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An Overview on Tympanoplasty

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Abstract:

Tympanoplasty is a widely performed surgical procedure aimed at repairing tympanic membrane perforations and restoring middle ear function. Persistent perforations may result from chronic suppurative otitis media (CSOM), trauma, or iatrogenic causes, leading to hearing loss, recurrent infections, and reduced quality of life. The main goals of tympanoplasty are to re-establish the integrity of the tympanic membrane, improve auditory outcomes, and prevent future episodes of otorrhea. Over the past decades, advancements in surgical techniques, graft materials, and visualization methods have significantly improved success rates and reduced postoperative complications.

Growing interest in minimally invasive otologic surgery has introduced endoscopic tympanoplasty as an effective alternative to the traditional microscopic approach. The use of high-definition endoscopes allows enhanced visualization of middle ear structures, including hidden areas that are difficult to access with a microscope. This approach offers similar graft uptake and hearing outcomes while potentially reducing operative time, postoperative pain, and external incision requirements. As surgical options continue to evolve, determining factors that influence healing and hearing improvement remains essential for optimizing patient outcomes.

Keywords: Tympanoplasty; Tympanic membrane perforation; Middle ear surgery; Chronic suppurative otitis media; Endoscopic ear surgery; Hearing outcomes; Graft uptake; Cartilage graft.

Introduction:

Tympanoplasty is the surgical operation performed for the eradication of the disease in middle ear together with reconstruction of the tympanic membrane and/or the small bones of the middle ear (ossicles). Tympanoplasty is a safe and effective procedure used to both eradicate disease from the middle ear and restore hearing and middle ear function. Myringoplasty (type I tympanoplasty) is the surgery performed to reconstruct a perforated tympanic membrane. Several surgical approaches and grafting techniques are available for use by the surgeon. Paramount to success is the accurate preoperative assessment, good hemostasis intraoperatively, and thoughtful surgical planning with careful placement of the graft **(1)**.

In recent years, minimally invasive approaches, including endoscopic tympanoplasty, have gained popularity due to their enhanced visualization, reduced operative time, and less postoperative discomfort. Endoscopic techniques have demonstrated comparable graft uptake rates to conventional microscopic tympanoplasty while offering advantages such as improved access to hidden recesses and a shorter learning curve. Moreover, innovations in graft materials, cartilage reinforcement, and biologically active scaffolds have expanded the surgical options available for tympanic membrane repair **(2).** Despite these advances, identifying predictors of successful outcomes remains essential for optimizing patient selection and guiding surgical decision-making.

History

The first recorded attempt to repair the tympanic membrane was made by Banzer in 1640 using an ivory tube covered by pig's bladder. In the middle of the nineteenth century, the British otologists James Yearsley and Joseph Toynbee each developed their own form of artificial eardrum **(3).**

Despite initial enthusiasm for these devices, experience amongst the medical profession over the following half century demonstrated their minimal value in the treatment of a perforated eardrum, which generally heals naturally **(4)**.

When planning tympanoplasty, the surgeon must consider the location of the perforation (marginal versus central), and size (total versus small). Areas of myringosclerosis and tympanosclerosis should be noted. Important comorbidities worth noting include craniofacial disorders and underlying environmental allergies or chronic allergic rhinitis. Critical factors that make tympanoplasty less successful include adhesive otitis media, severe eustachian tube dysfunction with ongoing intermittent otorrhea, cholesteatoma, or previous surgical repair **(5)**.

Various techniques and grafting materials can be used, and which approach is used depends on the size and location of the perforation, the presence or absence of cholesteatoma or granulation tissue, the status of the ossicles and mastoid, other anatomical considerations (e.g., narrow external auditory canals), as well as the surgeon's preference and expertise **(6)**.

Examining the middle ear and ossicles and removing any elements of adhesion or cholesteatoma is critical. The chosen approach should provide optimal visualization of the perforation and tympanic membrane. One should be careful not to disrupt an intact and mobile ossicular chain if the hearing loss is only low-frequency conductive, as is often the case with hearing loss secondary to a perforation **(7)**.

