Surgical Pediatric Otolaryngology

Second Edition

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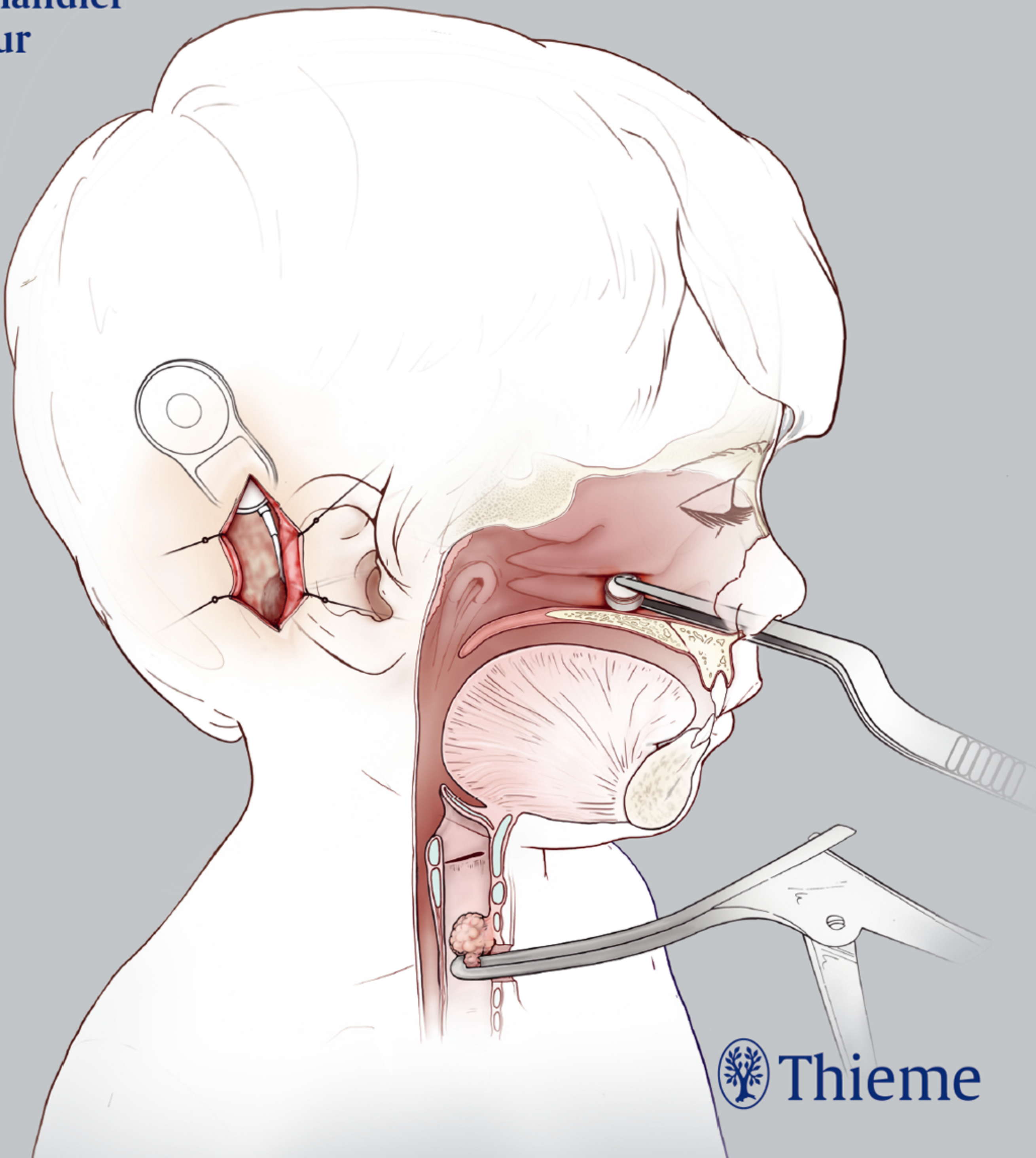
Robin T. Cotton
Steven D. Handler
Karen B. Zur



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Surgical Pediatric Otolaryngology
Second Edition

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Dedicated to those children who have taught us and to all those children in the future who may benefit from these efforts.

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Foreword

It has been 19 years since the first edition of *Surgical Pediatric Otolaryngology* appeared. The goal of the first edition was to provide a reference for surgeons who care for children and perform operative procedures on the head and neck, airway, skull base, paranasal sinuses, and temporal bone. This collection of surgeons includes pediatric otolaryngologists, general otolaryngologists who care for children, and pediatric general and thoracic surgeons. The first edition was enthusiastically received by the fields of otolaryngology and bronchoesophagology, and copies of this atlas still occupy a place of prominence on the bookshelves of many of my colleagues.

Since 1997, the breadth of pediatric otolaryngology has changed little, but the complexity of many surgical techniques is now reflected in the advanced procedures required to return an affected child to a normal or nearly normal life. For example, refinements in the electronics of cochlear implant devices and improvements in surgical techniques, especially the utilization of binaural devices, have brought deaf children even further into the hearing world, while advances in pediatric airway reconstruction have allowed children to live their lives without a tracheostomy.

When the first edition was published, many pediatric surgeons included the entire repertoire of procedures listed in this atlas as proof that they could care for the entire breath of pediatric otolaryngology. Now, many of these procedures are performed by a smaller but more experienced team of surgeons who benefit from performing a larger number of these complicated cases than they would have done in the past. This subspecialization has improved the care and outcomes of patients with complex diseases. The best example of the value of subspecialization may be airway reconstruction. In the past, many surgeons in our practice performed a few airway cases a year; all of these cases are now treated by a group of four surgeons, three fellows, five nurses, and both a gastroenterologist and a pulmonologist with superior care and improved outcomes. Some practices may not have the resources to perform a substantial number of airway reconstructions, and so this book is dedicated to those surgeons who only do a few cases a year, but benefit from techniques and postoperative care suggested in this atlas.

While adhering to the basic format used in the first edition, there are several important upgrades to the second edition. One significant improvement in this atlas is that all of the chapters have been written by more than 20 experts in their fields. Many of these authors have both national and international reputations and clearly live on the cutting edge of surgical pediatric otolaryngology. In addition to being referred the most difficult cases, these experts have honed their skills through years of teaching other colleagues, fellows, residents, and students. While most of this edition is devoted to routine pediatric otolaryngology care, numerous chapters are dedicated to very complex procedures. For those practitioners who only do a few of these procedures a year, this atlas will serve as a great reference to review operative steps and pearls of wisdom that help to improve outcomes. Finally, many of the figures in the text have been revised by a current generation of illustrators who bring a whole new dimension to their work.

In the preface to the first edition of *Surgical Pediatric Otolaryngology*, the authors described the atlas as a “workhorse” for those who perform these procedures routinely and an invaluable resource for those who do only a few. The second edition follows closely in these footsteps, but serves to bring these pediatric surgical procedures well into the 21st century. For that reason, I am sure this atlas will find a prominent place on the bookshelves of many surgeons in the coming years.

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Preface

Welcome to the updated second edition of *Surgical Pediatric Otolaryngology*, a step-by-step, well-illustrated description of the surgical procedures required for treating children with otolaryngologic diseases and conditions. The purpose of this atlas is to help otolaryngologists–head and neck surgeons to learn (or to reacquaint themselves with) the basic steps of the commonly performed procedures in pediatric otolaryngology. While the ideal method of teaching surgery involves a one-on-one interaction between the teacher (experienced surgeon) and the student (who may be a resident, fellow, or beginning practitioner), this scenario occurs mainly in large teaching centers and rarely in the general practice of surgery. We decided to write this atlas as an aid to understanding procedures because many practitioners find themselves considering an operation that they might have seen only once, or perhaps one that they had last performed some time ago.

The operations described herein each include a series of surgical steps that have been selected through years of experience at The Children's Hospital of Philadelphia and Cincinnati Children's Hospital. The procedures are not necessarily original creations of the authors but rather represent the refinement of techniques that have worked well for our patients, with limited surgical complications and excellent outcomes. We have assumed that the operating surgeon already has knowledge concerning the etiologies and disease progression for which the particular operation is being planned. The surgeon who desires more in-depth information about a specific disease process should consult one of the many excellent comprehensive textbooks of pediatric otolaryngology and/or the current literature.

Most surgeons are visual and spatial in their orientation, and for this reason our book relies heavily on the wonderful line drawings of artists Susan Shapiro Brenman, Birck Cox, and Eo Trueblood. The figures are often so clear that they lead the reader through the procedure even without the accompanying text. The adage "one picture is worth a thousand words" is well demonstrated in this atlas. Each step of each surgical procedure is clearly delineated. The text accompanying the figures is organized in small, concisely worded steps. The citations for the figures within the text enable readers to refer to a specific drawing for clarification of a written instruction, and vice-versa.

This book focuses on the procedures that comprise the majority of surgeries performed by pediatric otolaryngologists–head and neck surgeons. We have therefore left out very uncommon procedures intended for esoteric, rare conditions. You will find that the techniques described and illustrated herein are easy to follow. We have found them easy to teach to our own residents and fellows, and our trainees have found the same in helping others.

We believe that this atlas can serve as a reference for the surgeon who infrequently performs pediatric otolaryngology procedures, or as the "workhorse" for those who concentrate more of their efforts in this rewarding field. In either case, we hope and expect that these techniques will help you to obtain the same satisfying results that we have been privileged to enjoy.

Acknowledgments

The four editors thank our families for their support and encouragement, without which this atlas would not have happened. We are grateful to all our colleagues, especially those who have contributed to this second edition, and to their advances in pediatric anesthesiology and airway management, audiology, head and neck imaging, and head and neck oncology.

The authors gratefully thank Beth Ann B. McCullough for her invaluable work in the preparation of the book manuscript. We are grateful for the efforts of Timothy Hiscock, J. Owen Zurhellen, and Kate Barron at Thieme Publishers.

The drawings created by artists Susan Shapiro Brenman, Birck Cox, and Eo Trueblood have brought clarity and depth to our operative descriptions, and we thank them. Mr. Trueblood especially has the combination of exceptional biomedical illustration skills and steady personality necessary to work with pediatric otolaryngologists.

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Section I

The Ear

I

1 Otitis Media with Effusion

Mark D. Rizzi

Otitis media with effusion (OME) is one of the most common chronic conditions of childhood. The primary complications of OME are (1) conductive hearing loss; (2) recurrent acute otitis media; and (3) middle ear atelectasis and cholesteatoma formation.

1-1 Myringotomy and Tube Placement

Indications

Myringotomy and tube placement is indicated (1) when fluid has been present for 8 to 12 weeks, despite medical therapy, causing a significant conductive hearing loss; (2) when recurrent acute otitis is debilitating by its frequency and severity; or (3) when tympanic membrane retraction is present to a degree that one suspects potentially imminent development of ossicular erosion, cholesteatoma, or atelectasis.

Preoperative Evaluation

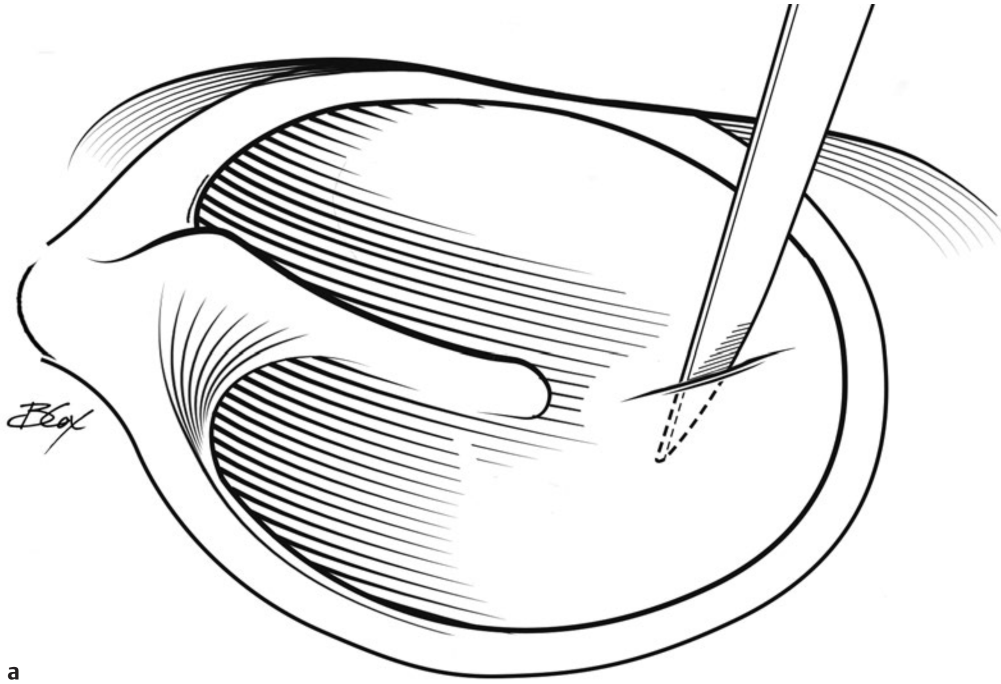
The preoperative evaluation requires a complete pneumatic otoscopic examination and audiologic evaluation. Radiography is rarely, if ever, helpful.

Operative Technique

1. General anesthesia is usually administered by mask. The head is turned to the side opposite the ear being operated upon.
2. The largest speculum that will fit in the external meatus is placed in the ear. Wax is cleared from the external meatus to provide visualization of the entire tympanic membrane.
3. A radial (**Fig. 1.1a**) or circumferential (**Fig. 1.1b**) incision is made through the ear drum. Choice and site of incisions depend on surgeon preference and exposure obtained. For example, if there is a prominent anterior bony ear canal, a radial incision placed in the inferior quadrant is more easily performed.
4. Fluid is aspirated from the middle ear with a 5-French suction cannula, preferably without touching the tympanic membrane.
5. The anterior medial flange of the tube is inserted in the incision, and the posterior flange is rotated into the incision with an alligator forceps or suction tip (**Fig. 1.1c,d,e**).
6. The lumen and area around the tube are aspirated free of blood. Oxymetazoline or antibiotic-containing ear (or eye) drops can be placed in the ear to prevent reaccumulation of blood and subsequent plugging of the tube.
7. Large-flanged or T tubes are used in patients in whom standard tubes extrude prematurely or in those instances where it is felt that a child will need 3 to 5 years of middle ear ventilation. These tubes can be placed in a fashion similar to that used when inserting standard tubes, except that they require a larger myringotomy incision (**Fig. 1.1f,g**). Some surgeons prefer subannular tube placement in order to facilitate long-term ventilation. In this technique, a tympanomeatal flap is elevated after incising the ear canal approximately 5 mm lateral to the annulus and lifting the posterior inferior annulus from the tympanic ring (**Fig. 1.1h,i**). A T tube is placed through the incision taking care to avoid the ossicles with its two legs, and the flap is placed over the tube (**Fig. 1.1j**). The flap can be held in position with a small amount of Gelfoam (Pfizer) (or antibiotic-containing ointment).

Complications

1. Purulent otorrhea
2. Early extrusion
3. Permanent perforation
4. Granuloma
5. Tympanosclerosis
6. Cholesteatoma



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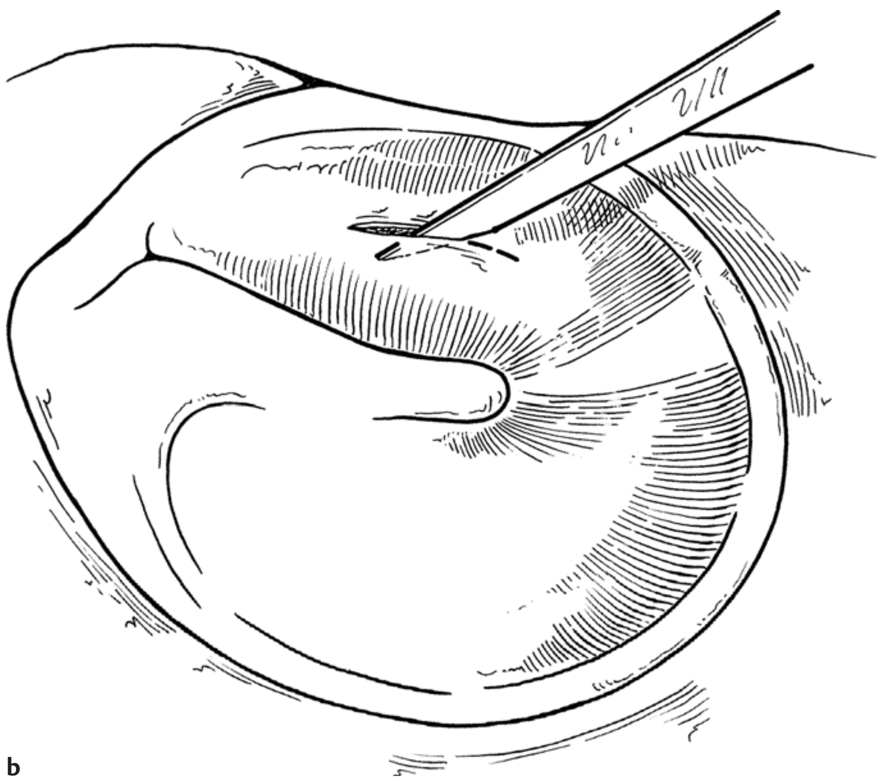


b

Fig. 1.1a,b

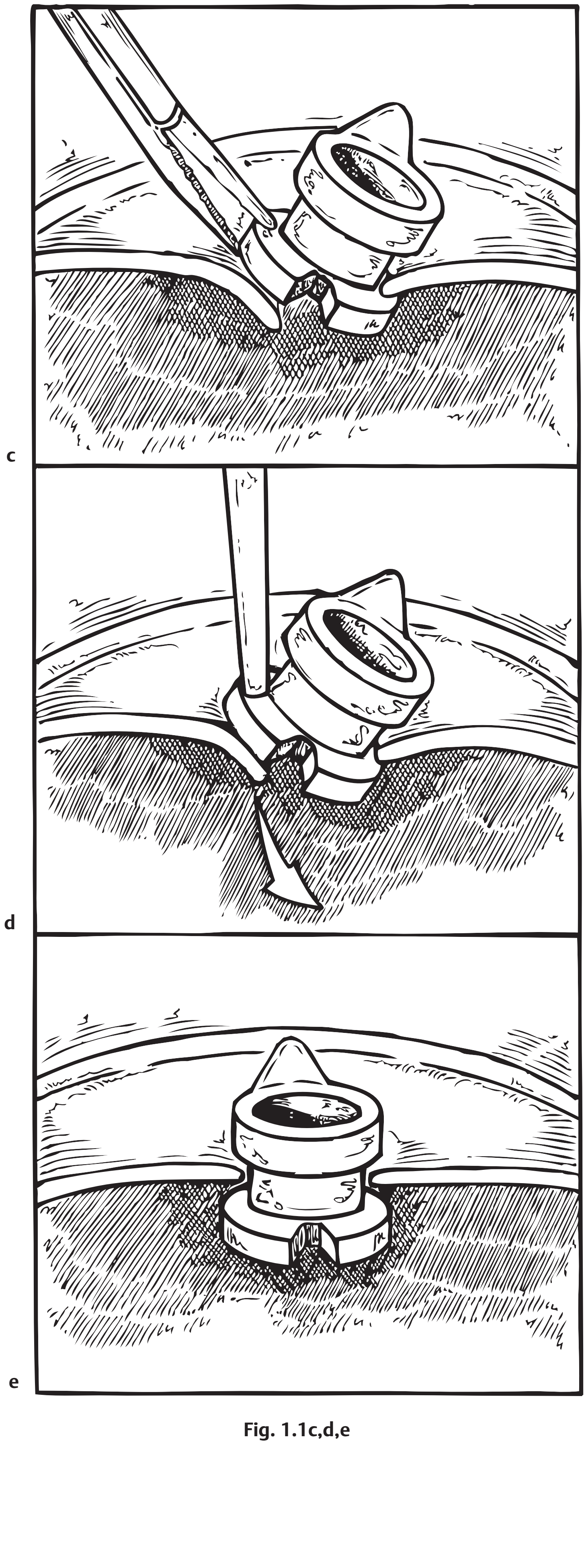
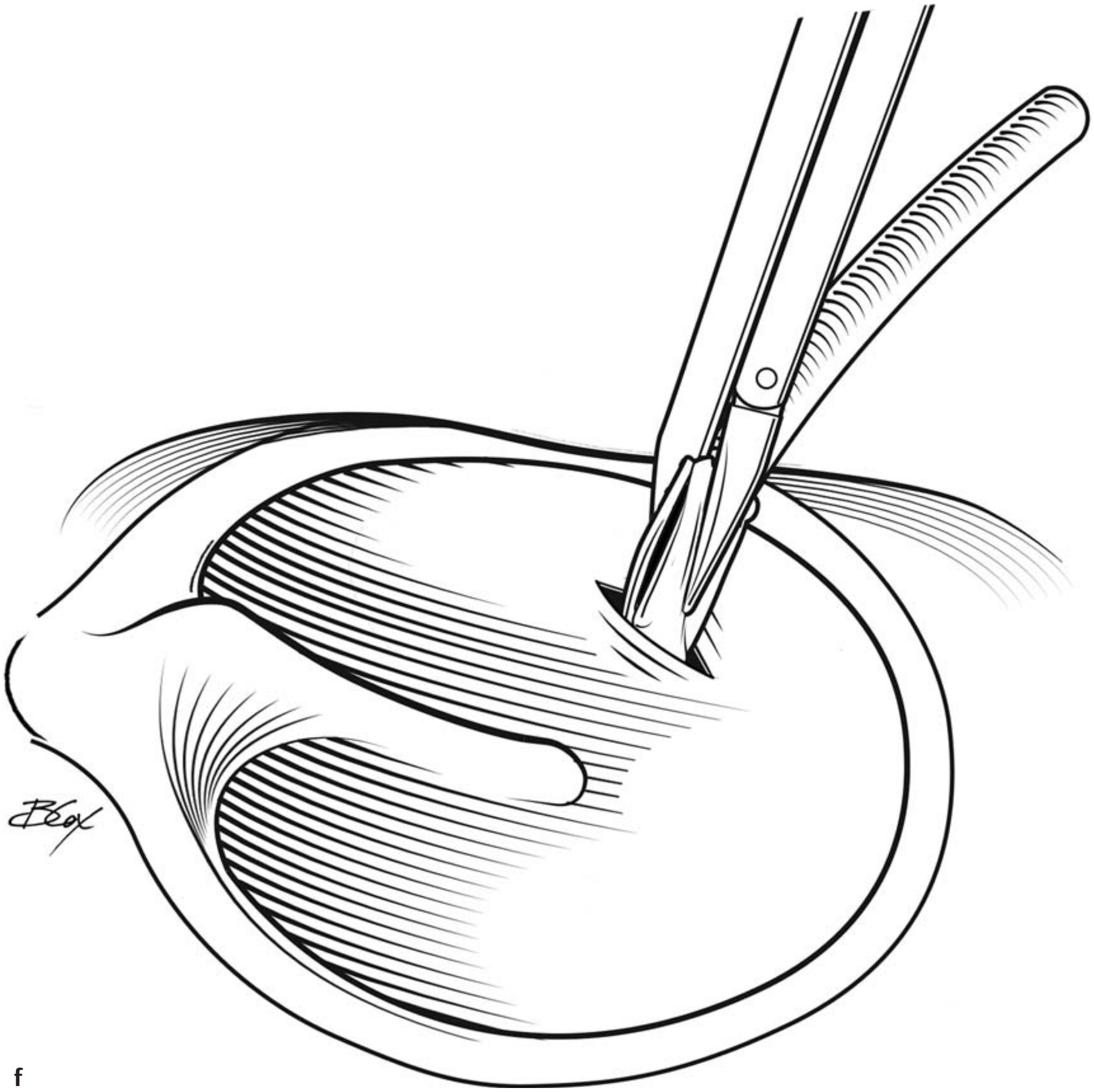


Fig. 1.1c,d,e



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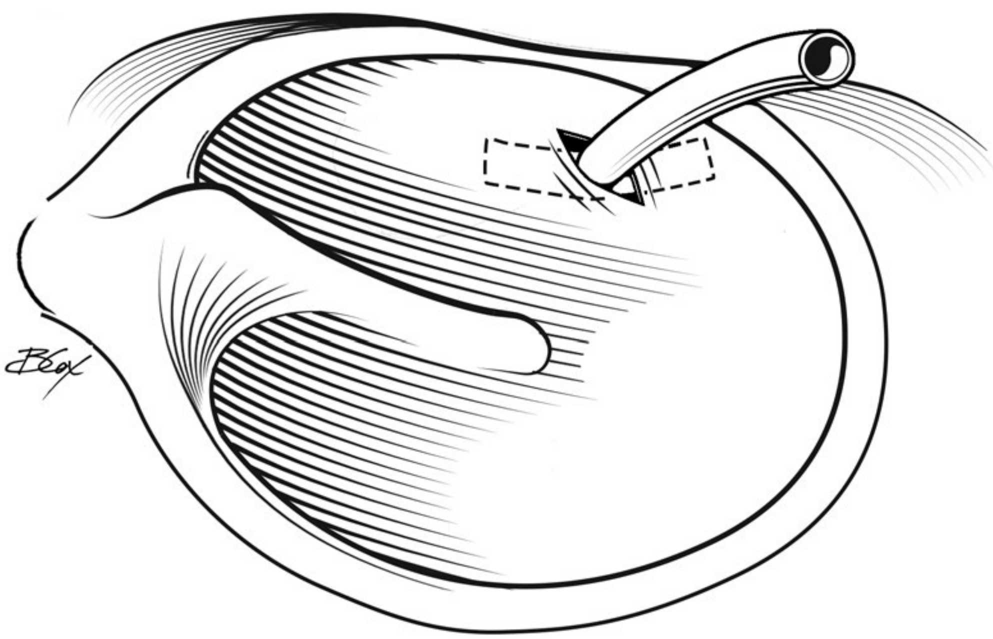


g

Fig. 1.1f,g

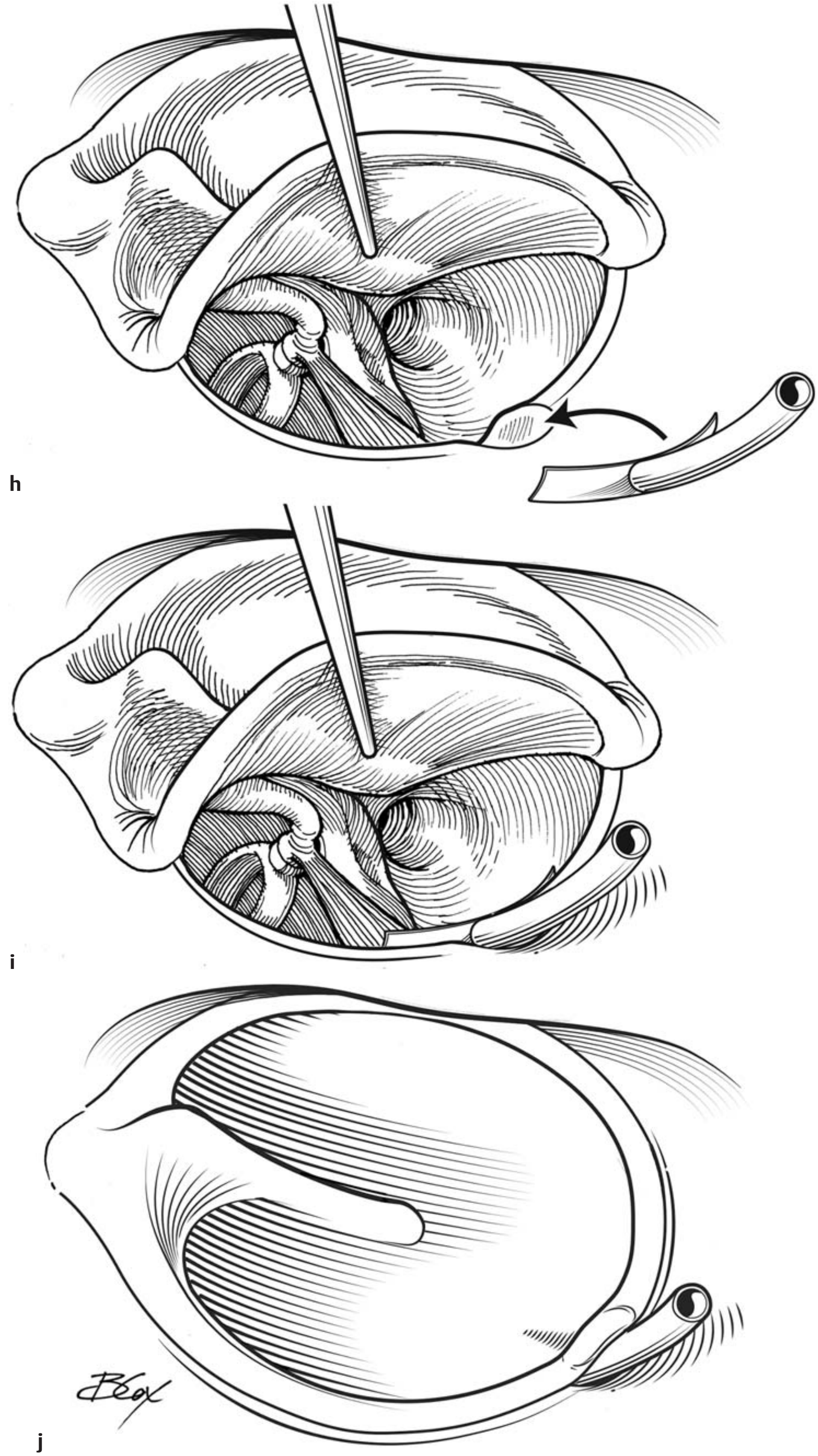


Fig. 1.1h,i,j

1-2 Management of Severe Tympanic Membrane Retraction

Indications

Surgical intervention should be considered when progressive retraction of the tympanic membrane (TM) results in concern for consequent development of ossicular erosion, cholesteatoma formation, or atelectasis of the middle ear. Tympanostomy tube placement as detailed above is often adequate if the process of retraction is intervened upon in its early stages. For more advanced disease, tympanoplasty may be necessary.

