Myringoplasty and tympanoplasty are descriptive terms defining surgical procedures that address pathology of the tympanic membrane and middle ear. Myringoplasty is an operative procedure used in the reconstruction of a perforation of the tympanic membrane. This assumes that the middle ear space, its mucosa, and the ossicular chain are free of active infection. There is no direct inspection of the middle ear during this procedure. Tympanoplasty implies reconstruction of the tympanic membrane but also deals with pathology within the middle ear cleft, such as chronic infection, cholesteatoma, or an ossicular chain problem.

The term myringoplasty was coined by Berthold in 1878, but the first myringoplasty was performed by Marcus Bancer in 1640. Berthold placed a court plaster against the tympanic membrane for 3 days to remove the epithelium, and then applied a thick skin graft. Despite success reported in two cases, little more was heard of myringoplasty until Schulhof and Valdez mentioned it in 1944, and then not again until 1952 when Wullstein published a method of closing perforations with a split thickness skin graft. Only a year later Zollner described his experiences with a similar graft: Wullstein and House then advised a full thickness graft taken from behind the ear. In 1961 Storrs used temporal fascia in order to close a tympanic perforation. Over the past three decades temporal fascia has been the most commonly used grafting material in tympanoplasty operations, although tragal perichondrium, periosteum, loose overlay tissue, fat, vein, and homologous dura are also employed.

Since the fundamental principles of tympanoplasty were introduced by Wullstein and Zollner, surgery of the ear has been directed toward the restoration of function as well as providing a stabilized trouble-free ear. Zollner and Wullstein provided a classification of tympanoplasty that focused on the type of ossicular chain reconstruction (OCR) needed. The five types of tympanoplasty they described refer to the most lateral intact structure on which the conductive mechanism will be constructed. Type I tympanoplasty indicates all three ossicles to be present and mobile. Thus, OCR is not needed. Type II grafts the tympanic membrane to an intact incus and stapes. A type III exists when an intact mobile stapes superstructure is present and the tympanic membrane or graft remains directly on the stapes superstructure. Type IV describes an absent or eroded superstructure with the graft or tympanic membrane overlying a mobile stapes footplate. Type V tympanoplasty refers to a fenestration created in the horizontal semicircular canal.

Permanent central perforations of the tympanic membrane may be of traumatic origin, but more often result from an acute suppurative otitis media of the necrotic type. After the acute necrotic otitis media has subsided, the perforation may heal spontaneously by means of a thin atrophic scar, or it may remain open permanently. Trauma leading to a permanent perforation of the tympanic membrane may be the result of sudden or explosive alterations in air pressure in the external meatus, or of hot water, slag or acid entering the meatus; or it may follow a lightning stroke or skull fracture. Patients with trauma typically
complain of the sudden onset of pain with associated hearing loss and occasional bloody otorrhea. Surgical trauma and prolonged use of ventilation tubes are additional causes. Traumatic perforations more often become permanent when accompanied or followed by an acute suppurative otitis media. 2

This discussion will focus on tympanoplasty and reconstruction of the tympanic membrane and will leave ossicular chain reconstruction for future talks. Pediatric tympanoplasty and its controversies with management will be covered with more detail.

**Basic Science – Sound Transmission**

The middle ear transforms acoustic energy from the medium of air to the medium of fluid. It is an impedance-matching system that ensures that energy is not lost. This impedance matching is accomplished by the area effect of the tympanic membrane and the lever action of the ossicular chain. Although the area of the adult tympanic membrane is between 85 and 90 mm², only about 55 mm² effectively vibrates (the lower 2/3 of the drum); the stapes footplate is 3.2 mm². Thus, the ratio of the vibrating portion of the tympanic membrane to that of the stapes footplate results in a 17:1 increase in sound energy. Also because the handle of the malleus is approximately 1.3 times longer than the incus long process, the force (pressure) received at the stapes footplate, through the use of leverage, is greater than that at the malleus by about 1.3:1. Thus, the combined transformer ratio of the middle ear is about 22:1 (17 x 1.3 = 22). This translates to approximately 25 dB.

