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Cartilage Tympanoplasty for Management of TM Perforation: Review of Literature

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Abstract

The usual technique of tympanoplasty is the use of a temporalis fascia graft. The use of temporalis fascia has certain limitations. Another popular graft material is cartilage graft taken either from the tragus or concha. Presented is a review of the literature for cartilage tympanoplasty.

Introduction

The Tympanic Membrane (TM) plays a significant role in the physiology of hearing as well as in the pathophysiology of chronic inflammatory middle ear diseases. The TM perforations significantly impair the quality of life for millions of patients.[1] The term 'chronic ear disease' includes a wide range of clinical entities, including chronic otitis media, chronic suppurative otitis media (with and without cholesteatoma), chronic mastoiditis, tympanosclerosis, and cholesterol granuloma.[2]

There are a number of materials for closure of TM perforations like skin,[3] perichondrium,[4, 5] vein,[6] temporalis fascia,[7] dura[8] and cartilage.[9, 10, 11, 12] The most frequently used technique for the repair of tympanic membrane perforations is underlay grafting of temporalis fascia. In the cases of subtotal perforations, atelectatic ear, retraction pocket, ossiculoplasty or mastoid surgery long term results of temporalis fascia graft may not be very satisfactory.[13, 14]

To overcome this, perichondrium and/or cartilage grafts are used with good results. Cartilage is being used in place of temporalis fascia as a grafting material, especially for repairing large perforations, scutum defects, for preventing or correcting the failure of previous procedures associated with chronic tubal dysfunction, atelectatic tympanic membranes, and for enhancing the biocompatibility of ossicular prosthesis with the tympanic membrane.

Cartilage contributes minimally to an inflammatory tissue reaction and is well incorporated with tympanic membrane layers; it also provides firm support to prevent retraction. The greatest advantage of the cartilage graft has been thought to be its very low metabolic rate. It receives its nutrients by diffusion, is easy to work with because it is pliable, and it can resist deformation from pressure variations.[15]

Perichondrium and cartilage share with fascia the quality of being mesenchymal tissue,[15] but they are thicker and stiffer. They mechanically reduce the vibratory pattern of the tympanic membrane, contributing to some impairment in functional results, especially in the higher tones. The mass effect of the cartilage over the prosthesis is always a concern. Ayache, et al.[16] have reported delayed luxation of the stapes into the vestibule after cartilage tympanoplasty. Cartilage has lower compliance than fascia and hence, sudden pressure variations may not be well regulated with a more rigid tympanic membrane.

The perceived disadvantage of the cartilage graft is that it creates an opaque tympanic membrane, which could potentially hide a residual cholesteatoma.[17]

Review of Literature

Historical Review: The first published account to close the tympanic membrane perforation was in 1640 by Marcus Banzer who inserted a small ivory tube covered with pig's bladder as a lateral graft.[18] Yearsley, in 1841, applied a ball of cotton wool moistened with glycerin against a TM perforation.[19] In 1853 ,Toynbee placed a rubber disk attached to a silver wire over the TM and reported significant hearing improvement.[20] In 1876, Roosa treated TM perforations with chemical cautery using silver nitrate to promote healing of the perforation.[21] In 1895, Okuneff started using trichloracetic acid as the cauterizing agent, which is used even today. Blake covered perforations with paper patches in 1877 - this procedure is used today to demonstrate the improvement in hearing likely to be achieved by tympanoplasty. [18, 20, 21, 22]

The term 'myringoplastik' was first coined by Berthold[23] in 1878 and he used a full-thickness free skin graft for tympanic membrane closure. It was not until Joynt, who combined the cautery and paper patch techniques, resulting in improvement in results of TM closure,[24] forming the basis of the modern day use of the paper patch technique as popularized by Derlacki.[25]

In 1953, the Zeiss operating microscope became available commercially and, in the same year, Wullstein and Zöllner launched their tympanoplasty methods with a split-thickness skin graft[26] at the Fifth International Congress of Otorhinolaryngology in Amsterdam. Later, Zöllner described his experiences with a similar graft.[23] In 1956, Zöllner successfully used autologous fascia lata.[27] Heermann (1960) reported successful myringoplasty results using autologous temporalis fascia 'onlay' grafts and successful results were also reporting using tragal perichondrium (Goodhill, Harris and Brockman, 1964) and free autologous fat grafts (Ringenberg, 1962).[28]

Shea (1960) accidentally tore the tympanic membrane during a stapedectomy procedure and repaired the tear successfully with a free autologous vein graft placed medial to the tympanic membrane, thus introducing the 'underlay' technique of myringoplasty.[29] In the 1960s and 1970s, homograft (cadaveric) materials, including tympanic membrane, dura, and pericardium, among others, were used with varying success.[30,31,32,33,34,35]

Surgical Techniques: Use of temporalis fascia for tympanic membrane reconstruction: Temporalis fascia is the commonly used graft material for tympanic membrane reconstruction, because it is an autograft with an excellent chance of take up, available close to the site of operation making its harvesting easier, a low basal metabolic rate, increased success rate, and its thickness is more or less similar to that of a tympanic membrane.

