

TITLE: Cartilage Tympanoplasty

SOURCE: Grand Rounds Presentation, UTMB, Dept. of Otolaryngology

DATE: March 19, 2007

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Introduction

Since Wullstein and Zoellner popularized tympanoplasty in the 1950s, various materials have been used for the procedure, including fascia, skin, vein, dura, and cartilage. At present, the most common material used in tympanoplasty is temporalis fascia. In cases like revision tympanoplasty and atelectatic ear, cartilage has been used with great success to reconstruct the tympanic membrane (TM).

Tympanic Membrane

The tympanic membrane is oval in shape with dimensions of approximately 8 mm X 10 mm. It is oriented at approximately 55 degrees with the floor of the meatus. The greater part of the circumference is thickened, and forms a fibrocartilaginous ring (also known as the annulus or annular ligament) which is attached to the tympanic sulcus at the medial end of the meatus (scutum). The annulus and sulcus are deficient superiorly which is known as the notch of Rivinus. The anterior and posterior malleolar folds extend to the lateral process of the malleus from the two ends of this notch. The triangular area created above these folds is known as the pars flaccida and is called such because it lacks the middle fibrous layer that gives tensile strength to the rest of the membrane. This characteristic makes it vulnerable to retraction under negative pressure. The rest of the membrane is called the pars tensa. The handle of the malleus is firmly attached to the inner surface of the TM as far as its center, which projects towards the tympanic cavity giving the TM a conical shape. The point of the cone is called the umbo. The membrane is approximately 130 microns thick. As mentioned before, it is a three layered structure consisting of an outer ectodermal layer composed of keratinizing squamous epithelium, an intermediate mesodermal fibrous layer (which consists of a superficial layer of radial fibers and deep layer of circular fibers), and an inner endodermal mucosal layer. The epidermal layer has migratory properties which gives the TM its self cleaning ability. The epidermis migrates centrifugally from the umbo outward in a posterosuperior direction at about 131 microns per day.

Etiology of TM perforation

Perforations in the TM are most commonly caused by infections of the middle ear and less commonly the external auditory canal. Other causes are trauma, and iatrogenic. The vast majority of perforations due to infection is small and heals spontaneously; however, recurrent infections may impair the regenerative process and result in a chronic perforation. Beta-hemolytic streptococci are associated with large central perforations secondary to its necrotizing toxins and proteolytic enzymes. Viruses, mycobacterium species and external otitis have also been associated with TM perforations

Prognostic factors of TM re-perforation

Larger perforation is associated with significant lower rate (56 vs. 74% in smaller perforation) of success of tympanoplasty. Success rate is lower in anterior (67%) perforation than posterior location (90%). Presence of middle ear mucosal and contralateral disease is also significant predictors for outcome. A finding of otorrhea at surgery is a poor prognostic factor for tympanoplasty. Smoking is associated with worse middle ear status and delayed graft failure according to Becvaroski's study in 2001. Despite concerns about operating on young children who are prone to otitis media, Albera's study shows that TM closure and re-perforation rates are similar among patients aged less than 18, 18-50, and greater than 50.

Advantages of Cartilage graft

Cartilage has been shown to be well tolerated by the middle ear. Long term survival is achieved since cartilage grafts are nourished largely by diffusion. Even in the cases of severe Eustachian tube dysfunction, cartilage maintains its rigid quality and resists resorption and retraction.

Indications of cartilage tympanoplasty

- Atelectatic ear
- Retraction pocket/ Cholesteatoma
- High Risk Perforation
 - Revision
 - Anterior perforation
 - > 50%
 - Otorrhea at the time of surgery
 - Bilateral

Techniques of cartilage tympanoplasty

Four techniques have been described for cartilage tympanoplasty, namely the inlay butterfly graft, Perichondrium/cartilage island flap, palisade flap, and cartilage shield tympanoplasty. The choice of technique is dictated by surgeon's preference, size of the perforation, integrity of the ossicular chain, and the presence of cholesteatoma.

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 beaver blade, a 2 mm circumferential incision can be 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. For perforation greater than 1/3 of TM or close to the annulus, the graft can be anchored onto the bony annulus, as described by Ghanem et al in 2006.

Perichondrium/ cartilage island flap

Tragal cartilage graft is harvested because it is flat, thin (~ 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 in the groove.

Palisade technique

Cartilage graft can be harvested from either the tragus or concha cymba. The latter is used when a post-auricular incision is planned, as in the case of mastoidectomy. For conchal cartilage graft, perichondrium is removed from the post-auricular side. Cartilage graft is cut into several slices or strips, which are subsequently pieced together medial to the malleus to reconstruct the TM. This technique is favored when ossicular chain reconstruction is performed because it provides a better visualization of the prosthesis and precise placement of graft onto the prosthesis. In cases of posterior perforation, the anterior half of the TM can be left alone to allow postoperative surveillance and future myringotomy tube placement.

Cartilage shield technique

A vascular strip incision is made in the ear canal, followed by a post-auricular incision. Areolar tissue overlying temporalis fascia is harvested. A round piece of conchal cartilage is harvested and 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 graft is then placed in between the cartilage graft and the remnants of the TM.

Postoperative care

Topical antibiotic drop is initiated for 2 weeks after surgery. 2 weeks after the surgery, all gelfoam in the EAC is removed. Audiogram is obtained in 3-4 months postop, mainly to evaluate air-bone gap since tympanometry is no longer reliable given the rigidity of the cartilage graft. If the entire TM is reconstructed with cartilage, surveillance by otoscopy might be difficult due to its opaque appearance. Air-bone gap is a good tool to assess the presence of middle ear effusion.

CT temporal bone can be obtained and a second look procedure can be performed especially in the case of cholesteatoma.

Hearing results after cartilage tympanoplasty

Dornhoffer et al reports 96 patients who failed at least 1 temporalis fascia graft tympanoplasty, of which 29 of them also underwent ossicular chain reconstruction. TM closure was achieved in about 95% of patients. There was a significant improvement in pure tone average (PTA) from 24.6 to 12.2 dB.

Gerber et al compared hearing results after temporalis fascia and cartilage graft. All eleven patients had normal ossicular chain function. The primary indication of the surgeries was retraction pocket. With an average follow-up period of 12 months, they found no significant difference between the improvement of speech reception threshold (approximately 10 dB) in the temporalis fascia group and the cartilage group. In addition, the cartilage group also shows significant reduction in air-bone gaps across various frequencies. (500, 1k, 2k, and 4k Hz).

Acoustic properties of various graft materials

Using a cartilage graft thinner than 1 mm or smaller cartilage pieces (palisade technique) may improve sound transmission properties of the reconstructed TM, as demonstrated by Murbe et al. Using scanning laser Doppler vibrometry, various thicknesses and sizes of cadaveric conchal cartilage were used. The sound-induced vibration of the 1-mm cartilage plate showed a first resonance frequency at 1188 Hz with amplitude of 30 nm/Pa. Slicing this plate into palisades decreased the first resonance frequency and increased its amplitude, reflecting improved sound transmission properties of the transplant. Reduction of the thickness of a cartilage plate to 0.7 mm revealed a similar effect on vibration characteristics. The 0.5- and 0.3-mm plate transplants showed results that were acoustically superior to the palisades or the 0.7-mm plate.

Conclusions

Cartilage tympanoplasty offers otologists a reliable armamentarium in TM reconstruction. The choice of techniques depends on surgeon's preference, the integrity of the ossicular chain, the size of the perforation, and the presence of cholesteatoma. Despite its rigid quality, cartilage tympanoplasty achieves good audiologic results comparable to temporalis fascia graft.

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