A simple perforation of the tympanic membrane without other lesions of the middle ear transformer has two different effects on the hearing. First, there is the diminished surface of tympanic membrane on which sound pressure is exerted, causing diminished excursions of the ossicular chain. For a small perforation one mm in size Bekesy found that the loss of ossicular motion is confined to sounds below 400 cycles; it is 12 dB for 100 and 200 cycles, 29 dB for 50 cycles and 48 dB for the lowest audible frequency of 10 cycles. The larger the perforation, the greater the loss of surface on which sound pressure can act, with the additional factor that sound pressure entering the middle ear through the perforation acts on the posterior surface of the tympanic membrane against the sound pressure on the outer surface.

The second effect on the hearing of a simple perforation results from sound reaching the round window directly without the dampening and phase-changing effect of the intact tympanic membrane. This effect becomes greater with a larger perforation. Moreover, as the size of the remnant of tympanic membrane decreases, the hydraulic advantage produced by a large tympanic membrane on a small oval window disappears, so that sound reaches both windows with more nearly equal force and at nearly the same time. The resultant cancellation of vibratory movement of the cochlear fluid column produces the maximum hearing loss observed in simple perforation, as much as 42 dB for the speech frequencies.

When healing of a perforation of the tympanic membrane results in the elimination of the air-bone audiometric gap, with the restoration of normal hearing, it is reasonable to assume that the hearing loss was solely the result of the perforation and not due in part to other lesions of the ossicles or cochlea. In general, the larger the perforation, the greater the hearing impairment, but this relationship is not constant and consistent in clinical practice; seemingly identical perforations in size and location produce different degrees of hearing loss. The reasons for the variations in the hearing effects of simple perforations are not easily defined. 2

**Indications**

Successful tympanoplasty, according to Sheehy is dependent on the achievement of a threefold goal: the eradication of pathologic conditions, if present; an intact tympanic membrane with an air-containing, mucous membrane-lined middle ear cleft; and a secure connection between the mobile drum and the inner ear. 4

The reasons for tympanoplasty are to eliminate recurrent disease, provide a dry ear canal and middle ear space with an intact tympanic membrane, and improve hearing. This includes perforation or hearing loss due to trauma, infection, or prior surgery that persists for more than three months. Inability to safely bathe or participate in water activities because of perforation of the tympanic membrane, with or without hearing loss is also an indication.
Technique

Preoperative care

The preoperative assessment includes key historical information that must be considered. Age of onset, drainage, eustachian tube function, and previous surgery are the key historical factors. The extent of the perforation, presence of cholesteatoma, continuity of the lateral attic wall, presence of tympanosclerosis, status of the annulus and ossicles, segmental middle ear aeration, and physiology of the ear canal skin are all evaluated. In general, careful otomicroscopy will give its own history. Also any previous operative reports must be reviewed although they may not reflect the current status of the middle ear. Every effort should be made to dry the ear with topical drops, systemic antibiotics, or both.

Audiometric evaluation is necessary and includes tuning fork testing by the surgeon, air-bone-speech audiometry, and an index of suspicion for Tullio’s phenomenon which may be a subtle sign for labrynthine fistula. Tullio’s phenomenon is said to be present when a loud noise precipitates vertigo.

During the preoperative period the risks, benefits, and alternatives of the procedure need to be discussed in the process of informed consent. General postoperative care should also be included in the preoperative visit.

Intraoperative technique

Tympanoplasty is usually performed under general endotracheal anesthesia although patients who are reluctant to undergo general anesthesia may be given local anesthesia supplemented with intravenous sedation. Nitrous oxide should be avoided as it can shift the graft position. Muscle relaxants should also be avoided if possible. The postauricular and canal skin are initially injected with 1% lidocaine with 1:100,000 concentration of epinephrine to assist with hemostasis.

Medial and lateral grafting techniques are probably equally successful in the hands of experienced surgeons. Despite this, experience has borne the conclusion that the medial or underlay technique is more suited to inexperienced residents or the occasional otologic surgeon because of its decreased complication rates.