Advantages of temporalis fascia graft: [36]

1. Easily available in sufficient quantity
2. Separate incision not required
3. Adequately firm
4. Thickness similar to TM
5. Low basal metabolic rate

Disadvantages of temporalis fascia graft: [36]

1. If it is not denuded properly of the muscles, then oxygen and the metabolic requirement increases and the graft may fail.
2. In revision cases, adequate graft maybe difficult to obtain.
3. Graft retraction
4. Graft medialization in cases of eustachian tube dysfunction.

Use of cartilage for tympanic membrane reconstruction: The use of cartilage to reconstruct the tympanic membrane is gaining popularity amongst otologists. Cartilage can be used in the form of several parallel, full-thickness strips (palisade technique) or in plates of different sizes and shapes; in the latter case, grafting can be modified by using composite cartilage-perichondrial grafts. Heermann was the first to introduce the cartilage palisade technique, in 1962. [9, 37]

Table 1: Cartilage graft vs temporalis fascia graft for tympanic membrane reconstruction.
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Table No.1: Cartilage Grafts VS Temporalis Fascia Graft for tympanic membrane reconstruction

study	Cartilage graft group	Comparative group	Outcome	Comment
Dornhoffer[37] 1997	22 cartilage tympanoplasties for perforations >25% TM size or subtotals cases	20 fascial perichondrium tympanoplasties for perforations >25% TM size or subtotals cases	Cartilage group: no residual perf, OME in 3 cases (13.6%), mean ABG = 6.8 dB Fascial perichondrium group residual perforations in 3 cases (15%), mean ABG = 7.7 dB	Number of cases too small for a case–control study Author claimed that amount of cartilage used in reconstruction did not adversely affect hearing
Gerber[38] et al 2000	11 cartilage tympanoplasties for medium sized perforations with intact chain	11 fascia tympanoplasties for medium sized perforations with intact chain	Majority of patients in both groups had ABG around 10 dB Conclusion: both groups' hearing results comparable	Number of cases too small for case–control study
Anderson[39] et al 2004	Cartilage palisade tympanoplasty in 52 children with small/mid cholesteatoma	Fascia tympanoplasties in 32 children with small/mid cholesteatoma during same period	Palisade group: 6% TM retraction, 75% of ears had hearing </=20 dB Fascia group: 36% TM retraction, 38% of ears had hearing </=20 dB For small cholesteatoma, palisade group has better mean hearing & smaller ABG 4 year post-op	Number of cases too small for a case–control study Fascia group had longer observation period than palisade group; many children had concomitant ossiculoplasties
Gersdorff et al 2004	112 cases with cartilage–perichondrium composite graft for myringoplasty	30 cases with temporalis fascia for myringoplasty	No significant hearing difference between 2 groups	Number of cases in comparator group too small for a case–control study
Christopoulos[40] et al 2005	59 may 'butterfly' cartilage graft in children	20 underlay fascia graft in children	Cartilage group: 71% TM closure, 5/59 myringitis, 5/59 retraction pocket Fascia group: 85% TM closure No post-op hearing difference between 2 groups	Number of cases too small for case control study Authors claimed the poor results of both groups was due to paediatric population

Salen used septal cartilage plates for subtotal tympanic membrane perforation, and Overbosch described a microslice technique in order to improve the acoustic properties of the reconstructed tympanic membrane.[39] Amedee, et al. reported on 52 cases of cartilage

palisade tympanoplasty used to treat recurrent perforations or atelectasis of the tympanic membrane.[40] Milewski used the cartilage palisade technique for "difficult" cases (i.e., large perforations, missing malleus, perforations above the tubal orifice, blunting, lateralization or atelectasis of the tympanic membrane, and second revisions).[38] Dornhoffer modified Heermann's technique by using several cartilage plates pieced together, like the pieces of a jigsaw puzzle, to reconstruct the posterior part of the tympanic membrane. However, Dornhoffer grafted the anterior half of the tympanic membrane with conventional materials in order to allow post-operative surveillance and tube insertion, if necessary. [39]

Murbe, et al. also described a modified cartilage plate technique, with several thin cartilage slices overlapping at their edges, like the petals of a tulip blossom.[41] The techniques of using composite cartilage-perichondrial grafts or island grafts for tympanic membrane reconstruction are even more variable, and a number of designs have been reported in the literature.

