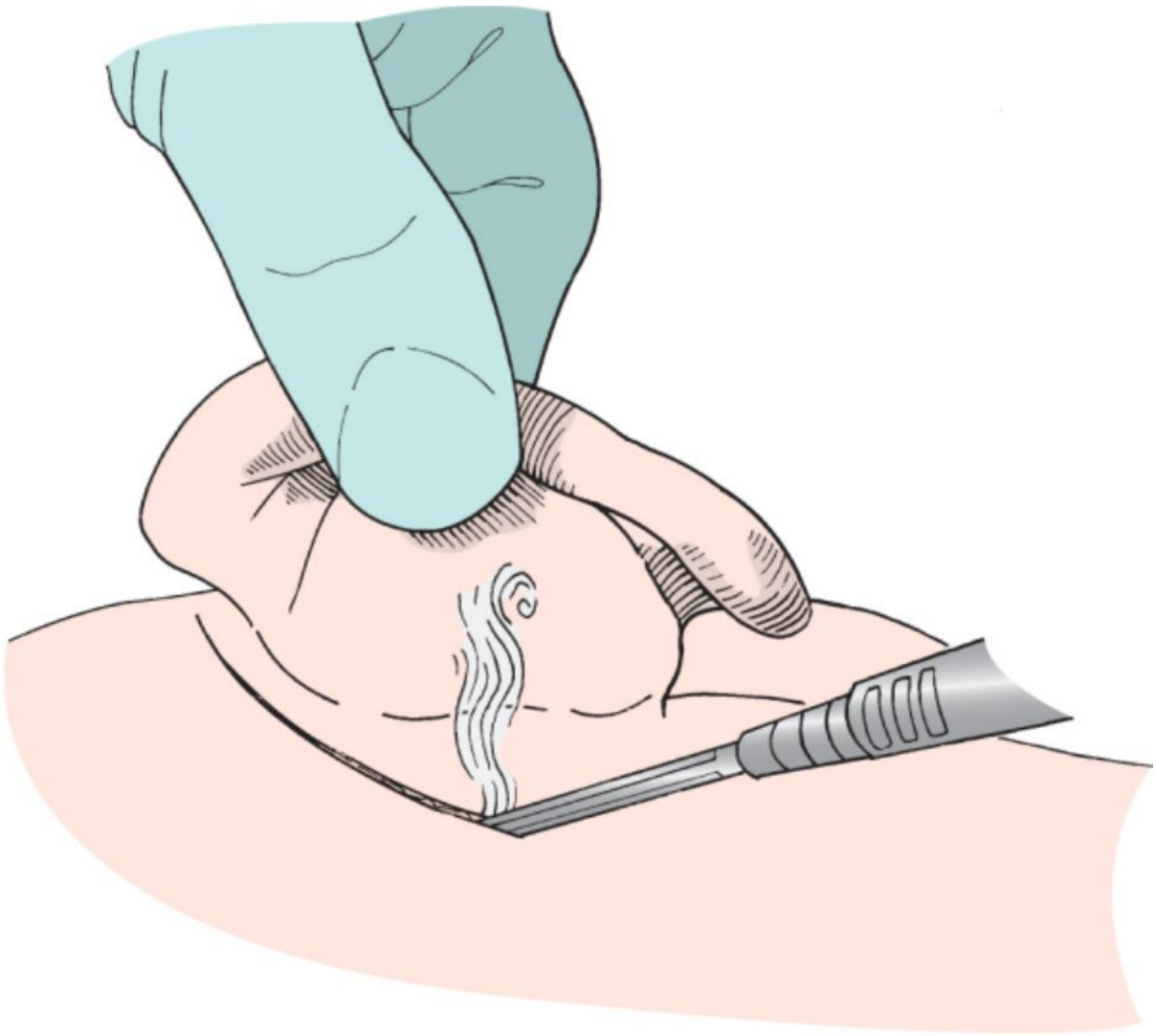

Figure 115-7 Postauricular skin incision used in children.

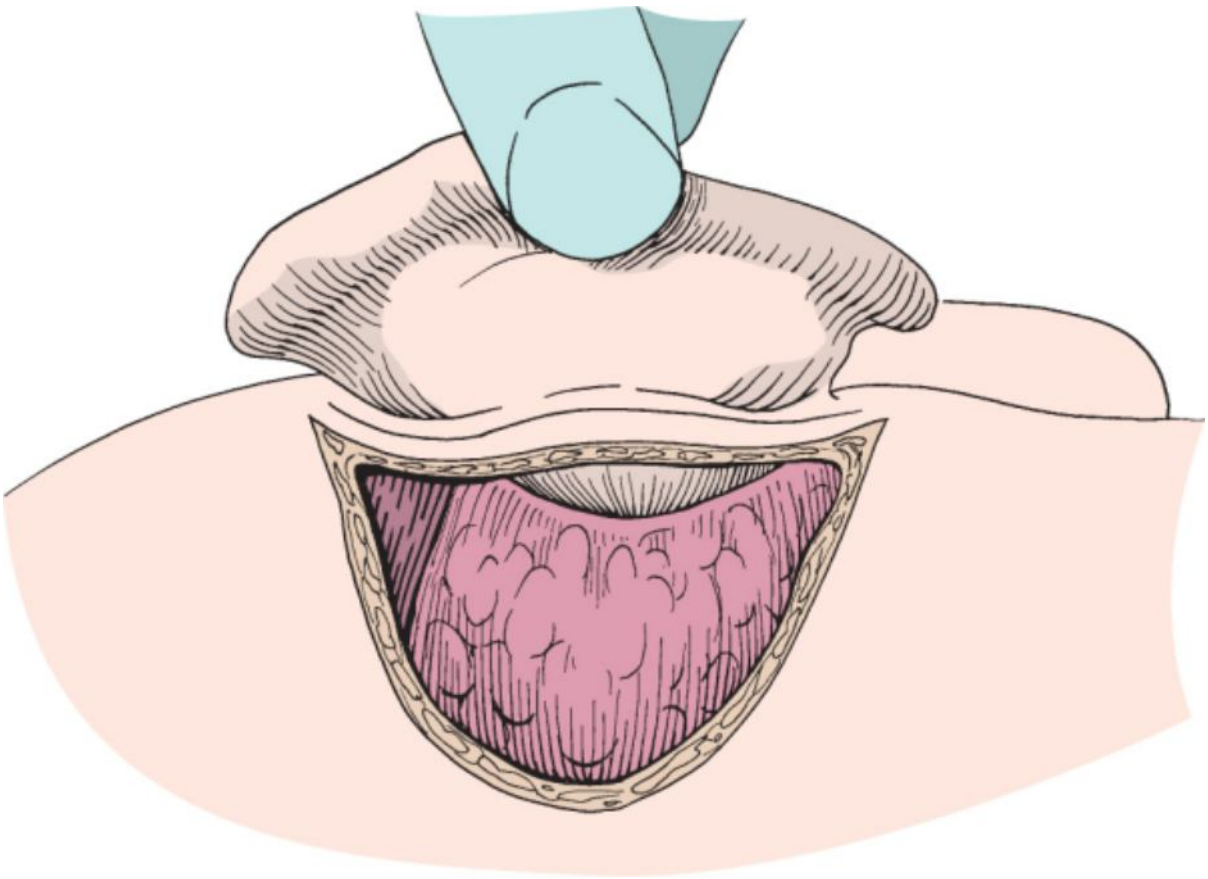

Figure 115-8 Dissection of subcutaneous tissue to expose the temporalis fascia and musculoperiosteal tissue overlying the mastoid cortex.

The mastoid cortex is exposed by incising the periosteum along the linea temporalis. A vertical limb is extended from the posterior aspect of the periosteal incision toward the mastoid tip. This can be performed in a T fashion (Fig. 115-9) or in a “7” shape with the apex positioned posterosuperiorly. A heavy Lempert or Fisch periosteal elevator is used to free the cortex of soft tissue. A large duckbill or Joseph elevator is used to expose the posterior aspect of the EAC. If a vascular strip was fashioned, it can now be elevated from bone with a round knife. Tracheostomy tape or a ¼-inch Penrose drain can be placed through the canal andbrought out through the postauricular incision to retract the ear anteriorly. Self-retaining retractors are positioned and the surface landmarks of the mastoid are identified, including the spine of Henle, the cribriform area, and the linea temporalis (Fig. 115-10). MacEwen's (suprameatal) triangle provides an approximation of the location of the antrum (Fig. 115-11).

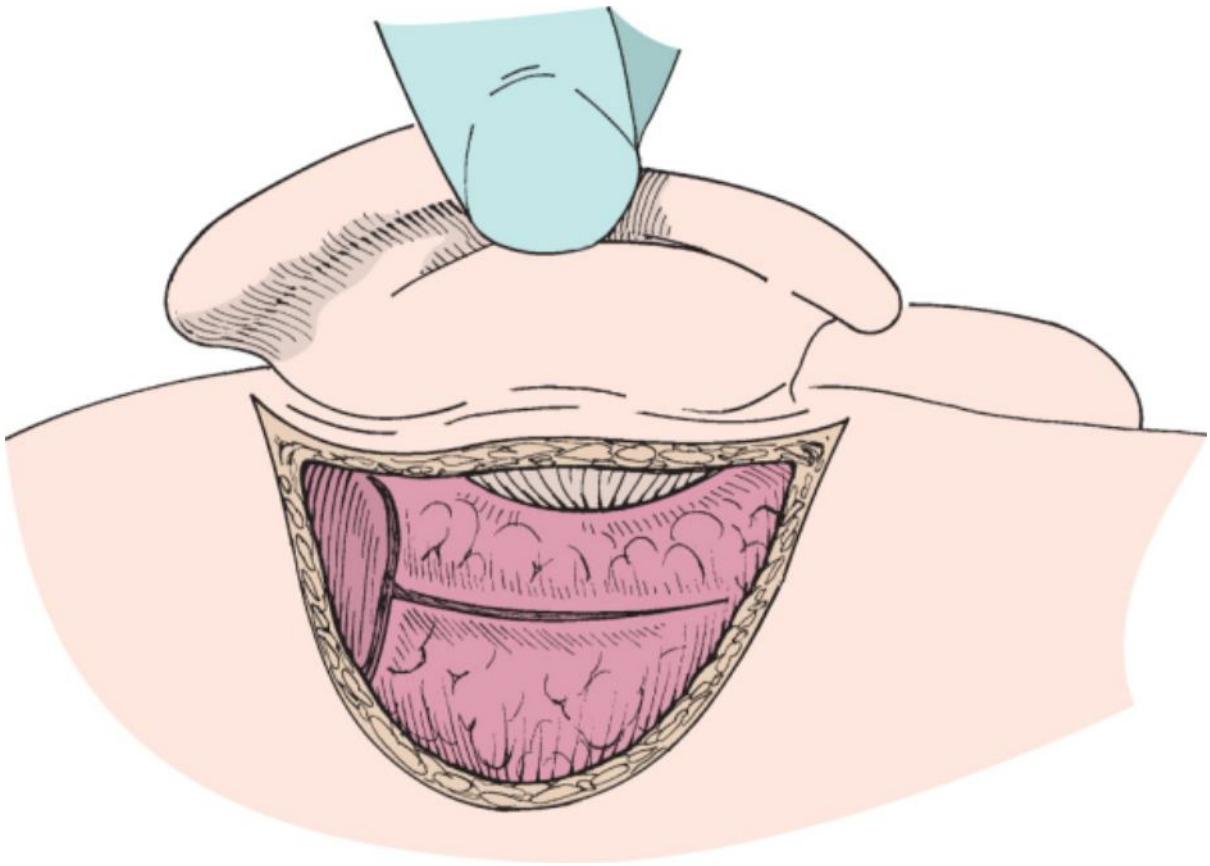

Figure 115-9 Incisions used to expose the mastoid cortex.

