

# A Review on the History of Tympanoplasty

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**Abstract** The history of myringoplasty and tympanoplasty is one of the most interesting in the history of ear surgery. The aims and ambitions of otologists have evolved along with time and experience. The objective of this article is to give an idea about the evolution of tympanoplasty, thus giving inspiration to future surgeons in their quest for a perfect technique which would be as good as a normal ear and its hearing. The history of otology starts from the early Egyptian healers. Hippocrates in his time observed that ear infections may be cause of death especially in young children. Early surgeries were performed mainly for drainage in order to save the life of the child having the ear disease. With time and scientific developments newer methods of treatment started to evolve. The invention of antimicrobials and their usage threw a new light into the treatment of otology infections. Then after the advent of microscope and with better understanding of the anatomy and physiology of ear and its diseases treatment strategies and surgical planning kept on advancing. Surgeons with time have become more interested in returning back the hearing along with curing infection from ear. But the quest is on for the perfect surgical technique which would give best results with minimal maneuvering. History of tympanoplasty nearly sums up the history of evolution of otology as a whole. The quest is still on to devise a way so as to give maximum post-operative hearing using minimal instrumentation.

**Keywords** History · Tympanoplasty · Evolution

## Introduction

The history of myringoplasty and tympanoplasty is a chapter which is worth remembering in the history of ear surgery. In the early years the aim of physicians was to primarily eradicate disease and save life of the patient, but with time the otology surgery have attained a state of art. The aim of otology surgeons at present is to provide with maximal hearing to the patient along with eradication of disease.

The present state of art in otologic surgery has evolved from multiple coincidences over the period of time. The provision of a dry ear was the main concern in the search to improve hearing along with closure of the drum. The development of tympanoplasty techniques were led by incidental and inspirational contributions from surgeons over the world. The discovery of the importance of tympanic membrane and ossicles in hearing and the advent of antimicrobials added up to better understanding the diseases and their treatment subsequently. Specialized instruments like the ocular magnifying loupe, and the operating microscope opened up a new dimension to the otology surgery. The search for an ideal graft material, and an ideal technique of performing the surgery kept the subject evolving and growing.

Myringoplasty is a surgical procedure which is confined to the drumhead without manipulation of the ossicles or middle ear. Tympanoplasty is the surgical procedure which includes the manipulation of the tympanic membrane and eradication of disease from the middle ear if present, if it is done in conjunction with manipulation of the ossicles it's known as tympanopossiculoplasty. Surgery that includes manipulation of mastoids along with tympanoplasty is known as tympanoplasty with mastoidectomy.

History always provides an insight into the future. The objective of this article is to give an idea about the

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evolution of tympanoplasty, thus giving inspiration to future surgeons in their quest for a perfect technique which would be as good as a normal ear and its hearing.

### The Surgical Evolution

From the very early times ear discharge used to be associated with dreadful consequences even by the Egyptian healers [1].

Hippocrates had observed that “acute pain of the ear with continued strong fevers is to be dreaded, for there is danger that the man may become delirious and die.” The early surgery for draining ear used to be lifesaving and was actually a mastoid surgery [2].

Banzer was the first to attempt repairing a perforated tympanic membrane. In 1640 he used a pig’s bladder stretched across an ivory tube and placed in the ear and obtained hearing improvement temporarily [3].

Jean Petit of Paris performed the first documented successful surgery for mastoid infection [4]. Thereafter a Prussian surgeon, Jasser performed a mastoid operation in a soldier with draining ear in 1776. But this operation was discredited when Bergen the physician of the King of Denmark died of sepsis following this operation. Bergen wrongfully presumed that his deafness and tinnitus would be cured if this operation is done on him. His death led the ear operations into the oblivion for at least for a century [5].

Then almost after a century Toynbee in 1853 placed a rubber disc attached over a silver wire over a perforation resulting in hearing improvement [6]. In 1853, Sir William Wilde published a procedure for sepsis and ear suppuration, where he described a post auricular incision and removal of the mastoid cortex. This most probably heralded the advent of a modern era of otosurgery [7]. After almost 20 years, Herman Schwartz in 1873 published an article stating the indications and procedure of mastoid operation. He in his publication had stated how to remove mastoid cortex and the underlying air cells with a mallet and chisel for acute mastoid infection. This technique of simple mastoidectomy was the main treatment of acute mastoiditis thus saving many lives. This technique of using mallet and chisel to perform mastoidectomy got appreciated and it persisted for about 75–80 years [8].