I. Classification

Tympanoplasty is classified into five different types, originally described by **Wullstein (8)** as follows:

1. Type 1 involves repairing the tympanic membrane alone, when the middle ear is normal. A type 1 tympanoplasty is synonymous to myringoplasty.

2. Type 2 involves repair of the tympanic membrane and middle ear in spite of slight defects in the middle ear ossicles.

3. Type 3 involves removal of ossicles and epitympanum when there are large defects of the malleus and incus. The tympanic membrane is repaired and directly connected to the head of the stapes.

4. Type 4 describes a repair when the stapes foot plate is movable, but the crura are missing. The resulting middle ear will only consist of the eustachian tube and hypotympanum.

5. Type 5 is a repair involving a fixed stapes footplate.

The term 'myringoplasty' refers to repairing the tympanic membrane alone. There are several options for treating perforated eardrums. If the perforation is from recent trauma, many ear, nose and throat specialists will elect to watch and see if it heals on its own. After that, surgery may be considered **(1)**.

II. Indications and contraindications

Although most perforations heal spontaneously, those that persist after dry ear precautions and ototopical drops should be considered for surgical repair. Operating on an actively infected ear is contraindicated **(9)**.

III. Evaluation

A. Pre-procedure planning

Evaluation of the patient for tympanoplasty should involve a detailed history and physical examination. Important aspects of history should include the duration of the perforation, severity of otorrhea, hearing loss, previous attempts for repair, otitis media, and otitis externa. The number and frequency of infections (including time of most recent infection) provided insight into the severity of disease. Past otologic surgical history is critical and should include any history of pressure equalization tubes and details of any prior tympanoplasties (including approaches, grafts used and outcomes) **(10)**.

B. Physical examination

The physical examination should focus on pneumatic otoscopy and otomicroscopy. In the office, tuning forks should give an important assessment of hearing; in older patients, tuning forks can be used to confirm audiometric findings. Additional assessments include documentation of facial nerve functionality and inspection for previous incisions. Although a small amount of cerumen is tolerated in the routine otoscopic examination, obstructive cerumen should be removed when evaluating a patient for tympanoplasty to provide an unimpeded view of the entire tympanic membrane **(11).**

Retraction pockets should be closely inspected for accumulation of squamous debris. Considering the status of the contralateral ear when considering repair of a tympanic membrane perforation is essential. The ear with more significant hearing loss is usually operated on first if bilateral perforations exist **(7)**.

C. Patient preparation

Prior to considering surgery in any patient, acute and chronic infections should be controlled using ototopical, oral, and/or intravenous antibiotics or antifungals, if indicated. Ototopical drops with steroids may also be needed if granulation tissue or aural polyps are visualized to improve inflammation. Ideally, an ear should be "dry" for 3-4 months before surgery is performed to enhance the chance of success. Individuals who undergo surgery must keep the operated ear dry for a period of several weeks or until the graft has healed. Operating on an actively infected ear is contraindicated.

D. Monitoring and follow-up

Although the ear must be kept otherwise dry, patients are allowed to wash their hair, while keeping a cotton ball with Vaseline in the canal for dry ear measures. Pain is usually managed with acetaminophen and/or ibuprofen. Oral antibiotics are the surgeon's preference and can be given for 5-7 days. A cotton ball is replaced in the external auditory meatus as needed for bleeding or drainage. Ototopical drops are typically administered postoperatively for 7-21 days after surgery.

Three to four 4 weeks after surgery, the ear is examined under the microscope, and any canal packing or residual antibiotic is removed. At this time, a good assessment can be made as to the healing and neovascularization of the graft. Granulation tissue at the tympanomeatal flap is addressed. Ototopical drops are continued as the graft continues to heal. Postoperative audiometric testing is delayed until healing is complete (typically 6-12 weeks). Follow-up visits are scheduled to ensure complete proper healing and restoration of hearing **(7)**.