Preoperative Evaluation

The preoperative evaluation requires a complete pneumatic otoscopic examination and audiologic evaluation. In cases where ossicular discontinuity or cholesteatoma are suspected, computed tomography (CT) scanning can be performed.

Operative Technique

1. If the retraction is to be managed by tympanostomy tube placement, general anesthesia is induced by mask and the head is turned to the side opposite the ear being operated upon. General endotracheal anesthesia is necessary in children should tympanoplasty be required.
2. The largest speculum that will fit in the external meatus is placed in the ear, and wax is removed from the ear canal. It is important to thoroughly examine the entire TM and to attempt to visualize the depths of the pocket completely to assess for cholesteatoma formation. Retraction pockets in the posterior superior quadrant are at the highest risk for development of cholesteatoma.
3. An attempt can be made to lift the pocket from the medial surface of the middle ear with gentle suctioning. Administration of nitrous oxide by the anesthesiologist can facilitate this elevation as this gas will expand within the middle ear (**Fig. 1.2**).
4. The myringotomy should be made in an adequately ventilated portion of the ear and not at a site of adhesive retraction. A tube is placed, as previously detailed in Section 1-1.
5. If the middle ear is completely atelectatic, or if tympanostomy tube placement fails to restore the middle ear air cushion, tympanoplasty may be necessary, which is detailed in Section 3-2.

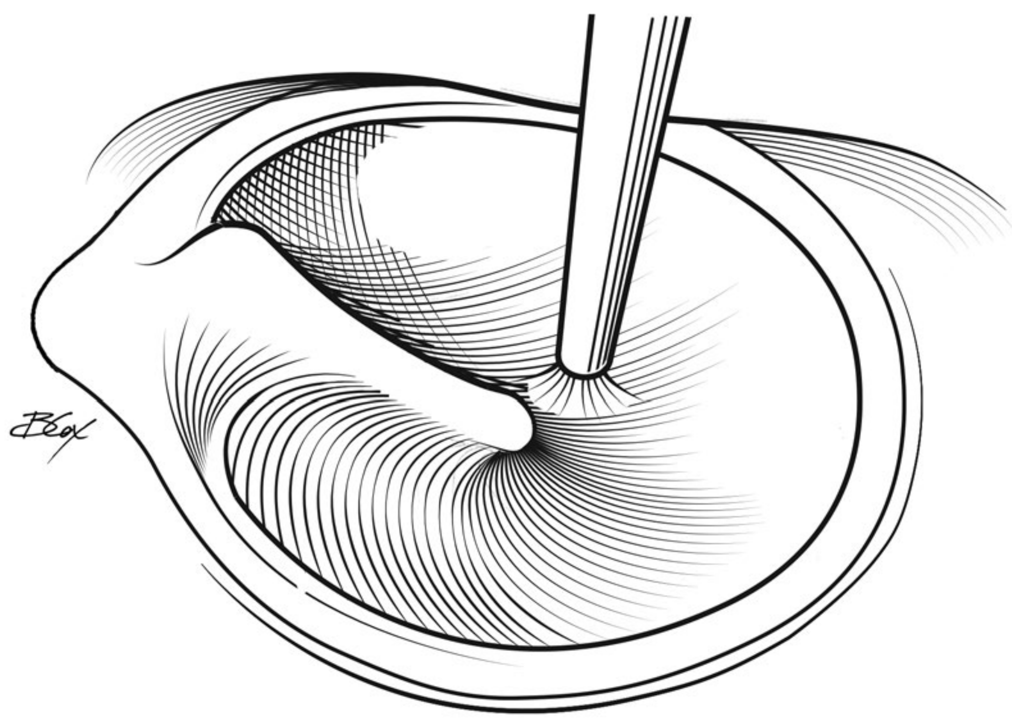


Fig. 1.2

2 Therapeutic (Wide-Field) Myringotomy

Mark D. Rizzi

When a patient has an impeding complication of acute purulent otitis media, a wide myringotomy provides drainage and access to material for culture and sensitivity.

2-1 Therapeutic (Wide-Field) Myringotomy

Indications

When a patient has facial nerve paralysis, vertigo, or intracranial complications (e.g., meningitis or cerebritis) caused by acute otitis media (AOM), a wide myringotomy for drainage and culture should be performed.

Preoperative Evaluation

Preoperative evaluation requires a complete pneumatic otoscopic examination. Audiologic evaluation may be difficult to obtain in an acutely ill child and is of limited value before this procedure.

Operative Technique

1. General anesthesia provides the maximum comfort and surgical exposure for therapeutic myringotomy. However, in some instances, depending on the child's condition, the procedure may be performed without anesthesia.
2. The ear canal should be cleared of wax to provide visualization.
3. A wide myringotomy should be made from the anteroinferior quadrant to the posteroinferior quadrant (**Fig. 2.1**).
4. The contents can then be aspirated and should be sent for culture if there is complicated acute infection.
5. A tympanostomy tube should be placed at the same time for long-term ventilation (see Section 1-1).

Complications

1. Purulent otorrhea
2. Early tube extrusion
3. Granuloma
4. Permanent perforation
5. Tympanosclerosis
6. Cholesteatoma

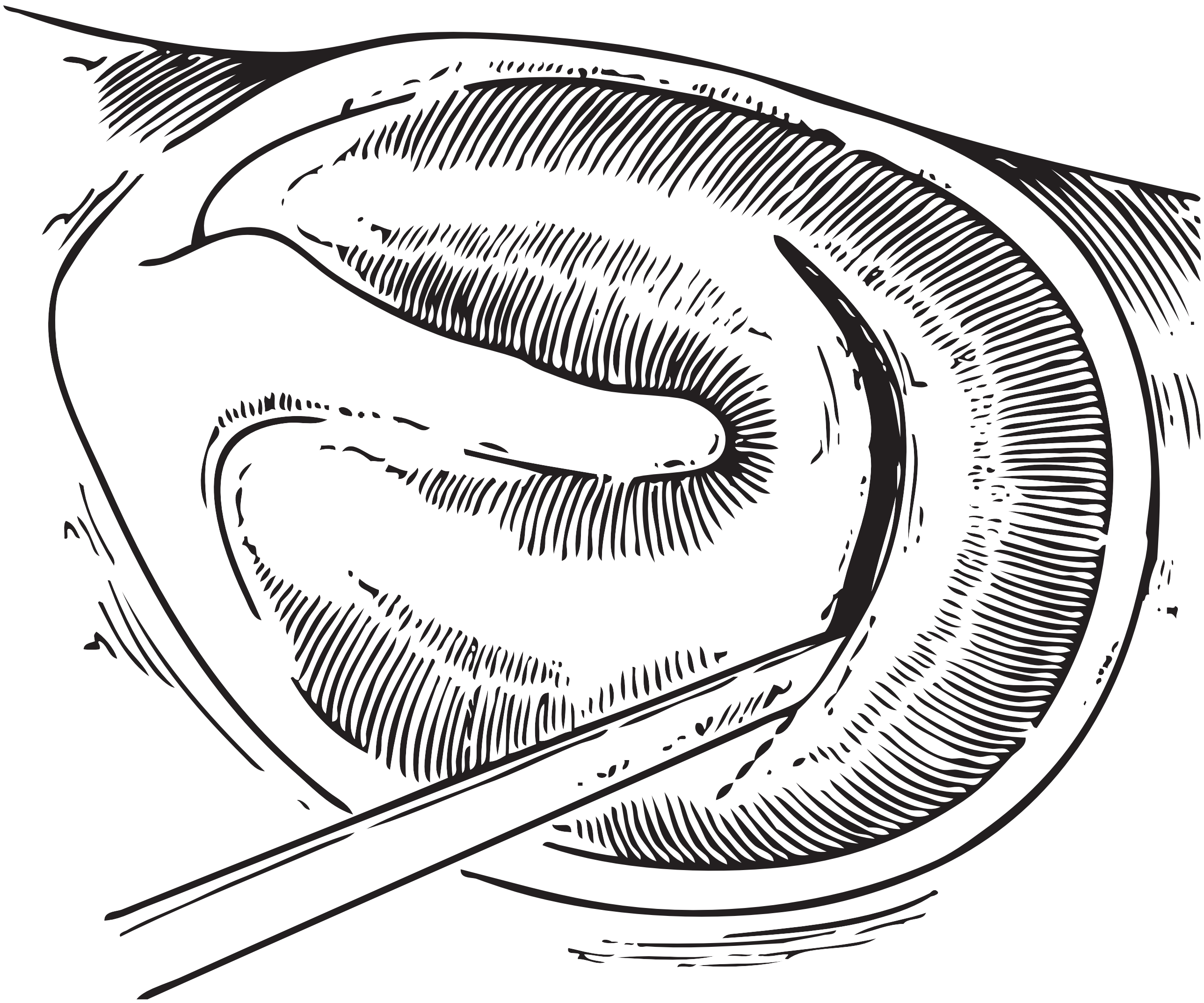


Fig. 2.1

3 Chronic Otitis Media

Daniel I. Choo

Throughout the history of otolaryngology, chronic otitis media (COM) has been described in a variety of ways, reflecting the varied presentations and clinical courses encountered by clinicians. As a result, it is reasonable to consider COM in the framework of a spectrum of diseases ranging from otitis media with effusion to chronic suppurative otitis media with cholesteatoma (as proposed by several authors). The voluminous and equally varied literature on this topic speaks to the tremendous clinical variations and challenges that are presented by this complex spectrum of ear diseases and to the wide array of management approaches that have evolved over the years.

From a clinically pragmatic perspective (and for the purposes of this chapter), COM can be divided into two categories, as described by Ian B. Thorburn in 1968. Type 1 disease involves a chronic perforation of the tympanic membrane (TM) that is not associated with chronic or recurrent infection and is typically associated with normal or near-normal hearing. Type 2 disease, in contrast, is associated with chronic mucosal infection, persistent or frequent otorrhea, as well as hearing loss. Cholesteatoma is often present or suspected in type 2 disease but is addressed specifically in another section due to the differences in management strategies.

For type 1 COM, closure of a chronic dry TM perforation is typically surgical in nature and can be achieved using several different techniques as described below. In type 2 disease, a combination of medical and surgical therapies is often required in order to attain a dry and safe ear with an intact TM and good hearing. The general strategy for approaching these ears is similarly outlined below.

3-1 Paper Patch Myringoplasty

Indications

A dry chronic perforation of the TM that has not spontaneously healed after a minimum of 3 to 4 months of observation can often be addressed through a simple paper patch myringoplasty.

Preoperative Evaluation

Following thorough microscopic exam of the ear in the clinic (with particular attention given to degree of myringosclerosis, mucosal disease, squamous debris, etc.), routine audiologic testing is requisite prior to myringoplasty.

Operative Technique

The vast majority of paper patch myringoplasties in children need to be performed under general anesthesia. In older patients, it is feasible to anesthetize the ear canal and drum using 1% lidocaine with epinephrine 1:100,000 in concentration, after which the procedure would be identical to the steps described here.

1. After cleaning the ear canal, the edges of the perforation are removed using a micro-pick or knife (e.g., Rosen pick or Sickle Knife). A common technique is to use a pick to methodically create a circumferential ring of stab incisions such that the rim of the perforation can be removed atraumatically (**Fig. 3.1a,b,c**).
2. Paper patches are fashioned by using a paper hole punch to create small disks out of cigarette paper. Some surgeons apply a liquid adhesive (e.g., Mastasol [Eloquest Healthcare]) to the undersurface of the patch.
3. The paper patch is applied directly over the freshened perforation (**Fig. 3.1d,e**).
4. Some surgeons will opt to patch then fill the ear canal with a viscous antibiotic ointment (e.g., mupirocin) to help hold the patch in place during the early postoperative period. Alternatively, Gelfoam (Pfizer) with or without a quinolone antibiotic solution can be used as packing to help hold the patch in position during the early healing period.

Alternative Techniques

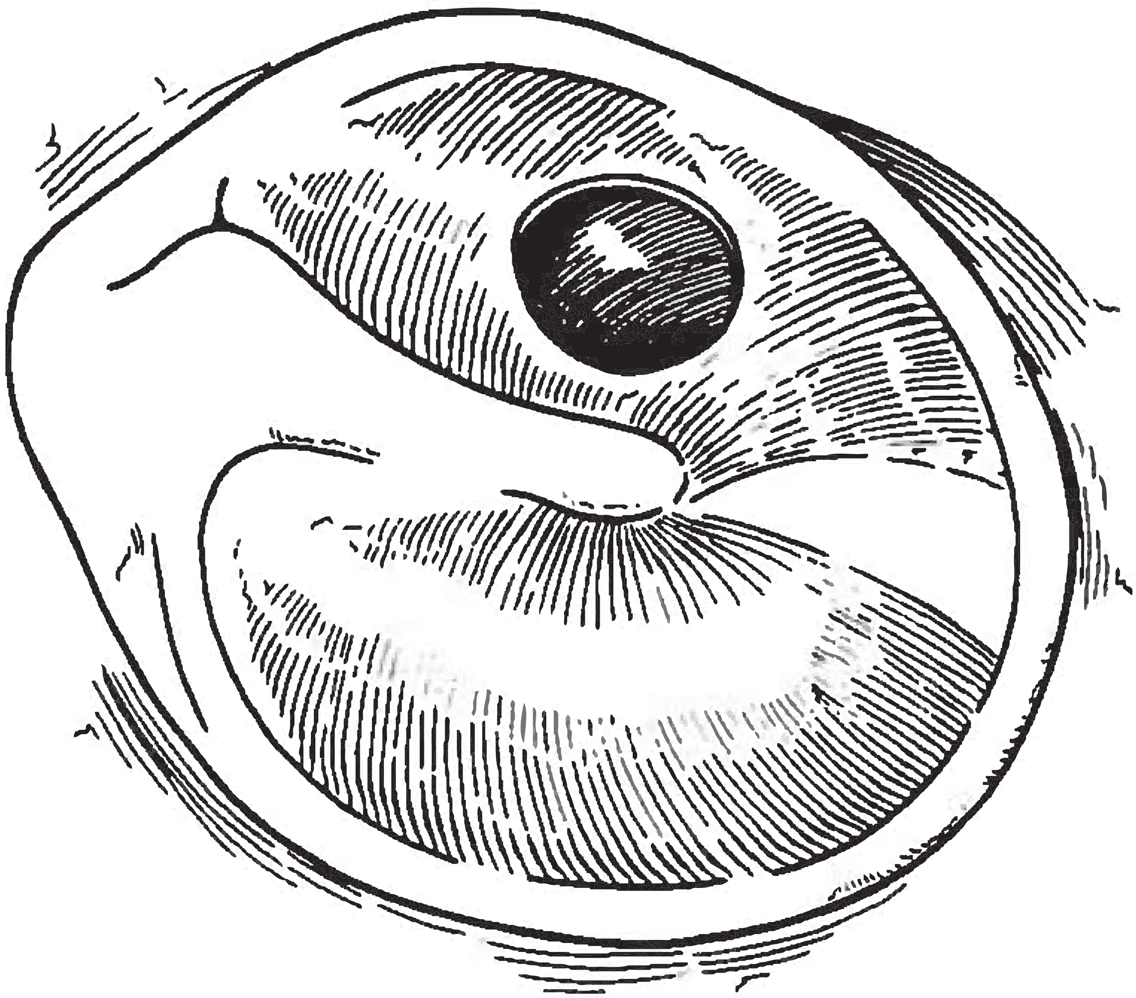
Variations of this basic approach for TM repair have included using different materials, such as Steri-Strips (3M), AlloDerm (LifeCells), Gelfoam, or gelatin film, as the scaffolding material as opposed to a paper patch. Results are very equivalent, with the more significant factors being proper patient selection for the procedure and a keen attention to detail in rimming the perforation and prepping the TM for patching.

Using a fat graft (from the ear lobule, the periumbilical region, or other convenient site) offers another effective option for repairing a chronically perforated TM and is attractive in its use of an autologous "biological" scaffolding that the body then remodels as it heals the TM defect.

Guidelines for the overall surgical technique are similar for all of the myringoplasty materials with a slight variation when using fat. In this instance, the fat is trimmed and then loosely packed into the defect in a dumbbell fashion with some redundant fat on the inner and outer aspects of the TM to help anchor it in position while healing.

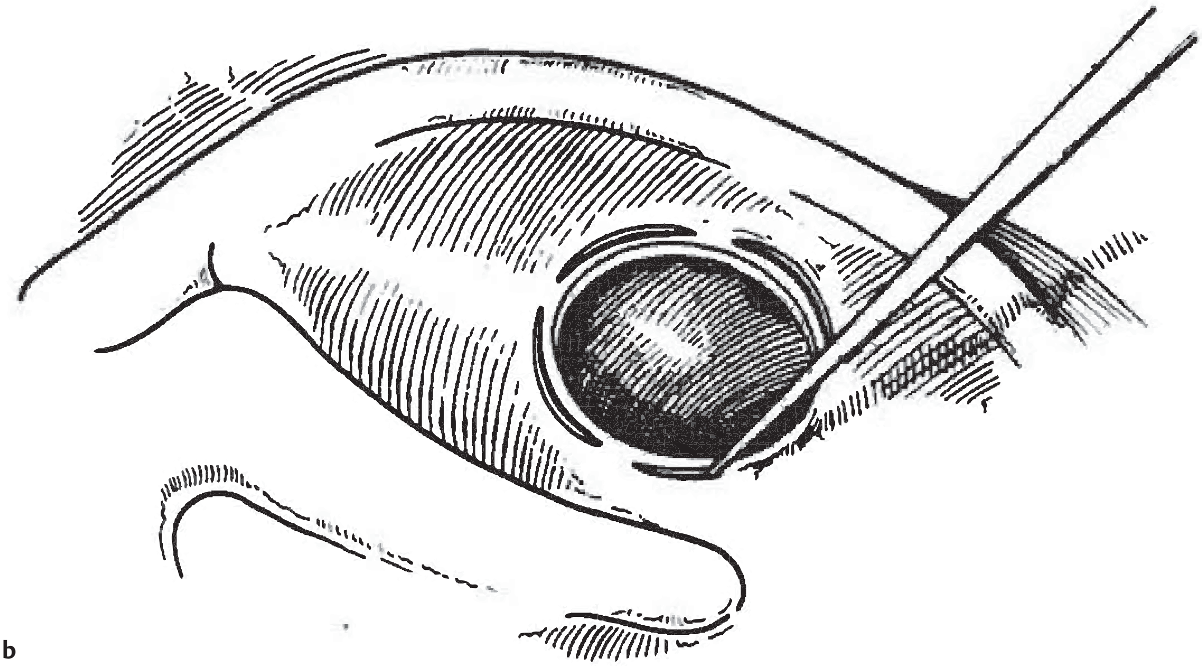
Complications

1. Persistent perforation
2. Purulent otorrhea



a

Fig. 3.1a,b



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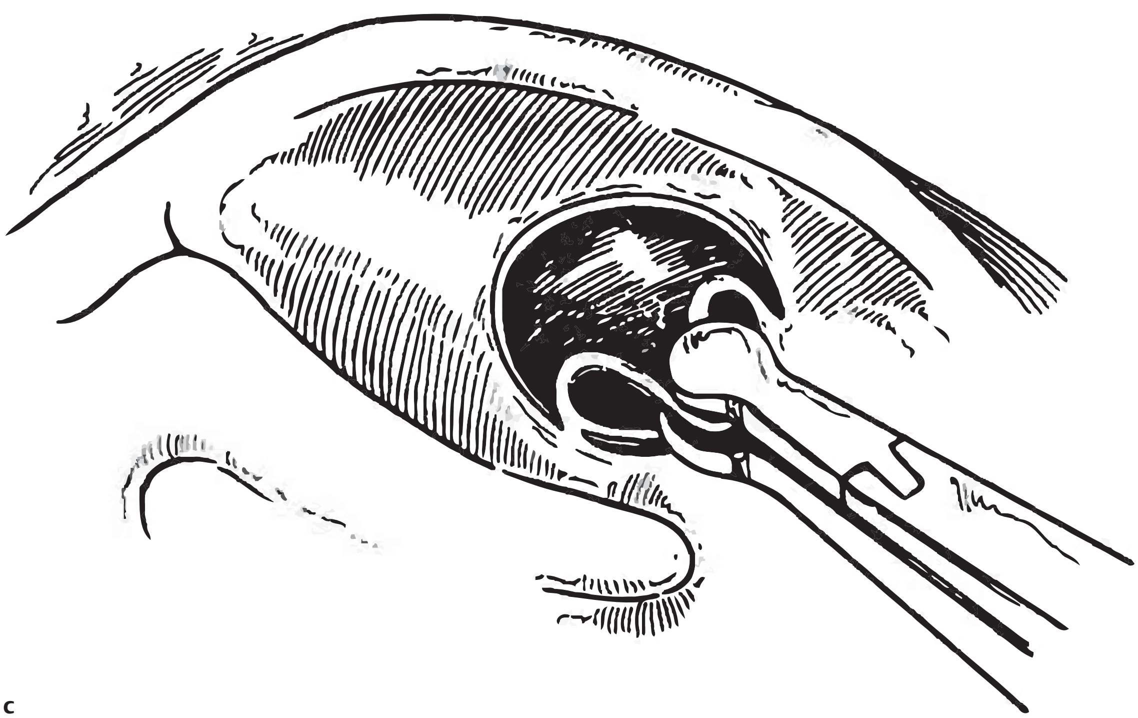

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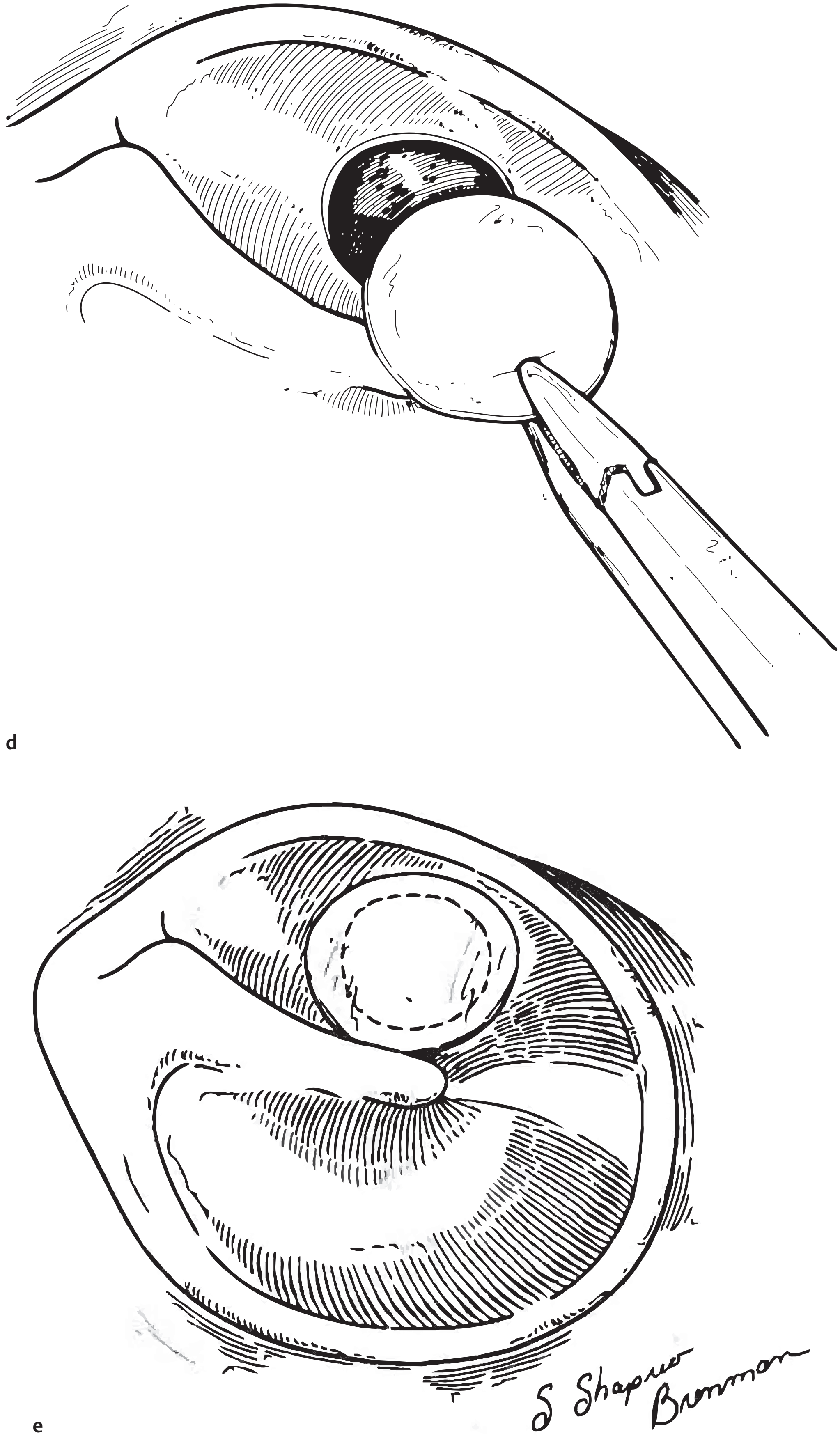
Fig. 3.1b,c



d

e

Fig. 3.1d,e

3-2 Tympanoplasty

Introduction

Over the decades, tympanoplasty techniques have been described in extensive detail and with a huge number of variations to address the spectrum of pathologies encountered and to avoid pitfalls inherent with each of the technical approaches. However, one of the standard techniques for tympanoplasty is to employ areolar temporalis fascia that is placed medial to the TM (an underlay graft or medial graft technique) after elevating a tympanomeatal flap. This straightforward method typically yields > 90% perforation closure rate in properly selected patients and is often performed on an outpatient basis.

