

Review Article

Overview of tympanoplasty techniques and results

Reshma P. Chavan^{1*}, Shivraj M. Ingole², Santosh N. Birajdar¹

¹Department of ENT, Dr. V. M. G. Medical College, Solapur, Maharashtra, India

²Department of Radiology, G. G. M. C and Sir J. J group of Hospitals, Mumbai, Maharashtra, India

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*Correspondence:

Dr. Reshma P. Chavan,

E-mail: entproblem@gmail.com

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ABSTRACT

The objective of this article is to overview about the changing techniques of tympanoplasty surgery and increase in the anatomical and functional success rate of surgeries. Introduction of endoscope in ear surgeries is time saving. Endoscopes are helpful to access hidden areas which was difficult with the help of microscope such as facial recesses, sinus tympani, extension of posterior-superior retraction pockets, etc. Also various modifications done in the techniques of using graft material for tympanoplasty surgery are reviewed in terms of graft acceptance and improvement of hearing. Articles reviewed are research articles, original articles and review articles published in pub med indexed journals. Because of newer techniques in ear surgeries, tympanoplasty is becoming day care surgery. Also newer techniques are with cosmetic view and gives maximum post-operative hearing using minimal instrumentation. Efforts are taken to review the tympanoplasty surgical technique and its results.

Keywords: Endoscopes, Tympanoplasty, Technique

INTRODUCTION

Perforation of tympanic membrane is sequelae of chronic supportive otitis media, trauma, etc. Tympanoplasty surgery is done to seal tympanic membrane and to improve hearing. Berthold had done first tympanoplasty in 1878 by applying plaster on de-epithelialized the tympanic membrane remnants for 3 days and removal of plaster applying skin graft over the defect.¹ Various surgeons have used different kinds of grafts to repair tympanic membrane perforations. Most popular are auto grafts. Zollner (1954) and Frenckner (1955)² used pedicled ear canal skin graft to close perforations.² Shea (1960) introduced vein graft to close tympanic membrane perforations.³ Heermann (1960) was first used temporalis fascia as a grafting material in the tympanoplasty.⁴ Split thickness and full thickness skin graft were being used previously. Because of graft eczema, desquamation, and poor results skin graft had not become popular among surgeons. Other graft material used to seal tympanic membrane perforation is vein graft, temporalis fascia

graft, fascia lata, tragal cartilage, conchal cartilage etc. Moore GF, et al has used fosse triangularis cartilage and functional outcome was measured by tympanometry. This study shows that fosse triangularis cartilage gives 100% success rate.⁵ Zahnert et al, had shown same audiological outcome for tragal and conchal cartilage graft for tympanic membrane reconstruction.⁶ Kazikdas et al had shown maximum functional outcome when size of cartilage is reduced to thickness of 500 micrometer.⁷ Yegin et al had shown that functional results with cartilage were independent of thickness of cartilage.⁸ Cavaliere had shown that acoustic properties of cartilage are same as that of fascia.⁹ Depending on size and site of perforation various approaches are used such as endaural, endomeatal and postaural. Microscope allows better instrumentation in bleeding circumstances. It gives magnification to operating field. Marchioni et al had operated on patients having non self-cleansing attic retraction pockets with endoscope.¹⁰ So the endoscope was first introduced for retraction pocket surgeries and for the disease limited to attic region. Use of endoscope

in the tympanoplasty is gaining popularity among surgeons. Aim of this article is to review outcome of tympanoplasty, different techniques and graft materials used for tympanoplasty.

SURGICAL TECHNIQUES AND RESULTS

Various techniques are developed over period of time to give maximal anatomical and functional outcomes. Also

long term follow up is required for tympanoplasty patients as there are chances of reperforation over period of time. Possibility of reperforation increases with increase in size of perforation.¹¹ Short follow up studies are showing higher success rate than long term follow up studies.¹² Studies were done to compare success rate of temporal muscle fascia grafts and cartilage grafts in tympanoplasty.