E. Audiometric testing

Audiometry should be performed preoperatively in all surgical candidates. Tympanometry can add useful information in younger children who are difficult to properly examine and to assess eustachian tube patency. The primary reason for audiometric analysis is to establish the degree of conductive hearing loss. Perforations usually cause low- frequency conductive loss. If underlying ossicular discontinuity exists and is not addressed during surgery, then postoperative hearing can be worse despite an intact neo-tympanum. Ossicular involvement is considered if the conductive hearing loss is flat across all frequencies or greater than 35 db and the presence and degree of any sensorineural hearing loss was documented preoperatively **(12)**.

IV. Grafting material

A. Perichondrium

Perichondrium are most commonly used to reconstruct tympanic membrane, an oval shaped piece of cartilage with perichondrium in center was harvested from cavum conchae, the cartilage was cut in rounded shape (O) shaped without removing the inner layer of perichondrium, the inner diameter of cartilage ring should be nearly the same as the diameter of tympanic ring **(13)**.

This cartilage framework stabilizes and fixes the perichondrium and prevents perichondrium from subsiding into middle ear cavity, also shrinking of perichondrium is reduced by cartilage ring **(14)**.

This technique seems to be valuable method for closure of subtotal and total perforation especially in perforation near anterior anular region, where the soft material which is only fixed by adhesion can easily be displaced during wound healing **(13)**.

According to **Kumar and Chilke (15),** the graft is taken as follows:

- The postauricular incision is marked and injected with lidocaine with epinephrine.
- Dissection is carried down onto the fascia (loose areolar / true temporalis).
- The graft is harvested.
- Muscle is removed from the fascia graft, and the graft is then set on the back table for later use.

Cartilage is available to be harvested easily from either the tragus or the conchal bowl, if a post-auricular approach is being used. Tragal cartilage is harvested with perichondrium attached via a small incision on the internal surface of the tragus. This graft is appropriate size and carries very little donor site morbidity. In addition, the perichondrium can be reflected to stabilize the graft. Conchal cartilage also carries no additional significant morbidity. Other grafting materials include lobular fat, periosteum, perichondrium, vein, and AlloDerm **(16)**.

B. Other grafting materials in tympanoplasty

i. Fat graft tympanoplasty

It's used in repair of tympanic membrane perforation (small sized) by using ear lobe fat as a graft substance **(17)**. Ear lobe fat was compared microscopically with abdominal fat and buttocks fat, and it was noted that there was more connective tissue in ear lobe fat than other fatty tissues **(18)**. It was easier to handle as its spongy, bulky adhesive quality **(19)**.

ii. Temporolis fascia

It's used in well aerated middle ear, in last decade there has been an increasing interest in using cartilage grafts as primary alternative to its use **(20)**. The stiffness and strength of cartilage offer greater stability to graft and has a key role in resistance against shrinkage **(21)**.

It was found that tympanoplasty using temporalis fascia showed similar results with cartilage graft, however cartilage graft had better morphological findings (intact tympanic membrane than temporalis fascia), and cartilage graft was shown to be safe option for tympanic membrane reconstruction in adults and children **(22)**.

iii. AlloDerm graft

It is an allograft material that has been processed to reduce its immunogenicity. Human donar skin is obtained from approved tissue banks and treated with a decellularizing agent. Also donars are screened for HIV, hepatitis B & C, syphilis and human T-lymphotrophic virus type I **(23, 24)**.

Removal of the cellular tissue components allows the graft to be tolerated in the host without inciting an immune response **(25)**. To allow the graft to be stored, it is freeze-dried and is rehydrated at the time of graft implantation **(26)**.

Alloderm has been used for myringoplasty in a model with similar rates of perforation closure as temporalis fascia **(27)** and Paper patch **(28)**.

V. Surgical approaches

Tympanoplasty can be performed through the ear canal (trascanal approach), through an incision in the ear (endaural approach) or through an incision behind the ear (postauricular approach). Common graft sites include the temporalis fascia and the tragus. The surgery takes 1/2 to 1 hour if done through the ear canal and 1 to 2 hours if an incision is needed. It is done with local or general anesthesia. It is done on an inpatient or day case basis and is successful 85-90% of the time **(1)**.

