MASTOIDECTOMY AND CHOLESTEATOMA

Charles D. Bluestone, MD

In the first section of this chapter, I describe my indications and surgical technique for mastoidectomy. In the next section, I describe specific surgical procedures for cholesteatoma (depending upon the site and extent of the disease), which may or may not include a mastoidectomy.

MASTOIDECTOMY

Many procedures include a mastoidectomy, but the most common indications in infants and children are mastoiditis (acute and chronic), cholesteatoma, or coexistence of these diseases.

There are three traditional procedures:

1. Simple (cortical, complete) mastoidectomy
2. Modified radical mastoidectomy
3. Radical mastoidectomy

A fourth procedure, tympanomastoidectomy, combines the simple mastoidectomy with a middle-ear procedure, maintaining the posterior and superior canal walls.

The basic steps in performing the three standard mastoidectomy procedures are described below. The approach in all cases is postauricular (see Chapter 2), and intraoperative monitoring of facial nerve function is used routinely.1

SIMPLE (CORTICAL, COMPLETE) MASTOIDECTOMY

A simple or complete mastoidectomy, which is more appropriately called a cortical mastoidectomy, is indicated for acute mastoid osteitis.2,3 An important distinction is acute mastoiditis without osteitis (with or without periosteitis), which generally does not require surgical management. When surgery is needed, the term acute “coalescent” mastoiditis is commonly
used, but a more consistent term related to the underlying pathology is *acute mastoid osteitis*. The term acute "surgical" mastoiditis is also used, but again does not appropriately describe the pathology.

Another indication for cortical mastoidectomy, which is more common in the antibiotic era than acute mastoid osteitis, is in conjunction with surgery for middle-ear disease. When performed in this manner, the procedure becomes a "canal wall–up" tympanomastoidectomy (see *Tympanomastoidectomy* later in this chapter).

**Indications**
- Acute mastoid osteitis, with or without subperiosteal abscess (or other extensions into the temporal bone and deep neck)
- Chronic suppurative otitis media (and mastoiditis), when nonsurgical management fails
- Cholesteatoma (with or without chronic suppurative otitis media), when the cholesteatoma extends into the mastoid gas cells (see *Cholesteatoma* later in this chapter)
- Cochlear implant, in which a posterior tympanotomy is part of the procedure (see Chapter 9)
- Other reasons, such as facial nerve decompression, translabyrinthine labyrinthectomy, neoplasm, and mastoid trauma, which are relatively uncommon indications in infants and children

**Anesthetic Considerations**
- The anesthesia and the preparation for this procedure are described in Chapter 2.

**Procedure**
- A postauricular approach and a drill are used to uncover the mastoid antrum (Figure 5–1).
- The mastoid antrum is identified (Figure 5–2).
Figure 5–1 A postauricular approach and drill are used to uncover the mastoid antrum.

Figure 5–2 The mastoid antrum is identified.
• A curette removes the thinned bone over the incus (Figure 5–3); drilling at this stage could injure the incus and result in conductive, sensorineural (due to acoustic trauma), or mixed hearing loss.

• Dissection is complete when the anterior epitympanum, zygomatic cells, body of the incus, and head of the malleus are identified (Figure 5–4), and there is free flow of the irrigant from the mastoid into the middle ear.

• Specimens for culture and antibiotic susceptibility are taken from the mastoid mucosa and bone, and also from the middle ear and mastoid purulent material.

• A tympanostomy tube (with or without the addition of a wide-field myringotomy) is placed when acute mastoid osteitis is an indication for surgery (Figure 5–5).

• The postauricular wound is closed with an absorbable suture. The need for drainage, if any, relates to the primary indication for surgery:
  • For acute mastoid osteitis, a plastic drain with holes cut into the portion that lies within the mastoid cavity, is placed in the mastoid cavity (Figure 5–6).
  • For chronic suppurative otitis media, a rubber band or Penrose drain is used.
  • For cholesteatoma, without acute or chronic infection, placement of a drain is optional.

• When the procedure is performed for acute mastoid osteitis, no packing is inserted into the external canal.

Postoperative Care
• The child is maintained on intravenous antimicrobial therapy, which can be adjusted after the results of the culture and susceptibility studies are available.

• The drain is removed when there is no further drainage from the wound.

• The child can be discharged on a culture-directed, oral antimicrobial agent when afebrile and when there is no further discharge from the middle ear or mastoid wound.
Figure 5–3  A curette removes the thinned bone over the incus.

Figure 5–4  Dissection is complete when the epitympanum, zygomatic cells, and heads of the incus and malleus are identified.

Figure 5–5  Tympanostomy tube and wide-field myringotomy.