Tympanoplasty is typically performed via a postauricular approach although transcanal approaches are also utilized. The postauricular incision is made approximately 1 cm behind the postauricular crease, a location that simplifies closure. A large temporalis fascia graft is harvested, cleaned of residual muscle, and placed on a ceramic block to allow drying. A T-shaped incision is made in the peristium overlying the mastoid. The peristium is elevated and moved anteriorly into the ear canal. The canal skin and periosteum is elevated using a duckbill elevator or round knife. A self-retaining retractor is placed to retract the canal skin and the ear forward. The canal incision is designed to create a laterally based canal skin flap or vascular strip. The horizontal incision is cut first approximately 2 to 5 mm lateral to the annulus from the 12 to the 8 o’clock position (right ear). The vertical incisions are made next. The superior limb follows the tympanosquamous suture line and the inferior limb follows the tympanomastoid suture line. A tympanomeatal flap is elevated anteriorly until the perforation is reached. The margins of the perforations are debrided and any other middle ear pathology is dealt with at this time.

The eustachian tube and middle ear are then packed with gelfoam. The fascia graft is then shaped to the proper size needed for the perforation. It is then carefully tucked into position under the anterior tympanic membrane remnant and onto the posterior canal wall. The annulus is then placed back into position posteriorly and the vascular strip is carefully moved into its anatomic place. Gelfoam is placed over the drum remnant, graft, and vascular strip and the external canal is filled with bacitracin ointment. The postauricular incision is closed subcutaneously with absorbable suture and steri-strips are applied over the incision. A mastoid dressing is applied to provide light pressure and protection. The patient is then carefully awakened from anesthesia attempting to avoid unnecessary coughing or straining which could increase eustachian tube and middle ear pressure.
Postoperative care

Hospital discharge occurs the same day of surgery, and the mastoid dressing is removed the following day by the patient or a family member. The incisions can be cleaned twice daily with hydrogen peroxide and topical antibiotic drops are applied twice daily. The steri-strips are removed in one week. Patients are instructed to follow dry ear precautions and limit activity initially to avoid Valsalva maneuvers.

Patients are seen at three weeks to remove and suction the packing from the external auditory canal and to ensure that adequate healing has begun. They are seen again at six weeks to evaluate complete healing and obtain a postoperative audiogram.

Complications

The complications associated with tympanoplasty are usually the result of two factors: first, the extent of destruction caused by the disease process, exposing vital structures to injury, and second, surgical accidents.

Postoperative infections are considered a complication and can be due to poor aseptic technique or to the presence of bacteria in the ear at the time of surgery. Graft failure is a complication that is often associated with postoperative infection. Graft failure can also occur because of inadequate packing of the anterior mesotympanum with gelfoam. This allows the anterior graft to fall away from the anterior drum remnant. Faulty undersurface grafting technique will often result in graft failure.

Chondritis is rare but can be a significant problem requiring antibiotics. This can occur if the vertical incision is carried too far laterally into the conchal cartilage. Small epithelial pearls or “drum cholesteatomas” occasionally develop postoperatively and are more common with the lateral grafting technique. These can be removed in the clinic with the cooperative patient by uncapping the dome and removing the pearl. Leaving remnants of epithelium on the tympanic membrane or anterior inferior sulcus when elevating the external canal skin from the medial canal can result in residual drum or canal cholesteatomas.

Injury to the chorda tympani nerve results in disturbances of sensation of the tongue and the sense of taste usually described as metallic. This typically results when the chorda is stretched, dessicated, or divided. Patients may remain symptomatic for 4 to 6 months or occasionally have permanent dysfunction.

Sensorineural hearing loss and vertigo are rare. Excessive manipulation or trauma to the ossicular chain may be transmitted to the inner ear. A greater conductive hearing loss may develop despite successful repair of a tympanic membrane perforation. Explanations for an unexpected result include an unrecognized eroded incudostapedial joint, significant blunting of the anterior sulcus, or lateralization of the tympanic membrane from the malleus handle and umbo.

Some complications have to do with the type of technique employed. For instance, lateralization and anterior blunting of the graft occur most commonly with the overlay technique, as does stenosis of the external auditory canal. A graft that is too thick, placed beyond the fibrous annulus, and extended onto the anterior inferior canal wall may result in blunting. This can be avoided by trimming the graft to the appropriate size and shape. The ear canal skin may attempt to heal with cicatricial midcanal soft tissue stenosis. If left unattended, this appears to be a laterized drum. In the immediate postoperative period most patients have relatively insensate canals, allowing office debridement and stenting with Merocel stents or wicks.