A. Transcanal approach

The transcanal approach is especially good for small posterior perforations but can be used for medium-sized perforations if the anterior tympanic membrane is easily visualized. This technique can be challenging for significant anterior perforations, narrow/stenotic ear canals, or individuals with a significant anterior canal bulge. Inspecting the perforation prior to preparing the patient and determining that at least a 5- mm speculum can be placed is important. Canaloplasty can be used to improve visualization if lightly limited **(29)**.

According to **Konstantinidis et al. (30)**, when performing a transcanal underlay graft tympanoplasty procedure, the following steps are followed:

1. The ear canal is cleaned and surgical betadine used during the surgical prep is removed.

2. The external auditory canal is injected with 1% lidocaine with 1:100,000 epinephrine primarily for vasoconstriction to optimize visualization during the procedure.

3. The edge of the perforation is dissected and removed using a sharp pick and cup forceps; this "postage-stamping" and "freshening" of the perforation is critical to ensure that the graft incorporates into the native tympanic membrane remnant.

4. Next, a tympanomeatal flap is created. It is customized based on the location of the perforation and surgeon's preference. The flap design should be such that it can be easily and a traumatically raised and the undersurface of tympanic membrane perforation can be readily accessed. A medially based tympanomeatal flap is usually created with radial incisions at 12 o'clock and 6 o'clock (ie, superiorly and inferiorly) that either connect directly or via a semilunar incision in the posterior canal just medial to the bony cartilaginous junction.

5. The tympanomeatal flap is raised medially with a round knife. To avoid traumatic tearing, take great care not to suction on the flap.

6. When the annulus is reached, the tympanotomy is made such that the instrument of choice (e.g., round knife, gimmick, sickle knife, pick) lifts the annulus while hugging the bony groove from which the fibrous annulus can be dissected. The fibrous annulus is then dissected circumferentially with care not to injure the ossicles, the chorda tympani nerve, or residual drum. The flap is then positioned, usually anteriorly, such that the perforation is exposed.

7. A canaloplasty of the posterior or anterior external auditory canal can be performed to optimize visualization. Take care not to injure the facial nerve or temporomandibular joint.

8. If indicated, the middle ear and ossicles are inspected and palpated to confirm ossicular continuity. Middle ear disease (granulation tissue, tympanoselerosis, adhesions, cholesteatoma) is completely removed. Removing hypertrophic middle ear mucosa with either a McCabe dissector or Duckbill elevator, particularly mucosa abutting the fibrous annulus in anterior tympanic membrane perforations, is important.

9. Ossicular reconstruction can be performed, if necessary, followed by grafting of the perforation. Elevating the tympanic membrane remnant off the handle of the malleus with a sickle knife may be necessary. This allows both closer inspection of the ossicles and better placement of the graft.

10. The middle ear must be carefully packed with the surgeon's preferred material - either Gelfilm, Gelfoam, or Surgicel. This is often soaked in either oxymetazoline, antibiotic ear drops, or diluted epinephrine (1:10,000). Packing the mesotympanum and hypotympanum is important, although excess packing should be avoided near the ossicles to prevent adhesions.

11. The graft is trimmed and should adequately cover the entire defect. Hemostasis is critical to intraoperative visualization and successful placement of the graft. The graft should be well supported so as to avoid shifting or displacement.

12. Some surgeons advocate that nitrous oxide anesthetic be switched off at this point because this particular agent has a tendency to accumulate in spaces such as the middle ear and can potentially dislodge the graft.

13. The tympanomeatal flap is laid back down over the graft, and the posterior canal skin edges are laid flat. Pieces of Gelfoam, Surgical, or antibiotic ointment are placed along the tympanic membrane and graft and layered laterally to cover the canal incisions.

14. Antibiotic ointment is placed in the lateral canal, and either Vaseline- coated or antibiotic-coated sculpted cotton ball is placed in the external auditory meatus.

15. An optional Glasscock or mastoid pressure dressing is placed at the end of the case, particularly if a mastoidectomy has been performed.