Figure 5–6  The postauricular wound is closed with an absorbable suture and drain is inserted.
MODIFIED RADICAL MASTOIDEKTOMY

A modified radical mastoidectomy is most commonly performed for congenital or acquired cholesteatoma, chronic suppurative otitis media with mastoiditis, or both. The mastoid cavity, the epitympanum, and the external canal are exteriorized into a common cavity, but the tympanic membrane is either maintained or grafted. In a study of 232 Pittsburgh children with cholesteatoma, there were 244 surgical procedures, of which 24% were modified radical mastoidectomies. A Bondy modified radical mastoidectomy was performed in selected cases (eg, small, constricted mastoid) in which cholesteatoma was localized to the epitympanum and lateral to the ossicles. Today, however, a canal wall–up tympanomastoidectomy, if possible, is preferred over a modified radical mastoidectomy for cholesteatoma (see Cholesteatoma later in this chapter).

When chronic suppurative otitis media and mastoiditis fail to improve following intensive medical management, a tympanomastoidectomy is usually the next step in management (see Tympanomastoidectomy later in this chapter). If, during surgery, there appears to be a persistent obstruction between the middle ear and the mastoid cavity when the simple mastoidectomy is completed (ie, irrigation fluid fails to flow freely between the two areas), then the canal wall may have to be removed and the operation converted into a modified radical mastoidectomy. An alternative would be a posterior tympanotomy approach to the facial recess, but this technique is not as effective in controlling and preventing the infection as removing the canal wall. An alternative to removing the posterior canal wall in a child would be to remove the incus.

Neither removal of the posterior canal wall nor the incus is desirable in a child, thus the surgeon should make every effort to be conservative by removing as much disease (eg, granulation tissue) as possible from the facial recess and attic, to promote adequate drainage from the aditus ad antrum and mastoid into the middle ear.

Indications

- **Cholesteatoma:** When the disease extends to the mastoid air cells and cannot be effectively managed using the more preferred method of an intact canal wall–up tympanomastoidectomy (see Cholesteatoma later in this chapter)
- **Chronic suppurative otitis media and mastoiditis:** When nonsurgical methods fail and a simple mastoidectomy will most likely be, or has been, unsuccessful in providing adequate aeration between the middle ear and the mastoid cavity

Anesthetic Considerations and Preparation

- The anesthesia and the preparation for this procedure have been described in Chapter 2 under Postauricular Approach.
- When chronic suppurative disease (with or without cholesteatoma) is present, perioperative antimicrobial therapy is usually administered; an agent effective against *Pseudomonas aeruginosa* is usually recommended, because it is the most commonly isolated organism.
**Procedure**

- A simple mastoidectomy is usually performed first (Figure 5–7).
- The posterior canal wall is taken down to the facial ridge (Figure 5–8).
- The tympanic membrane is replaced (Figure 5–9); the epitympanum and the mastoid cavity are exteriorized.

---

**Figure 5–7** A complete “simple” mastoidectomy is usually performed first.

**Figure 5–8** The posterior canal wall is taken down to the facial ridge.

**Figure 5–9** The tympanic membrane is replaced.
In children, the mastoid cavity is usually not grafted or obliterated because residual disease may be obscured, and the cavity frequently becomes smaller with advancing age.

A layer of Gelfoam is placed on the tympanic membrane/graft, and two strips of Adaptic gauze (Johnson & Johnson Medical, Inc, Arlington, TX) are lightly packed into the external canal; the mastoid cavity may or may not require packing depending upon the degree of bleeding encountered when performing the mastoidectomy.

A drain in the postauricular wound is usually unnecessary, since the mastoid (and the wound) is in continuity with the external canal.

**Postoperative Care**

- The postoperative care is similar to that described for the Postauricular Approach discussed in Chapter 2.

- When the indication is chronic suppurative otitis media and mastoiditis, perioperative and postoperative intravenous antimicrobial therapy is usually administered.

- Cavity care is more difficult in the infant and young child, and the procedure may have to be performed in the operating room with the patient under general anesthesia, especially when residual cholesteatoma is present. Thus, one of the goals of cholesteatoma surgery at this age should be to make every effort to avoid a cavity by preserving the canal wall (see Cholesteatoma later in this chapter).

**RADICAL MASTOIDECTOMY**

Radical mastoidectomy creates a common cavity that consists of the middle ear, epitympanum, mastoid cavity, and external canal. The operation is not performed as frequently today as it was in the preantibiotic era; however, it is performed when extensive cholesteatoma, which cannot be controlled with a less radical procedure, is present. In children, an extensive rapidly growing cholesteatoma is not uncommon, and radical mastoidectomy is still performed in selected cases. In our series of 244 surgical procedures for cholesteatoma, 26% were radical mastoidectomies.4

In the past, radical mastoidectomy was advocated when a suppurative intracranial complication developed in a patient who had acute or chronic otitis media and mastoiditis, but today, a lesser procedure is usually safe and effective in individualized patients, especially when cholesteatoma is absent. Even when cholesteatoma is present, the availability of the telescope frequently allows a canal wall–up tympanomastoidectomy, which is a more desirable procedure in children than a radical mastoidectomy (see Cholesteatoma later in this chapter).