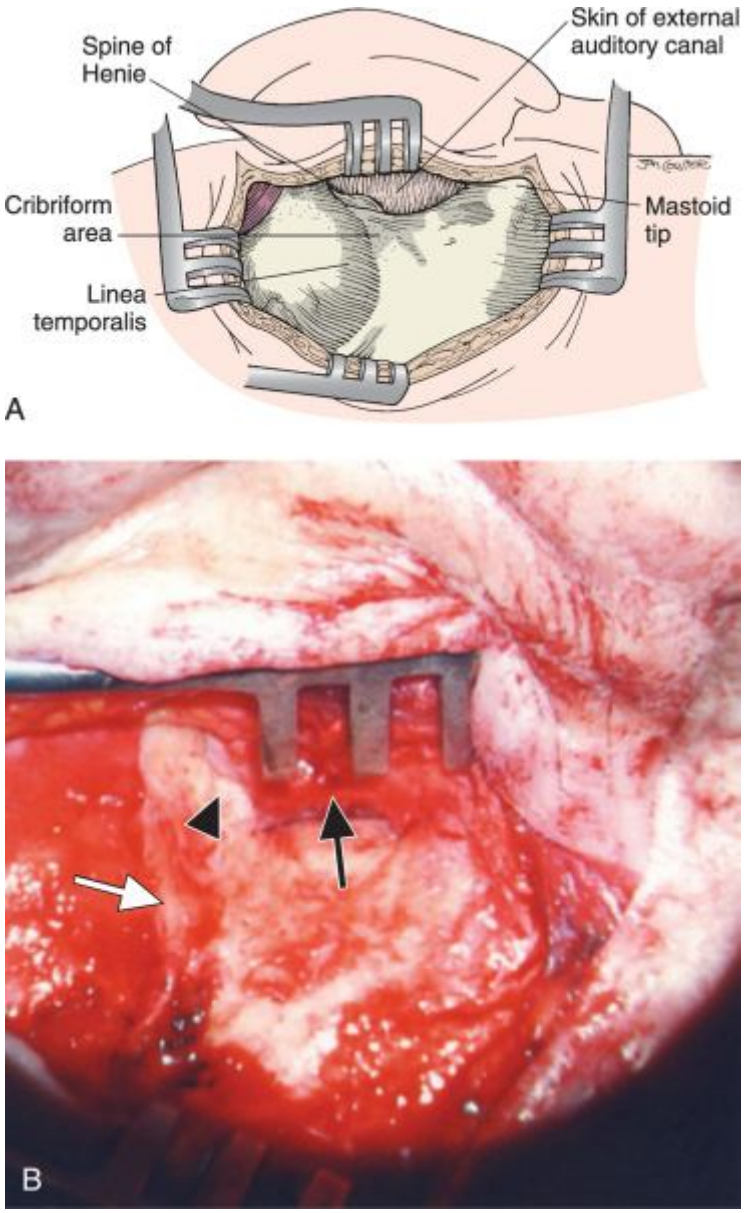

Figure 115-10 **A,** Surgical landmarks on the lateral surface of the temporal bone. **B,** Intraoperative view. The mastoid periosteum has been incised and reflected anteriorly to expose the linea temporalis *(white arrow),* spine of Henle *(arrowhead),* and posterior aspect of the external auditory canal *(arrow).*

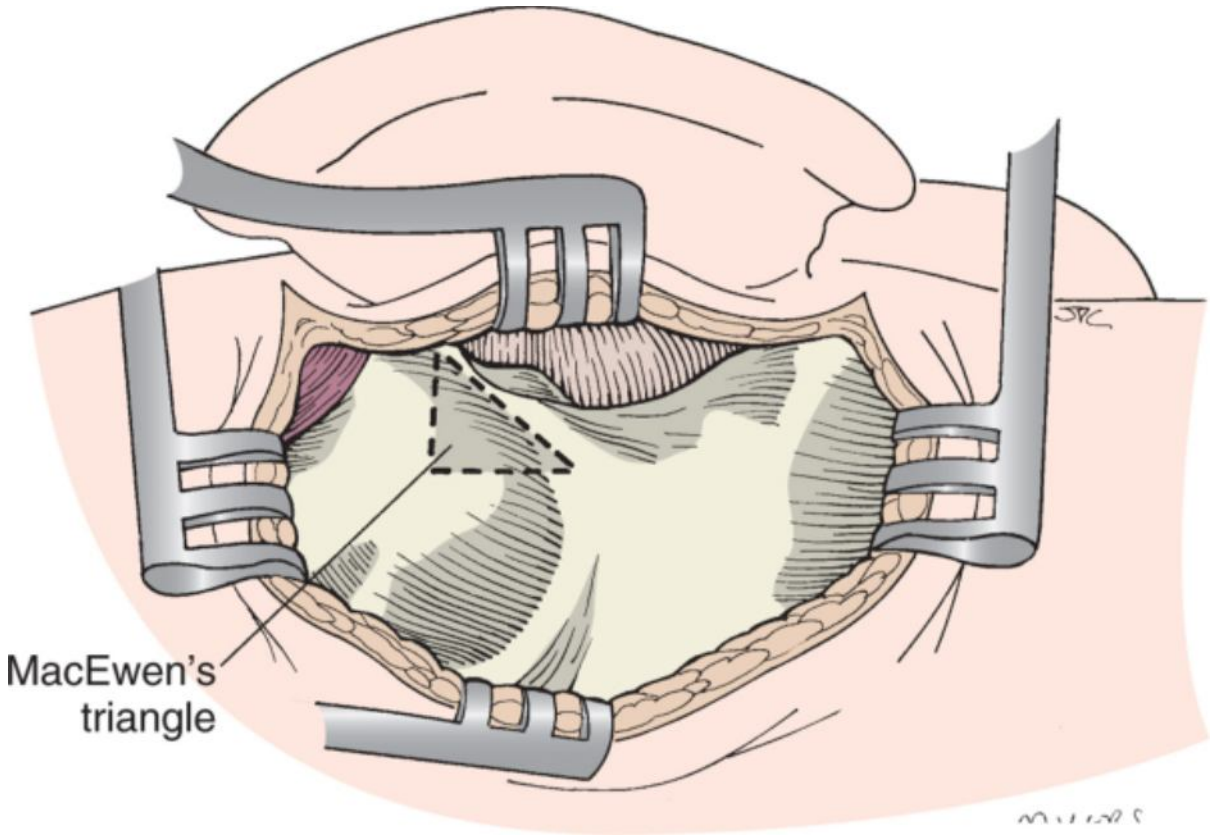

Figure 115-11 MacEwen's triangle (suprameatal triangle).

Intact Canal Wall Mastoidectomy

During the course of training in otologic surgery it is imperative that the surgeon first gain exposure to temporal bone drilling in the laboratory. This invaluable experience will allow familiarity with the anatomy and equipment and facilitate safe and speedy mastoidectomy in the operating room. Adequate irrigation is essential for safe drilling. Constant flow prevents accumulation of bone dust and thereby allows underlying structures such as the tegmen to be identified through intact bone. Irrigation also prevents thermal injury to underlying structures, such as the facial nerve. Either suction irrigators or a self-irrigating drill can be used. Generally, the drill is used in the forward direction and drilling performed in a clockwise direction. Counterclockwise drilling in the “forward” setting can result in “skipping” of the burr and potentially damage underlying structures. The use of long smooth strokes parallel to the underlying structures is safer and more effective and provides better visualization. Larger burrs are safer because they are less likely to plunge into critical structures, and the general rule is to use the largest burr that can safely be used in that particular region. Drilling typically starts with a large (6 mm) cutting burr that is downsized to a 4-mm cutting burr more medially, after entry into the antrum. A diamond burr should be used for the final thinning of bone overlying structures such as the middle fossa tegmen or sigmoid sinus or when drilling near the facial nerve. Drilling with a diamond burr in the “reverse” direction can also control small bleeders in the bone. The drilling trajectory should parallel the underlying structure to be identified to reduce the chance of unintentional injury. During the procedure it is important to “saucerize” the edges of the mastoid cavity to provide excellent visualization of structures as they are identified and help prevent inadvertent injury. The exception to such saucerization occurs in cochlear implant surgery, where a ledge of bone laterally may help retain the coiled wire within the mastoid cavity. In general, injury is best avoided by clearly identifying vital structures such as the tegmen, facial nerve, sigmoid sinus, horizontal canal, and incus. In this manner, structures may be followed throughout their course in the mastoid rather than risking injury by haphazard identification.

The initial drilling is often performed more readily without use of the operating microscope. If the surgeon prefers to use the microscope, a low-power view should be used so that the entire mastoid cortex is in view. A large cutting burr is used to begin drilling. The first cuts are made parallel to the linea temporalis and then posterior to the EAC to create a 90-degree angle. The third side of the triangle roughly approximates the course of the sigmoid sinus posteriorly (Fig. 115-12). The mastoid cortex is removed and the air cell system is exposed (Fig. 115-13). Drilling proceeds with identification of the tegmen mastoideum through bone. The tegmen will be visible as a pink color change in the bone superiorly in the mastoid cavity; small vessels signal that dissection is close to the dura. The sound of the drill may become higher pitched as the bone becomes thin. The tegmen should remain covered with a thin layer of bone to avoid injury to the dura or the future development of an encephalocele. The posterior

canal wall is thinned while taking care to not enter the canal. Drilling proceeds along a wide plane to avoid drilling in a hole, and the edges are saucerized so that one does not have to drill unseen under a ledge. The deepest point of the dissection should always be centered over the antrum, approximated by MacEwen's triangle. This will ensure that the antrum with its critical landmarks will be entered before reaching the plane of the facial nerve. The sigmoid sinus will come into view posteriorly in the mastoid cavity as the air cells are removed. Care must be taken to remove disease present in the sinodural angle, as well as in the mastoid tip. The digastric ridge can be identified posteroinferiorly; the cephalic edge of this ridge provides an important landmark for the course of the vertical portion of the facial nerve.

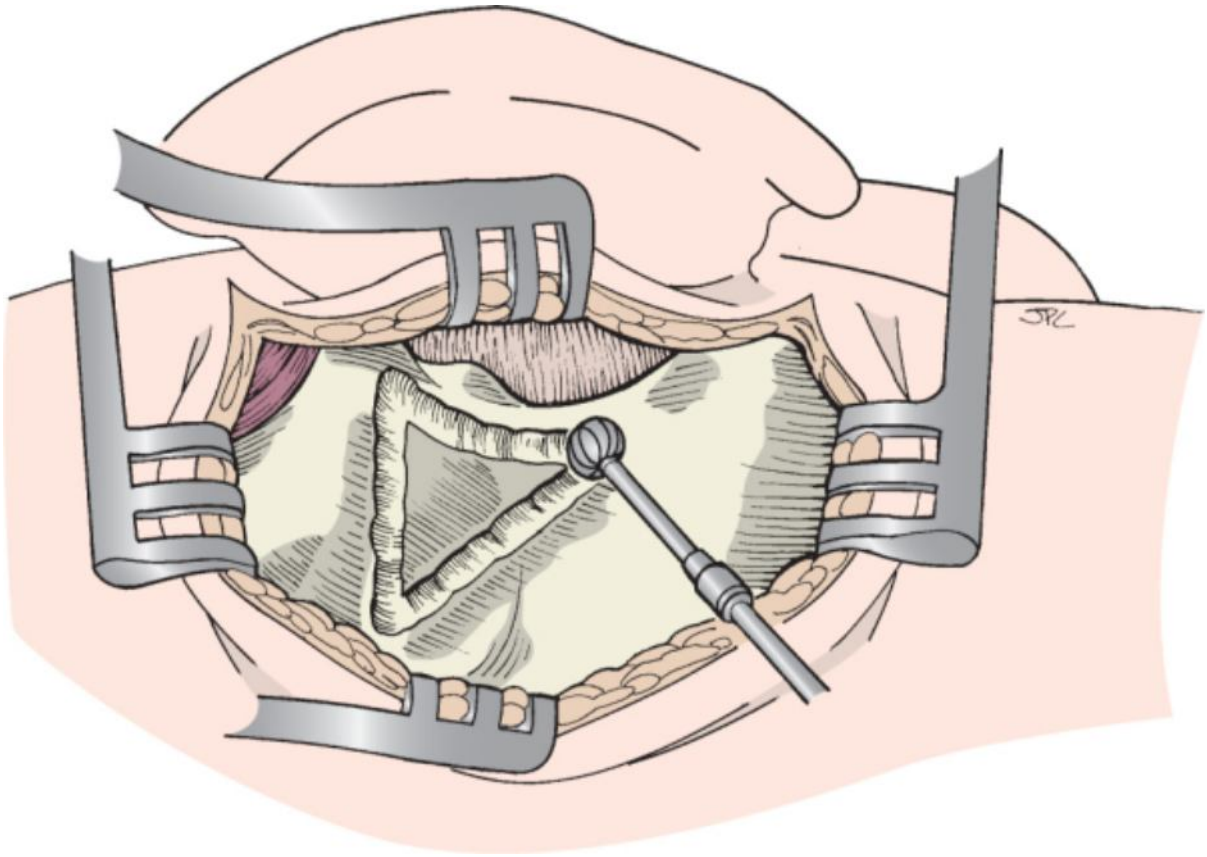

Figure 115-12 Location and direction of the initial bone cuts on the mastoid cortex.

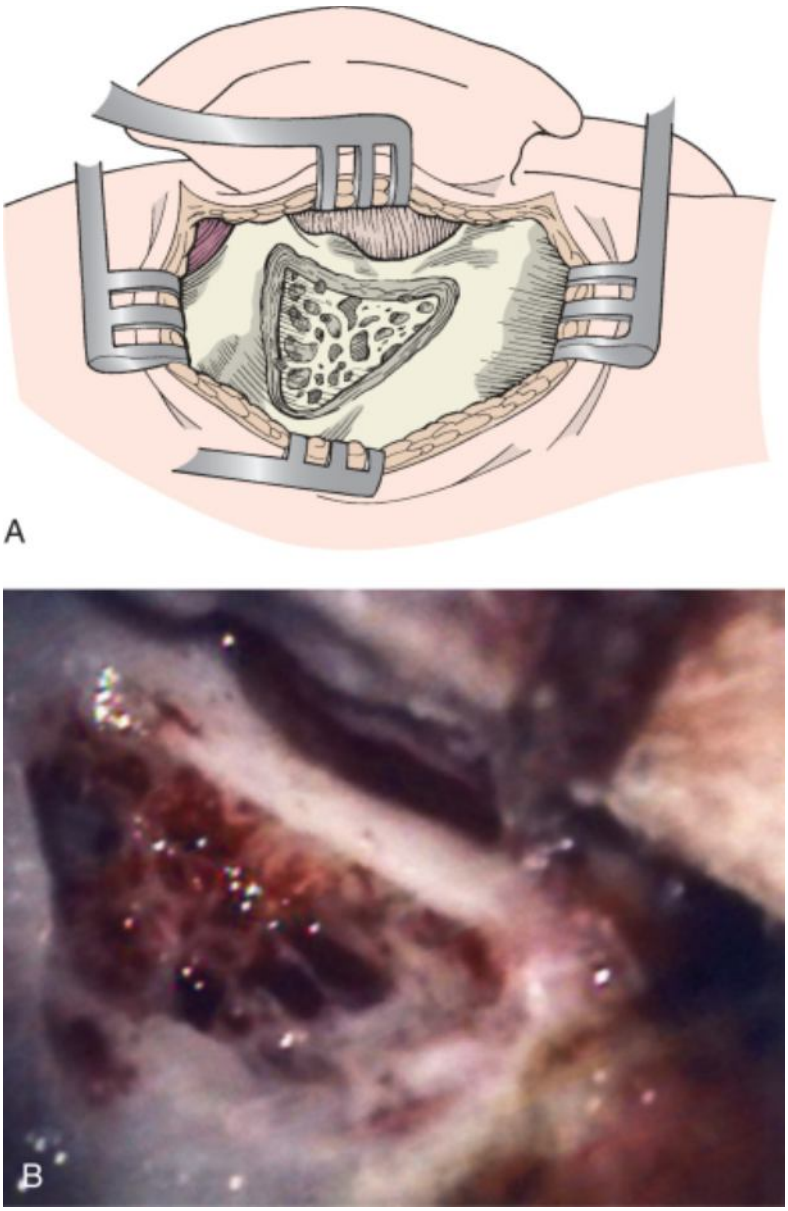

Figure 115-13 **A,** Removal of the mastoid cortex exposes the mastoid air cell system. **B,** Intraoperative view.