Otitis media was responsible was considered a dreadful disease as it used to be the reason for death of many children before the era of antibiotics. Simple mastoidectomy described by Swartz was the surgical procedure which used to save a lot of lives and became the main treatment of acute mastoiditis. Von Troltschin 1873 and then Von Bergmenn included attic and antrum thus expanding Swartz’s simple mastoidectomy. Their inclusion

of attic and antrum in the mastoidectomy increased the success of the suppurative ear surgery [9, 10]. In order for better control of chronically draining ear, Zaufal and Stacke described radical mastoidectomy [11, 12]. The surgical techniques thus described so far are all of importance and practiced in some way or the other till today. But for nearly 50 years after that, the progress got stagnant till the advent of Microscope and Antimicrobials.

Blake in 1877, placed a paper patch on a tympanic membrane perforation and observed hearing improvement in a number of patients [13]. The first true tympanoplasty is said to be performed by Berthold in 1878. He de-epithelialized the tympanic membrane remnant by applying plaster against it for 3 days. Then removing it along with the underlying epithelium, and then placing a skin graft over the defect [14].

Then came the sea change and in the twentieth century ear surgery advanced in leaps and bounds. The previous century surgical techniques made the surgeons to have better control over disease. The powerful new antimicrobials of the ‘30 s made it possible for surgeons to control infection and get dry ears. Then with the incorporation of operating microscope and instruments they became more equipped to in examining the ear and manipulating the drum and ossicles.

Thus the popularity and success that the technique of tympanoplasty had gained can be credited to many other surgeons who had refined each other’s techniques in the quest of better results.

The revolutionary change of tympanoplasty began in 1950s due to a number of reasons which includes the antimicrobials, incorporation of operating microscopes and the newly designed microscopic instruments. After Wullstein [15] and Zollner [16] introduced tympanoplasty in early 1950s, overlay graft was being used in all surgeries. The article “tympanoplasty as an operation to improve hearing in chronic otitis media and its results” by Wullstein had prepared the arena for the operation to be performed with a goal to improve hearing and protect the middle ear from the outside environment [15]. Split thickness and full thickness skin graft were being used at that period of time, but graft eczema, desquamation, with poor long term results made surgeons search for alternate grafting materials. Canal skin pedicle grafts had been used by Sooy in 1956 [17]. House and Sheehy [18, 19] and Plester [20] began using canal skin as free overlay graft independently of each other in 1958. Satisfactory techniques were created by House, Sheehy and Glasscock [21] in respect to the onlay placement of the tympanic membrane graft.

Shea during a surgical misadventure while performing stapedectomy found out that vein graft can be placed under the ear drum to repair satisfactorily in 1959 [22]. Austin [23] and Tabb [24] working independently also employed

vein as an undersurface graft to repair tympanic membrane perforations in 1959. But problem arose when vein graft tended to atrophy and get re-perforated over a period of few months.

Storrs then discovered the use of fascia in grafting and his thoughts were seconded by Patterson, who in his study had stated the reasons for the success of a fascia as a grafting material. Storrs in 1961 was the first to describe the undersurface fascia technique used in the United States of America. The use of connective tissue graft solved most of the problems faced with free skin grafts [25, 26].

In 1964 Ned Chalot was the first to perform tympanoplasty with homograft tympanic membrane in US. The experience of whom were reported in the Harper Hospital Bulletin, and was unnoticed for many years [23]. Promising results were reported by many authors starting in 1968 by House and Glasscock, closely followed by Perkins, Smith and Wehrs [27–31]. But the procurement and sterilization became a stumbling block with this technique. Down the years otolaryngologists have been using myriad living or homograft's which include loose areolar tissue, perichondrium, cartilage fat and periosteum [32, 33]. But fascia has scored over all of them because of its internal structure and its abundance in the operative field. The internal structure of mucopolysaccharides and collagen most probably accounts for its high success rate. Collagen provides the tensile strength to the wound area and the complex mucopolysaccharides play a role in the healing process by attracting fibroblasts into the wound area by chemotaxis [34].

The surgical procedure tympanoplasty has achieved a state of art over the years. Various techniques have been attempted in order to achieve better results with improved hearing. These include the overlay tympanoplasty [18], the underlay tympanoplasty [35], over underlay tympanoplasty [36], Gelfilmsandwich tympanoplasty [37], Crown cork tympanoplasty [38], swinging door tympanoplasty [39], laser assisted spot welding techniques [40], and microclip techniques [41] and others like the fascial pegging [42], annular wedge tympanoplasty [43], loop tympanoplasty [44] which are but modifications of the basic technique. Office tympanoplasty techniques like the paper patching, lobule fat graft and the self-stabilizing tympanic membrane patchers [45].