Closure of the eustachian tube at the bony (protympanic) portion can prevent troublesome postoperative recurrent or chronic otorrhea caused by reflux of nasopharyngeal secretions (see Chapter 6). This author does not routinely perform this part of the procedure, because all patients do not have postoperative drainage. Moreover, future reconstruction of an aerated middle-ear space may not be possible unless a tympanostomy tube is inserted or a perforation is present in the reconstructed tympanic membrane.
Indications
- Extensive congenital or acquired cholesteatoma, when a less radical procedure is not possible.
- For suppurative intracranial complications of cholesteatoma, on an individualized basis, or for selected children who have chronic suppurative otitis media (and mastoiditis), when a less radical procedure (eg, canal wall–up tympanomastoidectomy) is not likely to control the disease process.

Anesthetic Considerations and Preparation
- When suppurative disease is present within the middle-ear cleft, intravenous antimicrobial therapy is frequently administered perioperatively (and postoperatively) and should be given when there is a suppurative complication of middle-ear mastoid disease.
- The anesthesia and preparation for this procedure are the same as described earlier in this chapter.
- If an intracranial procedure is to be performed in conjunction with the mastoidectomy, the patient should also be prepared for that procedure.

Procedure
- The posterior external auditory canal is taken down and a facial ridge is created as in a modified radical mastoidectomy (Figure 5–10).
- The tympanic is removed. Removal of the malleus and incus is included in the classic operation, but depends upon the extent of the disease (Figure 5–11).
- A meatoplasty, in which soft tissue and a portion of conchal cartilage are removed through the postauricular wound, is usually performed.

Postoperative Care
- The postoperative care is similar to that described above following a modified radical mastoidectomy.
TYMPANOMASTOIDECTOMY
A tympanomastoidectomy combines a simple mastoidectomy with a middle-ear surgical procedure, which frequently includes a tympanoplasty, ie, tympanomastoidectomy with tympanoplasty. The goals of this procedure, in addition to eradication of the disease, are to maintain an intact canal wall, and to maintain, or reconstruct, the tympanic membrane and ossicular chain. For children, this procedure should be the goal of the operation, since it is much more desirable than a radical modified radical mastoidectomy.

Tympanomastoidectomy is used when chronic suppurative otitis media (and mastoiditis), or cholesteatoma, or both, are present (see Cholesteatoma later in this chapter). When chronic suppurative otitis media (without cholesteatoma) is unresponsive to medical management, including intravenous antimicrobial therapy, a tympanomastoidectomy is indicated, which includes a simple mastoidectomy (see Simple Mastoidectomy above). The middle ear is entered as described in Chapter 2 under Postauricular Approach.

CHOLESTEATOMA
Classification and Etiology
Aural cholesteatoma can be congenital or acquired. Congenital cholesteatoma is caused by a congenital rest of epithelial tissue within the middle ear (including intratympanic), or in other portions of the temporal bone, which may appear as a white cyst-like structure or as sheets of tissue. The tympanic membrane is usually intact, and the cholesteatoma is apparently not a sequela of otitis media or eustachian tube dysfunction; however, Tos recently proposed that a congenital cholesteatoma may be acquired and may be a sequela of otitis media.

The most common site of congenital cholesteatoma, in the early phase, is within the middle ear in the anterosuperior quadrant of the mesotympanum. Disease frequently extends into the anterior attic, or into the posterosuperior portion of the mesotympanum, and can also invade the facial recess, sinus tympani, and the attic. Also, the site can be in the posterosuperior portion of the mesotympanum. More advanced congenital middle-ear cholesteatoma can extend into the aditus ad antrum, mastoid, petrous apex, labyrinth, and can even spread outside the temporal bone, such as into the intracranial cavity. The tympanic membrane may not be intact if the disease is extensive.

Acquired cholesteatoma can be a sequela of middle-ear disease or may arise from implantation of epithelium, caused by trauma or surgery (ie, iatrogenic) of the middle ear (including the tympanic membrane), ear canal, or mastoid. Acquired cholesteatoma can be present anywhere in the middle-ear cleft, can extend to any portion of the temporal bone, and can spread outside the temporal bone. Often the cause of the cholesteatoma, either congenital or acquired, is uncertain, especially when the disease is far advanced and the tympanic membrane is not intact.