Goodhill described using perichondrial grafts with a circumferential cartilage in cases with a shallow middle-ear cavity, in order to avoid sagging of the perichondrium onto the promontory. Other surgeons have trimmed the cartilage part of the composite cartilage perichondrial graft into the shape of a "shield",[42] "double islands",[43] "Mercedes Benz" sign,[44] "wheel",[45] "coin with butterfly edges",[46] "crowncork" [47] or "lamellae" [48] among others. In general, cartilage tympanic membrane grafts have high "take" rates and the audiological results seem good. However, even cartilage grafts cannot prevent retraction pockets in some ears. Also, some authors reported rare cases of thinning[42] and even dissolution of the cartilage over time.[41] Eavey was the first to describe the butterfly cartilage inlay grafting technique. The edges of the cartilage perichondrial composite graft curve out like butterfly wings when the edge is split.[46] Fernandes also described a permeatal triple 'C' technique. The perichondrium is elevated only at the outer edge of the cartilage composite graft, circumferentially. The edge of the perforation is then wedged into the groove created between the perichondrial and cartilaginous layers, in order to keep the composite graft in place.[48] Both Eavey[46] and Fernandes used such inlay grafts only for small to medium-sized central perforations in which the surgeon could see the whole of the perforation, permeatally. However, Ghanem, et al.[17] extended the indication for Eavey's butterfly inlay graft to include medium-sized and large perforations, including even marginal ones. The overall results of these grafts appear good.

The rigidity of the cartilage graft has some benefits in reducing retraction of the tympanic membrane; however, it is unclear if the increase in rigidity and mass reduces the sound conduction properties of the graft. Concerns that the stiffness and mass of cartilage grafts may adversely affect hearing have not been reported in clinical outcome studies. To date, there has been no randomized or prospective case–control study comparing the outcome of fascia and cartilage tympanoplasties. All the comparative studies currently available have been retrospective. The number of cases included in these comparative studies was small.

Using laboratory models, some researchers investigated the acoustic transfer characteristics of cartilage plates and their resistance to pressure changes. Zahnert, et al. examined the frequency response function of tragal and conchal cartilage plates, using a laser Doppler interferometer. They found no statistical difference in the acoustic transfer characteristics of conchal and tragal cartilage. There were transmission losses at the lower frequencies when large tympanic membrane defects were reconstructed with thick pieces of cartilage. Reducing cartilage thickness led to an improvement of the acoustic transfer qualities. Using a normal tympanic membrane as a reference, Zahnert, et al. noted that a cartilage plate with a thickness of less than 0.5 mm gave the least acoustic transfer loss.[50]

Murbe, et al.[41] investigated the sound-induced vibrational amplitudes of four different tympanic membrane reconstruction techniques (cartilage plates of varying thickness, cartilage palisade, and large and small

cartilage island transplants). Using an ear canal-eardrum model, the vibrations of the cartilage grafts were measured by scanning laser Doppler vibrometry. Slicing thick cartilage into thin plates or palisades decreased the first resonance frequency and increased its amplitude, reflecting improved sound transmission properties of the transplant. The 0.5 mm cartilage plate seemed preferable compared with the palisade technique. Cartilage island techniques showed vibration characteristics superior to those for plate or palisade techniques. [41] Cartilage grafts placed within the middle ear become less rigid with time, and this could improve their vibrational properties.

Advantages of Cartilage graft: [51]

1.Well tolerated by the middle ear
2.Long term survival is achieved since cartilage grafts are nourished largely by diffusion.
3.Cartilage maintains its rigid quality and resists reabsorption and retraction even in the cases of severe Eustachian tube dysfunction.

Indications for Cartilage Tympanoplasty: [51]
In 2003, Bernal-Sprekelsen and co-workers recommended the following indications for cartilage tympanoplasty:

1. Total and subtotal perforations
2. Perforations with tympanosclerotic plaques
3. Perforation with atrophic membranes
4. Revision surgery for failed myringoplasty or tympanoplasty
   a. type I
5. Anterior and inferior perforation with tubal discharge
6. Retraction pockets
7. Partially or completely atelectatic tympanic membranes
8. Tympanic adherences
9. Revision surgery for failed tympanoplasties of type II and type III as well as tympanomastoidectomies

Cartilage Tympanoplasty Methods : Proposal of a Classification: Mirko Tos described 23 known cartilage tympanoplasty methods to reconstruct the eardrum and proposed a classification into six main groups.[51] Following is the brief description of each method:

Group A: Cartilage tympanoplasty using palisades, strips, and slices. The eardrum is reconstructed by several, various, full-thickness pieces of cartilage with attached perichondrium on the ear canal side. In this group, six different methods are described.