Körner's septum will be present to a varying degree just lateral to the mastoid antrum. Using the tegmen as the superior landmark and the posterior canal wall as the anterior landmark, Koerner's septum is removed and the antrum is entered (Fig. 115-14). This step highlights the importance of identifying the tegmen and following it toward the antrum. Failure to identify the tegmen may result in entering the antrum too low and risking injury to the HSC and facial nerve. Drilling through the septum will allow visualization of the HSC. Once the antrum has been entered, cholesteatoma matrix or mucosal disease should be removed so that the HSC may be identified. Once the HSC and tegmen are clearly visible, the short process of the incus may be identified. The burr is downsized at this time and drilling continues toward the root of the zygoma until the incus is seen in the fossa incudis. It is helpful to tilt the bed away from the surgeon to visualize the incus. Frequently, the incus is visible through the irrigation fluidfilling the antral air cell before being visible through air because of the refractive properties of water. Care must be taken to not touch the incus with the drill or high-frequency sensorineural hearing loss may result. The completed intact canal wall mastoidectomy should be bounded by a thin but intact middle fossa plate, the sigmoid sinus should be visible through intact bone, the posterior wall of the EAC should be thinned yet intact, the short process of the incus should be visible via the aditus ad antrum, and the horizontal SCC should be clearly identifiable (Fig. 115-15). Additional work may be undertaken to clean Trautmann's triangle, the mastoid tip, and the retrofacial air cell tracts as necessary. If cholesteatoma is present in the aditus ad antrum, it may be necessary to disarticulate the incudostapedial joint and remove the incus to facilitate more complete resection of cholesteatoma medial to the canal wall by working from both the mastoid cavity and the middle ear. Umbilical tape may then be used in a “flossing” technique to further remove squamous epithelium from the antrum. This is done by passing the tape from the mastoid cavity through the antrum to the middle ear and out of the ear canal and then

moving it back and forth over the medial surface of the canal wall (see Video 115-1). For certain procedures such as endolymphatic sac decompression or labyrinthectomy, it may be desirable to identify the posterior semicircular canal by removing the retrolabyrinthine air cells.

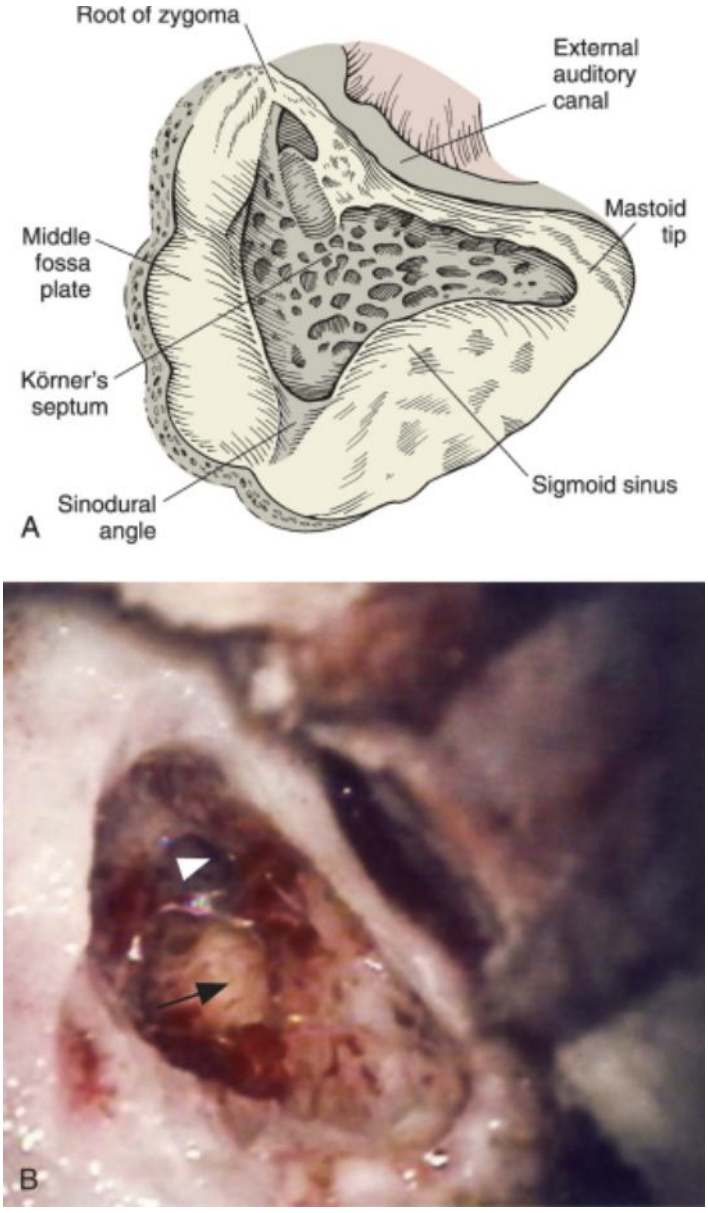

Figure 115-14 **A,** Körner's septum. The lateral semicircular canal and mastoid antrum lie under Körner's septum. **B,** Exposure of the mastoid air cells will vary depending on the nature of the surgery. For this right-sided cochlear implantation, the posterior and superior margins of the mastoidectomy have not been saucerized. The dome of the horizontal semicircular canal *(arrow)* is identified, and the short process of the incus *(arrowhead)* is just visible in the fossa incudis.

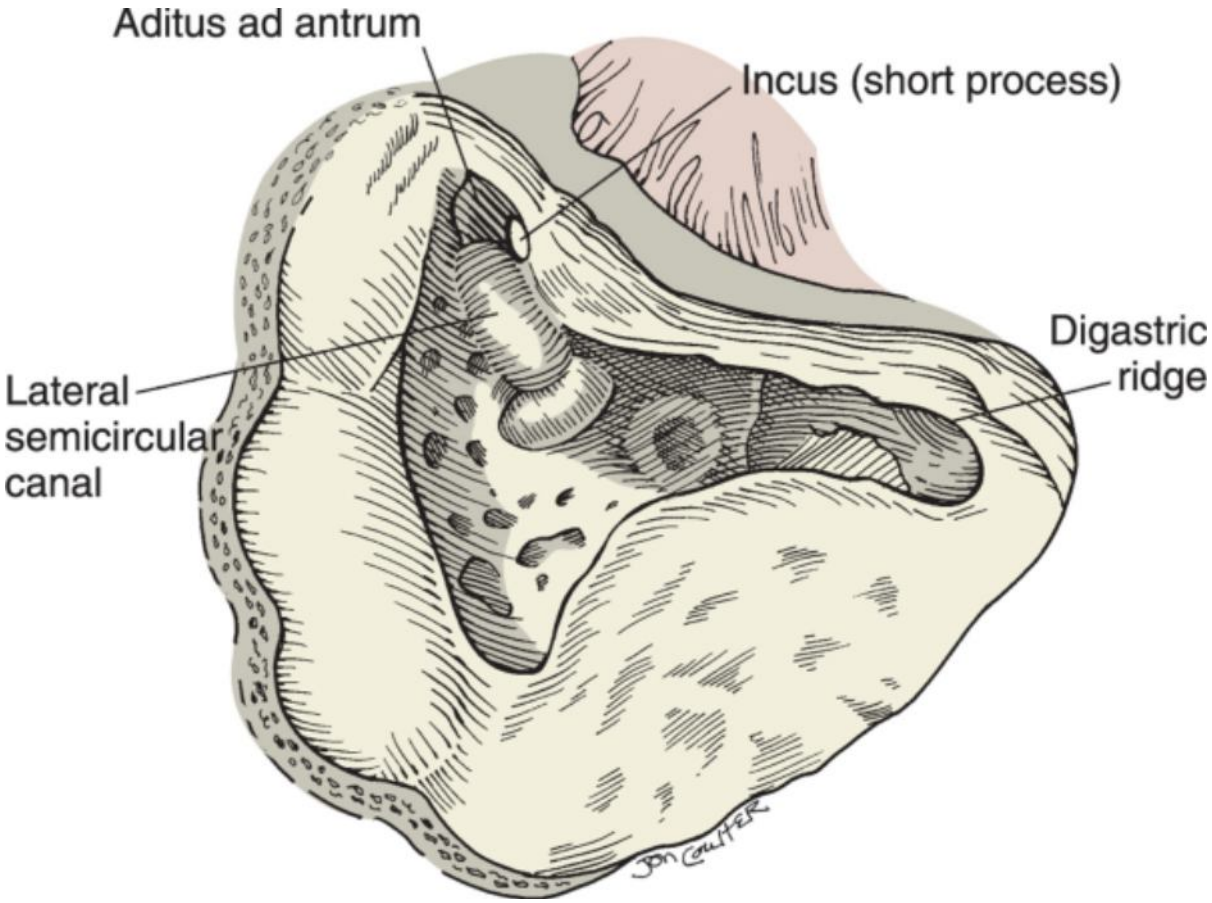

Figure 115-15 Completed intact canal wall mastoidectomy.

Drilling the Facial Recess

The facial recess is a triangle defined by the incus buttress, the facial nerve, and the chorda tympani. Opening the facial recess allows access to the posterior mesotympanum, through which inflammatory tissue or cholesteatoma may be removed. This technique is also referred to as a posterior tympanotomy and is used to create access to the round window niche for drilling of the cochleostomy during cochlear implantation. Safely entering the recess relies on identification of landmarks for the facial nerve, including the incus, HSC, posterior EAC, and digastric ridge (Fig. 115-16). The posterior EAC should be thinned laterally to medially to improve visualization of the chorda tympani and facial recess; air cells lateral to the plane of the incus should be removed. The short process of the incus points to the second genu of the facial nerve. Because it lies in the same plane, the incus provides a very useful landmark for identification of the facial nerve. The HSC is another critical landmark, and the second genu of the facial nerve is just anterior and medial to the HSC. The digastric ridge may also be useful; the cephalic edge of the digastric ridge leads to the stylomastoid foramen and is a good inferior landmark for the vertical portion of the facial nerve.

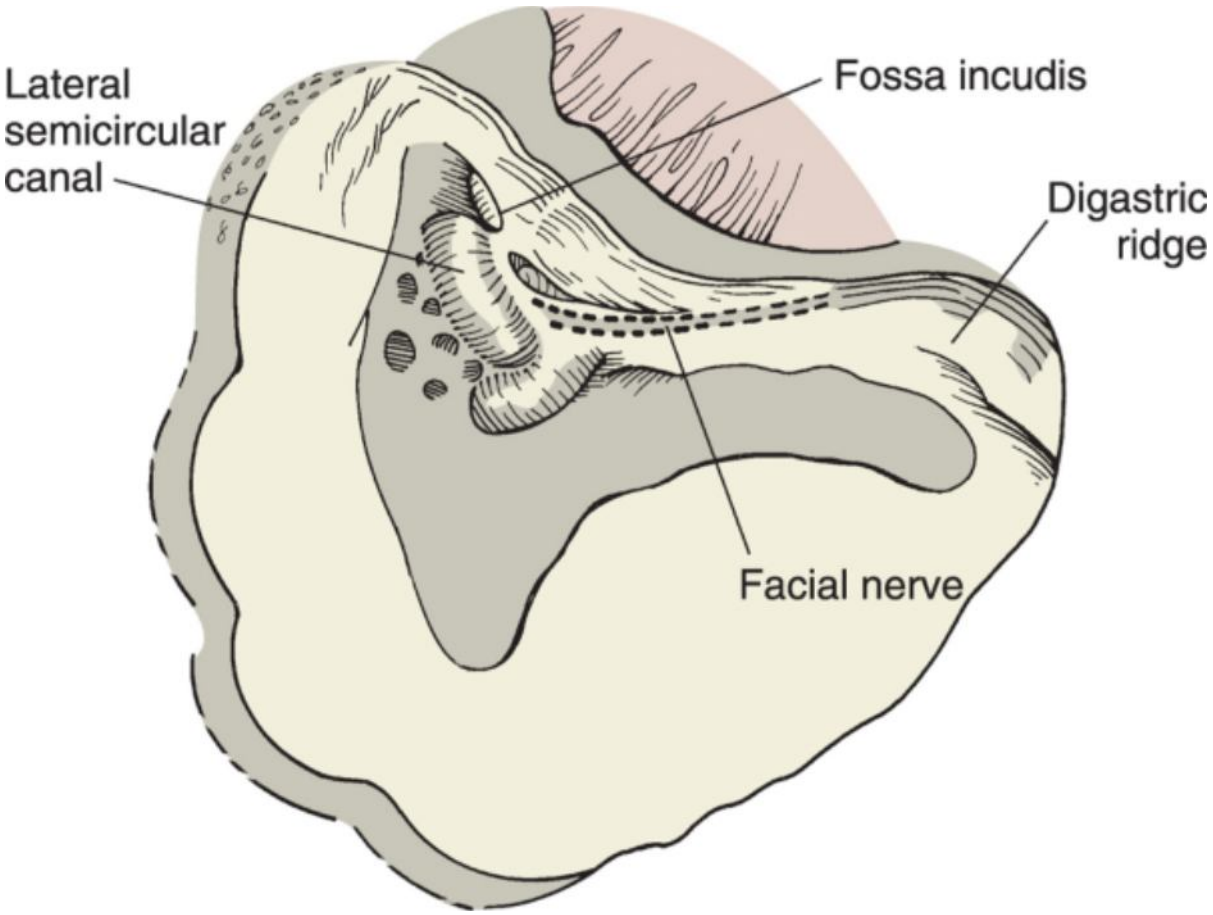

Figure 115-16 Landmarks for identification of the facial nerve.