Of 232 children operated on at the Children's Hospital of Pittsburgh between 1973 and 1990, 43 (18%) had a congenital cholesteatoma (excluding intratympanic), 83 (36%) had an acquired cholesteatoma, and in 106 (46%) children, the cholesteatoma could not be distinguished as
Mastoidectomy and Cholesteatoma

either congenital or acquired. Of 59 children who had a cholesteatoma treated in Switzerland between 1981 and 1996, 18 (29%) were congenital and 41 (71%) were acquired.

**Cholesteatoma Surgery in Children vs. Adults**
The ideal goals of surgery for cholesteatoma in children are similar to those in adults:

1. Eradicate disease
2. Preserve or reconstruct the anatomic structures
3. Preserve or restore hearing
4. Prevent residual and recurrent disease

Many surgical procedures have been advocated to achieve these goals, but, unfortunately, none have been subject to randomized clinical trials. The lack of rigorously designed trials relates to many factors, but primarily to the variation in site, extent, and severity of the disease, and the rather limited number of pediatric cases at any one individual center. As well, most otologic surgeons have their own preferences based on their skills, training, and experience. Therefore, controversy remains over the optimal procedures to treat and prevent residual cholesteatoma (disease remaining after surgical attempts to eradicate it) and recurrent cholesteatoma (development of new disease).

**Canal Wall–Up vs. Canal Wall–Down Mastoidectomy**
Controversy exists over whether to perform a canal wall–up or canal wall–down procedure when the extent of cholesteatoma requires mastoidectomy. In infants and children, every effort should be made to avoid a canal wall–down mastoidectomy because it is especially desirable to maintain or reconstruct the anatomy in this age group. Among the many disadvantages of having a potentially life-long open mastoid cavity, is the fact that children usually require a general anesthetic for the periodic cleaning and debridement that ensues. The cavity is more difficult to clean postoperatively for children than in adults because children are frequently apprehensive during the procedure. Furthermore, since swimming is a common activity in youngsters, they are more susceptible to infection when an open mastoid cavity is exposed to water.

Therefore, whenever possible, perform a canal wall–up tympanomastoidectomy and additional tympanoplasty, if needed. Since the middle ear and mastoid are not directly visible following these procedures, a “second look” operation is performed approximately 6 months later to detect any residual cholesteatoma. Exploration is recommended at 6 months because cholesteatoma is more aggressive in children than adults. Waiting 12 months, as advocated for adults, can result in more extensive residual disease than is desirable. If a residual cholesteatoma is encountered at the “second look,” it is removed and the child is re-explored in another 6 months. These repeat procedures are performed until there is no further residual cholesteatoma.

In our study of 232 children who had 244 surgical procedures, residual or recurrent cholesteatoma developed in 38% of cases and 23% of those cholesteatomas were detected at the time of the “second look” procedure.
Residual or recurrent disease was significantly associated with ossicular erosion at the time of the original surgery, in direct proportion to the number of ossicles involved. In a Japanese review of children operated on for cholesteatoma, residual cholesteatoma was uncovered at the “second look” tympanotomy in 64% of cases. During the “second look” exploratory tympanotomy this author uses the 70° Hopkins rod-lens telescope to inspect the middle ear for residual and recurrent disease.

Currently, a canal wall–down mastoidectomy is performed for:

1. Suppurative complications (intratemporal or intracranial) of cholesteatoma, with cholesteatoma in the mastoid. The decision for or against removing the canal wall, however, should be individualized, based on the site, extent, and severity of the complication, as well as other factors below.

2. Cholesteatoma in inaccessible areas (by transmastoid approach) of the temporal bone, such as the retrolabyrinthine region or the petrous apex.

3. Children with another medical condition (eg, severe congenital heart disease) which would make a re-operation (eg, “second look” tympanotomy) a potential health hazard.

4. Children who are unable (eg, living in remote areas) or unlikely (eg, poor compliance) to return for a “second look” tympanotomy. This applies not only to developing countries, but also to certain populations in the United States.

5. “Second look” procedures revealing aggressive extensive residual cholesteatoma that is unlikely to be controlled in the future without a canal wall–down procedure.

**Otologic Telescope**

The most significant factor in the preservation of the posterior and superior canal walls in most children is the relatively recent availability of an optical telescope, which enhances visualization of the middle-ear cleft. I use the 2.7-mm 70° Hopkins rod-lens telescope (Hopkins-Karl Storz, Endoscopy-America Inc, Culver City, CA). With this instrument, the surgeon can directly visualize the facial recess and the attic; whereas in the past, the superior canal wall (medial portion) would have to be removed to ensure that cholesteatoma was not attached to the lateral attic wall. The telescope can be placed in the attic following the tympanomastoidectomy, and focused inferiorly to determine whether or not there is persistent disease.