Indications

Tympanoplasty is usually considered for patients with type 1 COM that has not healed spontaneously after 6 months or more of conservative observation. In contrast to perforations in which paper patch myringoplasty is used to repair the defect, TM perforations that involve a larger portion of the TM (e.g., > 30% of the pars tensa) are better addressed through this formal tympanoplasty approach.

Preoperative Evaluation

As in most cases of COM, comprehensive history and physical examination, followed by microscopic exam of the ears, is required prior to surgery. Preoperative evaluation of the residual TM, the ossicular chain, the middle ear mucosa, signs of active infection, or cholesteatoma can significantly impact the surgical management at the time of tympanoplasty. Preoperative audiologic evaluation is also mandatory and is essential in counseling patients and families about anticipated hearing outcomes.

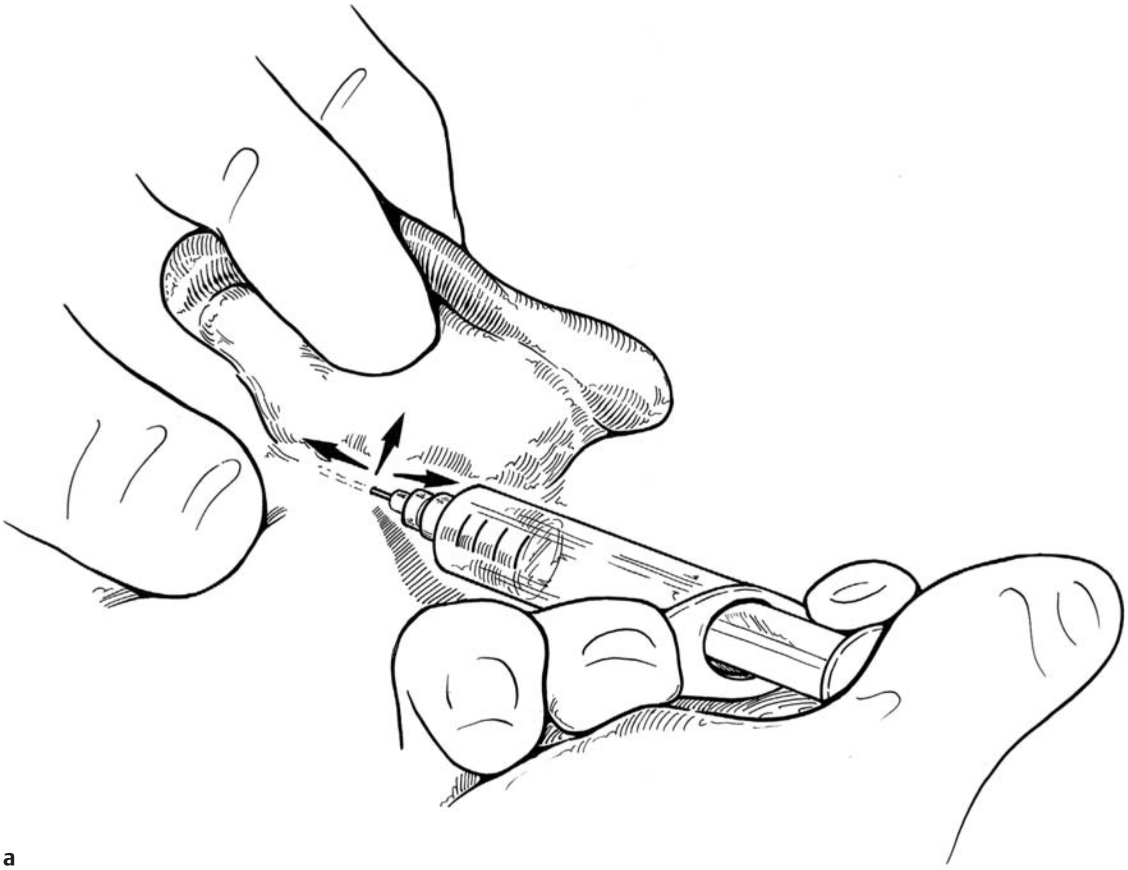
Operative Technique

1. Meticulous injection of the ear canal and postauricular region with 1% lidocaine containing 1:100,000 epinephrine is critical to a smooth and well-executed tympanoplasty (**Fig. 3.2a,b**). Inadequate or ineffective infiltration of this local anesthetic and vasoconstrictive solution results in a constant need to obtain hemostasis during the procedure and/or the need to constantly suction away blood that obscures visualization. Such nuisance issues often incur more suction trauma to the delicate tissues that, in turn, can yield poorer wound healing and grafting results. The local anesthetic and vasoconstrictive effects of the lidocaine and epinephrine solution are also time-dependent. Accordingly, it is pragmatic to cleanse the areas to be injected with an alcohol swab, inject the solution, and then formally prep and drape the ear, thus allowing adequate time for the local agents to act. After sterile prep and drape, the ear canal is often re-injected while using the microscope to ensure a thorough infiltration of the entire ear canal and TM (**Fig. 3.2c**).
2. A standard postauricular incision is made approximately 0.5 cm behind the postauricular crease with sharp dissection continuing down to the level of the temporalis fascia. Firm retraction of the auricle laterally facilitates separation of the tissue planes and entry into the avascular plane of the loose areolar temporalis fascia (**Fig. 3.2d,e**). After undermining anteriorly, superiorly, and posteriorly, meticulous hemostasis should be obtained with the electrocautery.
3. Self-retaining retractors are placed at this point allowing harvesting of loose areolar temporalis fascia for grafting later on in the procedure. Injection of the previously used lidocaine solution is an effective way to hydrodissect a tissue plane that makes harvesting of the graft simple (**Fig. 3.2f,g**). The graft should be thinned to transparency and either pressed or set aside to dry on a nonstick surface (Teflon block).
4. The periosteum overlying the mastoid cortex is then incised with the electrocautery, classically in a C-shaped fashion, starting over the mastoid tip, extending posteriorly and superiorly before curving back anteriorly over the superior aspect of the ear canal. This Palva flap is then elevated anteriorly using a Lempert periosteal elevator and tucked into the front flange of the self-retaining retractor (**Fig. 3.2h,i,j**).
5. Under the microscope, the skin of the posterior ear canal is then gently elevated using microinstruments and suctions, with care being taken to avoid directly suctioning the elevated tissue flaps. After elevation of the posterior ear canal skin down to the level of the annulus, a vascular strip is incised and preserved by first making a transverse cut that parallels the curve of the TM approximately 3 mm lateral to the annulus from the 6 o'clock position (directly inferior) to the 12 o'clock position (directly superior) (**Fig. 3.2k**). Next, two releasing incisions are made starting at the superior and inferior apices of the first cut. These releasing incisions extend laterally out the ear canal, thereby mobilizing the vascular strip that provides the necessary blood supply to the TM and graft (**Fig. 3.2l**).
6. After placing a self-retaining retractor (**Fig. 3.2m**), proper incision and mobilization of the vascular strip typically provides a wide exposure of the entire TM area. Through this exposure, small releasing incisions are often used to facilitate turning of a tympanomeatal flap that does not require constant retraction out of the surgical field (**Fig. 3.2l**). The placement and extent of these releasing incisions can be adapted dependent on the location of the TM perforation and disease in the middle ear or ear canal.

7. Prior to turning a tympanomeatal flap, it is often preferable to rim the edges of the perforation as previously described (**Fig. 3.2n,o**). The undersurface of the TM surrounding the perforation defect is also scraped prior to grafting (**Fig. 3.2p**).
8. Under higher magnification, a round knife or lancet knife can be used to carefully elevate the annulus and TM allowing entrance into the middle ear space (**Fig. 3.2q**). Initial dissection typically starts in the posteroinferior quadrant in order to avoid injuring the chorda tympani nerve during this initial maneuver. An annulus elevator, aka "gimmick," is then commonly used to sweep inferiorly and complete elevation of the inferior portion of the TM. More careful dissection is required in the posterosuperior quadrant in order to preserve the chorda tympani nerve and avoid damage to the ossicular chain deep to the TM.
9. Thorough evaluation of the integrity and mobility of the ossicles is routinely performed during tympanoplasty in order to avoid missing pathology that might impact healing and hearing (**Fig. 3.2r**).
10. A supporting bed of Gelfoam saturated with an antibiotic-steroid solution (e.g., ciprofloxacin with dexamethasone) is placed in the middle ear space against the promontory, filling the hypotympanum and around the ossicular chain (**Fig. 3.2s**). While an adequate amount of Gelfoam is required to maintain the graft in contact with the medial surface of the tympanomeatal flap, an excessive amount can hamper proper placement of the temporalis fascia graft.
11. After placing the supporting Gelfoam, the fascia is trimmed to the appropriate size to fill the defect with an additional 2 to 3 mm (minimum) beyond the edges of the perforation circumferentially. The graft is then placed under the tympanomeatal flap (underlay or medial graft fashion) (**Fig. 3.2t**). Placement of an inadequate graft (too small or improperly placed) such that the defect is just barely filling the TM defect is a frequent cause of failure in tympanoplasty.
12. With the graft in proper position, the tympanomeatal flap is then laid into its normal anatomical position on top of the temporalis fascia (**Fig. 3.2u**) and then secured using the same Gelfoam packing in the medial half of the ear canal (**Fig. 3.2v,w**).
13. Prior to closing, the self-retaining retractor(s) are released and the vascular strip gently stretched and unfurled so that it rests flat along the posterior canal wall.
14. The postauricular incision is closed using resorbable sutures (e.g., 3-0 chromic suture) at the periosteal and deep subcutaneous tissue layers, followed up a running subcuticular suture that is similarly resorbable in nature (e.g., 4-0 chromic) (**Fig. 3.2x,y**).
15. A final look through the operating microscope ensures that the vascular strip and grafts are all well-seated, and then the lateral half of the ear canal is filled with mupirocin ointment (**Fig. 3.2z**).
16. A standard mastoid compression dressing is applied and the procedure terminated at this point.

Complications

1. Persisting perforation
2. Hearing loss (typically conductive in nature)
3. Facial nerve injury
4. Vertigo
5. Dysgeusia from chorda tympani sacrifice
6. Cholesteatoma



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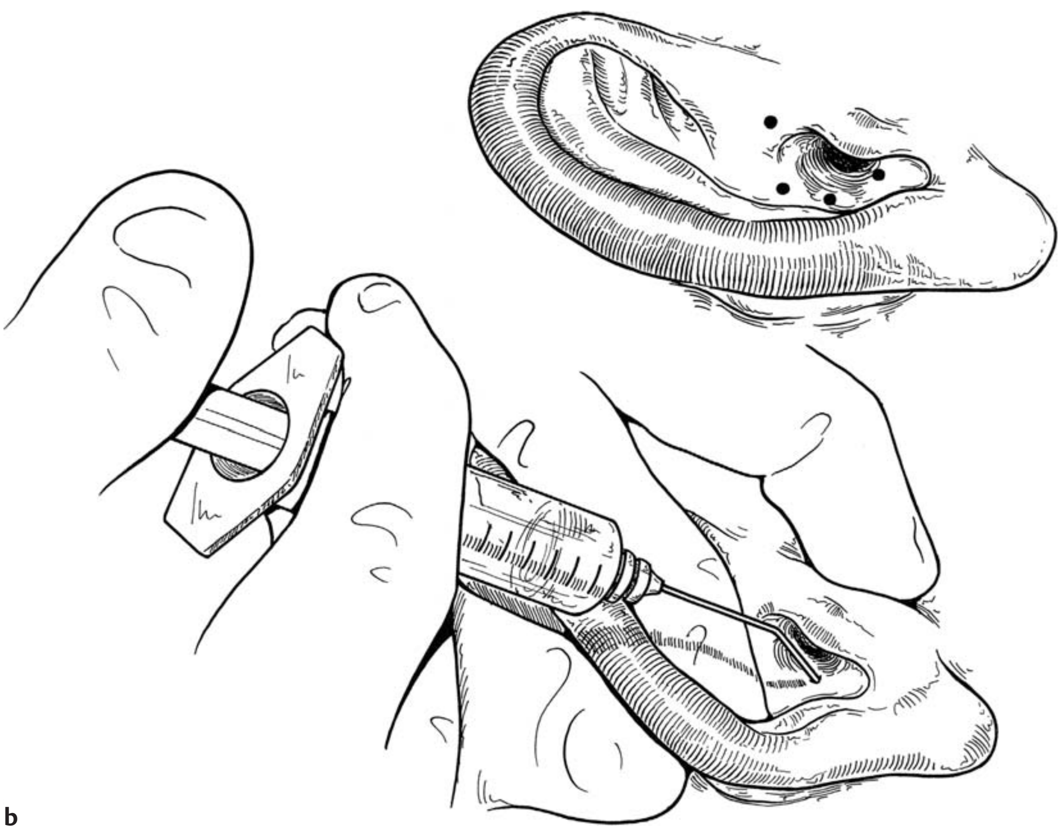
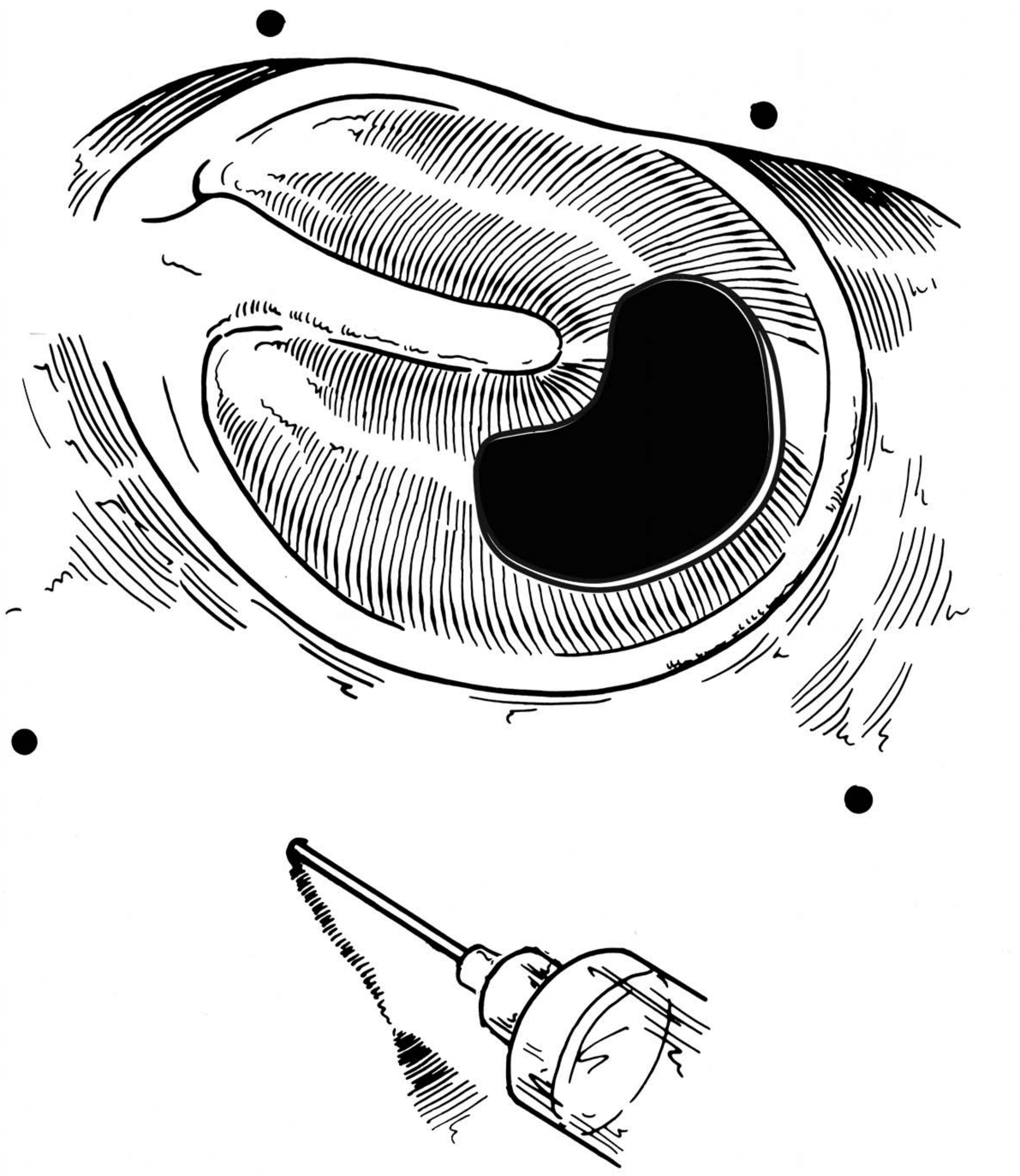


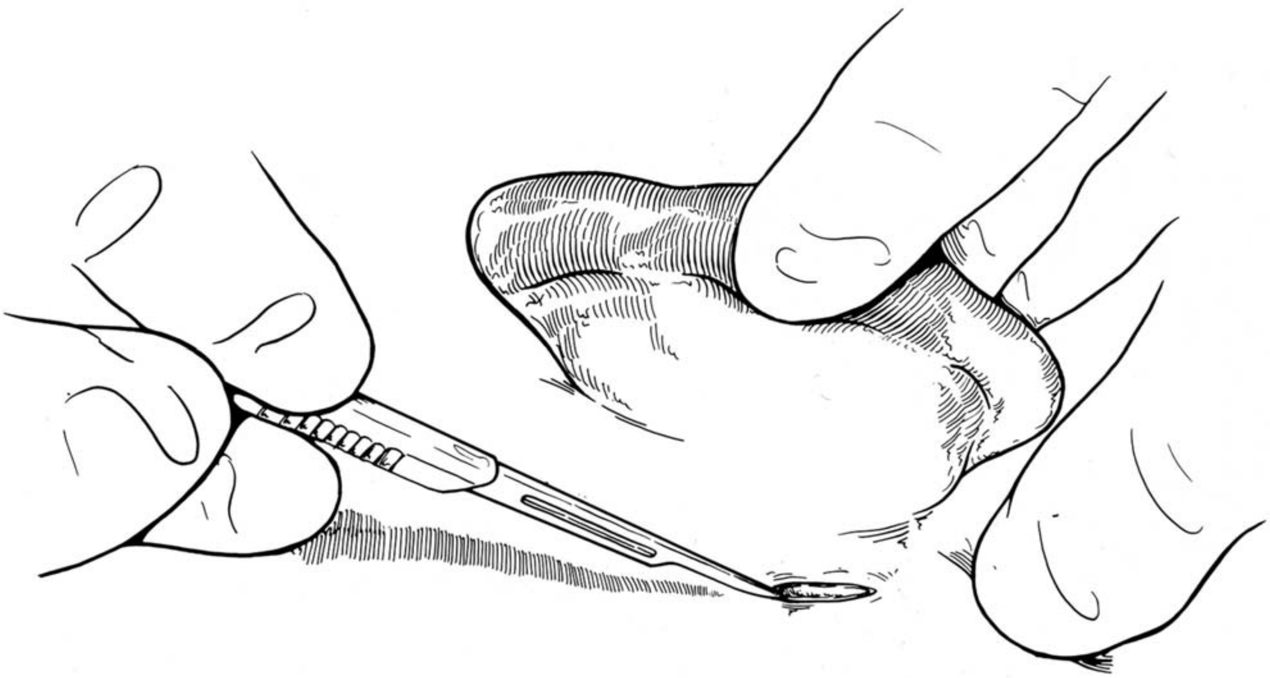
b

Fig. 3.2a,b



c

Fig. 3.2c



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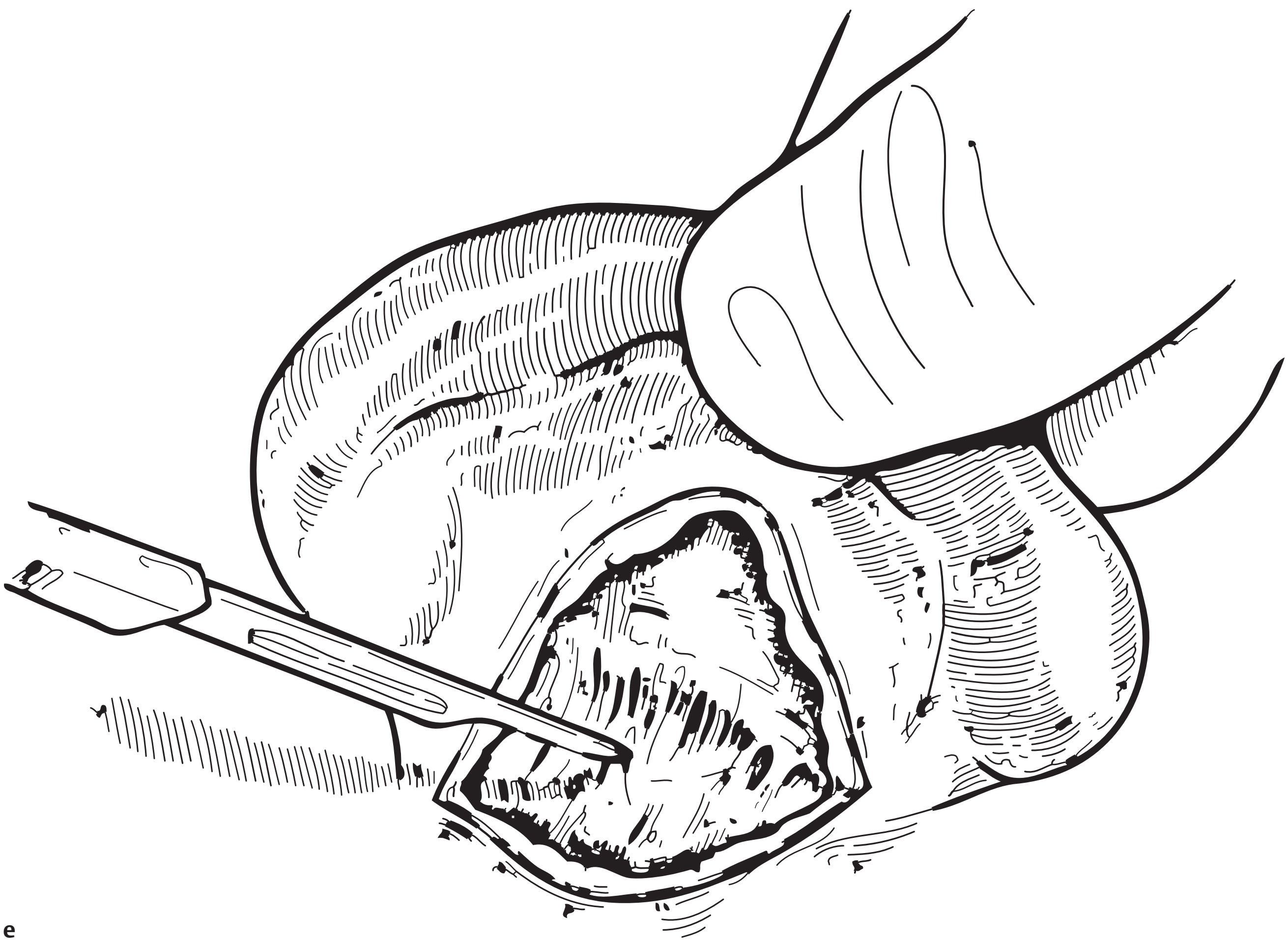