### Overlay

In the 1960s the overlay technique consisted of removing the surface epithelium of the drum after assessment, through a preferred incision. Then a graft was placed on the perforation and the ear packed with various materials.

Storr's results of tympanoplasty had been inspiring but the dismal outcome of canal skin grafts, made Sheehy and Glasscock [46] replace the pedicled canal skin grafts with

temporalis fascia overlay grafts. They concluded that the high survival rate of dry fascia grafts was due to low metabolic rate as well as low viability.

### Underlay

Originally this technique was described by Shea. When vein and fascia could be placed beneath tympanic membrane remnant the groundwork for underlay procedure was laid [35, 47].

Doyle et al. in his study in 1972 compared overlay with underlay techniques of tympanoplasty and concluded that in inexperienced hands the medial grafting of tympanic membrane gives better healing and fewer complications [48]. But the problem of this study was that, at that time endaural technique was infrequently taught and practiced in the 1990s.

Glasscock in his study in 1973 [49] compared the techniques of overlay and underlay tympanoplasty. 57 cases were performed with the overlay technique and 180 were performed with underlay technique. The overlay techniques had complications like epithelial pearl, some degree of blunting, and lateralization of the graft occurred in all the cases without a malleus. On the other hand underlay technique had minimal complications and better success rate 96 %, 4 % more than overlay technique. There were no cases of anterior blunting, graft lateralization or epithelial pearl formation. In cases where underlay technique was used the graft healed faster taking only 1–3 weeks, whereas in overlay technique it took 4–6 weeks to heal [50].

Sheehy and Anderson in their study at House Ear Clinic at Los Angeles, on tympanoplasty had made some conclusions which are: Graft failure is more common when the surgeon operates through a speculum, canal skin is inferior to fascia for tympanoplasty and hearing results are poorer in the ears with worse pre-operative hearing results (suggesting presence of ossicular difficulties) [49]

The advantages and disadvantages of the two procedures are summarized below.

The advantages of the underlay technique:

1. Anterior blunting and lateralization of the graft can be avoided.
2. The level of healing of the drum is correct in respect to the annulus and ossicles
3. It is quick and easy to perform.
4. An ideal technique to repair tympanic membrane perforations that are small and easily visualized.

The disadvantages of the underlay technique:

1. The middle ear space is reduced. Especially in cases where there is extensive middle ear mucosal disease

with or without malleus retraction. Adhesions may result if sialistic films are not placed in between the promontory and the drum.

2. Adhesions may also be invited by the presence of gelfoams in the middle ear.
3. If a transcanal approach is used, the exposure of the middle ear is limited.
4. Chances of failure is there as there is a limited bed size for the graft, because there is only a limited area of mucosa that can be denuded blindly through the perforation to serve as the graft bed.
5. For perforations extending into the anterior annulus this is not an ideal technique because the graft placement is difficult.

The advantages of overlay tympanoplasty:

1. The visualization of the anterior meatal recess is very good, which is important in cases of anterior perforations, especially in cases which reach the anterior annulus.
2. Good success rate as the drum is replaced intact at the end of the procedure. Healing tends to occur centrally and there is no defect in the drum.
3. Middle ear space remains unreduced because the graft is placed on the external surface of the tympanic membrane remnant.

The disadvantages of overlay technique:

1. The conspicuous disadvantages are blunting of the anterior meatal recess and lateralization of the graft.
2. Squamous cysts may form if remnants of the drum epithelium are left behind while meatal flaps are being developed.
3. In cases of small perforations overlay technique tends to be more laborious than what is required.
4. Healing may take longer time

#### Over Underlay Tympanoplasty

Over-underlay tympanoplasty had been developed as a combination of the techniques described before i.e. overlay and underlay. It had come up as quite a simple technique in nearly all tympanoplasty situations, especially in situations where malleus is present.

In this the temporalis fascia graft was placed lateral to the long process of and medial to the tympanic membrane remnant and anterior annulus. The advantages of this technique are: (1) can be performed in all types of perforations in any quadrant of the tympanic membrane, (2) the exposure of the anterior middle ear is very good, (3) anterior blunting not present, (4) good success rate, (5) relatively simple to perform, (6) middle ear space is not reduced.

The success of this procedure can also be attributed to its properties which addresses the problems of the previous techniques. The total elevation of the tympanic membrane remnant from the malleus has the following advantages: (1) the overlap between the graft and drum remnant is increased, (2) the graft bed is better prepared, (3) the graft placement is precise unhindered by the malleus and (4) a very good medial support provided by the handle of malleus. The malleus which otherwise is a liability in other techniques plays an important role in this procedure. To add to it the over-underlay tympanoplasty is well suited for use in ossicular reconstruction surgeries by the virtue of its graft position [36].