Although not related to performing a canal wall–up versus a canal wall–down procedure, the telescope also greatly enhances examination of the middle ear in areas not visible with the otomicroscope (especially when the canal walls remain intact), such as the osseous portion of the eustachian tube, the sinus tympani, and the hypotympanum.

**Timing of Ossiculoplasty**

If an ossiculoplasty is required to restore the hearing, it is delayed until there is no residual or recurrent cholesteatoma, and otitis media and eustachian tube dysfunction (including atelectasis) are absent and unlikely to recur. Persistent or recurrent middle-ear problems can result in an unfa-
Mastoidectomy and Cholesteatoma

A favorable outcome of ossiculoplasty, such as postoperative extrusion of the prosthesis (see Chapter 4). Residual cholesteatoma found during “second look” at the site of ossiculoplasty not only inhibits attempts at removal of the cholesteatoma, but the ossiculoplasty may have to be disassembled.

Since children are more likely than adults to have recurrent or persistent otitis media and eustachian tube dysfunction, prevention of these middle-ear problems is a required part of cholesteatoma surgery. Placement of a tympanostomy tube, cartilage batten, or both, may be necessary not only at the time of the surgery, but for as long as middle-ear or eustachian tube problems persist. Postoperative formation of a retraction pocket is often associated with cholesteatoma recurrence (see Chapter 3).

Follow-up Visits
Following surgery for cholesteatoma that involves the middle ear, with or without extension into the mastoid gas cell system, children are re-examined periodically for at least 5 years. There are two major concerns:

1. Residual cholesteatoma that remains following the initial surgical procedure
2. Recurrent cholesteatoma (new disease) because of persistent eustachian tube dysfunction, and a new retraction pocket in an anatomic site similar to the original one, or in another area of the tympanic membrane.

Recurrent cholesteatoma is most effectively prevented in children with a tympanostomy tube, cartilage graft tympanoplasty, or both, as described in Chapter 3 under Cartilage Graft Tympanoplasty. In addition, implantation (iatrogenic) cholesteatoma can develop following this type of middle-ear and mastoid surgery. This author usually follows children every 3 months during the first postoperative year, every 6 months during the second and third postoperative years, and then yearly for another 5-7 years.

CONGENITAL CHOLESTEATOMA

In general, the surgical procedures for removing a congenital cholesteatoma are similar to those employed when an acquired cholesteatoma is diagnosed. There are two additional procedures for congenital cholesteatoma, however, that are not described in the section on Acquired Cholesteatoma: (1) removal of intratympanic membrane cholesteatoma, and (2) removal of cholesteatoma in the anterosuperior quadrant of the middle ear. Cholesteatoma is encountered relatively frequently in both of these anatomic sites in infants and children. Another commonly encountered site is the posterosuperior portion of the mesotympanum, which is approached in a similar manner as that described for acquired cholesteatoma.

In our study of 45 surgical procedures for congenital cholesteatoma performed in the 1970s and 1980s (excluding intratympanic disease), 56% were limited to the middle ear (with or without atticotomy), 13% were canal wall–up tympanomastoidectomies, 9% were modified radical mastoidectomies, and 20% were radical mastoidectomies. The present trend, however, is to maintain the posterior canal wall, and avoid a postoperative open cavity (radical or modified radical mastoidectomy) whenever possible.
Indications
- Intratympanic membrane congenital cholesteatoma.
- Congenital cholesteatoma medial to the intact tympanic membrane in the anterosuperior quadrant of the middle ear

Anesthetic Considerations and Preparation
- The anesthesia and the preparation depend on the site and the approach.
- For an intratympanic membrane cholesteatoma, the anesthesia and preparation are similar to those described in Chapter 2 under Transcanal Approach.
- For a congenital cholesteatoma that is within the anterosuperior portion of the middle ear and epitympanum, the anesthesia and preparations are the same as described in Chapter 2 under Endaural Approach.
- A facial nerve monitor is used when the disease is in the middle ear.

Procedures

No 1. Intratympanic membrane congenital cholesteatoma
- Congenital cholesteatoma is seen within the intact tympanic membrane (Figure 5–12).
- The cholesteatoma is removed with a pick; a cup forceps is also used (Figure 5–13).
- A Steri-Strip patch is placed over the defect if a small perforation is present (Figure 5–14).
- If the perforation is large, a tissue graft myringoplasty is performed, as shown in Chapter 3.

Figure 5–12 Congenital cholesteatoma within the intact tympanic membrane.
Figure 5–13  Cholesteatoma is removed with a curved pick.

Figure 5–14  A Steri-Strip patch is placed over the defect.
No 2. Anterosuperior middle-ear congenital cholesteatoma

- A congenital cholesteatoma is visualized in the middle ear, medial to the anterosuperior quadrant of the intact tympanic membrane (Figure 5–15).