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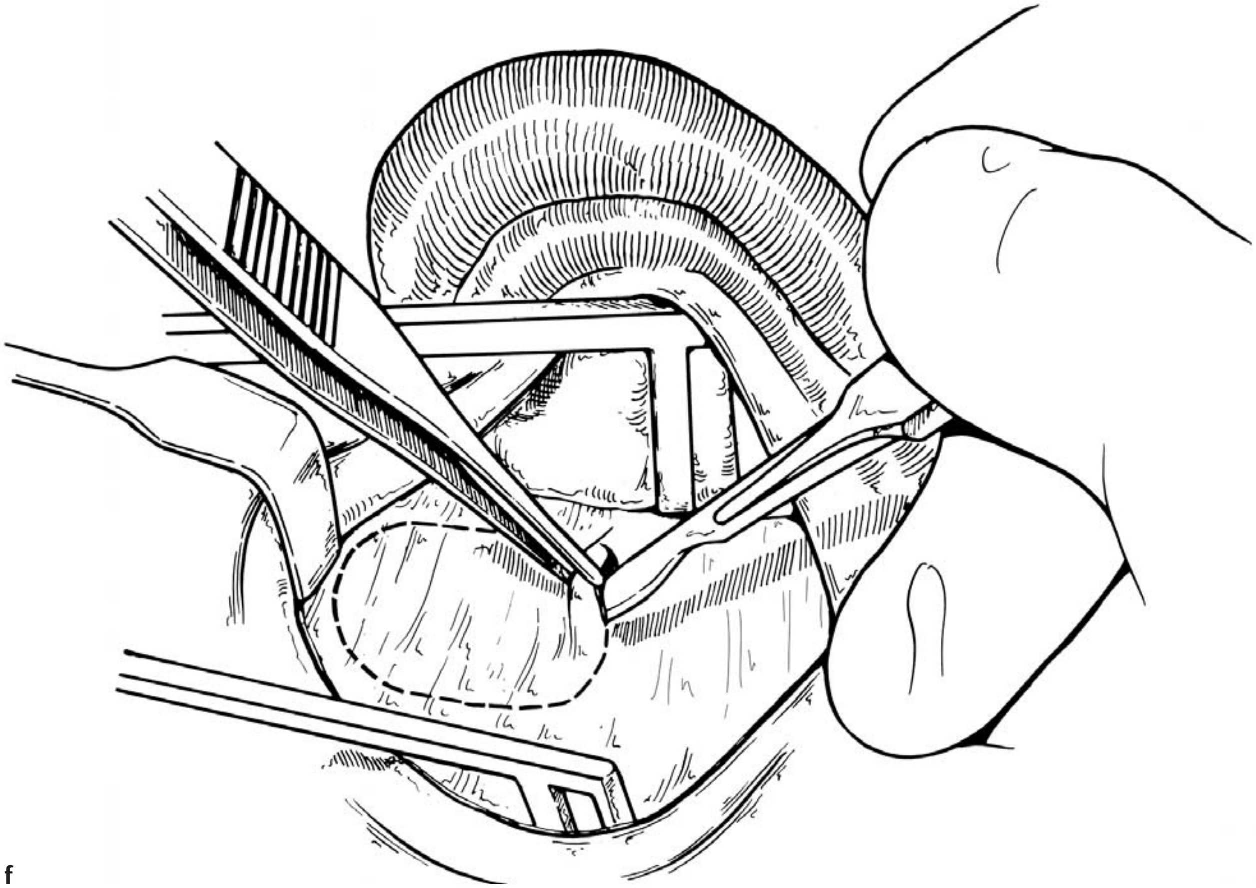
Fig. 3.2d,e



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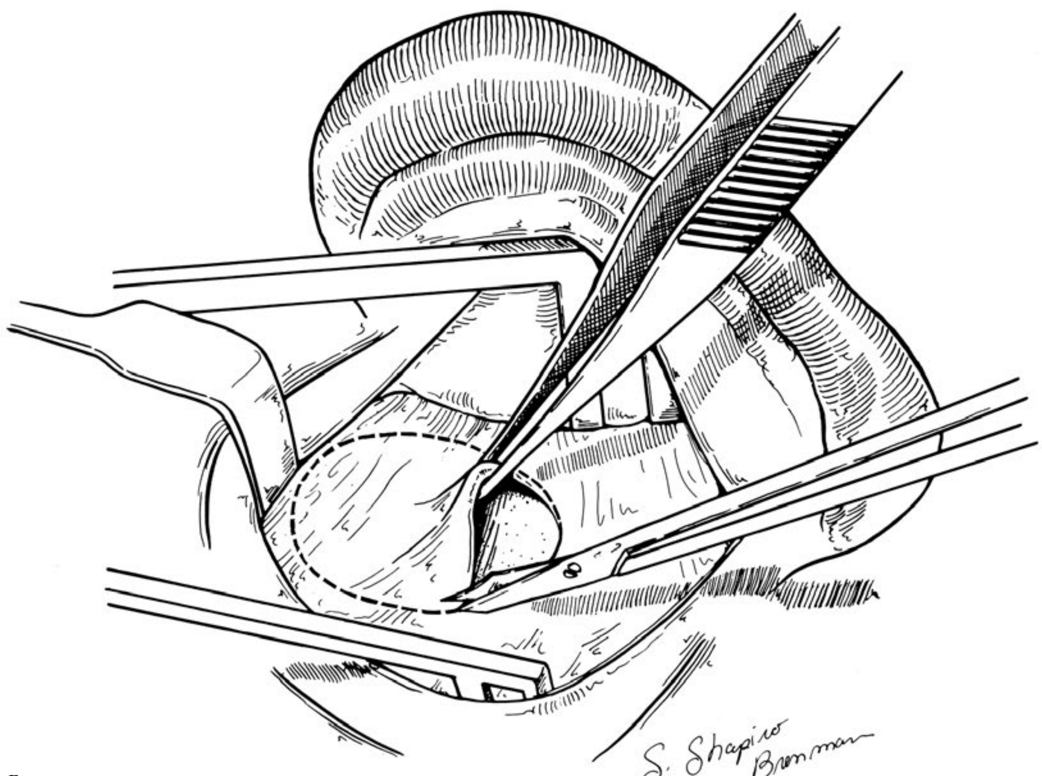
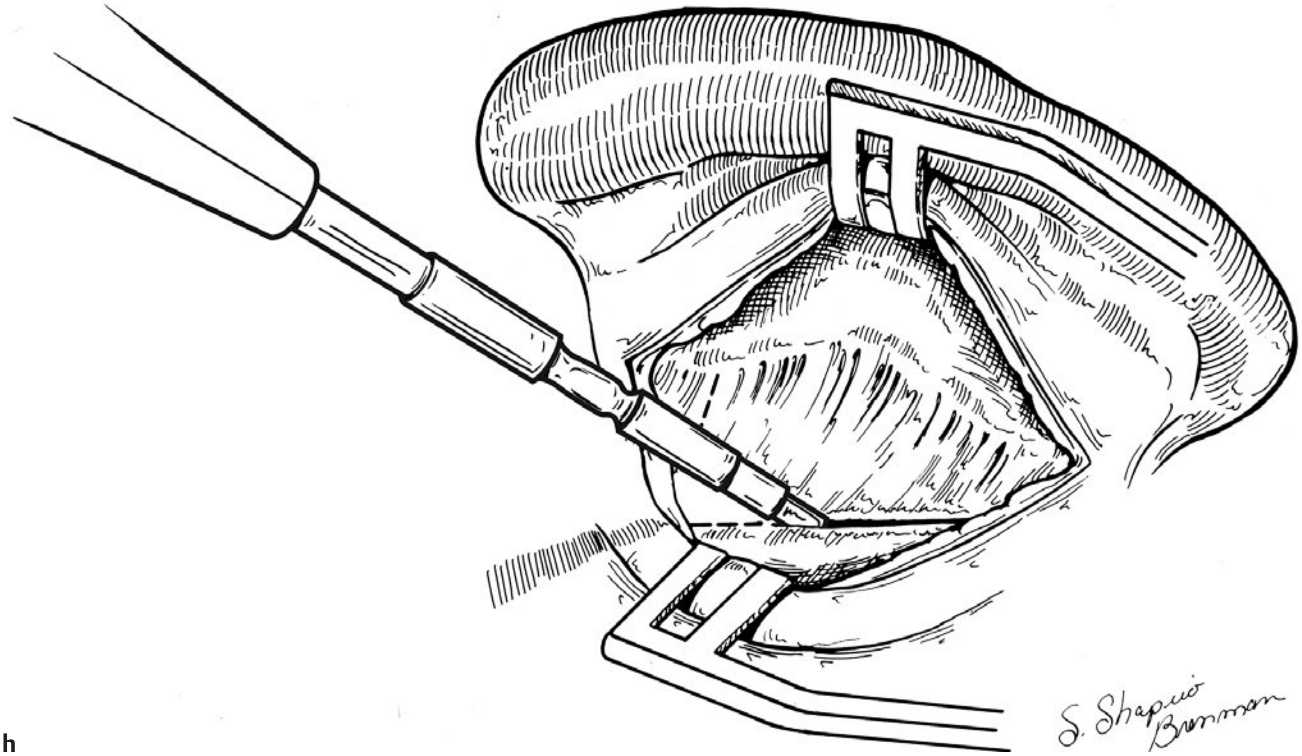


g

Fig. 3.2f,g



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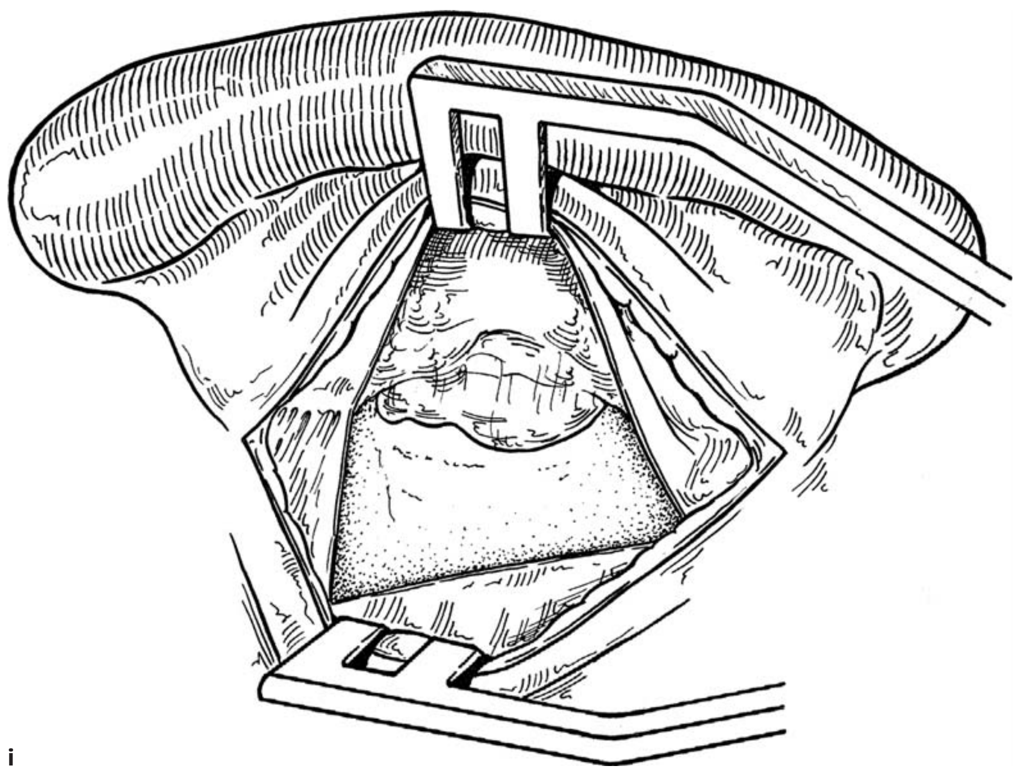

i

Fig. 3.2h,i

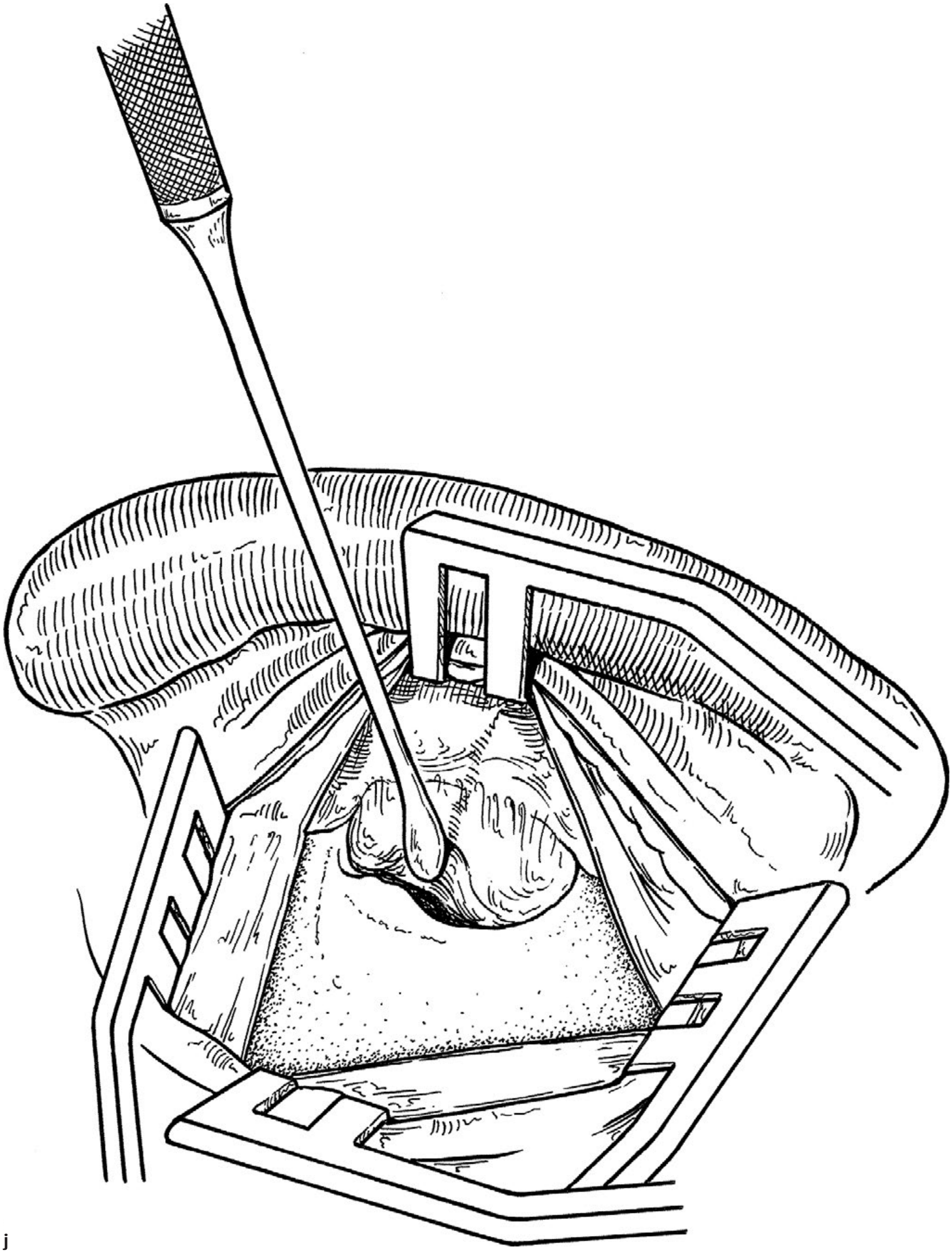

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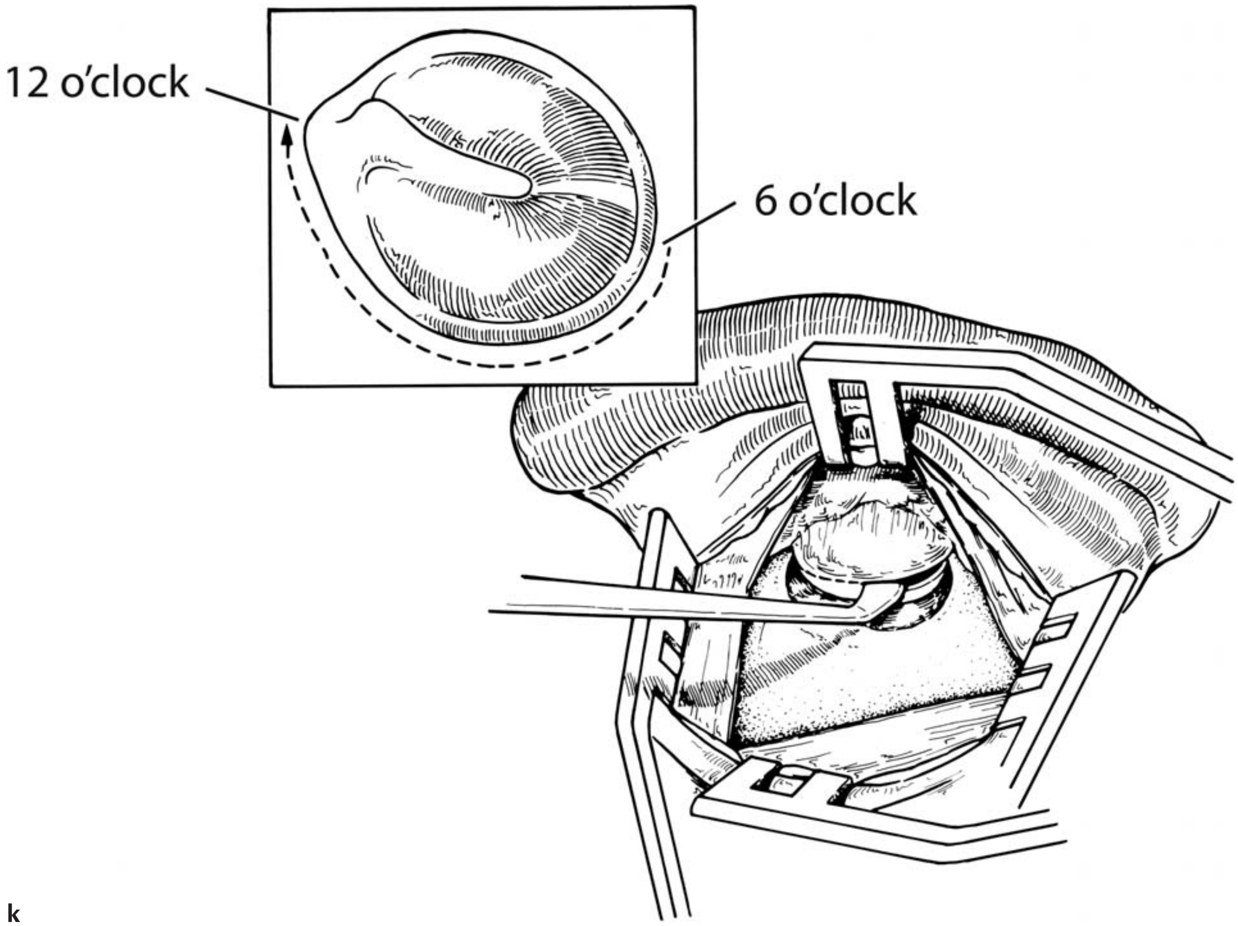
Fig. 3.2j



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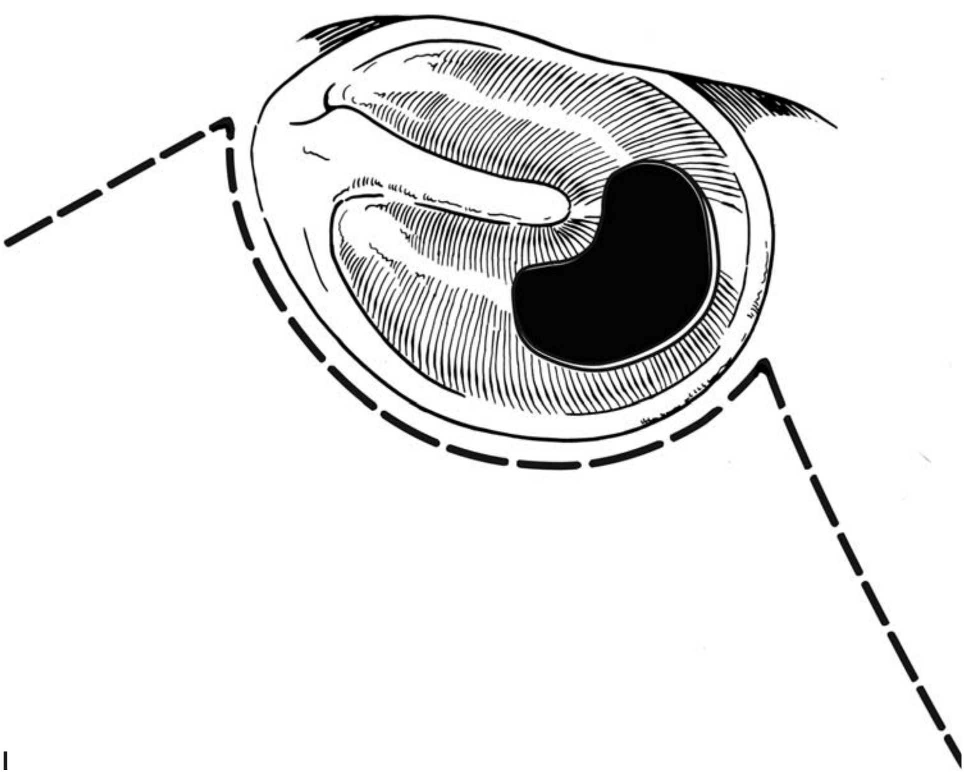
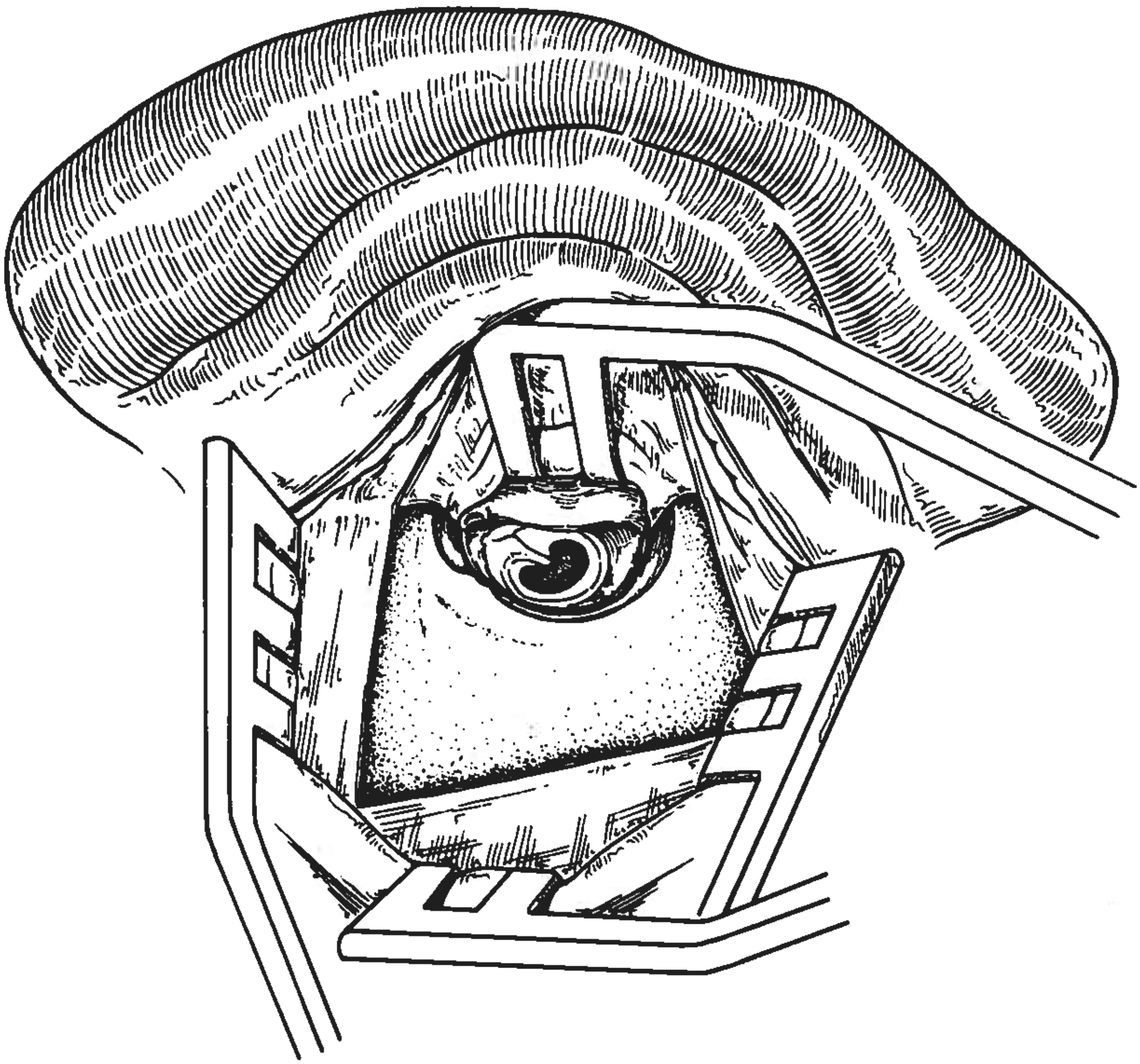