A 2- or 3-mm diamond burr should be used for drilling medial to the plane of the incus. Drilling shouldcommence just inferior to the short process of the incus. The bridge of bone between the incus and the recess is termed the incus buttress. Removal of bone between the chorda tympani nerve and the vertical facial nerve proceeds just below the incus buttress by drilling parallel to the course of the facial nerve. Copious irrigation prevents thermal injury and enhances visualization through bone. Because the facial recess is larger superiorly than inferiorly, it is safest to enter the recess at its superior aspect (Fig. 115-17). Once the recess has been entered, drilling can proceed medial to the chorda tympani with caution to expand the view toward the round window niche. Bone is thinned over the facial nerve as necessary to provide a sufficient view of the middle ear (Fig. 115-18). A thin shell of bone is maintained over the nerve. Care must be taken to not allow the shaft of the burr to contact the facial nerve because such contact may cause thermal injury to the nerve. After the middle ear has been entered, the recess can be expanded to allow visualization of the incudostapedial joint, round window niche, promontory, and other middle ear structures (Fig. 115-19).

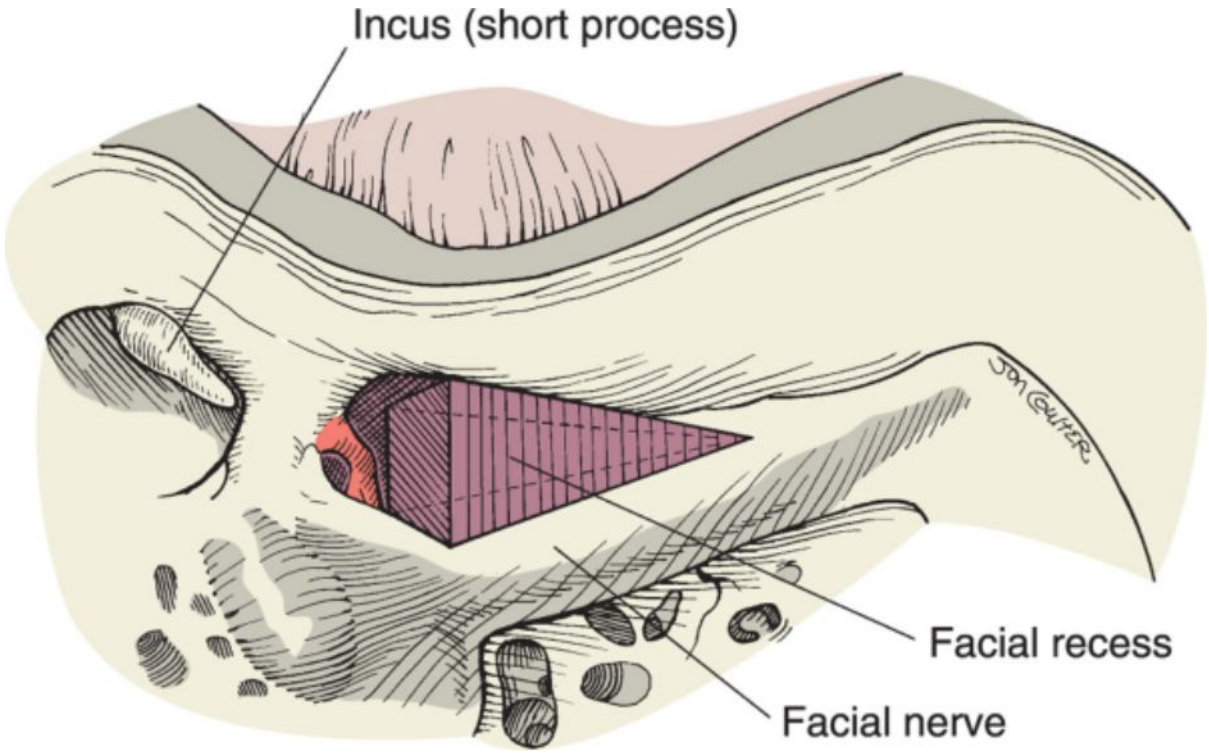

Figure 115-17 Anatomy of the facial recess.

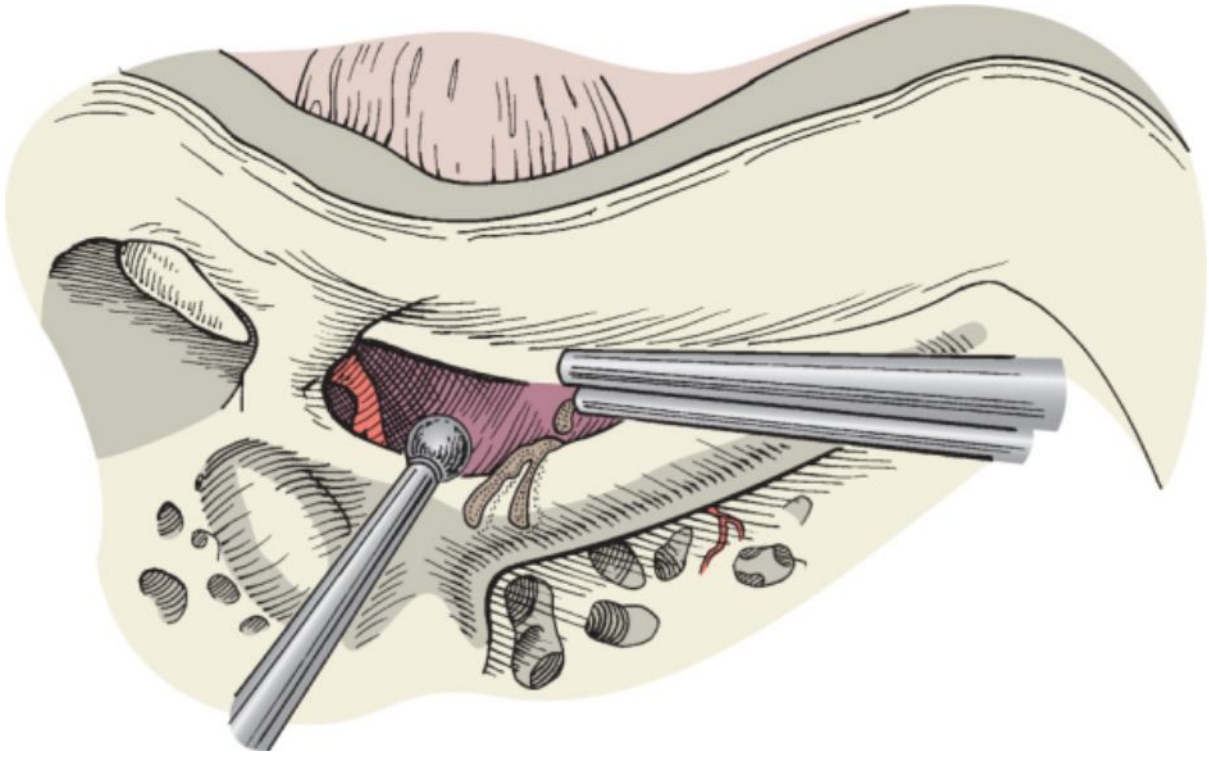

Figure 115-18 Removal of air cells to open the facial recess.

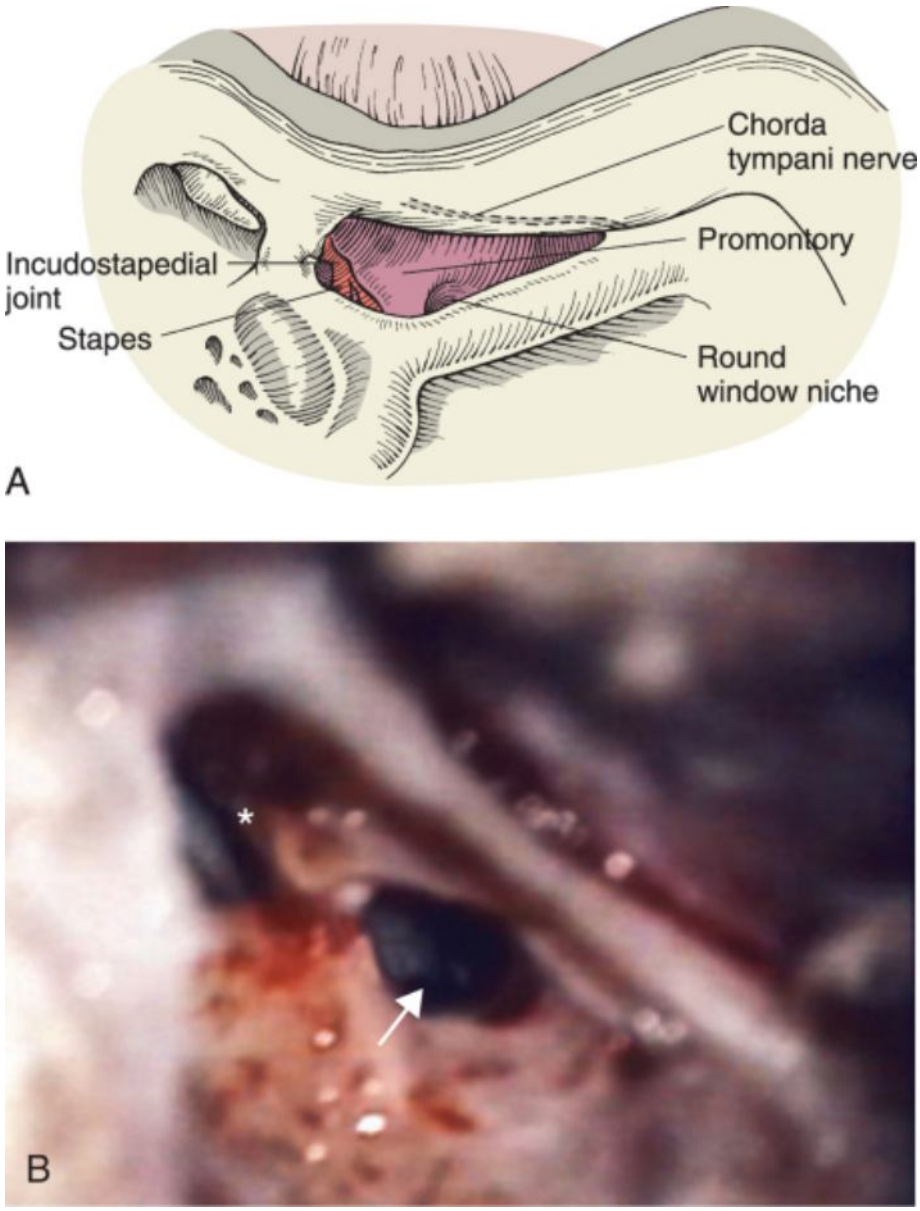

Figure 115-19 **A,** Exposure of middle ear structures through the completed facial recess. **B,** Using the short process of the incus *(asterisk),* horizontal semicircular canal, and thinned posterior wall of the external auditory canal as landmarks, the facial recess has been entered. The cochlear promontory and the round window niche *(arrow)* are visible.

Once drilling has been completed, the mastoid and middle ear are irrigated thoroughly to remove bone dust and debris. To close the postauricular wound in a CWU procedure, the mastoid periosteum should be reapproximated to avoid unsightly retraction of postauricular skin into the bony defect. We use 3-0 Vicryl interrupted sutures for closure of periosteum. The deep layer of skin is then closed with interrupted 3-0 or 4-0 Vicryl, depending on skin thickness. If a vascular strip was elevated, a rolled Telfa strip coated with bacitracin ointment is used to stent the meatus. The superficial layer of skin is then closed with running 5-0 fast-absorbing plain gut suture. The incision is then dressed with bacitracin ointment, Xeroform, Telfa, and a Glasscock cup. The dressing may be removed 24 hours postoperatively; the patient is instructed to keep the operated ear dry.