Results

Closure of perforation

Ideally, all tympanoplasty efforts result in an intact tympanic membrane. Tympanic membrane grafting in a clean, dry ear with normal eustachian tube function should be successful routinely. Residual perforations do occur and frustrate the surgeon and the patient. One must attempt to determine whether failure of the graft was due to technical error, infectious complications, or poor tubal function. Failure due
to the first two reasons are often amenable to revision surgery. Patients with poor tubal function and recurrent otorrhea may require a revision tympanomastoidectomy.  

Smyth in his 1992 Toynbee Memorial Lecture stated that most publications that discuss the results obtained with tympanoplasty report a success rate of around 90 percent. Such a statistic can be seen as justifying modern techniques of tympanic membrane repair and engendering patient’s confidence. However, reliance on the available data must be diminished if the frequently short durations of follow-up and the usual methods of calculating success rates are taken into account. Observation times in the majority of operated ears are less than one year. Most data analyses are confined to numbers of ears with maintained healing of the tympanic membrane and do not include the formation of atelectatic pockets.

Halik and Smyth found a success rate of 89% with regard to maintained healing of the tympanic membrane and 95% with regard to atelectatic pocket formation. When corrected with survival life-table analysis they found their rate dropped to 81% for successful closure and 91% for avoidance of atelectatic pocket formation at 11 years. They found that reperforation and atelectatic pocket formation occurred with relentless frequency to at least 11 years. They also noted a poorer rate of subsequent success in these patients who redeveloped perforations and quoted a rate of approximately 60%. They feel that long-term results of 90% success or better are difficult to achieve even by experienced otologic surgeons. They found that the type of middle ear secretion present at surgery had no effect on result. Homograft dura and autologous temporalis fascia had no significant difference in take rates. They did report a trend for better results when using fascia and operating on dry ears. Many authors have reported less success with closure of anterior perforations. Recent work has shown the anterior portion of the tympanic membrane to be the least vascular. They recommend autologous temporalis fascia in this area as it is less antigenic, has a low metabolic rate, and is better able to withstand prolonged anoxia.

Hearing

Albu et al found many anatomic and technical factors responsible for postoperative hearing results. The mucosal status of the middle ear was the most important predictive factor. The presence of the manubrium mallei was the second most important predictive factor as it allows for the proper adaptation of the myringoplasty graft and optimizes the stability of the reconstructed ossicular chain. In cases with perforated TM, perforations <50% of the drum surface performed significantly better than larger ones. Halik and Smyth contradict this and found that secretion type, site of perforation, and graft material had no adverse effect on hearing. They report their success rates as being comparable to other quoted literature. They had approximately an 80% success rate of closure of the air-bone gap to within 10 dB at five years but could not comment on results beyond this period as many of their patients were discharged from follow up. They recommended aiming for a final air-conduction threshold less than 30 dB or within 15 dB of the other ear for the patient to benefit from binaural hearing and sound localization.

Controversies

Children

Otologic surgery in children is considered to be less successful than in adult patients. Success rates for pediatric tympanoplasties are reported to range from 35 to 93%. Most consider the higher incidence of otitis media and eustachian tube dysfunction in the pediatric population as the reason for poorer results. Most consider cholesteatoma or the chronically draining ear that is resistant to medical therapy as indications for surgery. The management of patients with persistent perforation of the tympanic membrane, with or without intermittent otorrhea, is cause of considerable controversy. Numerous factors to predict success or failure in elective cases have been studied including: age, surgical technique, status of the contralateral ear, presence of adenoids, presence of active infection, size of the perforation, and eustachian tube function. There is no consensus of opinion despite extensive literature on the topic.

The different views on the right time of closing a dry perforation on children can be summarized as follows: 1) A perforation should not be closed before the child has attained school age. 2) A perforation should not be closed before the child has reached the age of 10 to 14 years; and in cases of bilateral perforations in which tubal function is considered to be seriously affected, the child should be at least 12
years of age. 3) The indications for surgery in noncholesteatomatous chronic otitis media and its sequelae should be very strict. 4) In older children the ear must be dry for a period of at least one year, and in younger children for two years, before the perforation is closed.