- The choice of approach (see Chapter 2) depends on the extent of cholesteatoma and the size of the child’s ear canal:
  - An endaural approach (Figure 5–16A) is used for disease localized to the anterosuperior mesotympanum, but with inadequate direct access or visualization because of a narrow ear canal. Only a short incision is needed in the incisura, because the mastoid will not be entered.
  - A transcanal approach (Figure 5–16B) is used for disease localized to the anterosuperior mesotympanum, with a large enough ear canal to permit adequate visualization and access to the anterosuperior canal wall.
  - A postauricular approach is used for disease extending into the posterior attic, aditus ad antrum, and mastoid (see Acquired Cholesteatoma below).

- The tympanomeatal flap is elevated off the malleus to completely expose the cholesteatoma. Although the tympanic membrane can often be maintained intact, any portion that appears penetrated by the cholesteatoma should be excised to prevent recurrence and the tympanic membrane grafted.

- Cholesteatoma extension into the anterior epitympanum is common and can be visualized on the preoperative computed tomography (CT) scan. An anterior atticotomy is done with a microdrill (Figure 5–17), and the cholesteatoma is removed (for more extensive disease, see Acquired Cholesteatoma below).
Mastoidectomy and Cholesteatoma

Figure 5–16  A. Endaural incisions and approach when the cholesteatoma is localized to the anterior mesotympanum and the anterior epitympanum. B. Transcanal approach is used, if feasible.

Figure 5–17  An anterior attico-tomomy is done with a microdrill, and cholesteatomas are removed.
• The tympanomeatal flap is replaced (Figure 5–18). A defect, if present, is repaired using a medial fascia graft as described in Chapter 2.

• If the endaural approach was used, the incision is closed with 2-3 absorbable sutures.

Postoperative Care
• The postoperative care is dependent on the approach used (see Chapter 2).

• A “second look” exploratory tympanotomy is usually performed 6 months after the procedure to remove any residual middle-ear or epitympanic cholesteatoma. The site and extent of the cholesteatoma, the status of the hearing, and the degree of translucency of the tympanic membrane are key factors in recommending a “second look” operation (see Acquired Cholesteatoma below).

Figure 5–18  A tympanomeatal flap is replaced.
ACQUIRED CHOLESTEATOMA

The most common type of cholesteatoma is acquired, which is a sequela of middle-ear disease (eg, eustachian tube dysfunction, otitis media). Acquired cholesteatoma can also occur as an unwanted sequela of otologic surgery, such as tympanostomy tube placement. The most frequent anatomic site in which an acquired cholesteatoma is encountered in children is the posterosuperior quadrant of the pars tensa; the second most common site is the pars flaccida area.

In a study of 1024 patients (adults and children), a cholesteatoma of the attic was seen in 42% of cases and a cholesteatoma of the posterosuperior quadrant in 31% of cases. A cholesteatoma was present in 18% of patients when there was a total perforation, in 6% when there was a central perforation, and in 3% when there was no perforation (possibly congenital). However, it is possible that the patients in whom the cholesteatoma was associated with a total perforation originally had involvement of the posterosuperior portion of the pars tensa.

In children, the most common defect in the tympanic membrane (ie, retraction pocket) develops first in the posterosuperior quadrant of the pars tensa, or less commonly, in the pars flaccida. The term marginal perforation has been used to describe the defect in the posterosuperior quadrant, and the defect in the pars flaccida has been called an attic perforation. These are frequently not true perforations, however, but rather retraction pockets or cholesteatomas that otoscopically appear as perforations; no continuity between the defect and the middle ear occurs until later in the disease process.

Selection of Procedure Related to Site and Extent of Disease

Each child’s final procedure should be individualized based on several factors. One surgical procedure is not advocated for all cholesteatomas. The following factors are important in the preoperative planning and the intraoperative decision-making process:

- Anatomic site
- Extent of disease
- Condition of ossicular chain and tympanic membrane
- Presence or absence of chronic suppurative otitis media and mastoiditis
- Presence or absence of suppurative or nonsuppurative complications
- Anatomy of the temporal bone and the middle-ear cleft
- Status of eustachian tube function
- Age and general health of the child
- Findings of CT scans
- Availability of postoperative follow-up care

As stated above, the long-standing goals of cholesteatoma surgery are to eradicate disease, reconstruct the tympanic membrane, maintain the anatomy of the middle-ear cleft, and preserve (restore) hearing. In addition, try to preserve the external auditory canal to prevent the potential morbidity of an exposed mastoid cavity. Unfortunately, this is not always possible,
because cholesteatoma in children is frequently more invasive, grows more rapidly, and is associated with a higher residual and recurrence rate than cholesteatoma in adults. Other factors that may be related to this difference are the higher rate of recurrent and chronic middle-ear disease and poor eustachian tube function in the pediatric population.