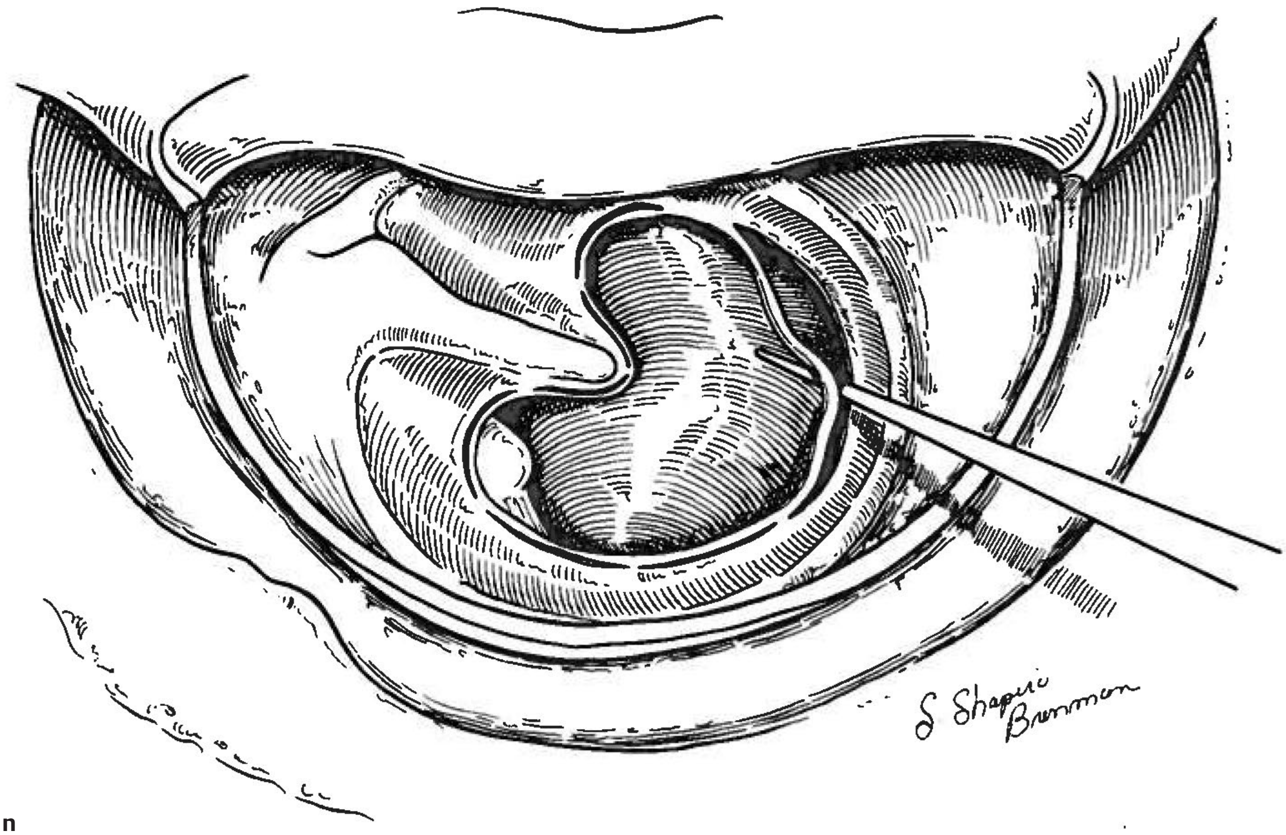
l

Fig. 3.2k,l



m

Fig. 3.2m



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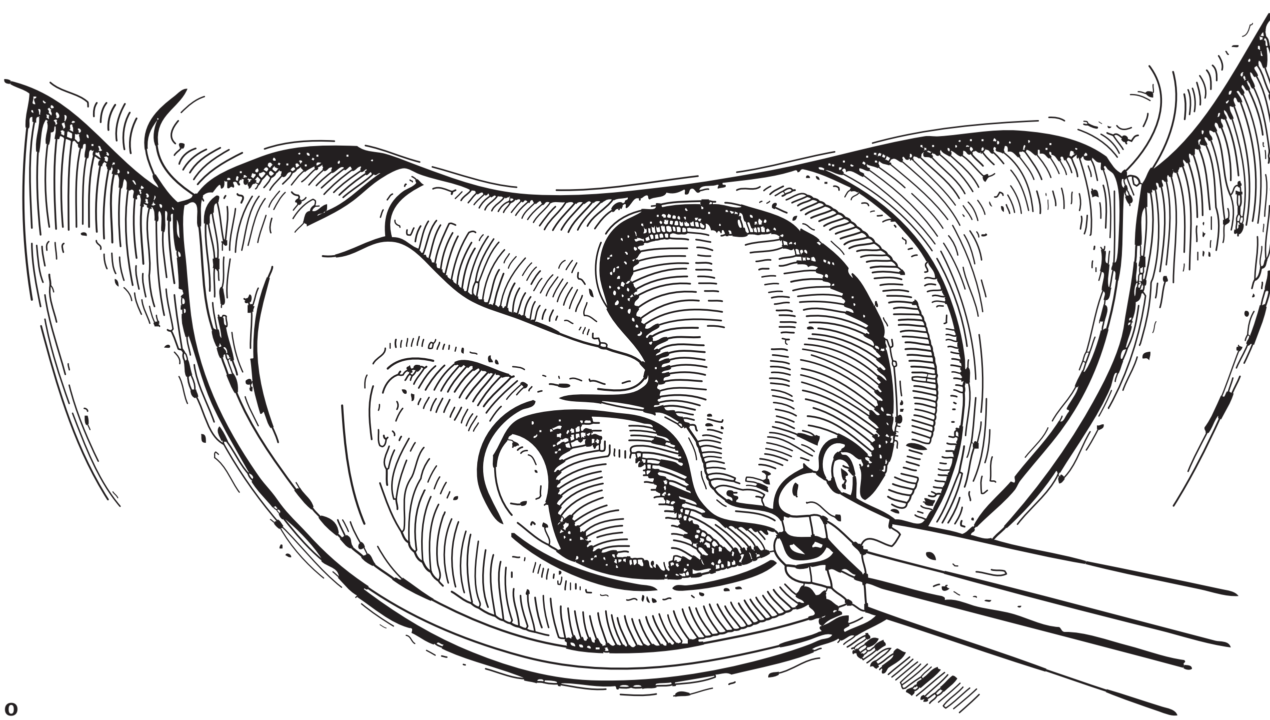
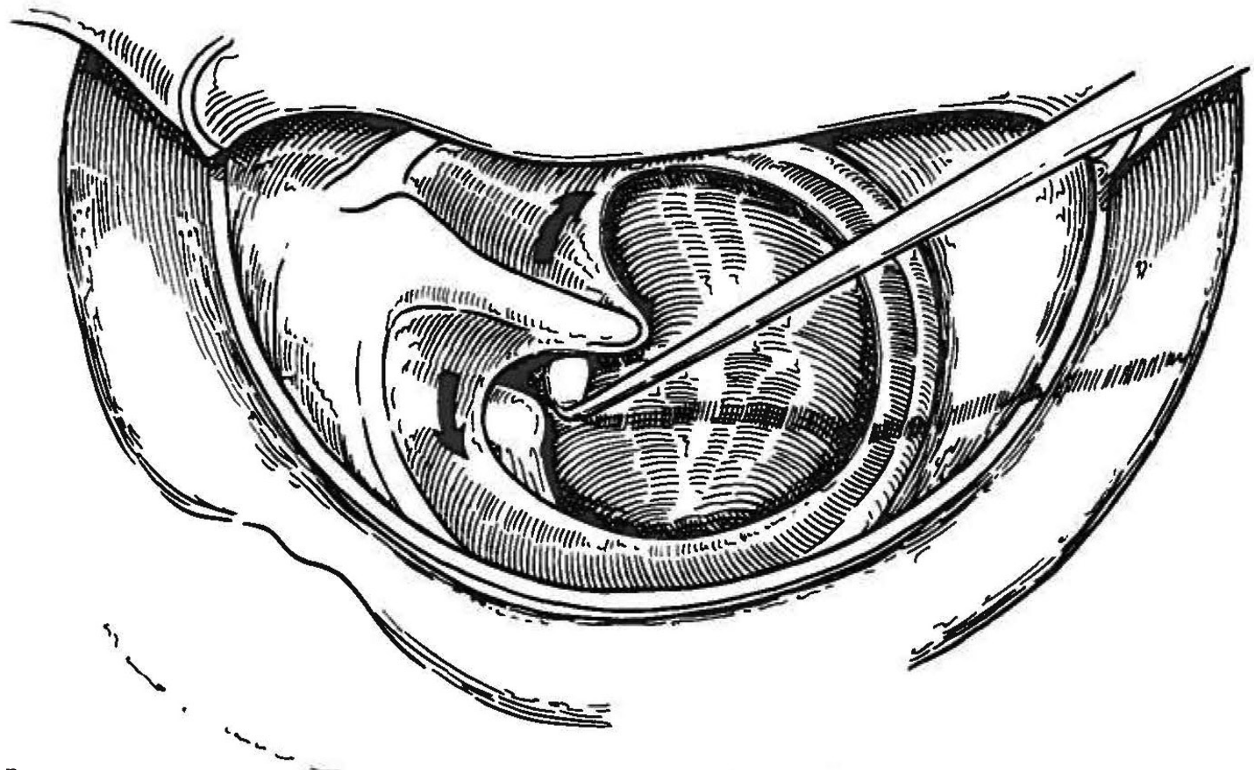


o

Fig. 3.2n,o



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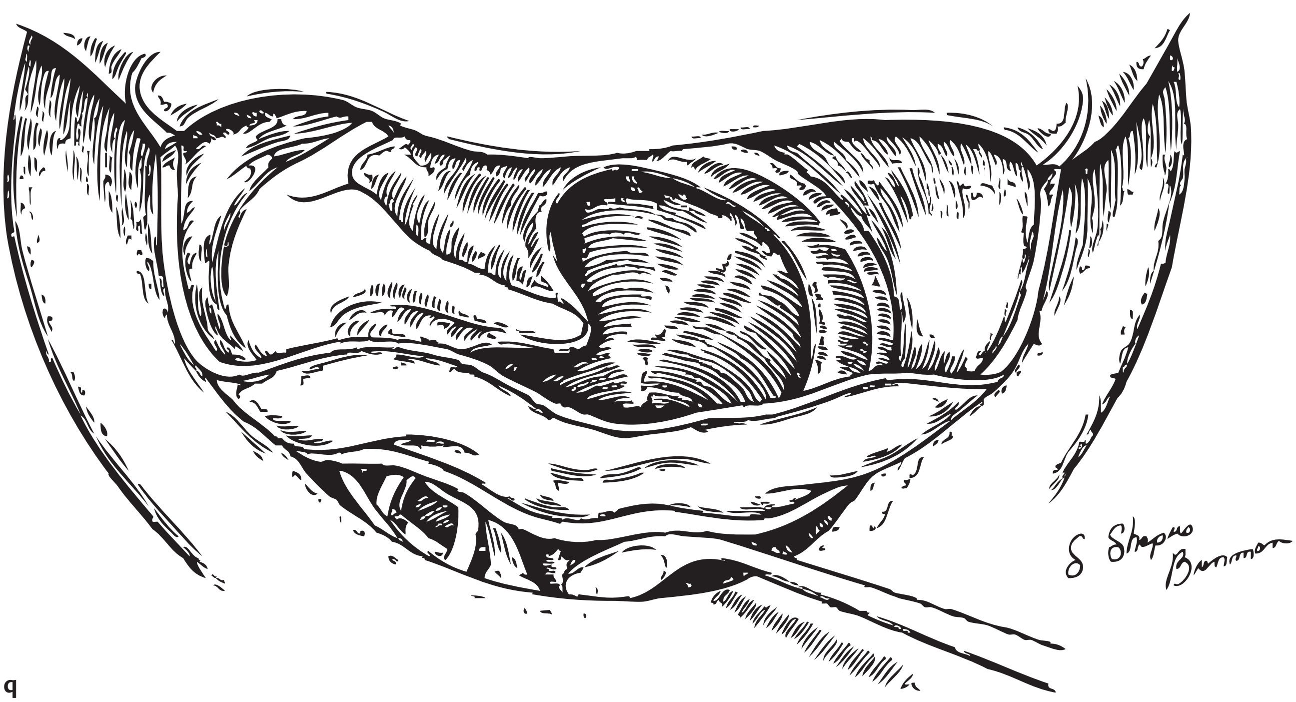
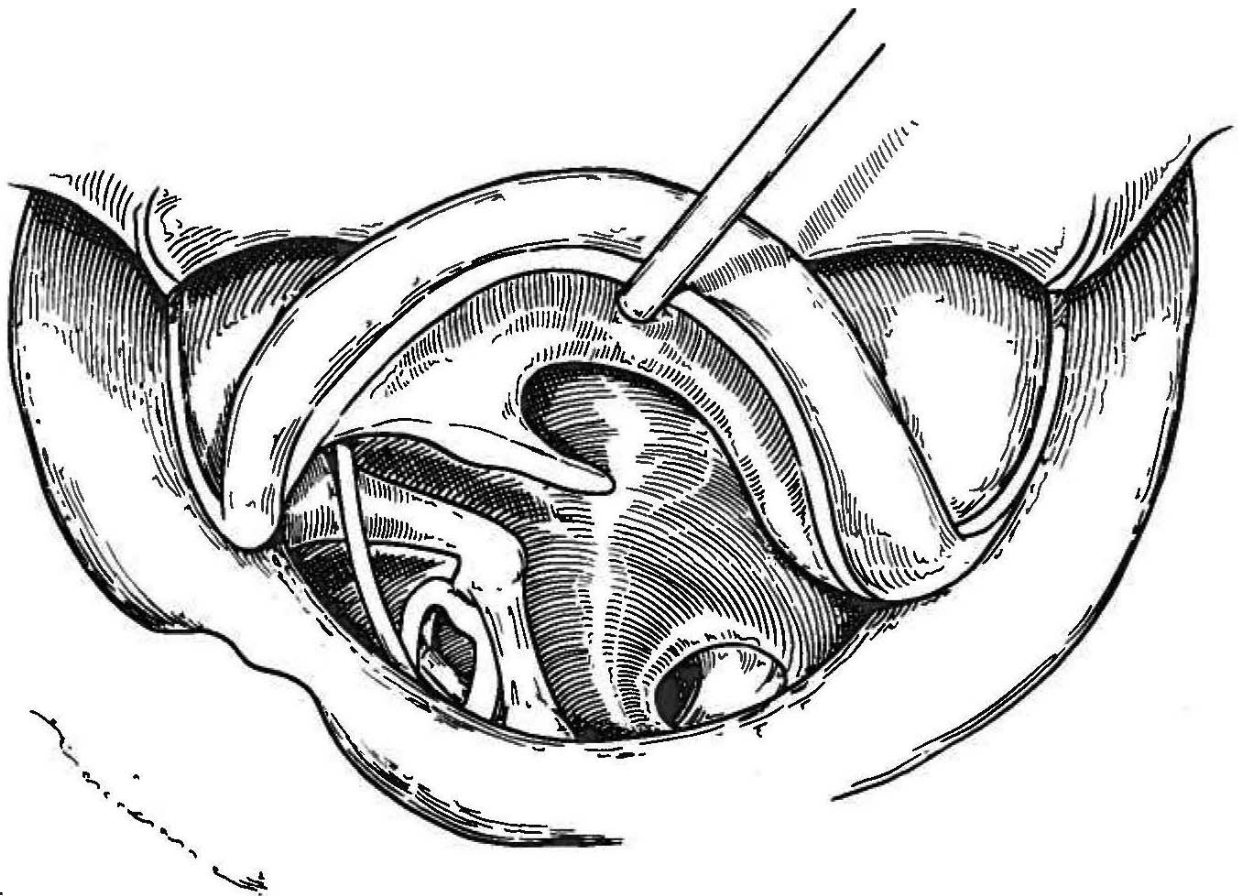


q

Fig. 3.2p,q



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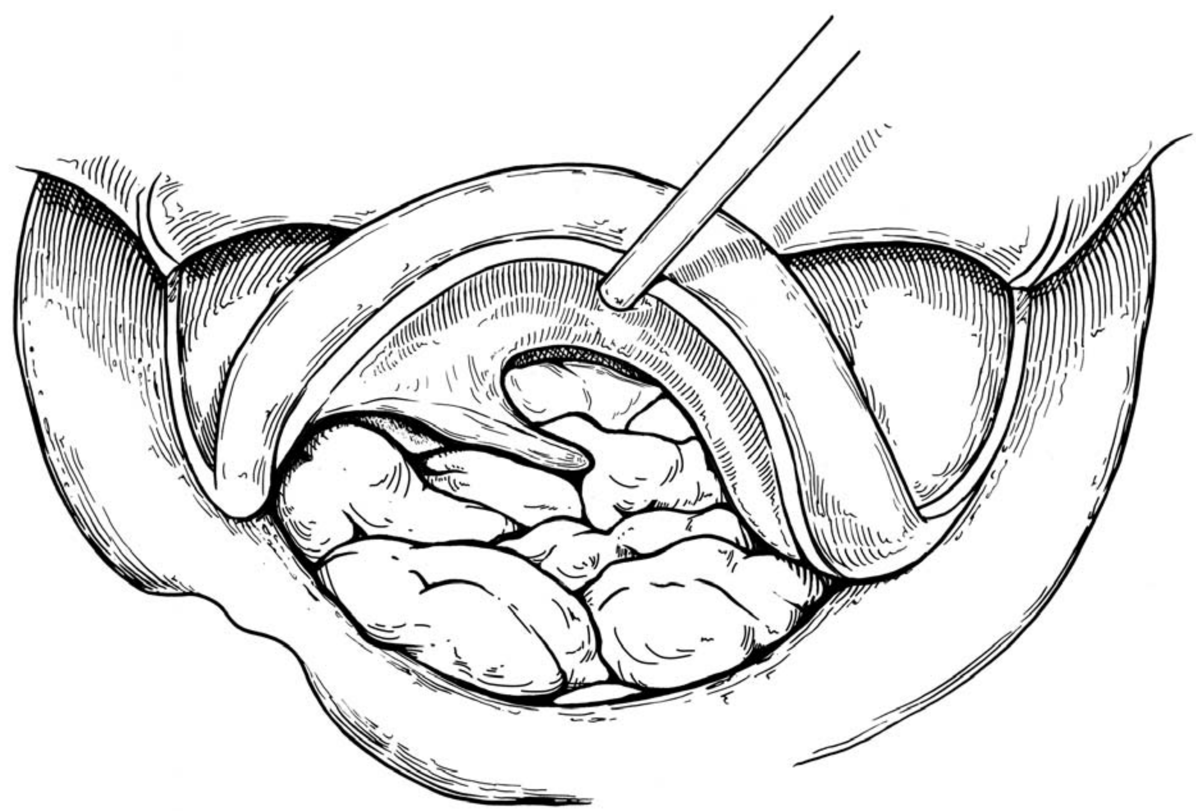
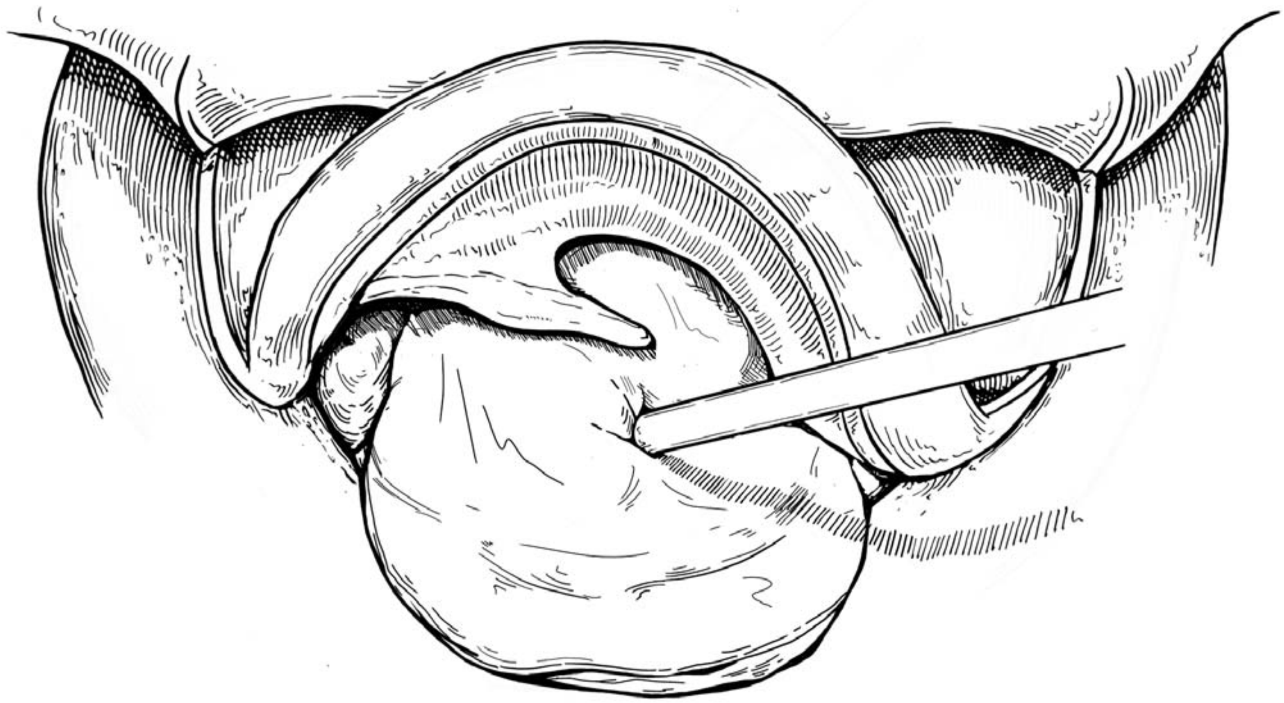


s

Fig. 3.2r,s



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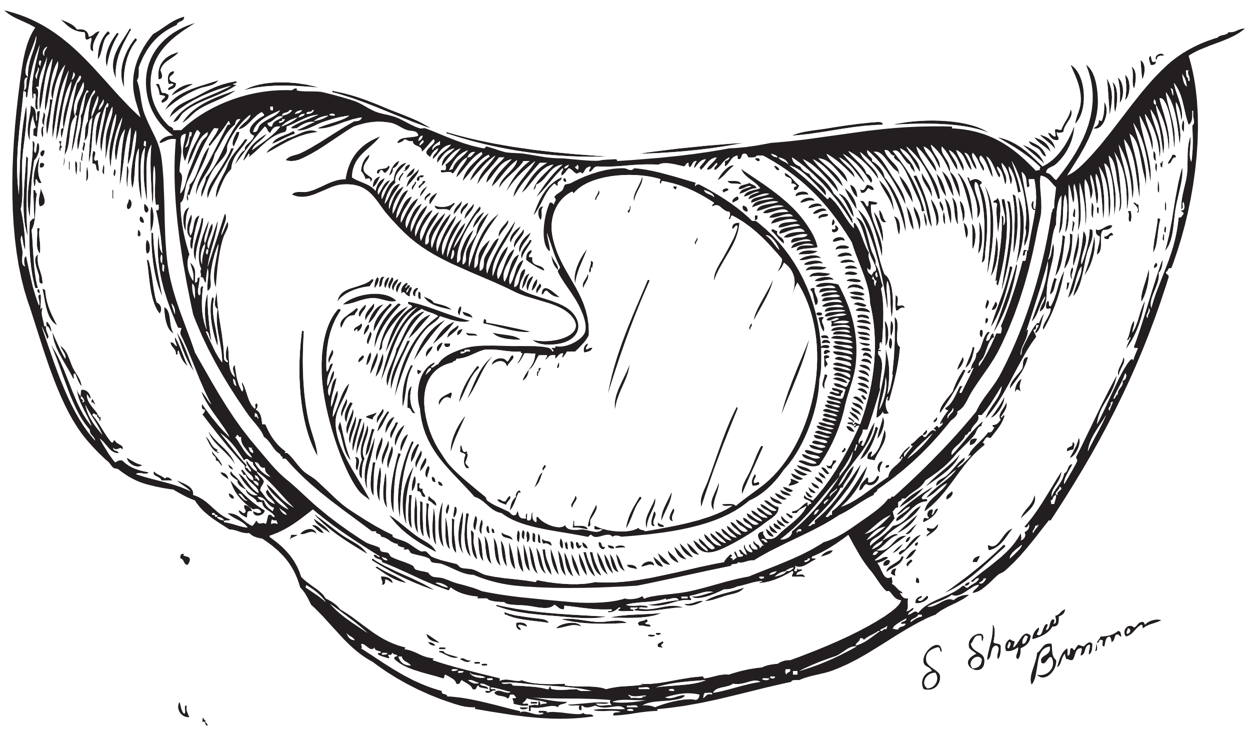
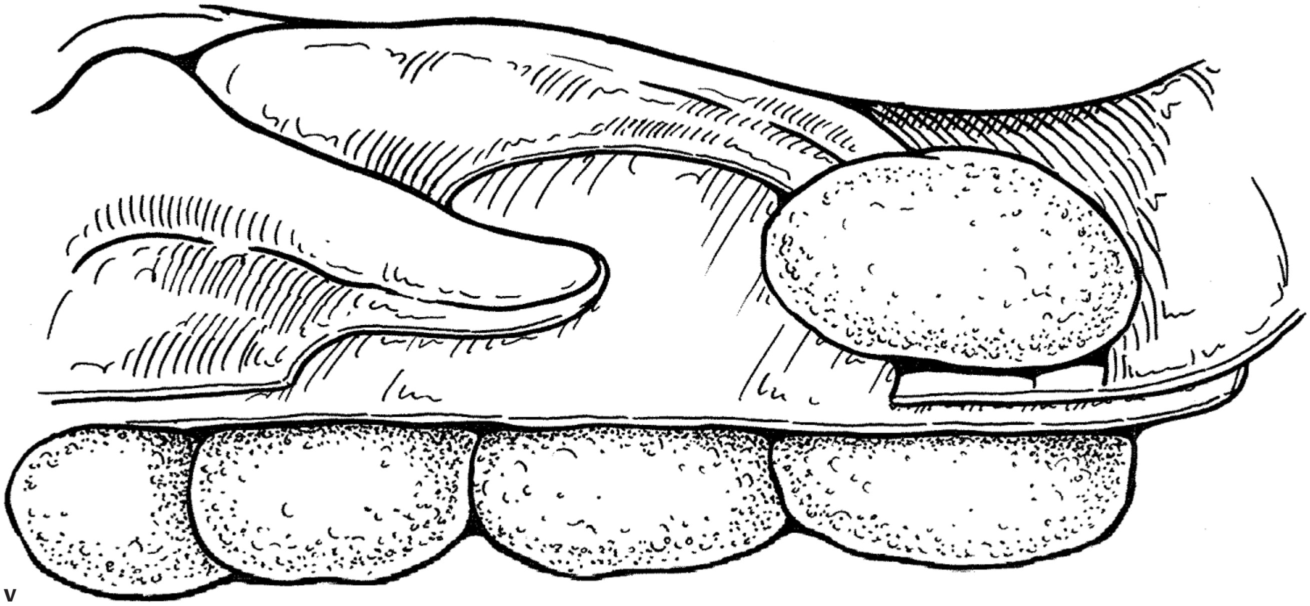