Group B: Cartilage tympanoplasty with foils, thin plates, and thick plates, not covered with the perichondrium. In this group, four methods are included.

Group C: Tympanoplasty with cartilage-perichondrium Composite Island grafts. The perichondrium flap suspends or fixates the cartilage. In this group, four methods are included.

Group D: Tympanoplasty with special total pars tensa cartilage-perichondrium composite grafts. All three methods are used to close a total perforation, but differ from each. Three special methods are included in this group.

Group E: Cartilage-perichondrium Composite Island grafts tympanoplasty for anterior, inferior, and subtotal perforations. Two onlay and two underlay methods are included.

Group F: Special cartilage tympanoplasty methods: The cartilage disc is placed under the perforation: the perichondrium onto the denuded eardrum remnant.

Popular Techniques of cartilage tympanoplasty: Six groups of cartilage tympanoplasty have been proposed in the literature by Mirko Tos. The choice of technique is determined by the surgeon's preference, size of the perforation, integrity of the ossicular chain, and the presence of cholesteatoma. The following techniques are commonly described in cartilage tympanoplasty:

Inlay butterfly graft: This technique was originally described for small TM perforation myringoplasty. The tragal cartilage graft is harvested with intact perichondrium on both sides. Using a surgical blade, a 2 mm circumferential incision is made on the cartilage to create a groove with an appearance similar to the wings of a butterfly. After the perforation rim is freshened, the cartilage graft can then be anchored onto the perforation similar to a tympanostomy tube. A split thickness skin graft can be placed over the graft, if the perforation is large. Cartilage butterfly graft inlay tympanoplasty is effective in the vast majority of patients with moderate to large perforations.

Perichondrium-cartilage island flap: Tragal cartilage graft is harvested because it is flat, thin (about 1mm) and abundant. Perichondrium from the side away from the external auditory canal is removed. A flap of perichondrium is produced, posteriorly, that will eventually drape over the posterior canal wall. Next, a complete strip of cartilage 2 mm in width is removed vertically from the center of the cartilage to accommodate the entire malleus handle. The entire graft is placed in an underlay fashion, with the malleus fitting into the groove.

Palisade technique: Cartilage graft can be harvested from either the tragus or cymba conchae. The latter is used when a post-auricular incision is planned, as in the case of mastoidectomy. For a conchal cartilage graft, perichondrium is removed from the postauricular side. The cartilage graft is cut into several slices or strips, which are subsequently pieced together, medial to the malleus, to reconstruct the TM. The use of the palisade cartilage technique brings very good functional and better long-term results.

Cartilage shield technique: A vascular strip incision is made in the ear canal, followed by a postauricular incision. Areolar tissue overlying the temporalis fascia is harvested. A round piece of conchal cartilage is harvested and the perichondrium on both sides is removed. A small wedge of cartilage is removed to accommodate the handle of the malleus. The graft is then placed medial to the malleus and the remnants of the TM. The areolar temporalis graft is then placed in between the cartilage graft and the remnants of the TM.

Comparison of Cartilage graft with other graft materials: There are few studies done on the cartilage graft tympanoplasty and its comparison with other materials as a control. The major studies which are close to our study are as follows: In 1997, Dornhoffer[52] performed 22 cartilage graft tympanoplasties and he observed that there was no residual perforation in this group. Control group was fascia / perichondrium graft (20 cases). He observed that there were residual perforations in 3(15%) fascia / perichondrium tympanoplasties. Both series of patients had undergone type I tympanoplasty, and the middle ear pathology was considered to be similar between the two groups. The number of cases was too small for a case-control study.

Gerber, et al.[53] studied 11 cartilage and 11 temporalis fascia graft tympanoplasties in 2000. They observed comparable hearing results in both groups.

Thirty-two cartilage and 32 temporalis fascia graft tympanoplasties were performed by Anderson, et al. [54] in 2004. They observed a 6% TM retraction in the cartilage group and a 36% TM retraction in the temporalis fascia group.

In 2004, Gierek, et al.[55] performed 112 cases with cartilage and 30 cases with temporalis fascia. They observed that there was no significant hearing difference between the two groups.

Couloinger, et al.[56] observed 59 cartilage graft tympanoplasties and 20 temporalis fascia graft tympanoplasties in 2005 and they reported no postoperative hearing difference between the two groups.

Conclusion

Tympanoplasty is a common surgical procedure for treatment of chronic otitis media. Although the temporalis fascia is considered the best grafting material, various surgeons have used alternatives to simplify the grafting procedure. In general, cartilage graft is the most predictable material of choice for ear surgeries and can be used as an alternative to temporalis fascia graft.

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