Of the 199 procedures performed for acquired cholesteatoma (or cholesteatoma of uncertain etiology) at Children’s Hospital of Pittsburgh from 1973 to 1990, 28% involved only a middle-ear procedure, 20% were canal wall–up tympanomastoidectomies, 25% were modified mastoidectomies, and 28% were radical mastoidectomies. The current trend, however, is to maintain the posterior canal wall and avoid a postoperative open cavity (radical or modified radical mastoidectomy) whenever possible.

Staging of Acquired Cholesteatoma

It is appropriate to stage cholesteatomas for management, reporting, and research. When staging cholesteatoma, the presence or absence of infection should be noted, and if present, the duration of the otitis media. This author has proposed the following classification:

• **Cholesteatoma without infection** is a cholesteatoma that is not associated with infection, either within the cholesteatoma itself, or in any other portion of the middle-ear cleft.

• **Cholesteatoma with infection** is a cholesteatoma that is associated with infection, which can be either acute (with or without otorrhea) or chronic. The most common infection associated with cholesteatoma is chronic suppurative otitis media.

Cholesteatoma is further classified based on its site and extent:

• **Stage 1.** Cholesteatoma confined to the middle ear (hypo- and mesoepitympanum), without erosion of the ossicular chain

• **Stage 2.** Same as Stage 1, but with erosion of one or more ossicles

• **Stage 3.** Middle ear and mastoid gas cell system involved, without erosion of ossicles

• **Stage 4.** Same as Stage 3, but with erosion of one or more ossicles

• **Stage 5.** Extensive cholesteatoma of the middle ear, mastoid, and other portions of the temporal bone, the extent of which is not totally accessible to surgical removal (eg, medial to labyrinth), with one or more ossicles involved; fistula of the labyrinth may or may not be present

• **Stage 6.** Same as Stage 5, but cholesteatoma extends beyond the temporal bone

Surgical Planning

The following examples (posterosuperior quadrant and pars flaccida/attic cholesteatomas) describe the two most common types of acquired cholesteatoma encountered in children. Each example includes the common sites of extension of the cholesteatoma and the final procedure selected, depending on the extent of the disease. There is a logical progression of the operation, and the reader can follow the decision-making process. Preoperative evaluation of the CT scans can be helpful in planning the proce-
Mastoidectomy and Cholesteatoma

Procedure and discussing the risks versus the benefits (ie, informed consent) with the parents. The CT scans do not have a high enough sensitivity to accurately identify the extent of the cholesteatoma in all patients, but they are a valuable diagnostic aid.\textsuperscript{16}

The following procedures are not only reserved for presumed acquired cholesteatoma, but can also be used for cholesteatoma of congenital or uncertain etiology.

**POSTEROSUPERIOR QUADRANT ACQUIRED CHOLESTEATOMA**

Cholesteatoma that occurs in the posterosuperior quadrant of the pars tensa of the tympanic membrane has been called a “marginal perforation,” but this is in almost all cases a misnomer or misconception, because there is no perforation, at least when encountered in children. It is most likely the result of recurrent or persistent middle-ear negative pressure, due to eustachian tube functional obstruction, and immediately preceded by a retraction pocket.\textsuperscript{17}

The following surgical procedures describe an acquired cholesteatoma according to four possible extensions:

1. Confined to the posterior mesotympanum, facial recess, and sinus tympani
2. Extending into the superior portion of the facial recess and epitympanum
3. Extending into the aditus ad antrum and mastoid gas cells
4. Extending into the remaining portion of the middle ear, in addition to other areas

**Indications**

- Cholesteatoma in the posterosuperior quadrant, with or without extension into the epitympanum, mastoid gas cells, and middle ear (Figure 5–19)
Anesthetic Considerations and Preparation
- The anesthesia and the preparation for this procedure are the same as for a postauricular approach (see Chapter 2).
- A facial nerve monitor is used during the procedure.

Procedures
- Incisions for a Koerner flap and postauricular approach are completed (Figure 5–20) as described in Chapter 2 under Postauricular Approach.