u

Fig. 3.2t,u



v

w

Fig. 3.2v,w

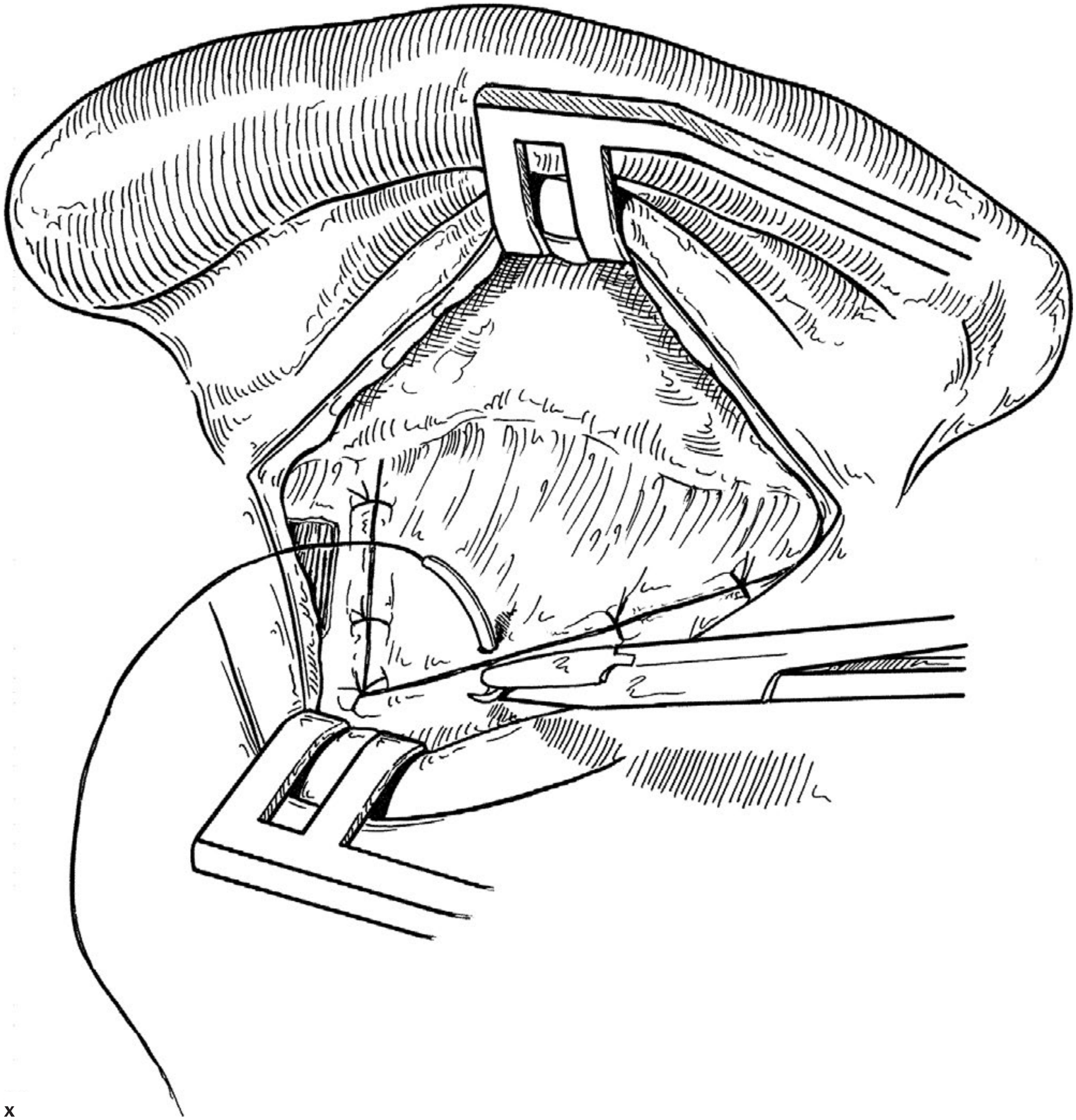

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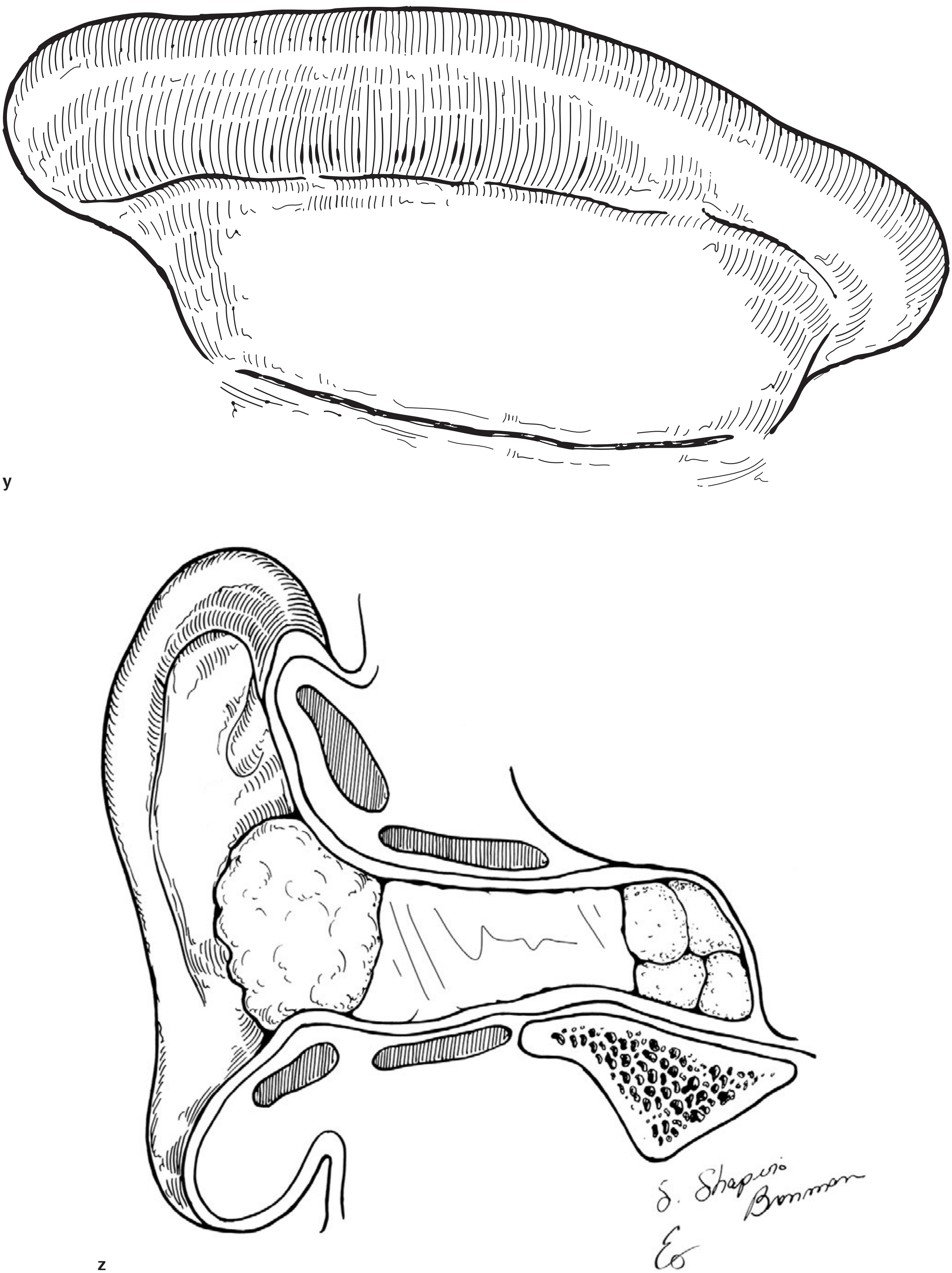
Fig. 3.2x



y

z

Fig. 3.2y,z

3-3 Ossicular Reconstruction

Introduction

The goal in ossicular reconstruction (OCR) is to restore the middle ear conductive machinery in order to improve hearing. Innumerable variations on the surgical techniques have been reported in the literature. Attention is often focused on the types of materials used for reconstruction of the middle ear ossicles and the technical aspects of inserting these prostheses. However, proper timing, complete eradication of underlying disease, and consideration of a patient's residual anatomy are just some of the critical factors that determine successful hearing outcomes following OCR. In addition to comprehensive audiologic testing, high-resolution computed tomography (CT) is helpful in delineating the pathology as well as surgical planning and counseling.

Indications

OCR is indicated in patients with conductive hearing losses due to defects of the malleus, incus, and/or stapes.

It is common (and prudent) practice to counsel patients with conductive losses that hearing aid amplification is a very safe and effective option that does not rule out the option of OCR at a later time.

Operative Technique

1. As described in the preceding sections, the middle ear space is widely exposed by meticulously elevating canal tympanomeatal flaps and drilling or curetting scutum or ear canal bone in order to improve visualization of the ossicles or the oval window niche (**Fig. 3.3a,b**).
2. If possible, the chorda tympani nerve is preserved, not only for taste function, but also for use in stabilizing the ossicular replacement prosthesis in some cases.
3. The incus is particularly vulnerable to damage from cholesteatomas, retraction pocket erosion, or even traumatic disruption. When the incus is partially eroded or damaged (**Fig. 3.3c**), the surgeon must determine if the residual incus is sufficient to leave in situ and to reconstruct using that remnant (e.g., an incus–stapes prosthesis or a hydroxyapatite cement) or if the residual incus is insufficient to rebuild upon and therefore requires removal of any incus remnant. Removal can be accomplished by separating the incus from the malleus using a pick or micro-Tabb knife. The remnant is grasped with an alligator forceps and gently removed (**Fig. 3.3d**). In this scenario, a malleus–incus prosthesis or partial ossicular replacement prosthesis (PORP) is used. Some of the reconstructive options include reshaping the incus remnant and interposing the remodeled incus to sit on the capitulum of the stapes with a long process that is then positioned under the manubrium of the malleus (**Fig. 3.3e**).

   Alternatively, the incus can be completely removed and a titanium or other synthetic prosthesis used to connect the stapes superstructure to the TM or from stapes to malleus and TM (**Fig. 3.3f**).

   In scenarios where the PORP is brought directly to the undersurface of the TM, the chorda tympani nerve can sometimes be used to stabilize the prosthesis by draping it over the top of the prosthesis or sometimes allowing the chorda to prevent the PORP from falling over (either inferior or superiorly, depending on how much the chorda can be mobilized in relation to the ossicular chain reconstruction).
4. For most synthetic (i.e., nonautologous) OCR prostheses, a cartilaginous "cap" is used in order to reduce the risks of the prosthesis extruding through the TM. Tragal cartilage is the most common site for harvesting such cartilage grafts. In a patient with poor eustachian tube function and a tendency to retract the TM, this is a particularly important step in OCR (**Fig. 3.3f**).
5. In instances where the stapes superstructure is compromised (e.g., eroded), it is necessary to use a total ossicular replacement prosthesis (TORP). In this case, the prosthesis is seated on the footplate of the stapes and brought up to the level of the malleus and TM (**Fig. 3.3g**). Again, a variety of techniques and prosthesis material have been proposed as being superior or preferable. Surgeon familiarity with the techniques likely outweighs the impact of specific differences in the materials or design of the prosthesis. However, as a general concept, most surgeons have migrated toward titanium or titanium-hydroxyapatite hybrid devices that seem to yield fairly consistent hearing outcomes in a variety of hands. One notable advance has been development of a two-part TORP that includes a "shoe" that is placed directly on the footplate and provides a stable position for the "foot" of the prosthesis. This design reduces the sliding and displacement of the TORP off the footplate, which is likely a common cause for some of the poor hearing results observed after ossicular reconstruction with TORPs.
6. Finally, it is requisite to emphasize the importance of attention to detail in order to obtain good hearing outcomes with OCR. Inadequate canalplasty, for example, hinders exposure and placement of the prosthesis and also increases the likelihood of the PORP or TORP contacting the ear canal and causing a persistent conductive hearing loss. Similarly, even subtle errors in trimming the length of the prosthesis or in positioning the PORP or TORP can result in the prosthesis extruding or falling over or not making adequate contact with

the remaining ossicular components—all of which would then result in poor hearing outcomes.

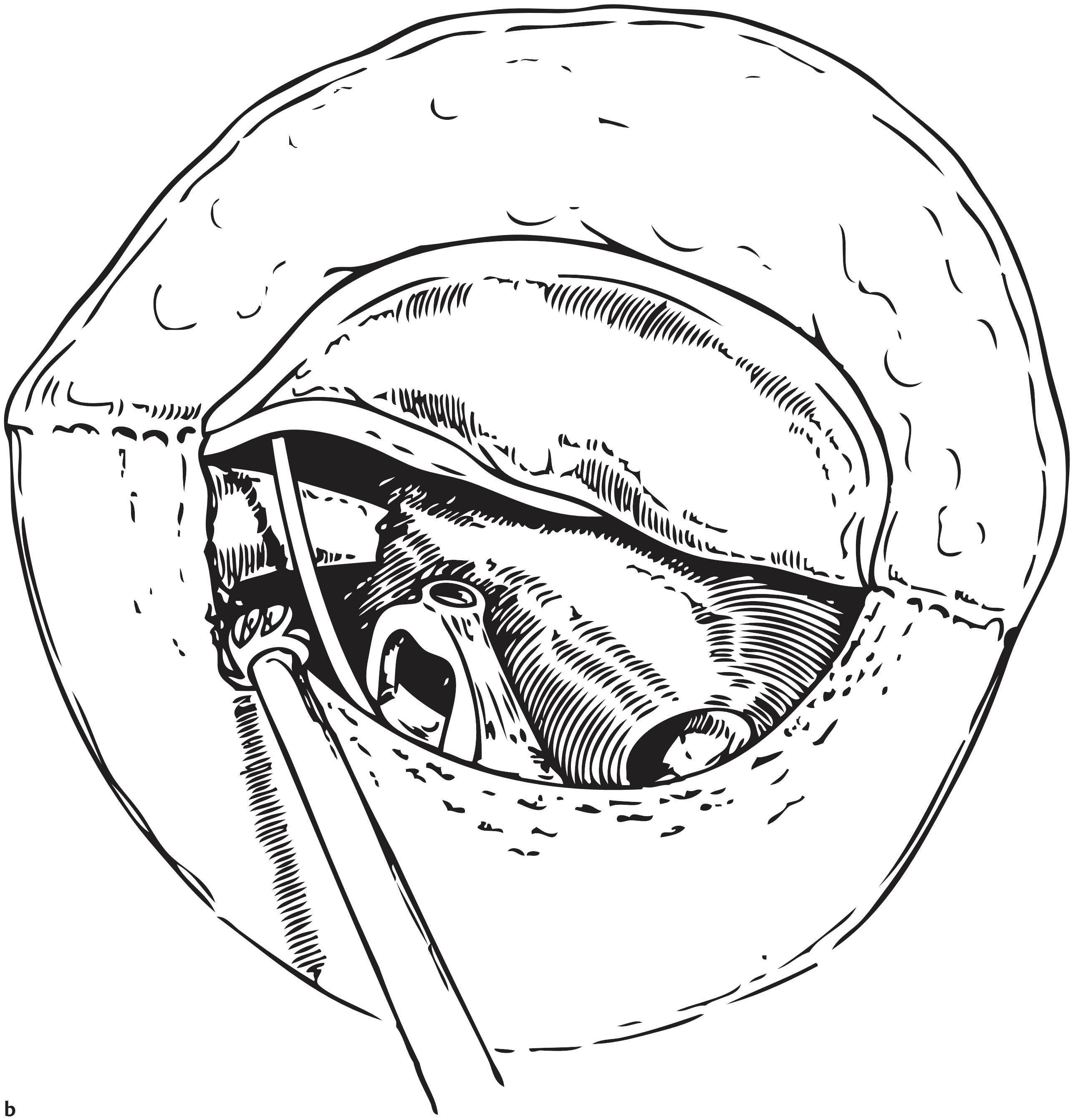
7. After satisfactorily placing the prosthesis (with or without a cartilage cap), the middle ear space is packed with Gelfoam and a ciprofloxacin-dexamethasone solution in order to completely surround and support the PORP or TORP. The tympanomeatal flap is then re-laid into its normal position on top of the reconstructed ossicular chain and also packed in place using the same saturated Gelfoam (refer to **Fig. 3.2z**).

Complications

1. Tympanic membrane perforation
2. Persistent conductive hearing loss
3. Vertigo
4. Facial nerve injury
5. Chorda tympani nerve injury and dysgeusia
6. Prosthesis displacement or extrusion

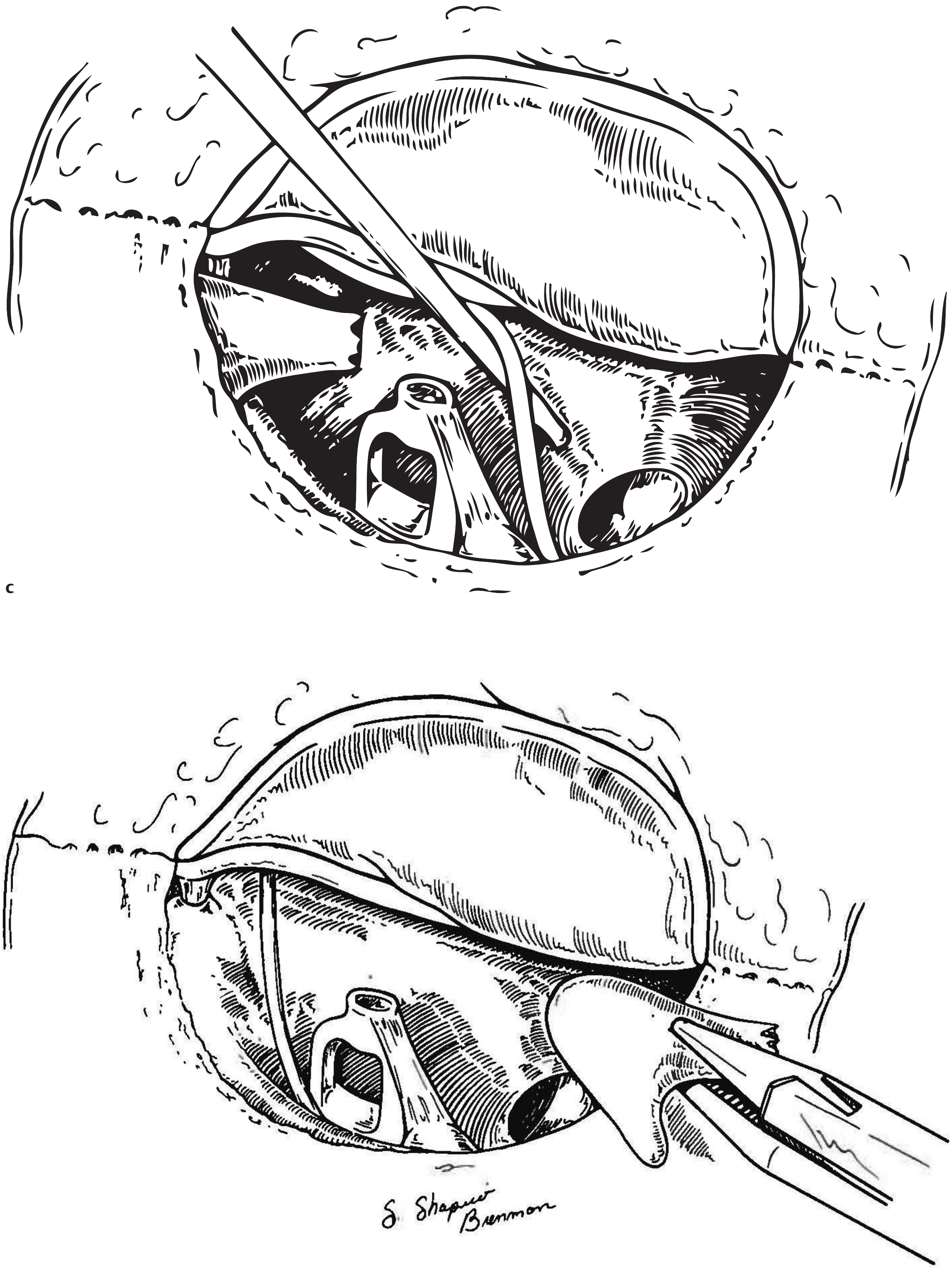
a

Fig. 3.3a



b

Fig. 3.3b



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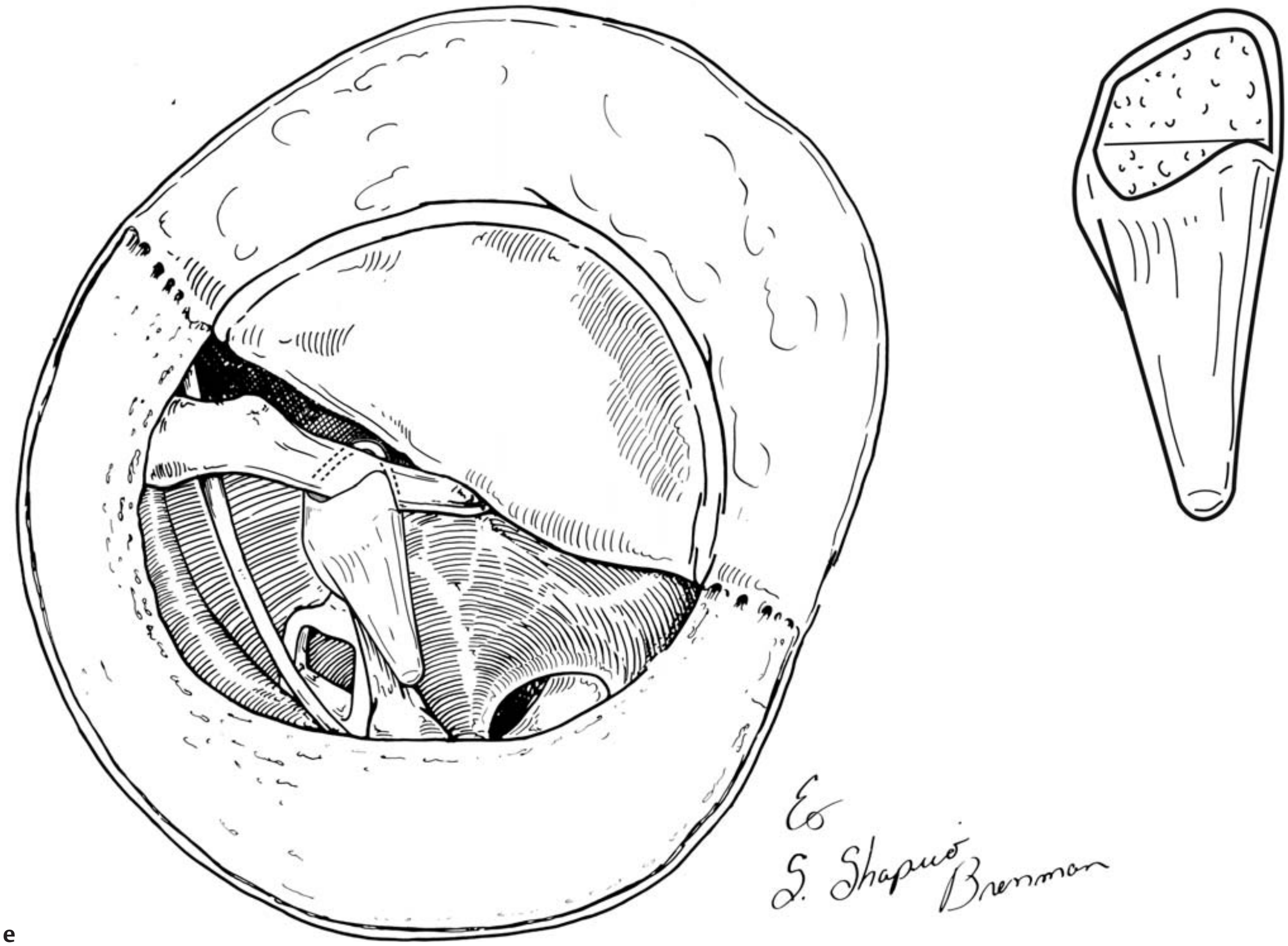
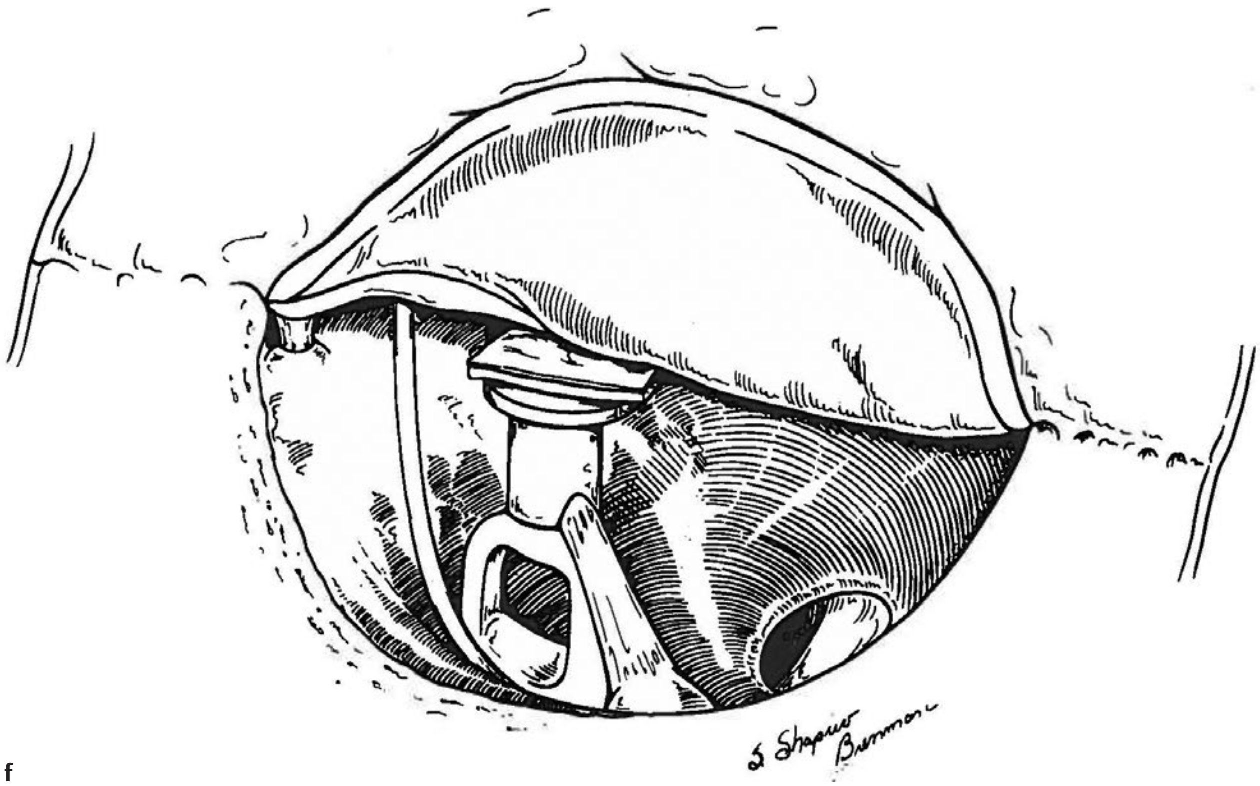
d

Fig. 3.3c,d



e

Fig. 3.3e



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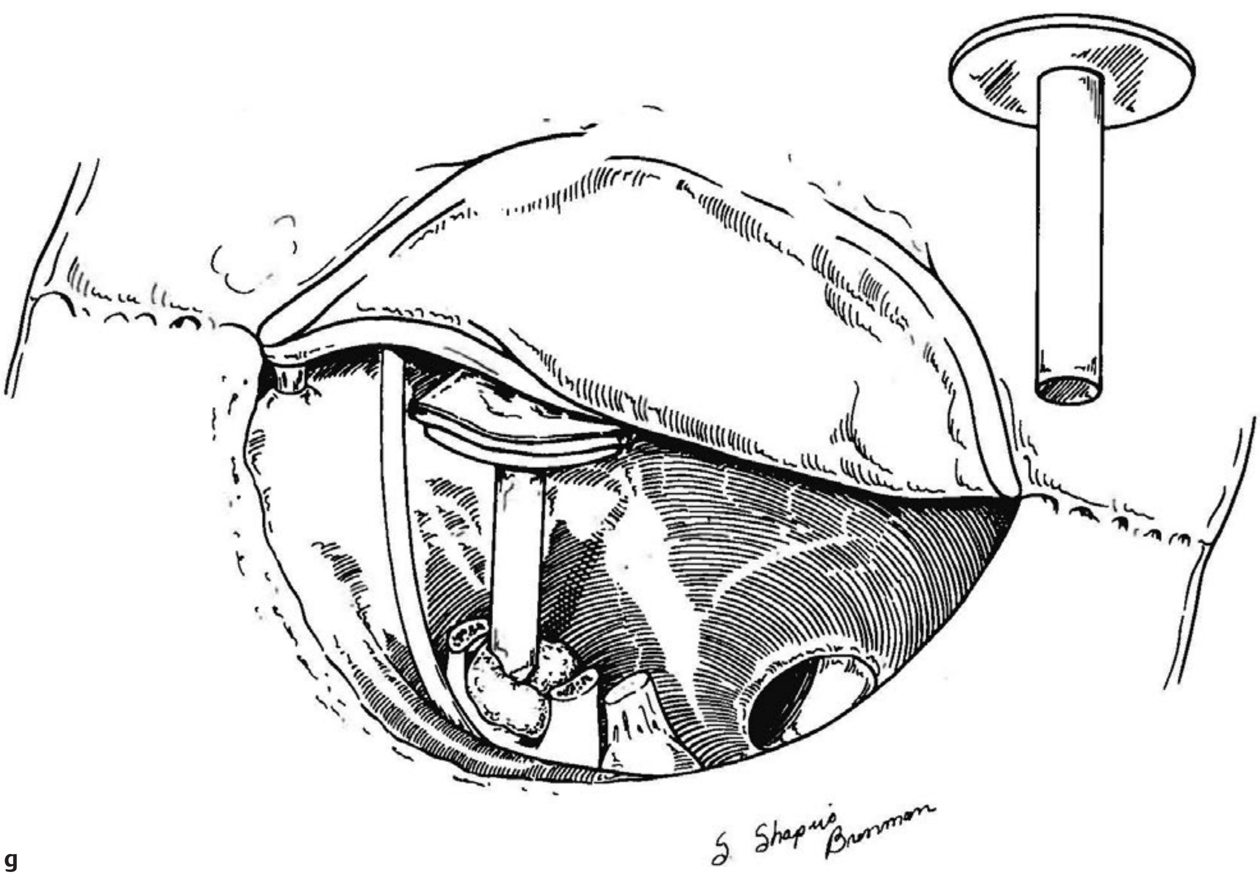


g

Fig. 3.3f,g

3-4 Cortical (Simple) Mastoidectomy

Introduction

The primary purposes of a cortical mastoidectomy are to provide drainage of an acute infection, remove chronic inflamed and infected disease within the mastoid air cell system, remove cholesteatoma, and improve aeration of the middle ear–mastoid air cells as a whole.