B. Endaural approach

The endaural technique is useful with many perforations, especially when a small atticotomy is anticipated (when improved access to and visualization of the epitympanum is needed). Many of the steps involved in the transcanal technique are similarly performed in the endaural tympanoplasty as well **(31).**

According to **Raj et al. (32),** when performing an endaural medial tympanoplasty procedure, the following steps are followed:

1. The canal is prepared as detailed above, but the injection may continue laterally to the lateral external auditory canal and tragus.

2. An incision is made at 12 o'clock and extended superolaterally between the tragus and helical root.

3. A medially-based tympanomeatal flap is raised, and the middle ear is entered with the same care as described previously. The tympanic membrane is freed superiorly and inferiorly.

4. Middle ear work is carried out as indicated. Atticotomy can be performed using a small curette or drill if access into the epitympanum is needed.

5. Grafting is performed and the tympanomeatal flap is laid back down. Gelfoam is placed along the tympanic membrane and fills the canal. Antibiotic ointment and a cotton ball are used laterally.

C. Post-auricular approach

The postauricular technique is the most performed approach for either revision tympanoplasties or those in which a mastoidectomy is anticipated. This technique offers the best visualization of the anterior tympanic membrane and is preferred for large anterior perforations. In addition, it can be combined with mastoidectomy if disease is found in the mastoid that requires the surgeon's attention **(33).** It will be discussed in patients and methods section.

VI. Grafting technique

Although variations exist, 2 primary grafting techniques exist: medial grafting (or underlay) and lateral grafting (or overlay). These terms refer to the position of the graft in relation to the fibrous annulus, not to the malleus or tympanic remnant. The medial grafting technique is performed. The primary advantage of the medial graft technique is that it is quicker and easier to perform than lateral grafting. It also carries a high success rate (approximately 90% in experienced hands). The biggest disadvantage is its limited exposure and poor utility for larger perforations and its difficulty with repair of near-total perforations **(34).**

Advantages of the lateral graft technique include wide exposure and versatility for larger perforations and for any needed ossicular reconstruction. Disadvantages include the requirement of a higher technical skill level, a longer operative time, slower healing rate, and the risk of blunting and lateralization of the graft. The lateral graft technique is championed by some doctors as a technique more suited for total drum replacement **(35).**

According to **Konstantinidis et al. (30),** the basic steps involved in lateral grafting are described as follows:

1. Lateral (overlay) tympanoplasty is performed through the previously described postauricular incision. Important differences exist in the canal incisions. In this procedure, a vascular strip is created by making radial incisions at about 2 o'clock and 5 o'clock on right side. These incisions are connected medially just lateral to the annulus on the posterior canal wall and laterally just medial to the bony-cartilaginous junction along the anterior canal wall.

2. The skin of the anterior external auditory canal is raised medially. When the annulus is reached, squamous epithelium is raised off of the tympanic remnant, and the canal skin is removed in continuity with the

3. remnant skin and stored in saline solution. This maneuver is done with cupped forceps.

4. Bony canaloplasty can be performed anteriorly to ensure visualization of the entire annulus. Protecting the flap with a portion of trimmed Silastic as a shield is helpful. Care must be taken not to enter the glenoid fossa, which risks injuring the temporomandibular joint (TMJ) and causing prolapse into the ear canal.

5. Antibiotic-soaked Gelfoam is packed into the middle ear to support the tympanic remnant. The fascia graft is placed medial to the malleus and draped onto the posterior canal wall for stabilization. If possible, the graft should not extend onto the anterior canal wall in an effort to prevent blunting of the graft.

6. The canal skin/tympanic remnant is returned and placed lateral to the graft and carefully positioned. Gelfoam is then packed tightly into the anterior aspect of the medial canal to prevent blunting, and the vascular strip is laid back down, covering the lateral extension of the fascia graft to improve its blood supply. Antibiotic-soaked Gelfoam is then packed into the rest of the external auditory canal.

7. The postauricular incision is closed in layers, and antibiotic ointment is placed on the incision and in the lateral canal. A cotton ball is placed in the external auditory meatus, and a mastoid pressure dressing is applied.

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