No 1. Cholesteatoma in the posterior mesotympanum, facial recess, and sinus tympani
- The tympanomeatal flap is elevated to reveal a cholesteatoma confined to the posterior mesotympanum, facial recess, and sinus tympani (Figure 5–21).
- The posterosuperior portion of the canal wall scutum is removed with a curette to further visualize the cholesteatoma (Figure 5–22). Alternatively, a microdrill can be used.
- Cholesteatoma in the facial recess is removed, and visualization of the sinus tympani is enhanced with the aid of a 2.7-mm 70° Hopkins rod-lens telescope (Hopkins-Karl Storz, Endoscopy-America Inc, Culver City, CA). (See Chapter 3, Figure 5–44).
- An ossiculoplasty, if indicated, can be performed at this time (see Chapter 4).
- Gelfoam is placed in the middle ear and a cartilage-perichondrial graft is placed over the defect (Figure 5–23). The graft is harvested from the conchal cartilage through the postauricular wound, as described in detail in Chapter 3 under Cartilage Graft Tympanoplasty.
- A tympanostomy tube is inserted into the anterior portion of the tympanic membrane (Figure 5–24) to prevent cholesteatoma recurrence.18
Figure 5–22 The posterosuperior portion of the canal wall scutum is removed with a curette.

Figure 5–23 A cartilage-perichondrial graft is placed over the defect.

Figure 5–24 A tympanostomy tube is inserted into the anterior portion of the tympanic membrane.
No 2. Cholesteatoma extending into the epitympanum

• The tympanomeatal flap is elevated to reveal cholesteatoma extending into the epitympanum (Figure 5–25).

• An atticotomy is performed with a microdrill and the incus is removed (Figure 5–26).

• Incus interposition is one reconstructive option (see Chapter 4), but removal of the entire malleus and a myringostapediapexy is an alternative.

• A cartilage-perichondrial graft and a fascia graft are placed medial to the tympanic membrane remnant (Figure 5–27).
No 3. Cholesteatoma extending into the mastoid gas cells
- Atticotomy reveals cholesteatoma extending superiorly and posteriorly into the attic and the aditus ad antrum (Figure 5–28).
- The mastoid cortex is entered (Figure 5–29) and, if a cholesteatoma can be removed without taking the canal wall down, a simple mastoidectomy is performed as described earlier.
- A cartilage-perichondrial graft and a fascia graft are placed medial to the tympanic membrane remnant (see Figure 5–27).
- Thus, a canal wall–up mastoidectomy with tympanoplasty is performed.

Figure 5–28  The cholesteatoma extends posterosuperiorly.

Figure 5–29  “Simple” mastoidectomy is completed.
No 4. Extensive cholesteatoma

- Mastoidectomy and middle-ear examination reveal extensive cholesteatoma that cannot be adequately excised without removing the posterior and superior canal walls (Figure 5–30).

- A modified radical mastoidectomy can be successful in selected cases with this extent of disease. However, as stated earlier, the use of the telescope enhances removal of the cholesteatoma even when the disease is extensive, and may obviate the need for a canal wall–down procedure. A canal wall–up tympanomastoidectomy (see Figure 5–29) is safe and effective in many children even when the disease is extensive.

- A radical mastoidectomy (Figure 5–31) is reserved for only those cholesteatomas that are so extensive that a canal wall–up procedure, or even a modified radical mastoidectomy, will not safely control the disease (see Cholesteatoma Surgery in Children vs. Adults earlier in this chapter).

Postoperative Care

- The postoperative care and follow-up are as for the procedures described earlier in this chapter.

Figure 5–30 Mastoidectomy and middle-ear examination reveal extensive cholesteatoma in the mastoid and entire middle ear.

Figure 5–31 A radical mastoidectomy is performed when disease is too extensive to perform a less radical procedure.
PARS FLACCIDA ATTIC CHOLESTEATOMA

A cholesteatoma that is otoscopically visualized in the pars flaccida area has been inappropriately termed an “attic perforation,” when in reality there is no perforation but simply a cholesteatoma (or retraction pocket). The etiology and pathogenesis are most likely similar to cholesteatoma that develops in the posterosuperior quadrant of the pars tensa, and as described earlier, a retraction pocket precedes the cholesteatoma.15

The following surgical procedures describe a cholesteatoma in the pars flaccida according to three possible extensions:

1. Confined to the anterior epitympanum
2. Extending into the aditus ad antrum and mastoid
3. Extensive cholesteatoma

Preoperative CT scans can be helpful in the decision to use an endaural or postauricular approach, since the scans usually determine if the disease extends into the mastoid gas cell system.

- If the cholesteatoma appears confined to the epitympanum, the endaural approach is used. In contrast, a postauricular approach is used when the cholesteatoma has most likely extended into the mastoid.
- If the cholesteatoma does indeed extend into the mastoid, then a classical Bondy modified radical mastoidectomy is performed in selected cases; however, if there is extensive disease in the mastoid, the postauricular approach is more feasible.

Also, as stated before, a canal wall–up tympanomastoidectomy should be the goal in children, not a modified radical or radical mastoidectomy.

Indications

- Cholesteatoma in the pars flaccida, with or without extension into mastoid air cells and middle ear (Figure 5–32)