Indications

Cortical mastoidectomy is performed acutely in the setting of coalescent mastoiditis (particularly if refractory to conservative measures such as placement of a tympanostomy tube and parenteral antibiotics).

Chronic ear disease with cholesteatoma or chronic suppurative disease involving the mastoid are also clear indications for cortical mastoidectomy.

Chronic otomastoiditis complicated by facial nerve paresis/paralysis, extratemporal abscess formation, sigmoid sinus thrombophlebitis, or meningitis is also an indication for mastoidectomy.

Preoperative Evaluation

After routine history and physical examination, a careful microscopic exam of the ear is requisite. Many, if not most, cases requiring mastoidectomy will have otorrhea or other otologic findings that mandate suctioning and recognition of subtle findings (e.g., retraction pocket formation, squamous debris, granulation tissue, or bony erosions) that might not be readily discernible with a handheld otoscope.

CT scanning also remains a routine component in preoperative assessment of patients being considered for mastoidectomy. Such imaging studies are invaluable in demonstrating coalescence of air cells, erosions of the tegmen or the bony sigmoid covering, as well as thrombosis of the sigmoid or epidural abscess formation—particularly when performed with intravenous contrast.

Whenever possible, routine audiologic testing is performed for all patients prior to mastoidectomy (or any otologic surgery in general). Identification of sensorineural hearing loss, in addition to the expected conductive hearing loss, should alert the surgeon to the possibility of inner ear/labyrinthine complications from the ear disease.

Operative Technique

1. After induction of general anesthesia and an orotracheal intubation, the patient's ear is prepped and draped after infiltrating the ear canal and postauricular crease with a 1% lidocaine solution with a 1:100,000 concentration of epinephrine (see Section 3-2).
2. A facial nerve monitor is routinely used for most otologic surgeries as an additional layer of patient safety to prevent iatrogenic facial nerve injury. Although the likelihood of requiring the facial nerve monitor on a simple mastoidectomy may be very small, the unpredictability of those rare instances makes routine use of the monitor prudent.
3. The same skin incision used for a routine tympanoplasty can be used for mastoidectomy and similar soft tissue techniques are used to harvest areolar temporalis fascia (**Fig. 3.4a**) (see Section 3-2). The fascia is conveniently harvested at this stage in case an unexpected defect is encountered and needs to be repaired (e.g., a lateral canal fistula or dural defect in the tegmen).
4. A large C-shaped Palva flap is incised in the mastoid periosteum and reflected anteriorly in order to expose the bulk of the mastoid bone. Self-retaining retractors are placed to allow easy access to the mastoid tip, the posterior aspect of the ear canal, the bone overlying the sigmoid sinus, as well as the sinodural angle (**Fig. 3.4b,c**).
5. The dense cortical bone is removed using a large cutting bur and copious irrigation to clear away the bone dust. Drilling typically commences in the triangular area posterior to the spine of Henle (fossa mastoidea), with long strokes running parallel to the temporal line. Care should be taken to create smooth edges (saucerization) at the margins of the mastoid cavity to maximize visualization and to avoid creating overhanging ledges that might trap disease (**Fig. 3.4d**).
6. Bone is removed in the roughly triangular area delineated by the middle fossa dura superiorly (approximately at the temporal line), the sigmoid sinus posteriorly, and the bony posterior ear canal anteriorly.
7. Diseased mucosa is removed with forceps and blunt tip dissectors as drilling proceeds (**Fig. 3.4e**).
8. Once the mastoid antrum is entered, the first landmark to be recognized is the prominence of the lateral (horizontal) semicircular canal. The lateral canal provides a consistent reference point for the position of the incudal fossa as well as the facial nerve in its vertical portion.
9. With the lateral canal as a landmark, careful drilling with smaller burs allows identification of the incus head and short process. With the patient's head turned away, sighting along a more anterior vector allows the incus to be seen before inadvertently drilling into this ossicle. Often the incus can be visualized in the irrigation solution prior to be directly seen (**Fig. 3.4f**).
10. At this point, a simple mastoidectomy has been mostly accomplished. Drilling down toward the mastoid tip, into retrosigmoid air cell tracts, and back into the sinodural angle is largely determined by the extent of the disease.
11. Depending on the disease, a penrose drain can be inserted into the mastoid cavity prior to closing and brought out

through the inferior aspect of the skin incision (**Fig. 3.4g**). Copious irrigation of the wound should be performed prior to closing as well to remove the usual bone dust and debris that collects after performing a mastoidectomy.

12. The soft tissue is closed in multiple layers using interrupted resorbable sutures at the Palva flap layer as well as the deep subcutaneous tissue layers. A running resorbable suture is used to reapproximate the skin edges, and a standard mastoid compression dressing is then applied (**Fig. 3.4h**).

Complications

1. Facial nerve injury
2. Labyrinthine injury (most commonly, fenestration of the lateral semicircular canal)
3. Dural laceration with cerebrospinal fluid leak
4. Sigmoid sinus laceration
5. Ossicular damage (most commonly incus drill trauma)

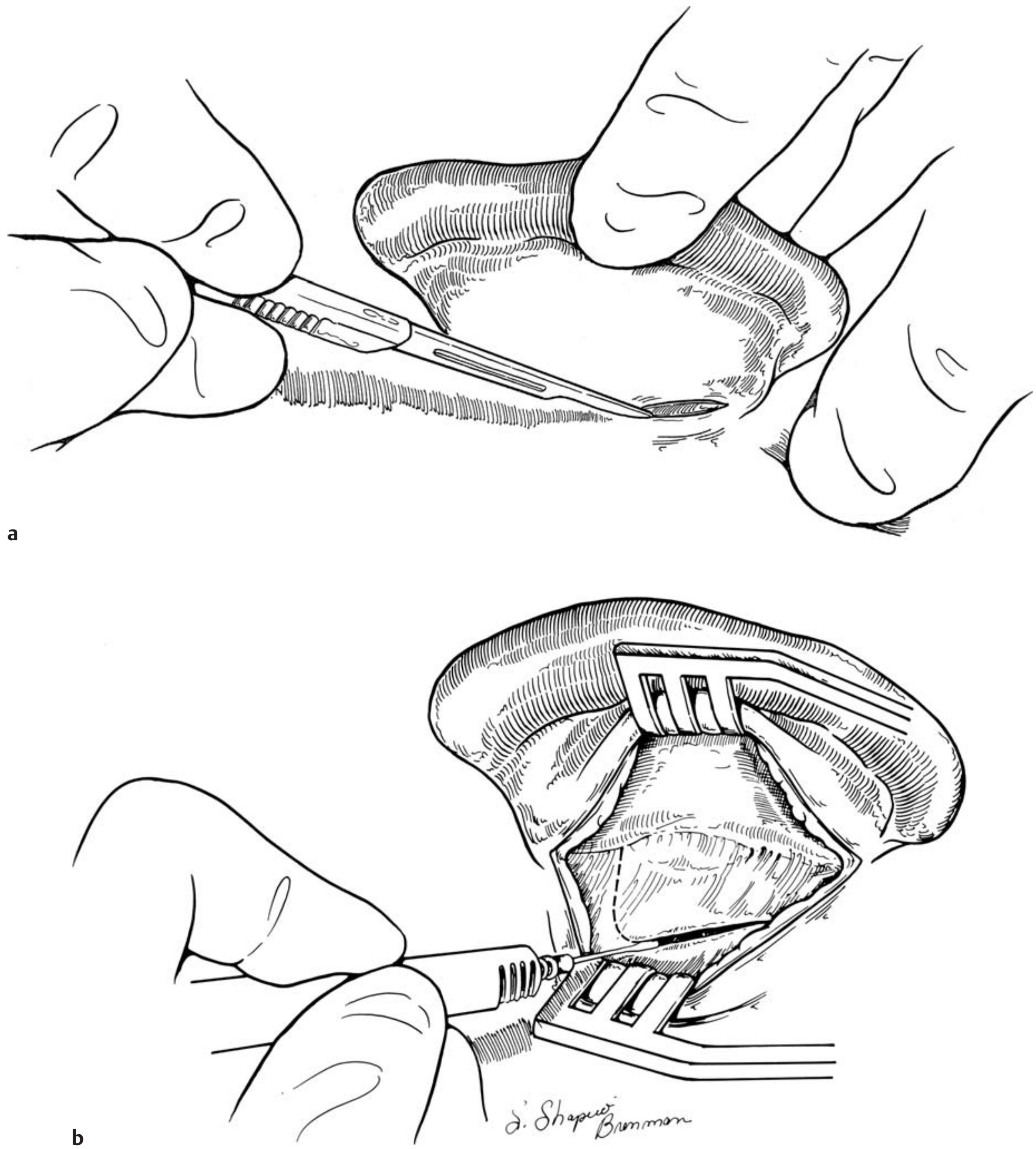
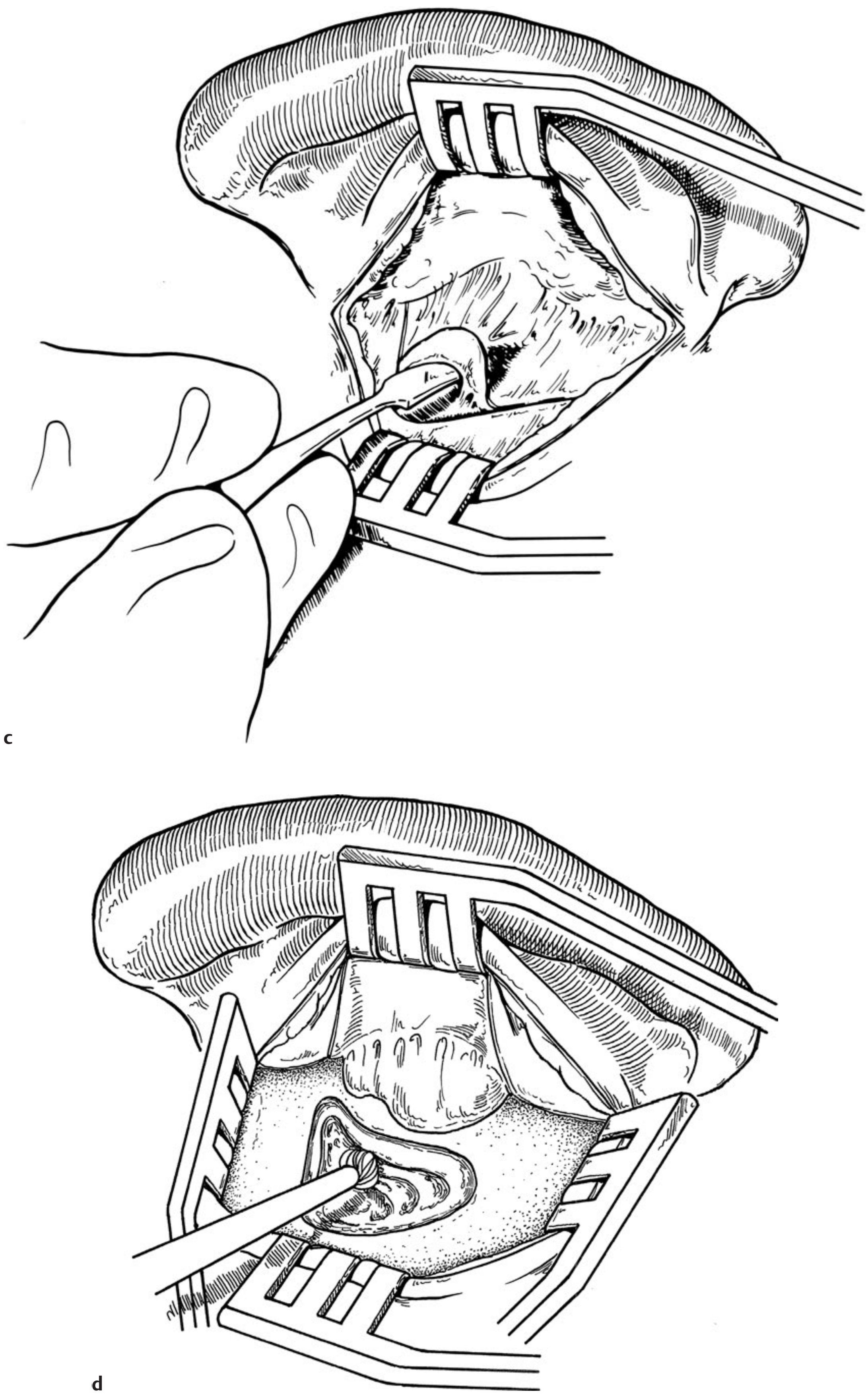


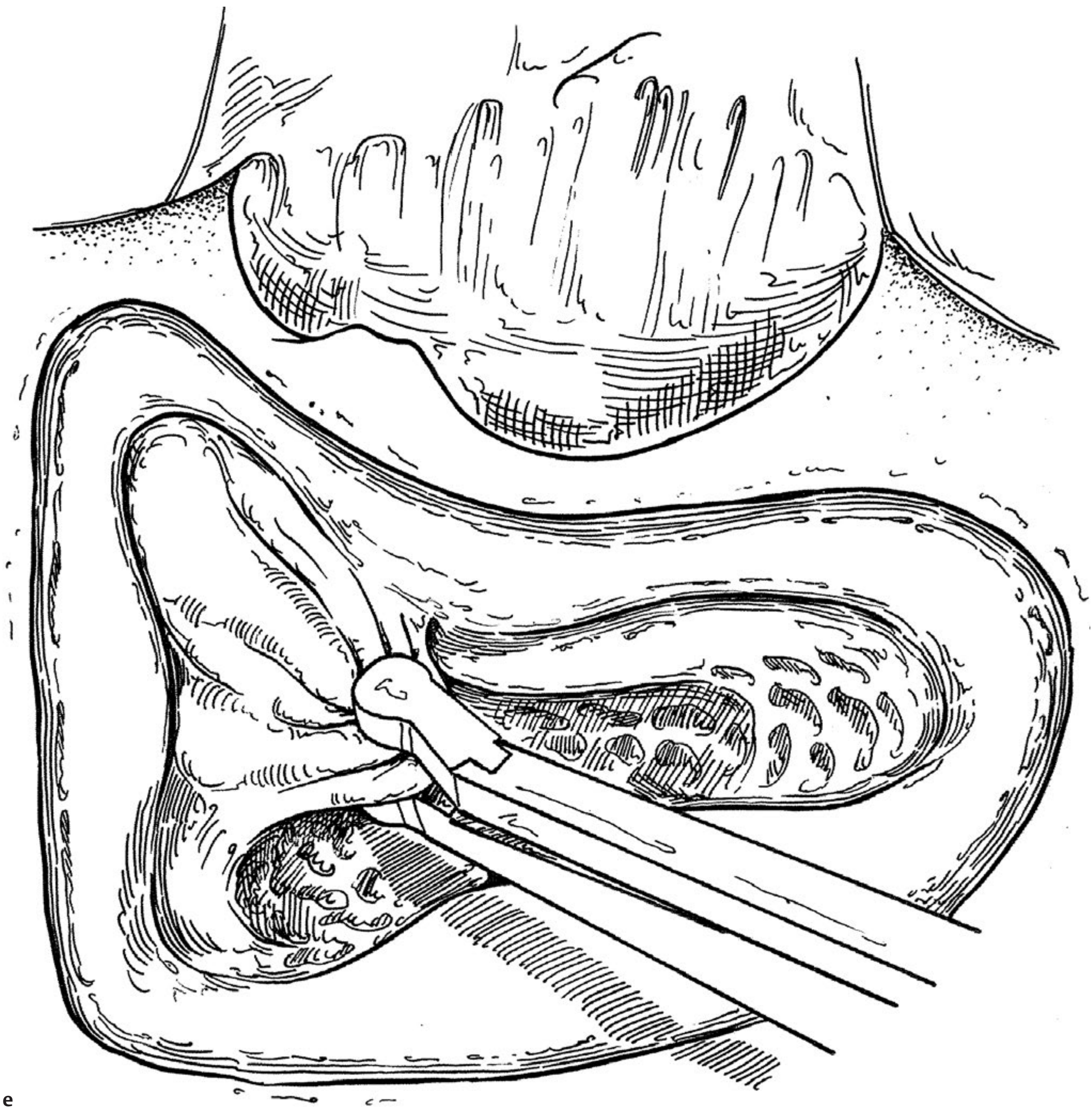
Fig. 3.4a,b



c

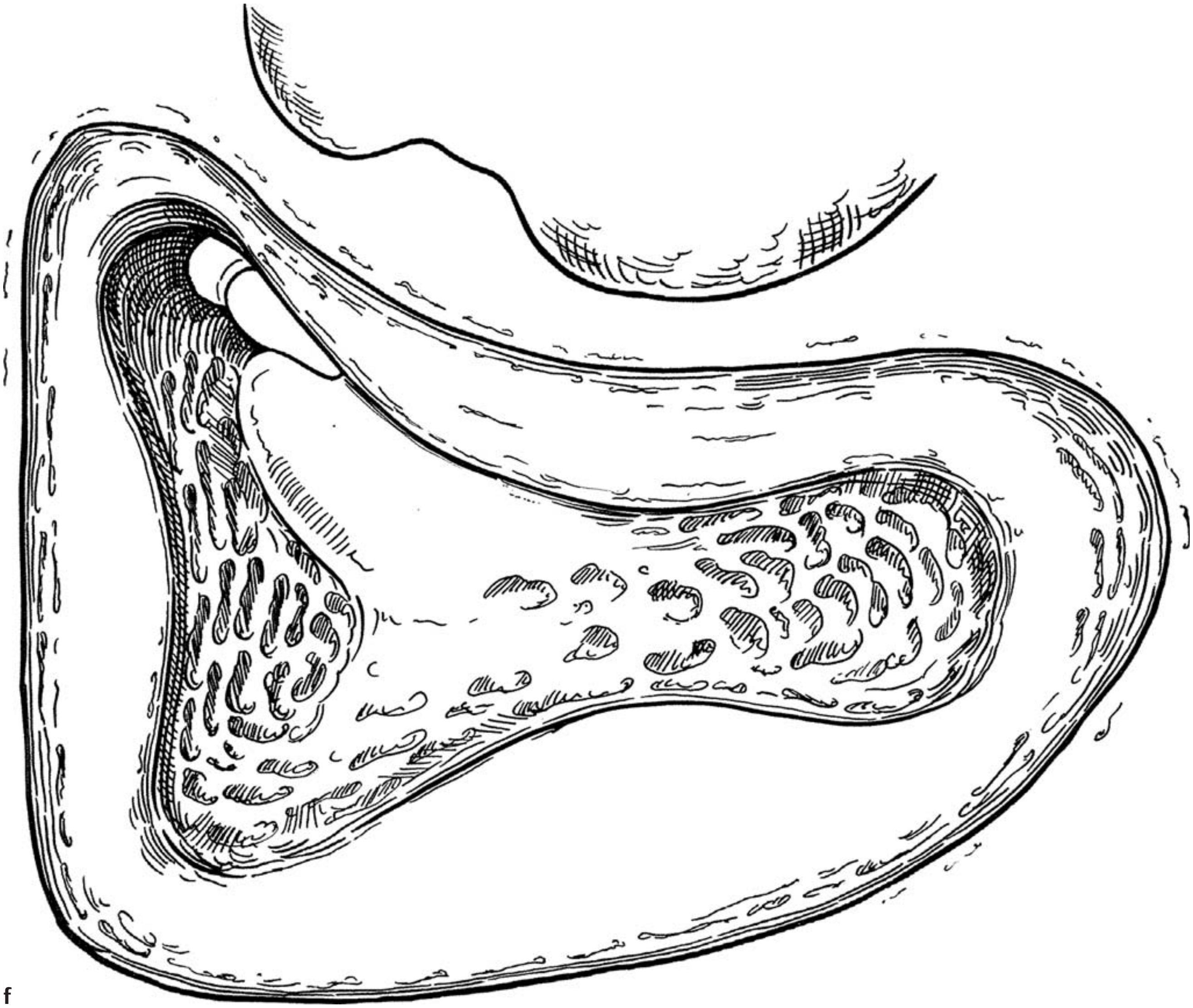
d

Fig. 3.4c,d



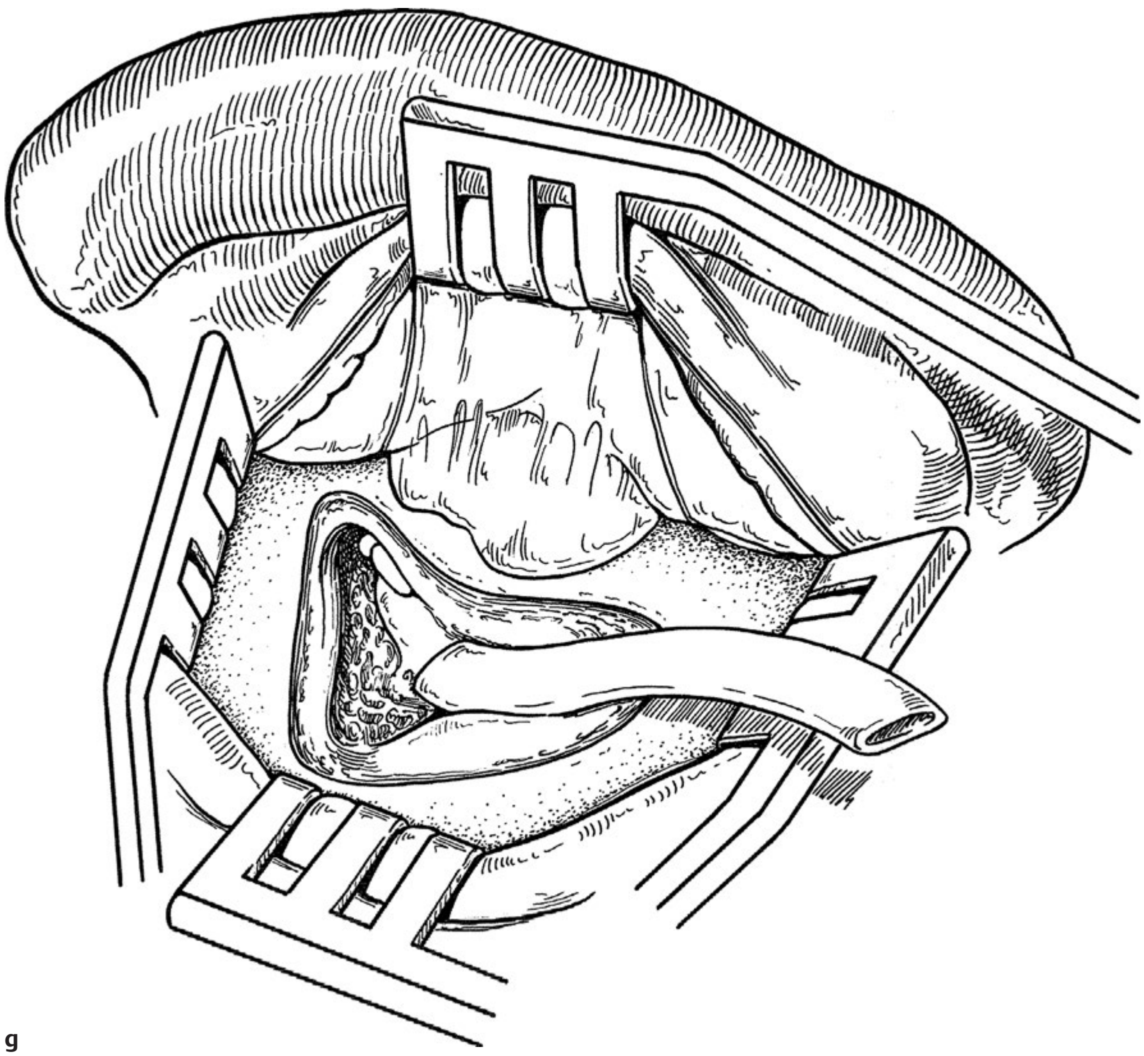
e

Fig. 3.4e



f

Fig. 3.4f



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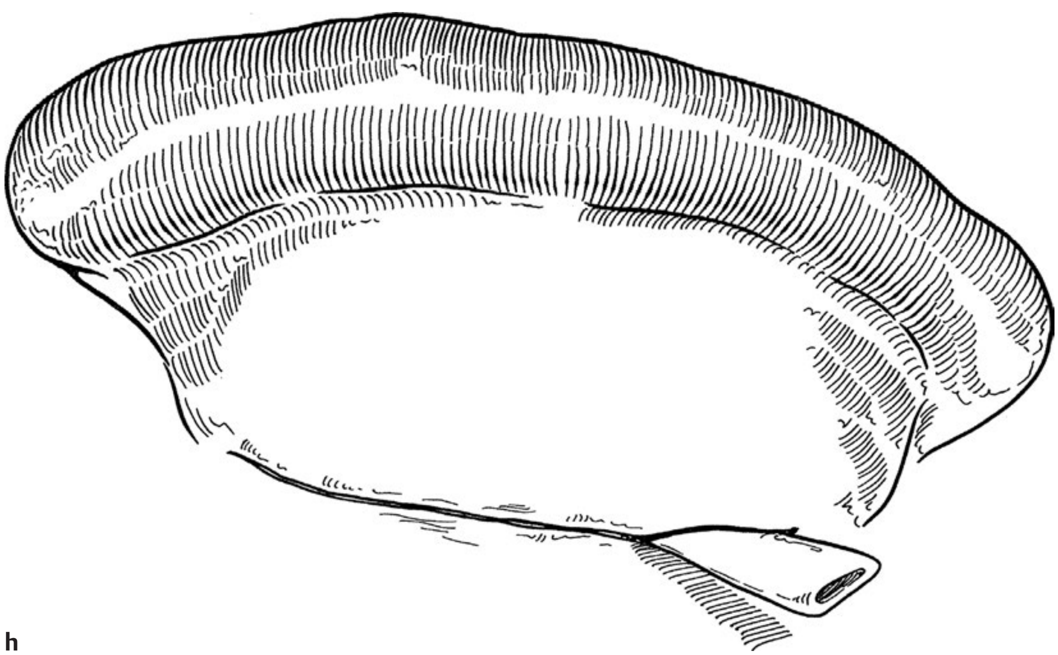


h

Fig. 3.4g,h

3-5 Intact Canal Wall Tympanomastoidectomy

Introduction

For several reasons, intact canal wall tympanomastoidectomy (ICW-TM) remains one of the standard surgical strategies for chronic ear disease. In this procedure, an aggressive exposure and resection of disease can be accomplished, and yet, by leaving most anatomical structures (e.g., the ear canal bone and eustachian tube) intact, it is possible to reconstruct the ear with the end goal of attaining a good hearing ear. A common criticism of the ICW-TM approach, however, is the fact that many surgeons employ a two-stage (i.e., two surgeries) approach in order to eradicate cholesteatoma, confirm that it has not recurred after several months, and then reconstruct the ossicular chain at that point. Confusingly, some studies suggest higher rates of recurrent cholesteatoma after ICW-TM, whereas others indicate rates similar to other surgical approaches.