#### Gel Film Tympanoplasty

In this technique two sheets of gelatin films are placed on either side of the graft and tympanic membrane remnant like a sandwich, so that support is being given medially and there is a lateral cover to the fascia grafts. The success rates of this technique were found to be satisfactory by the author [37]

#### Crowncork Tympanoplasty

The “crown cork tympanoplasty” is a technique especially suited for cases of ear malformation, blunting phenomenon, and total deficiency of tympanic which needs a total reconstruction of the tympanic membrane.

The technique involves removal of canal skin in continuity with the squamous epithelium of the tympanic membrane remnant, after exposure of the plane of the tympanic membrane. A cartilaginous transplant with a widely overlapping perichondrium is taken from the tragus. The cartilage diameter is smaller from that of the canal so that the vibration is optimal. The overlapping perichondrium is incised radially and fixed to the canal wall bone giving it a shape of a crown-cork. The inner side of the cartilage is brought in contact with the malleus or prosthesis. In this study the tympanic membrane remained intact with no atelectatic change in the post-operative period [38].

#### Swinging Door Tympanoplasty

Swinging door tympanoplasty was first described by Palva et al. in 1969 [51]. In this technique canal incisions are designed to create a laterally based skin flap which would be larger than standard vascular strip flap. Elevating the canal skin and the fibrous annulus, mesotympanum is entered. Then the tympanomeatal flap, the fibrous annulus and the tympanic membrane are cut vertically (or laterally) to create the swinging door flaps. After elevation of the

flaps the margin of the perforation is resected and if need be the undersurface of the tympanic membrane is abraded. The middle ear is packed with gelfoam following which the graft is placed. After proper placement of the graft the swinging door flaps are rotated on the graft placed. According to the author this is a very easy technique for tympanoplasty especially for beginners. From his study he had concluded that despite the fact that it is performed by residents it has a good success rate [39].

#### Laser Assisted Spot Welding Techniques

This technique was first reportedly used by Escudero et al. in 1977 [52]. In his study he had used argon laser for hemostasis by directly applying on to the bleeding vessel, and after placing the fascia. After placement of the temporalis fascia graft the laser was applied in the tympanic area so as to make it coincide with the underlying cone of the external auditory canal. An average ten spots were applied per case, the immediate effect being contraction of the tissue. The graft adhered to the underlying bone which was tested by pulling at the edges. These points of adherence are the areas of vascularization of the graft in the immediate post-operative period. Thus in this study they found out the use of laser in tympanoplasty techniques [52–54].

#### Microclip Technique

In this technique 1 mm stainless steel microclips are used to hold the tympanic graft securely in position. Williams et al. in 1977 discussed about this technique in his study claiming to have had satisfactory results with the technique [41].

#### Endoscopic Tympanoplasty

The newest technique of performing tympanoplasty, the endoscopic tympanoplasty. Initially endoscope was being used for exploration and operations were mainly performed with the microscope. The use of endoscope as the main tool for surgery needs change in surgical procedures. In a study done by Marchioni et al. in 2010 [55], he operated on patients having non self-cleansing attic retraction pockets Type3 and Type4 (according to Sudoff and Tos). The exclusion criteria of his study were patients having pars tensa retractions, suspected middle ear cholesteatoma, simple chronic otitis media, or patients who had undergone middle ear surgery before.

Three main types of tympanoplasty were performed with endoscopic surgical treatment of attic retraction pockets. The tympanoplasties were dependent on the ossicular chain conditions, tensor fold anatomy, scutum

erosion, and the extent of the pathology. These tympanoplasties were based on principles which strongly depend on the physiopathologic theories of selective dysventilation of the epitympanic compartment, and they were focused on the restoration of an adequate ventilation route between the mesotympanum and epitympanum.

Surgical treatment of attic retraction pockets can be achieved by sparing the mastoid and without external incisions with an exclusive endoscopic approach. Only long-term follow-up will be able to confirm results in terms of recurrent disease compared to traditional microscopic techniques [56–58, 59].

#### Conclusion

Thus the history of tympanoplasty nearly sums up the history of evolution of otology as a whole. As physicians started to understand physiology and anatomy better, their understanding of the diseases of ear and its treatment also got better. The advent of antimicrobials significantly decreased the morbidity of ear disease, and the incorporation of microscope in operations made a surgical procedure like tympanoplasty possible. Learning from each other's failures surgeons started developing newer strategies and techniques of performing this operation. The goal for each surgeon, being to eradicate underlying disease and provide a functional hearing to the patient as far as practicable. The quest is still on to devise a way so as to give maximum post-operative hearing using minimal instrumentation.

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