Again, special care must be taken in the case of revision surgery. When making periosteal incisions and entering the previously drilled mastoid cavity, bony dehiscences may be encountered over the tegmen, sigmoid sinus, or facial nerve. The surgeon must use caution to prevent inadvertent injury to these structures. Often, cortical bone has regrown to some extent in a previously drilled cavity. This must be removed to provide adequate identification of landmarks via the same principles as described earlier.

Canal Wall Down Mastoidectomy

A problem-free mastoid bowl begins with a complete cortical mastoidectomy to identify the tegmen mastoideum, the short process of the incus if present, and the HSC. Successful CWD mastoidectomy entails more than simply drilling down the posterior wall of the EAC. It is especially critical to saucerize the bony edges of the

mastoidectomy superiorly and posteriorly to allow the surrounding soft tissue to collapse into the mastoidectomy defect and ultimately create a smaller cavity. Trouble spots that can result in a wet cavity include the sinodural angle and the mastoid tip. Removal of the mastoid tip is accomplished by identifying the digastric ridge posteroinferiorly and following its cephalic edge toward the stylomastoid foramen. Once this has been completed, the bone lateral to the ridge can be removed safely with the drill.

The posterior wall of the EAC is thinned and maintained as a useful landmark until the facial recess has been opened. Sequentially smaller diamond burrs are used to remove the bone between the chorda tympani and the facial nerve. It is important to establish the location of the facial nerve and maintain a thin layer of bone over it. Identification of the facial nerve is critical for two reasons. First, the best way to protect the nerve is to positively establish its location. Second, attempts at protecting the nerve by leaving excess bone over it result in a bony ledge, referred to as a “high facial ridge,” which makes subsequent mastoid bowl care challenging and may ultimately require revision surgery (Fig. 115-20).

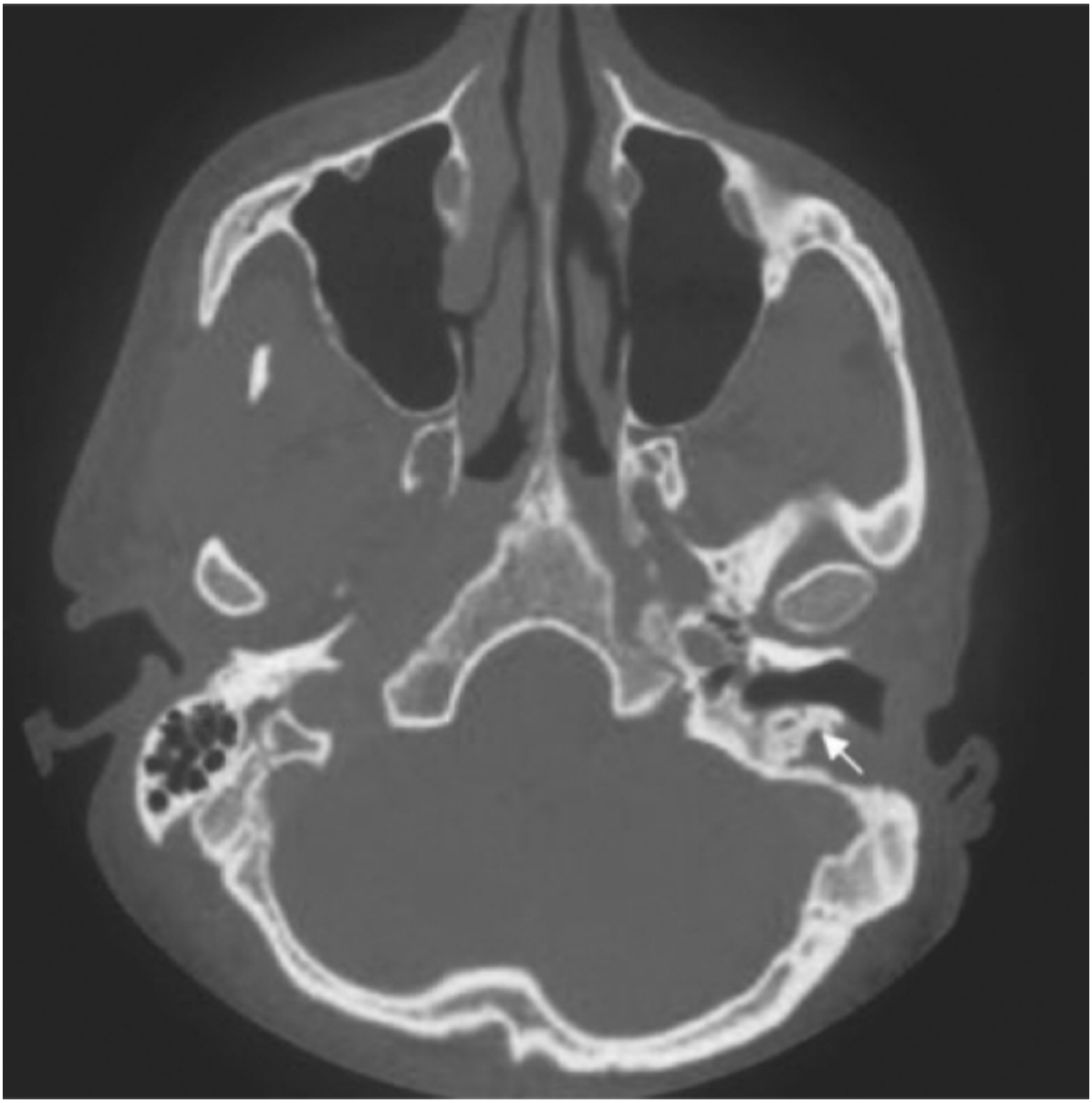

Figure 115-20 High facial ridge. Excess bone has been left in place lateral to the fallopian canal *(arrow)*. This results in excess buildup of cerumen and squamous debris, which is difficult to clear in the office.

Once the level of the nerve is identified, the EAC wall can be removed. The area to be drilled can be conceived of as an anterior buttress (involving the tympanosquamous suture and lateral wall of the epitympanum or scutum), a posterior buttress (involving the facial ridge), and the intervening bridge of bone (Fig. 115-21). Removal can be accomplished with a 4-mm cutting burr (Fig 115-22). Frequently, disease that necessitates CWD surgery also requires removal of the incus, in which case it is preferable to proceed with separation of the incudostapedial joint and removal of the incus before removing the canal wall. However, if the ossicular chain is mobile and the ear pathology is such that the incus can be kept in situ, a small bridge of bone thinned to an eggshell thickness can be

maintained over the short process of the incus. The remaining bone overlying the short process of the incus can then removed with a pick or curette (Fig 115-23). Once the canal wall has been removed, a smooth transition must be established between the roof of the EAC and the tegmen mastoideum at the anterior buttress. Similarly, inferiorly the floor of the ear canal must be contoured such that there is a smooth transition to the facial ridge at the posterior buttress. With an anteriorly positioned sigmoid or low tegmen in the setting of a contracted mastoid cavity, the canal wall must sometimes be removed to permit safe identification of deeper structures. The mastoid cavity should then be inspected to ensure that all diseased cells have been exenterated with a smoothly contoured appearance (Fig 115-24). Once the middle ear disease, if present, has been addressed, the middle ear is packed with Gelfoam. The previously harvested, pressed, and dried fascia can then be used in an underlay fashion by draping the graft onto the horizontal facial nerve superiorly and onto the facial ridge posteriorly, followed by further packing lateral to the drum and graft.

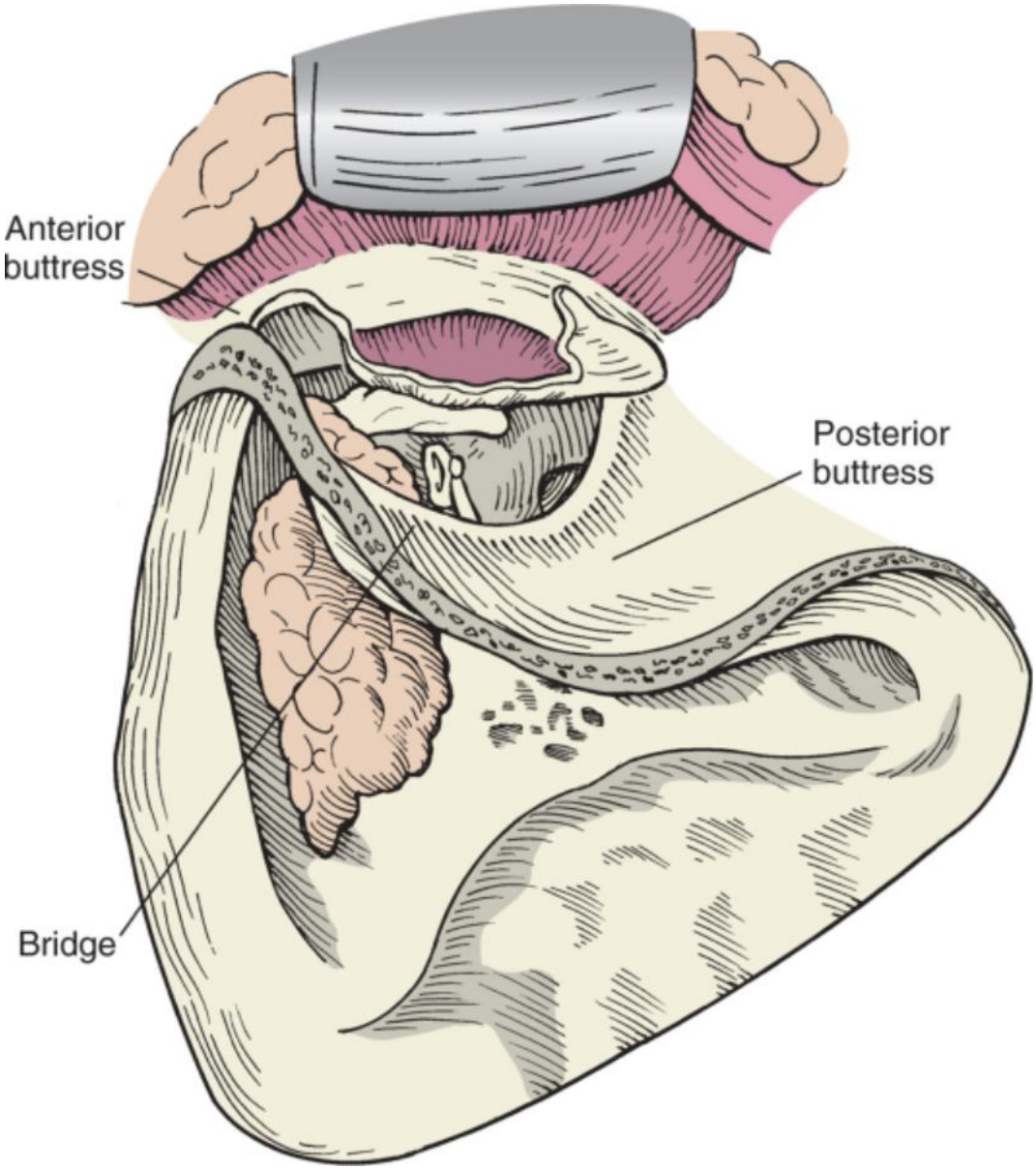

Figure 115-21 Buttresses and bridge of the posterior canal wall.

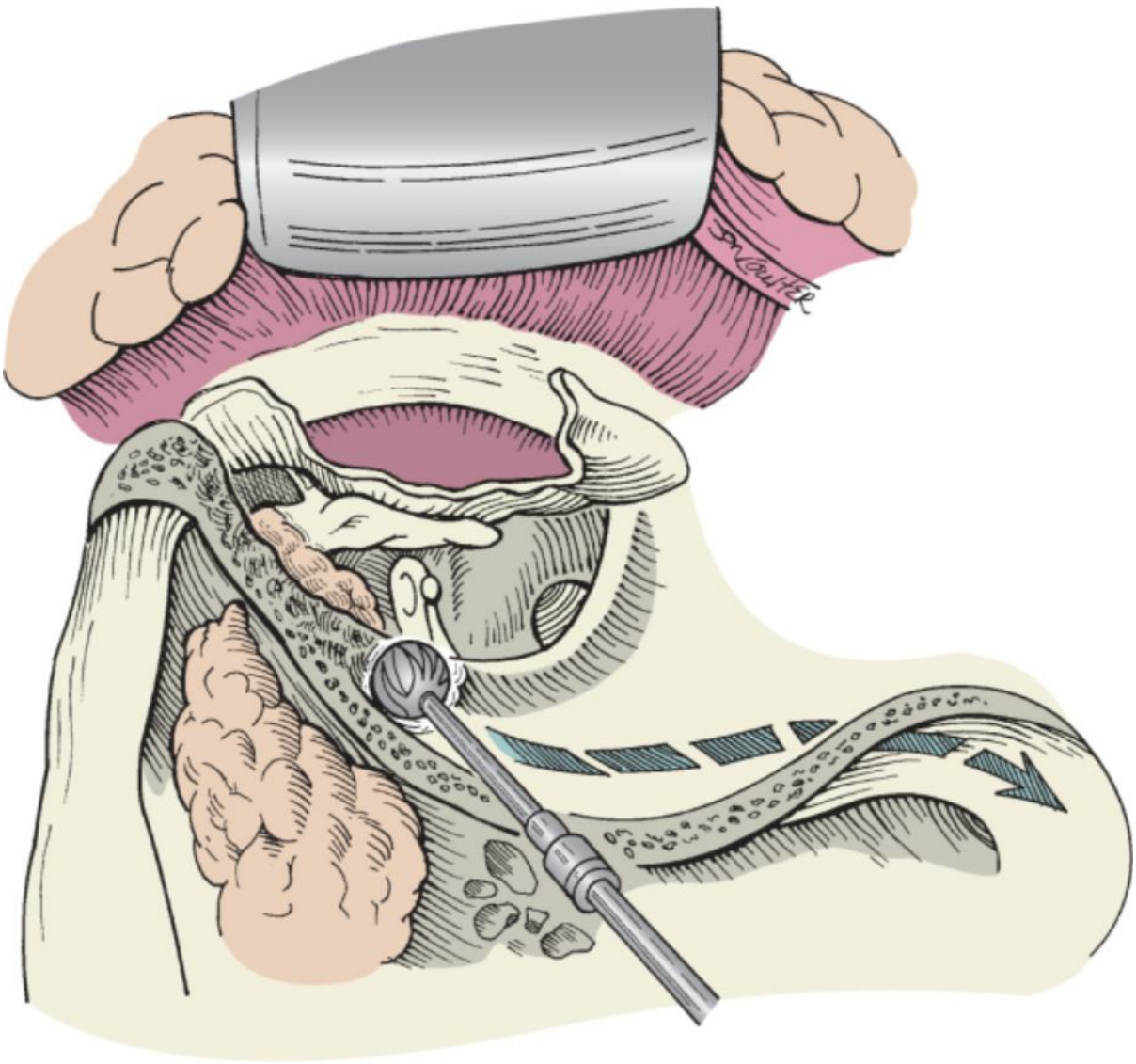

Figure 115-22 Technique of removing the canal wall.