Nonetheless, in the clinical setting of young children with chronic ear disease, it seems intuitively preferable to avoid irreversible surgical procedures (especially those that have associated hearing loss sequelae) given the long-term implications for such patients.

Indications

ICW-TM is useful in most cases of chronic otomastoiditis and cholesteatoma involving the middle ear and mastoid compartments.

Preoperative Evaluation

As discussed previously, the critical elements of the preoperative evaluation include: comprehensive history and physical exam, a detailed microscopic exam of the ear, a full audiologic test battery, and preoperative imaging (usually in the form of a CT scan).

Operative Technique

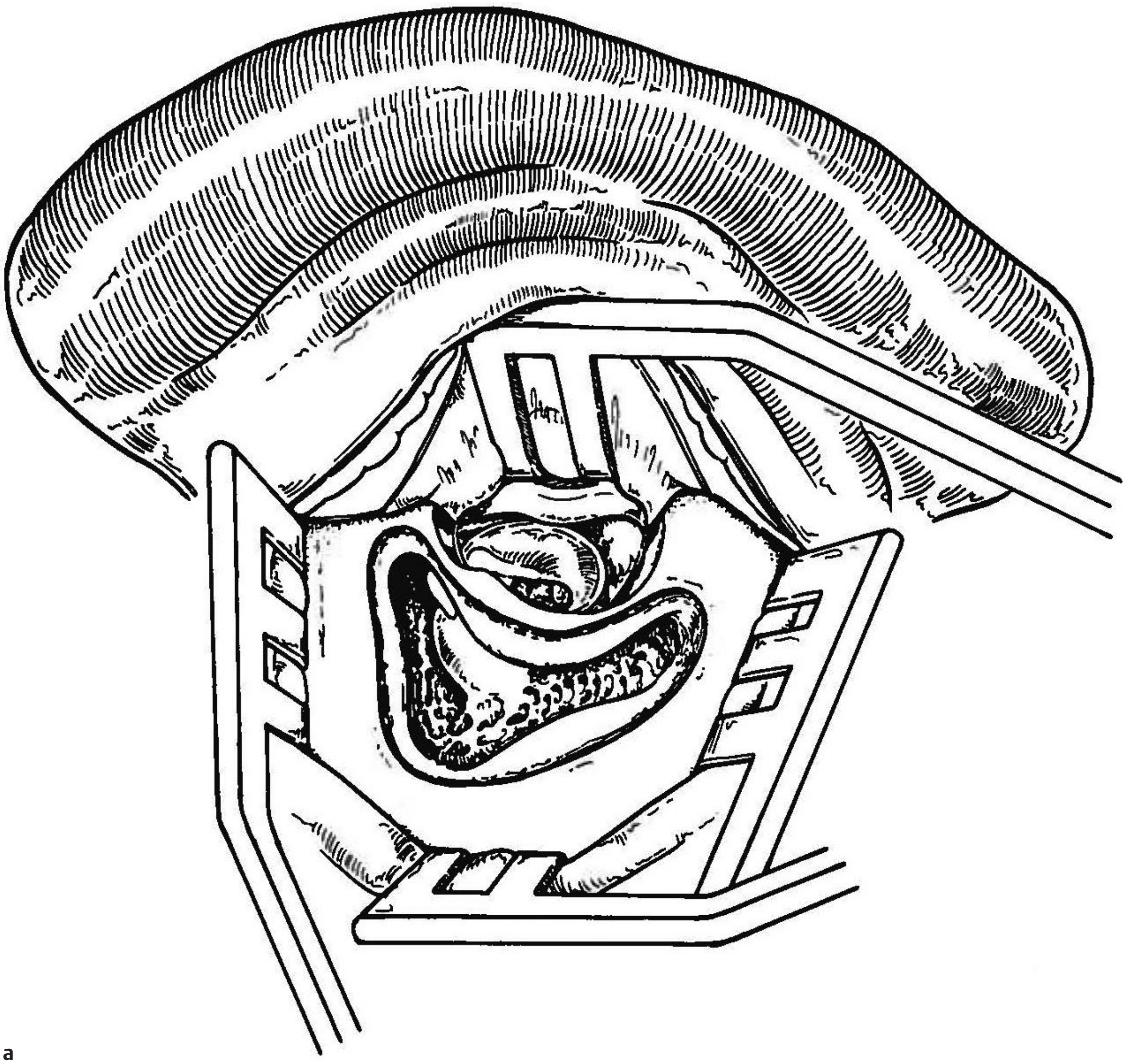
1. The standard postauricular soft tissue work and temporalis fascia grafting are initially completed as described previously (refer to **Fig. 3.2a–g**).
2. A standard tympanomeatal flap is incised and elevated in the ear canal to allow entry into the middle ear space, to determine the extent of disease in this middle ear cleft, and to assess the status of the ossicular chain (refer to **Fig. 3.2l**).
3. A cortical mastoidectomy is next performed per routine (see Section 3-4) (**Fig. 3.5a**).
4. Specific key facets of ICW-TM include a careful but aggressive thinning of the posterior ear canal bone. Thinning this bone down allows greater visualization of the attic and epitympanum as well as the incudal fossa and the superior end of the facial recess (**Fig. 3.5b**).
5. A low threshold is also maintained for performing an aggressive canalplasty in order to better visualize the facial recess and posterior mesotympanum from the middle ear side.
6. Very intentional thought should be given to performing a facial recess (or posterior tympanotomy) if significant disease is located in this cell tract or involves the stapes and oval window niche. Opening a facial recess provides an excellent view and access portal through which disease can be successfully cleaned out. In order to perform a facial recess, the facial nerve monitor should already be in place and confirmed to be functional prior to beginning the dissection. Using the lateral semicircular canal as one landmark (depth) and the short process of the incus as another landmark (a pointer), the position of the vertical facial nerve is first determined by carefully drilling with a 3-mm diamond bur along the anticipated course of the nerve. A broad field should be lowered posterior to the ear canal and down to the level of the lateral semicircular canal in order to find the nerve. A copious amount of irrigation is used to avoid thermal injury to the nerve through the bone. In most cases, small vessels running on the epineurium can be seen through the bone prior to exposing the nerve sheath. It is preferable to leave a thin layer of bone over the nerve to protect it during further dissections. The position and integrity of the facial nerve should then be confirmed with the nerve stimulator at this point. The air cells/bone immediately anterior to this vertical portion of the facial nerve then represent the facial recess. Using small diamond burs, the recess is opened superiorly where it is widest. Care is taken to look for the chorda tympani nerve, which delineates the anterior extent of the facial recess (2 mm and smaller). A small bridge of bone is also often left at the superior end of the facial recess where it comes in close proximity to the incus (the incus buttress). These structures then define a triangular shape to the facial recess bordered by the vertical facial nerve posteriorly, the chorda tympani nerve anteriorly, and the incus buttress superiorly. By opening this posterior tympanotomy, a significant access pathway as well as ventilation pathway are created that greatly enhance the ICW-TM approach without resecting any critical structures of the middle ear or mastoid (**Fig. 3.5c,d**).
7. Diseased TM and ossicles are resected at this stage and the TM repaired in standard underlay (medial graft) fashion. Although it is feasible to perform an ossicular chain reconstruction at this point, it is preferable to allow the ear drum and middle ear to heal from the aggressive first-stage resection and to plan on performing the ossicular chain reconstruction at the second stage (in approximately 6 months). By allowing the middle ear to re-epithelialize and allowing infection and inflammation to subside, the ossicular chain

reconstruction at the second stage occurs in a much healthier microenvironment with less likelihood of adhesions to the prosthesis and greater chances of good hearing outcomes.

8. The middle ear and ear canal are packed with antibiotic-impregnated Gelfoam as previously described for tympanoplasty and the incision closed in multiple layers using resorbable sutures (see Section 3-2). A standard mastoid dressing is applied and only maintained for 24 hours postoperatively.

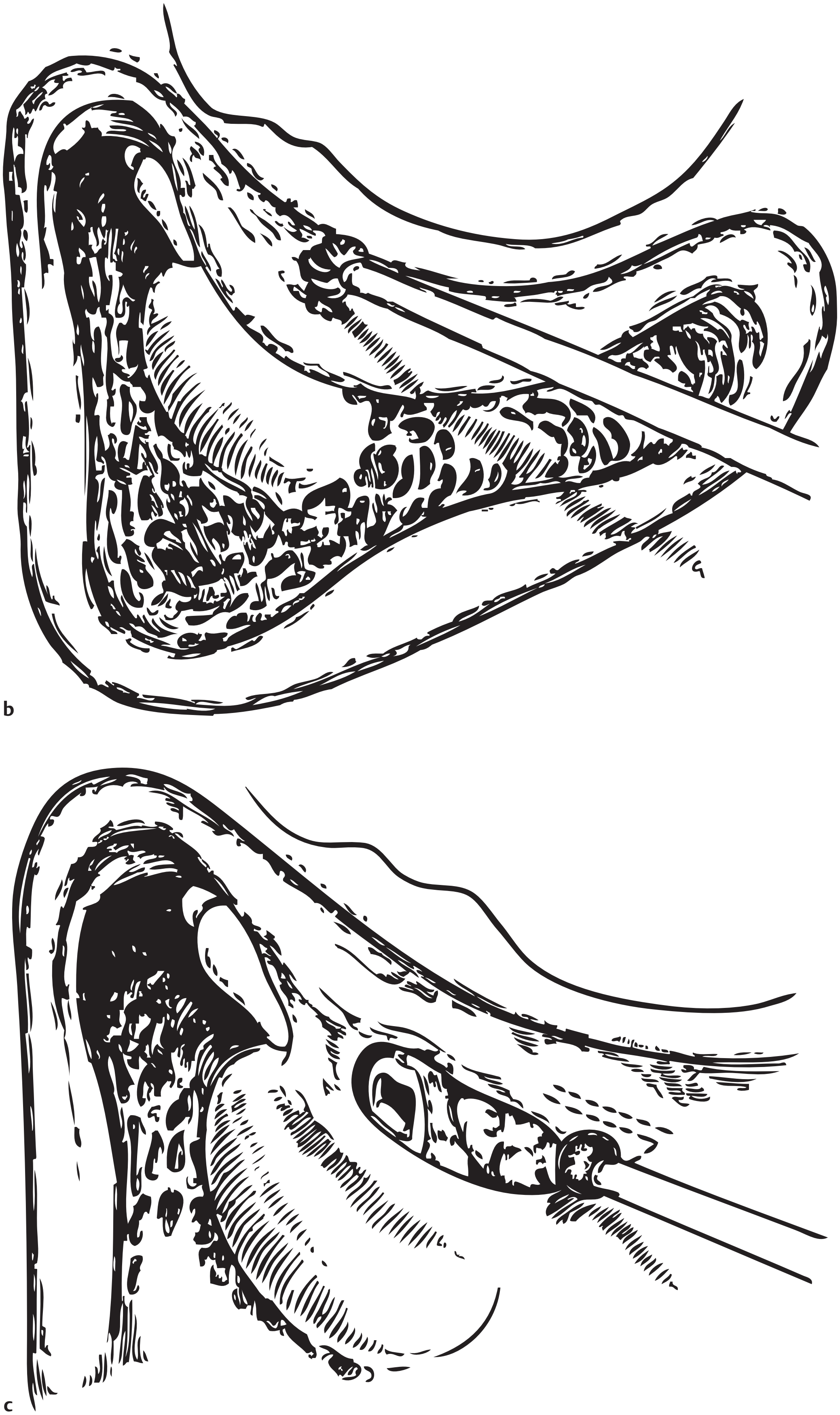
Complications

1. Recurrent cholesteatoma
2. Facial nerve injury
3. Labyrinthine trauma (semicircular injury)
4. Dural laceration with cerebrospinal fluid leak
5. Sigmoid sinus laceration
6. Ossicular chain damage



a

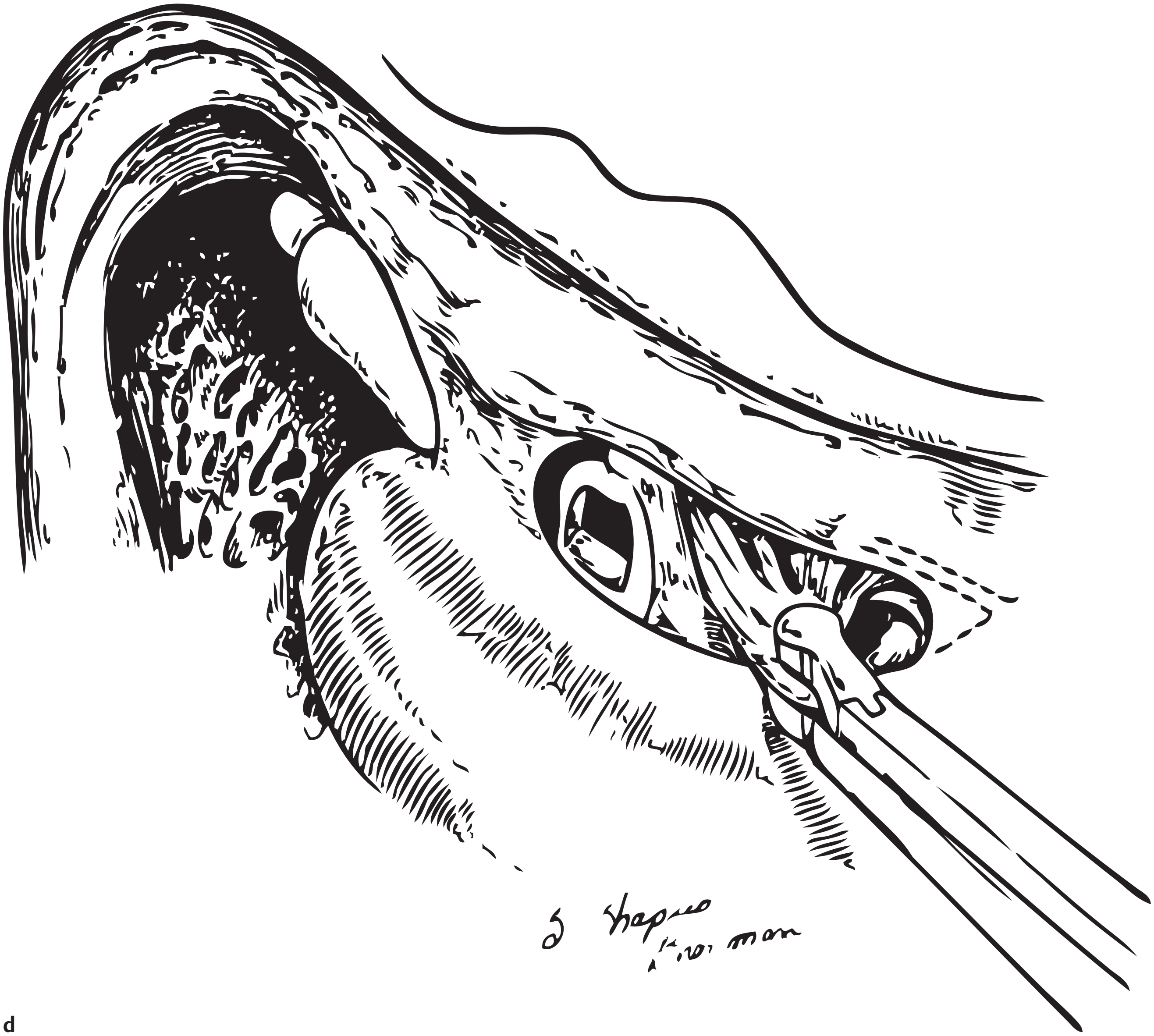
Fig. 3.5a



b

c

Fig. 3.5b,c



d

Fig. 3.5d

3-6 Canal Wall Down Mastoidectomy

Introduction

A key feature of a canal wall down (CWD) mastoidectomy is the removal of the posterior bony ear canal that normally separates the mastoid compartment from the external auditory canal. By doing this, disease in the mastoid (most commonly cholesteatoma) is externalized, creating a "safer" ear. In severe and/or recalcitrant disease of the middle ear and mastoid cavity, a radical mastoidectomy is performed in which the middle ear and mastoid are completely externalized with the ossicles typically being removed and the eustachian tube often being packed off and obliterated at the middle ear side.

Indications

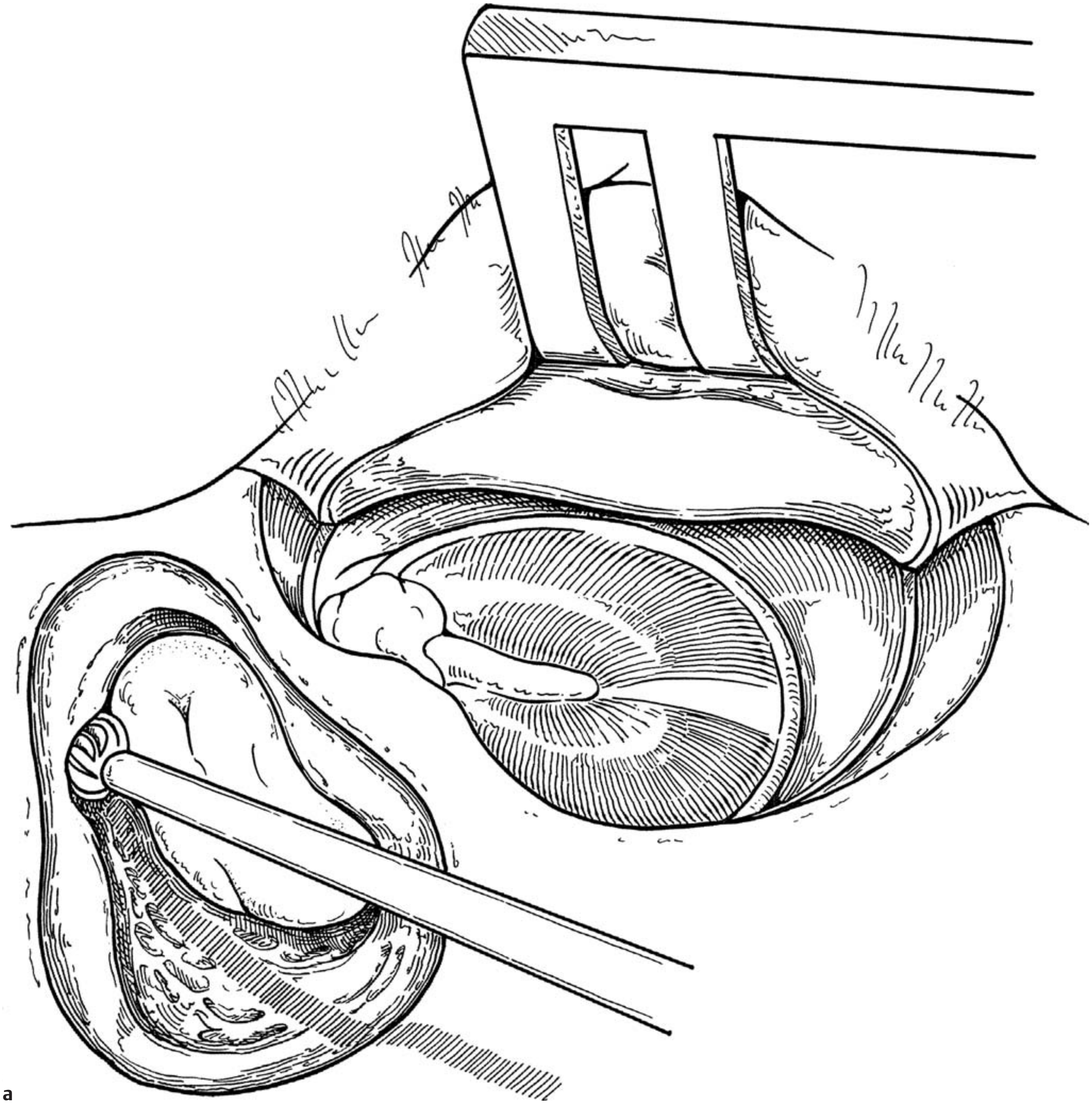
CWD is indicated when there is cholesteatoma lateral to the ossicular chain or when there is extensive cholesteatoma involving both the middle ear and mastoid that makes complete removal either extremely difficult or impossible. Other indications such as large cholesteatomatous disease with labyrinthine or cochlear complications can also be safely managed by externalizing the disease via CWD.

Operative Technique

1. The soft tissue approach prior to starting on the mastoidectomy has been described above and is identical to that for tympanoplasty or cortical mastoidectomy (see Sections 3-2 and 3-4).
2. After completing a cortical mastoidectomy (**Fig. 3.6a**) and typically after a tympanomeatal flap has been elevated in the ear canal, the bone of the posterior ear canal is carefully removed using a series of cutting and diamond burs. While cutting burs can be safely used at the lateral aspects of bone removal, diamond burs provide a greater safety margin at the medial end of the ear canal bone removal due to proximity to the facial nerve (**Fig. 3.6b,c**).
3. Careful removal of the diseased mucosa and cholesteatoma is then performed, using caution near important structures as there may be bony erosion (**Fig. 3.6d**). The surfaces of the mastoid cavity are smoothed with a diamond bur to avoid trapping of cholesteatoma. In cases where the ossicular chain is not involved by disease, it may be possible to leave flat regions of cholesteatoma matrix in the mastoid cavity.
4. If the ossicles are involved, care must be taken to avoid any trauma to the cochlea and inner ear; it is prudent at an early stage to ensure that the ossicular chain is not in continuity or to intentionally (and delicately) disarticulate the incudostapedial joint. By doing this, the incus and malleus can be manipulated aggressively without fear of traumatizing the stapes and/or the oval window and cochlea (**Fig. 3.6e**).
5. An adequate meatoplasty is requisite for any ear being managed with a CWD mastoidectomy. This is accomplished by gently elevating the skin overlying the conchal bowl (either from the endaural side or from the postauricular side) and excising a crescent of conchal cartilage that forms the posterior boundary of the external meatus (**Fig. 3.6f**). A releasing incision in the canal skin may also need to be made (at the 12 and 6 o'clock positions) in order to allow the meatus to open fully (**Fig. 3.6g**).
6. The patency of the meatoplasty is gauged by grasping the perichondrium of the remaining concha and pulling it back to the position it will have after closure of the postauricular incision.
7. If the meatus is not large enough to permit access to the entire mastoid cavity, additional soft tissue and cartilage are removed from around the meatus until adequate exposure of the mastoid is accomplished (**Fig. 3.6h**).
8. The periosteum of the remaining concha is sutured posteriorly to the periosteum of the mastoid with 3-0 chromic suture (**Fig. 3.6i**).
9. The posterior soft tissues are then closed as described above and the meatus packed using an expanding Merocel sponge (Medtronic), and a mastoid dressing is applied. The sponge is saturated with antibiotic ear drops immediately and then twice daily until the packing is removed (typically 2–3 weeks).

Complications

1. Recurrent cholesteatoma
2. Facial nerve injury
3. Labyrinthine injury (fistulization of semicircular canals)
4. Dural laceration with cerebrospinal fluid leak
5. Sigmoid sinus laceration
6. Ossicular chain damage
7. Meatal stenosis and recurrent infections due to inadequate meatoplasty



a

Fig. 3.6a