In discussing the need and timing for tympanoplasty in children, the following points must be considered. 1) Frequent upper respiratory tract infections and frequent episodes of acute OM may be contraindications, 2) narrow external auditory canals and technical difficulties are more frequent in children than in adults, 3) tubal function is poorer in children than in adults, 4) poorer long-term results occur in children than in adults and a high reperforation rate is present, and 5) closure of the perforation may result in secretory otitis with fluid accumulation or retraction and adhesive otitis; there is no immediate need for closing a small unilateral perforation associated with only a minor hearing impairment, particularly in view of the associated difficulties and complications. A small perforation may even function as a useful ventilation tube.

Despite all of this concern, Tos and Lau found high take rates and found that the age of the child is not a decisive factor in the success rate of tympanoplasty which, “when performed for the right indications, is a more rewarding procedure in children than in adults.” They found that tympanoplasty at an early age helps to lessen progression of ossicular pathology and recommended early closure because of this concern. They quote a graft-take rate of 92% with only four late perforations (6 of 10 reperforations were closed with repeat procedures) at an observation time up to 15 years. They report closure of the air-bone gap to within 20 dB in 88% and only a 5% rate of subsequent insertion of grommets secondary to middle ear effusions. They do not mention rates of atelectatic pocket formation. Podoshin et al studied older children aged 9 to 14 trying to define the “magic age” of closure and report a “success rate” of 92% but do not comment on rates of residual disease or reperforation.

Many authors dispute this high success rate although they concede that initial healing rates can be as high as in the adult population. They contend that delayed failure and recurrence of middle ear disease prohibit long term success in the majority of patients. A study by Manning et al found successful closure of the tympanic membrane in 78% of tympanoplasties initially but only 52% had a healed graft with good postoperative middle ear function. Gianoli et al had a 92% rate of successful graft healing but when using the strictest reporting criteria at two years of followup only had a 38% success rate. They also found that patients with previous adenoidectomy and more impressively adenotonsillectomy had statistically higher success rates of tympanoplasty.

Vrabec and Deskin recently performed a meta-analysis of all the variables commonly questioned in the literature and found that advancing age is the only parameter that reached statistical significance when judging for success of the procedure. No other factor could be definitively associated with success.

It’s obvious from all the dispute on tympanoplasty success, especially in the pediatric age-group, that outcome measures need to be standardized. The ability to use published literature in guiding your management of pediatric patients has been compromised by variable reporting methods. There are many different definitions of success and many authors use different criteria to guage this. The ultimate objectives of the surgery are repair of an anatomic deformity and improved function, but a lower incidence of recurrent disease is critical for long-term success. This incidence of recurrent disease needs to be uniformly presented in future studies along with longer followup data in order to come to a more scientific conclusion.

Case Report

A six year old white male with a previous history of chronic otitis media with effusion since the age of one year is referred by his local pediatrician. He has required bilateral myringotomy tubes twice in the past, the last occurring at age three. Both tubes extruded approximately one year ago per the mother and the right ear has had a persistent perforation over this period.

The mother reports occasional yellow discharge from the right ear one to two times a summer after the child goes swimming but she does have him use swim plugs. He has gotten an “ear infection” in the left ear twice in the past year usually occurring with URI’s. She said the last episode required a two week course of additional antibiotics “because the fluid wouldn’t go away.” The child denies any hearing problems, otalgia, tinnitus, or vertigo.
Physical exam reveals a healthy, playful child who is hesitant in allowing full exam. His right ear exam reveals a 30% dry anterior perforation with healthy middle ear mucosa. His left ear reveals some tympanosclerosis more prominent anteriorly, retraction of the TM, and mobility only on negative pressure. The remainder of the ENT exam is normal.

Audiogram reveals a mild conductive hearing loss AD with PTA of 27 and 10 dB respectively.

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After following the child for several years he is now nine years old. He does complain of a slight decrease in his hearing AD but still denies otalgia, vertigo, or tinnitus. On physical exam he is cooperative and attentive. His right ear still has a dry anterior perforation of approximately 30% with healthy middle ear mucosa. There is no evidence of cholesteatoma or other middle ear pathology.

The audiogram is essentially unchanged with a mild CHL AD with PTA of 25 and 7 dB respectively.

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Bibliography

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