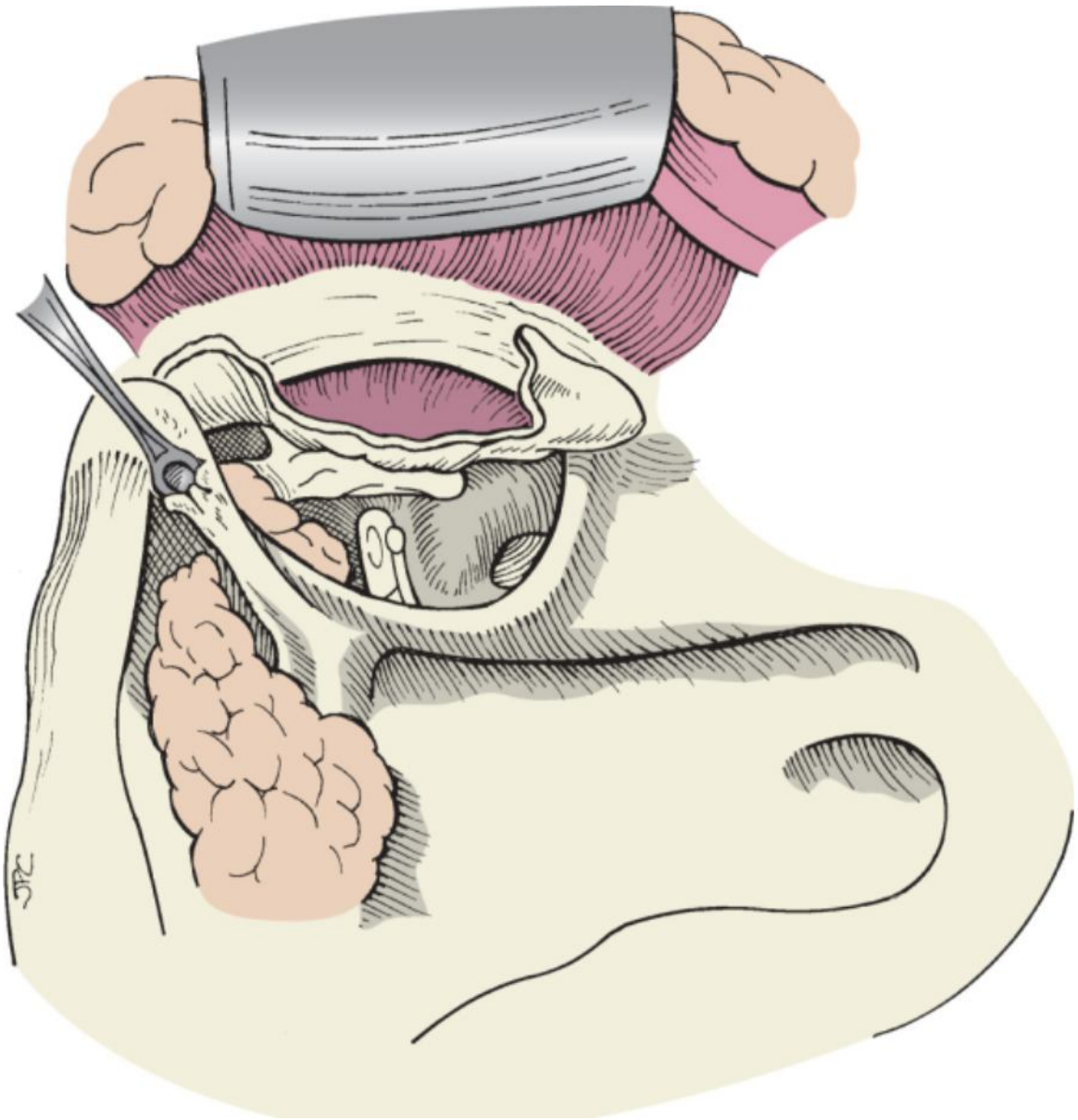

Figure 115-23 The last bridge of the posterior canal wall is removed while using a curette to protect the ossicles and facial nerve.

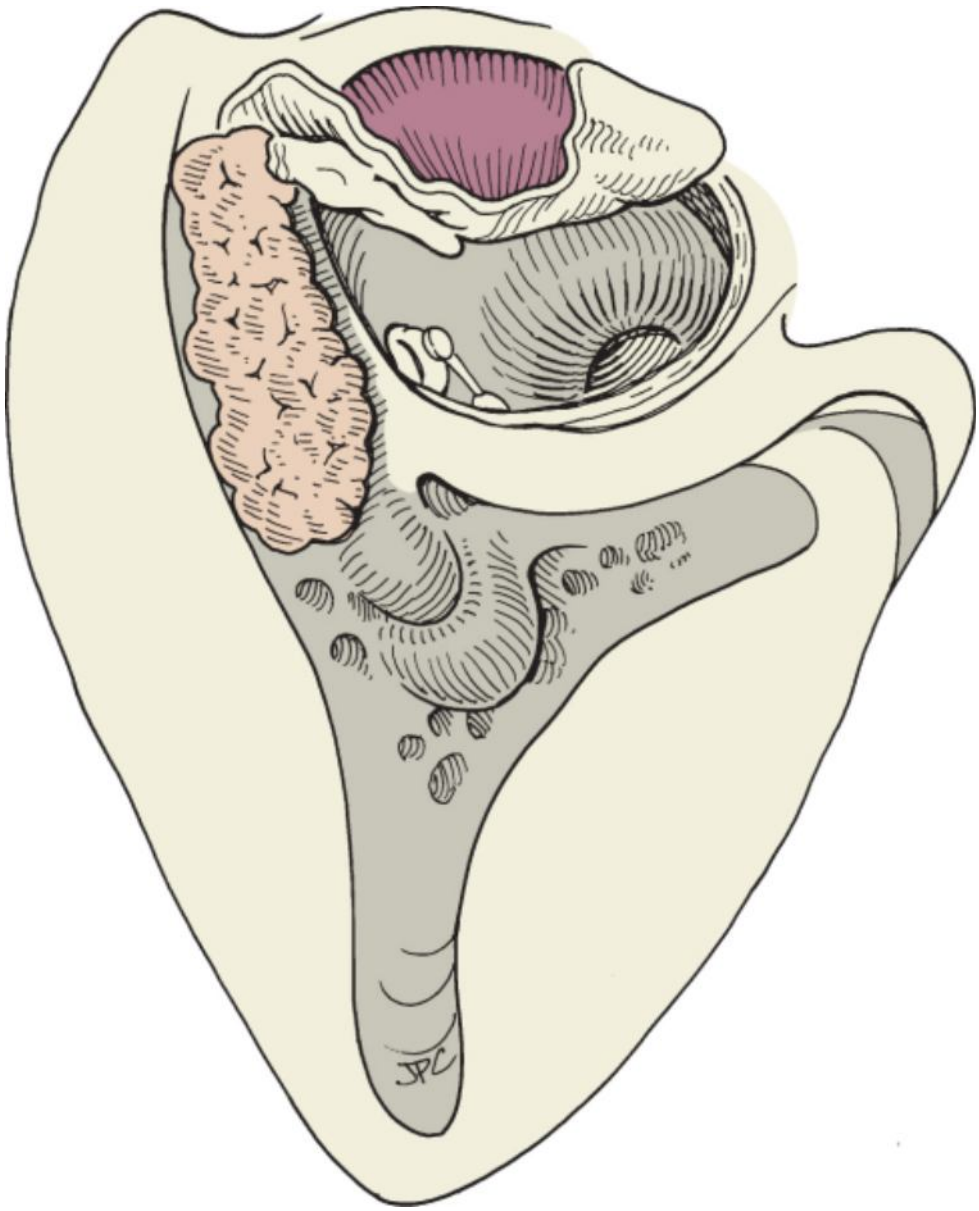

Figure 115-24 Completed canal wall down mastoidectomy with tympanoplasty.

Bondy-Modified Radical Mastoidectomy

A Bondy mastoidectomy refers to removal of the posterior canal wall for attic disease without entering the middle ear space. This technique may be used for attic cholesteatoma in the setting of an intact ossicular chain and normal or nearly normal hearing. The pars tensa is not disrupted and the mesotympanum is not entered. The epitympanic cholesteatoma is exteriorized through an endaural approach. The anterior buttress is removed and the canal wall is lowered to the level of the incus. In this instance, the cholesteatoma matrix is left in situ as the epithelial lining to the now exteriorized epitympanum (Fig. 115-25). A meatoplasty is necessary to facilitate cleaning of the Bondy mastoid cavity.

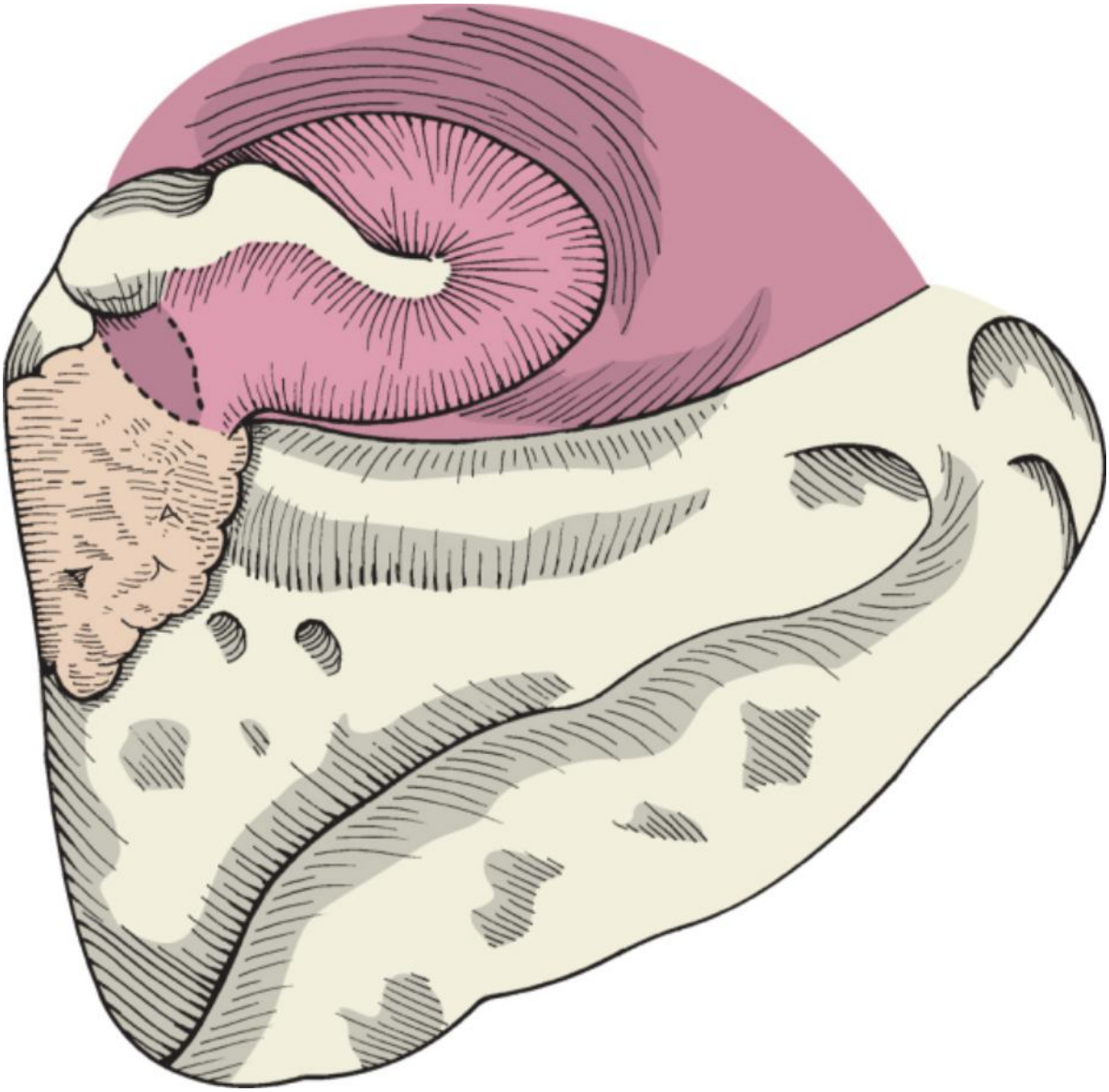

Figure 115-25 Completed Bondy-modified radical mastoid-ectomy.

Radical Mastoidectomy

When middle ear disease cannot be fully or safely addressed during a CWD procedure, the surgeon mayelect to proceed with grafting of the TM with plans to return for a second look. For example, when significant squamous debris is present in the oval window and the surgeon believes that it cannot be removed adequately, sometimes a second look 6 to 9 months later allows the epithelium to form a pearl, which is more readily dissected. However, in some instances when it is believed that the middle ear disease is irreversible, radical mastoidectomy is performed. Drilling proceeds as for a CWD mastoidectomy. The malleus, incus, and TM are removed and hearing restoration is not attempted. The middle ear mucosa is removed, including the lining of the eustachian tube orifice. The eustachian tube is then obliterated with muscle and bone. The epitympanum, mesotympanum, and hypotympanum are thus all exteriorized into the EAC (Fig 115-26). A meatoplasty is then performed.

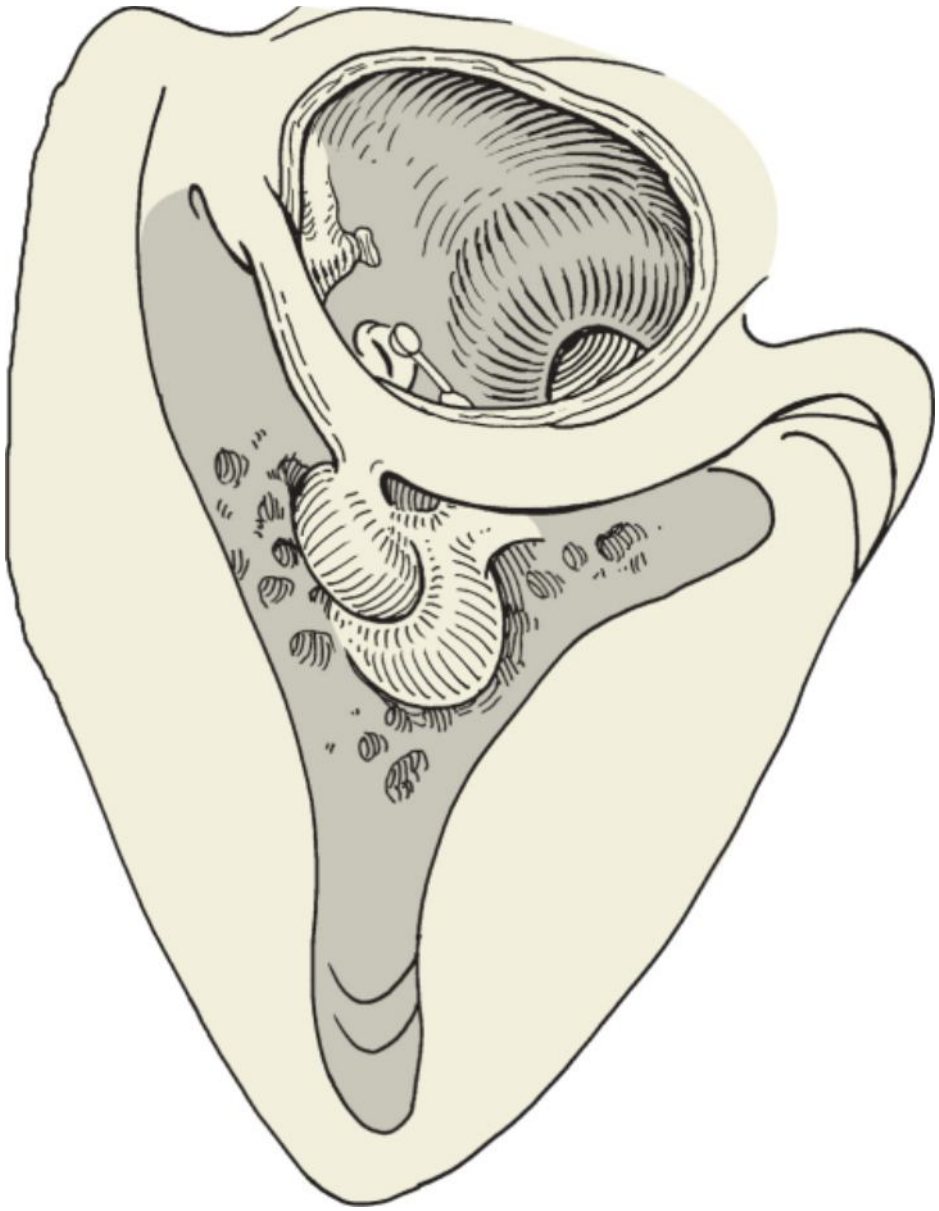

Figure 115-26 Completed radical mastoidectomy.

Meatoplasty

A meatoplasty should always be performed when the canal wall has been removed. This step is critical in allowing access for mastoid bowl care in the office. An inadequate meatoplasty results in accumulation of squamous debris or cerumen and contributes to chronic otorrhea. To enlarge the meatus, the skin of the external auditory meatus must be incised and cartilage removed. On the other hand, excessive enlargement of the meatus results in an unsightly cosmetic defect. The meatoplasty should be sized so that it matches the cavity and allows access to the most superior, posterior, and inferior aspects of the mastoid bowl for cleaning. Some contraction will occur in the postoperative period.

The meatoplasty begins with removal of a crescent of conchal cartilage. A Senn retractor or double-pronged skin hook is used to retract the auricle. The middle or ring finger of the retracting hand, when placed within the concha laterally, can provide resistance as the subcutaneous tissue overlying the concha is incised via the postauricular approach. The underlying cartilage is exposed to its medial rim (Fig 115-27). The conchal cartilage is then incised with a no. 15 blade. A round knife or Freer elevator can be used to elevate the cartilage from the conchal skin, and this segment of cartilage is removed (Fig. 115-28). A no. 15 blade is then placed in the auditory canal, and 12- and 6-o'clock incisions are made through the canal skin andsubcutaneous tissue (Fig. 115-29). Two or three 3-0 Vicryl sutures are placed in the subdermal tissue and used to anchor the posterior meatal skin to the deep periosteal tissue posterior to the mastoidectomy. When tied, these sutures should establish an open meatus that matches the size of the mastoid cavity (Fig 115-30). The attached vascular strip is pulled posteriorly by the stay sutures to line the lateral and posterior aspects of the mastoid cavity. The meatoplasty is stented for 10 to 14 days with a roll of

bacitracin-coated Telfa. The mastoid periosteum is not reapproximated. Closure of the postauricular skin incision then proceeds as for intact canal wall procedures.

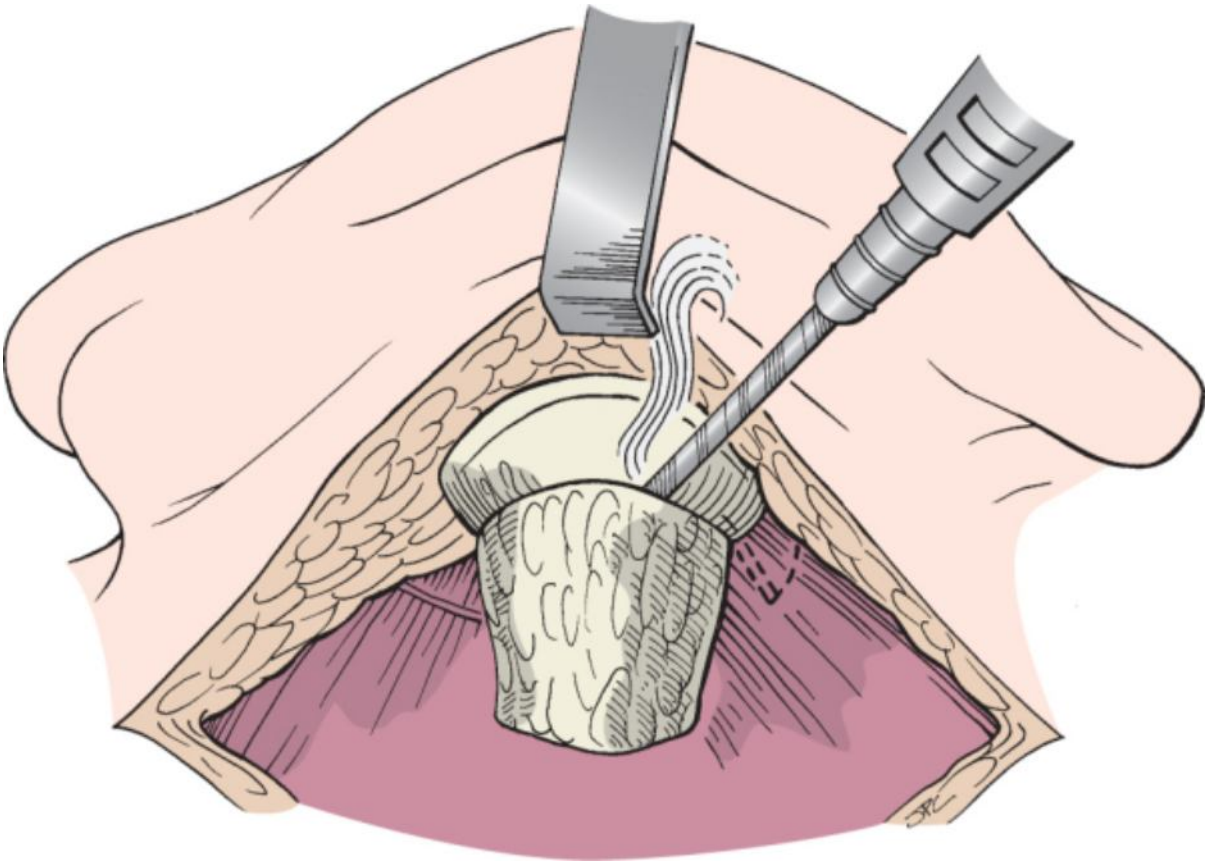

Figure 115-27 The conchal cartilage is exposed up to the medial edge of the cartilage at the bone-cartilage junction of the external auditory canal.

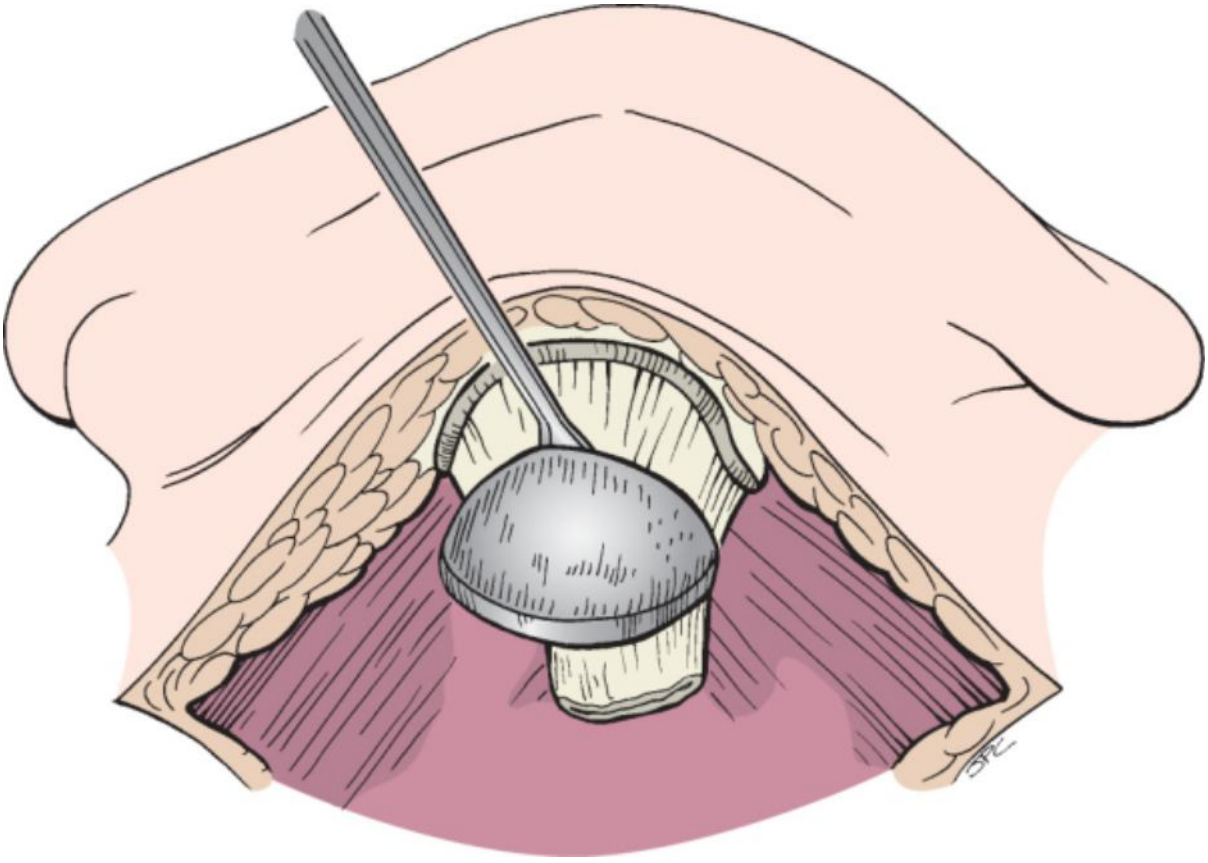

Figure 115-28 A Freer elevator is used to elevate the conchal cartilage from the overlying skin.

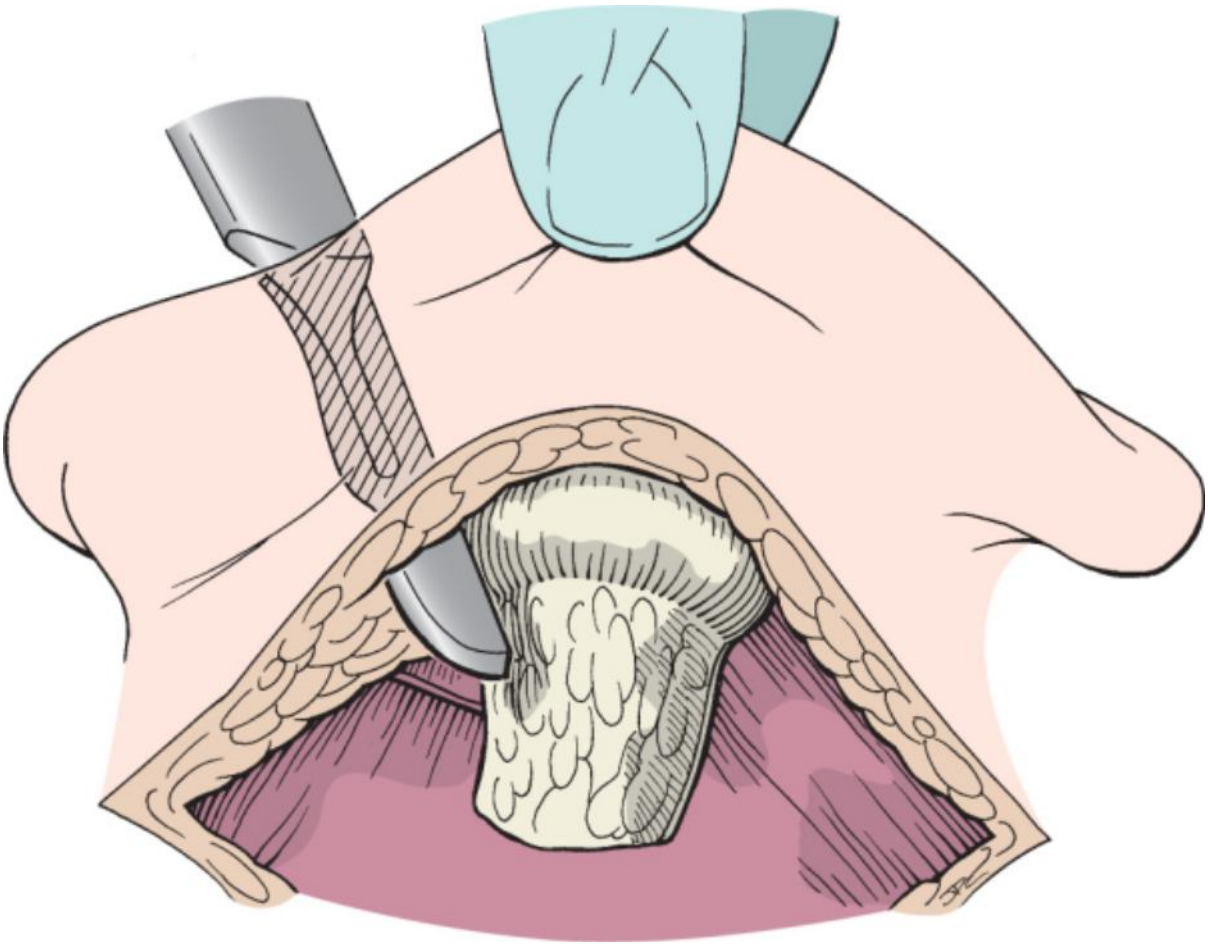

Figure 115-29 A superior canal incision is made and connected to the postauricular exposure to create a long Koerner flap.

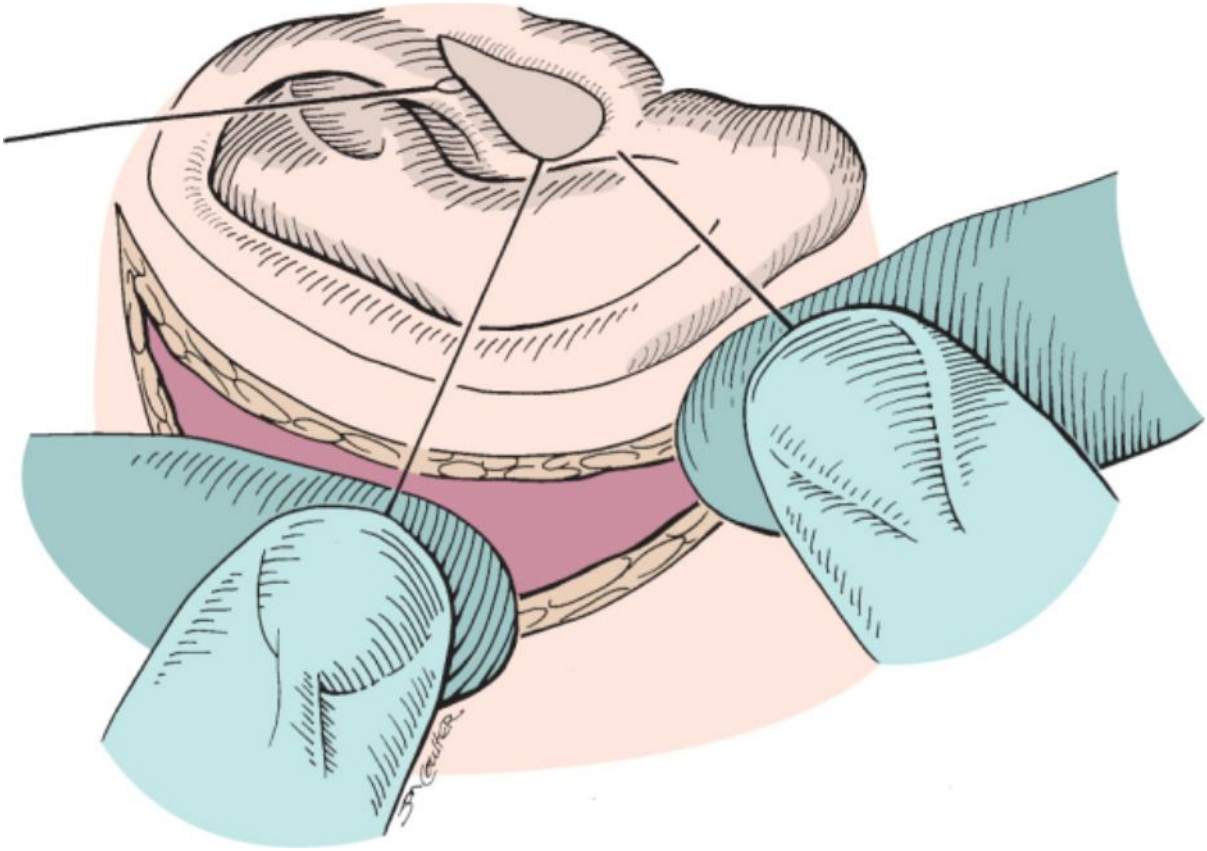

Figure 115-30 Stay sutures are used to properly match the size of the meatus to the size of the mastoid cavity.

Postoperative Management

The patient is instructed to wear a Glasscock ear dressing for 2 days postoperatively. After removal of the dressing, the patient may shower but is instructed to keep the ear dry. Bacitracin is applied to the postauricular incision twice a day for 1 week. The first postoperative visit occurs in 7 to 10 days, at which time the incision is checked and any packing in the EAC is removed. If a meatoplasty has been performed, the stent is left in place for 10 to 14 days. The second follow-up visit takes place 3 to 4 weeks later. Frequently, the TM will be healed sufficiently to allow an early postoperative audiogram at this time. Thereafter, the patient may be monitored routinely per the surgeon's usual practice. CWD mastoidectomies require more frequent follow-up for the first few months after surgery until the bowl is lined with healthy epithelium. During this healing period, silver nitrate cautery may be necessary to address granulation tissue.

COMPLICATIONS

Potential complications of tympanomastoidectomy include TM perforation, altered taste, vertigo, sensorineural hearing loss, facial paralysis, injury to the tegmen or underlying dura, iatrogenic injury to the ossicular chain, hemorrhage from injury to the sigmoid sinus, and inadvertent entry into the EAC. An intact TM may be perforated during elevation of the tympanomeatal flap in a tympanomastoidectomy, particularly if the TM is atrophic or tethered to middle ear structures. If perforation should occur, the torn TM should be grafted at the end of the procedure. Stretching or cutting the chorda tympani nerve can lead to dysgeusia; symptoms of altered taste often resolve within several months if it does occur.

Vertigo or sensorineural hearing loss (or both) may result from inadvertently dislocating the stapes or from entering the HSC. Touching the incus with the drill during the mastoidectomy may also result in high-frequency sensorineural loss. If the patient shows evidence of severe vertigo on awakening, inpatient admission may be required for control of nausea and vomiting and supportive care. Consideration should be given to high-dose corticosteroids if sensorineural hearing loss has occurred. Tuning fork testing performed in the postoperative care unit will help diagnose sensorineural loss, and an urgent audiogram may be obtained in cases with significant concern.

The facial nerve may be injured by direct trauma, either from the burr or from instrumentation of a dehiscent nerve, or by thermal injury if the rotating shaft of the burr comes in contact with a thin layer of bone overlying the nerve. The patient's facial nerve function should always be evaluated in the postoperative care unit. If facial weakness is discovered that did not exist preoperatively, the surgeon should observe the patient until any local anesthesia has

worn off to ensure that the palsy is not due to infiltration of the nerve by local injection. In addition, if a compressive dressing or ear packing has been used, it should be loosened immediately. If the weakness persists, the surgeon should note whether it is partial or complete paralysis. If partial, the patient should be treated with high-dose corticosteroids and monitored closely for the development of complete paralysis. In the case of immediate complete paralysis, the appropriate response depends on whether the surgeon is confident that the nerve has been visualized during surgery and left intact. If so, the patient should be treated with steroids and observed. If the nerve was not visualized, the patient should undergo electroneuronography and temporal bone CT. If indicated by CT or electrical testing, re-exploration of the ear should be undertaken for decompression or anastomosis. Strong consideration should be given to consultation with another surgeon because anxiety can run high when faced with this significant complication and affect one's ability to best deal with the situation.

Bony defects in the tegmen result from overly aggressive drilling along the roof of the mastoid cavity; on occasion, the dura is violated and a CSF leak results. If the bony defect is small (<1 cm) and the surgeon is certain that the dura has not been injured, the defect need not be repaired because the risk of encephalocele is low. Alternatively, larger bony defects or injury to dura necessitate repair, which may be accomplished at the time of surgery by using fascia or muscle to graft over the defect from below. Temporalis muscle may also be rotated into the cavity to cover the defect.

Any of the ossicles may be dislocated during surgery on the attic or mesotympanum, although the incus and stapes are more at risk. When dissecting cholesteatoma or inflammatory tissue off the ossicles, care must be taken to not use undue force. Dissection on the stapes should proceed in a posterior-to-anterior direction to take advantage of the countertraction provided by the stapedius tendon.

If significant bleeding is encountered because of a large emissary vein or injury to the sigmoid sinus, hemostasis can often be achieved by applying pressure over the bleeding site with Gelfoam soaked in epinephrine. Alternatively, Surgicel may be placed over the injury and held in place until the bleeding is controlled.

Finally, during a CWU mastoidectomy, the EAC may inadvertently be violated as the posterior canal wall is thinned. To prevent retraction of skin into the mastoid cavity and subsequent EAC cholesteatoma, the surrounding skin should be elevated and the defect covered with fascia in an underlay technique. Larger bony defects should be repaired with conchal or tragal cartilage as well to reinforce the skin.

PEARLS

- The use of long drilling strokes in a direction parallel to important structures such as the facial nerve, tegmen, and sigmoid sinus facilitates identification and minimizes injury to these structures.
- Constant irrigation prevents bone dust from obscuring underlying structures and prevents thermal injury, particularly to the facial nerve.
- Important structures should always be positively identified rather than relying on avoidance to prevent injury.
- Removal of the mastoid tip, lowering of the facial ridge, removal of air cells at the sinodural angle, and an adequate meatoplasty can prevent the need for revision surgery in CWD mastoidectomy.
- When performing CWD procedures, the canal wall should be left intact until all the landmarks have been identified—the thinned canal wall serves as an additional landmark that can be followed medially to identify the chorda tympani nerve and enter the facial recess.

PITFALLS

- Touching the ossicles with the high-speed drill may result in sensorineural hearing loss.
- Facial nerve injury may occur through failure to positively identify the nerve or as a result of bony dehiscence.
- Inadvertent injury to the tegmen and underlying dura may result in CSF leak or encephalocele, or both.
- Breaches of the posterior EAC wall during CWU procedures should be repaired by elevating the canal skin and covering the defect with fascia; cartilage may be added for larger defects.
- Inadequate meatoplasty is probably the most common reason for difficulties in CWD surgery—a large meatoplasty should be created and stented for at least 10 days postoperatively.