Table 1: Comparison of results of temporal muscle fascia and cartilage grafts.

Study (year)	Study population	Graft	Surgical technique	Graft acceptance	Hearing improvement
Yegin et al (2016) ⁸	78	Tragal Cartilage	Overlay underlay technique	92.1%	26.11±12.87dB
		Temporalis fascia		65%	24.25±12.68dB
Shishegar et al (2012) ¹³	27	Palisade cartilage	Underlay-overlay	100%	Same as Palisade cartilage
	27	Temporalis fascia			
	Review 14 articles >50 each	Temporalis fascia verses cartilage graft	Review article	Level 1, level 3, level 4 evidence to show better result with cartilage	Same as cartilage and Temporalis fascia
Onal et al (2011) ¹⁵	44	cartilage	-	93.2%	Better with cartilage
Demirpehlivan et al (2011) ¹⁶	34	cartilage	Island	97.7%,	24.54 db
Demirpehlivan et al (2011) ¹⁶	67	Temporalis fascia	Underlay	80.6	24.51 db
Demirpehlivan et al (2011) ¹⁶	19	cartilage	Palisade	79.0%,	23.23 db
Ulku et al (2010) ¹	17	Temporalis fascia	-	88.2%	8.5+/-4.4 dB
Ulku et al (2010) ¹⁷	23	cartilage	-	91.3%	9.0+/-3.9 dB
Lyons et al (2016) ¹⁸	3,783 unique studies	temporalis fascia verses cartilage perichondrium	-	-	no evidence of superiority of one-piece CCP grafting over TF grafting 1 tympanoplasty
Couloigner et al (2005) ¹⁹	29	Cartilage	Inlay	71%	
	29	Temporalis fascia	Butterfly		

OVERLAY TECHNIQUE

First technique used for tympanoplasty surgery is overlay technique for placement of graft. In this technique, surface epithelium was removed around the perforation site and graft was put on the fibrous layer of tympanic membrane. This technique is suitable for total perforation of tympanic membrane, anterior perforations and revision cases. Advantages of the technique are graft remains vascularised and middle ear space is not reduced during the procedure. Disadvantages of this procedure are lateralization of graft, blunting of anterior meatal recesses and chances of iatrogenic cholesteatoma formation. Healing may take longer time with use of this technique.

UNDERLAY TECHNIQUE

Underlay technique was introduced by SHEA. During underlay procedure, the graft was placed medial to the handle of malleus and graft remnant. It is easy to perform. It is an ideal technique to repair tympanic membrane perforations that are easily visualized. Other modifications in the technique of tympanoplasty are done to see the success results. Ralli et al had made anterior and posterior tunnel to create proper tension on the tympanic membrane and handle of malleus. Primrose and Kerr were had made anterior tunnel under the annulus. Sauvage et al had made anterior flap. Farior described elevation of tympanomeatal flap from 12'0 clock to 3'0

clock position.²⁰ This technique is modified by extension of incision from 12'o clock to 1'o clock position to allow the graft to be anchored under the handle of malleus and bony annulus, which allows good graft uptake and postoperative hearing results. The Anterior pull-through is another modified technique where anterior tip of the temporalis fascia was pulled through a short incision lateral to the anterior annulus. Data on graft take rate, pre-operative, and post-operative hearing status were analyzed. Harris et al had showed anatomical success rate of anterior pull-through technique was 84.6% and the air-bone gap reduced to 11.75 ± 5.7 dB after surgery.²¹

During underlay technique graft is placed middle to handle of malleus, middle ear space is reduced and there are chances of adhesion formation between promontory and drum. Also gel foam kept during surgery results in adhesion formation. Different comparative studies were done for the results of underlay and overlay techniques by Doyle et al, Glasscock et al and Sergi et al (2011) had done comparative study of overlay and underlay technique in the tympanoplasty showing underlay technique was slightly better than the overlay technique in terms of tympanic membrane closure (94.2% vs. 91.5%).²²

OVERLAY-UNDERLAY TECHNIQUE

During overlay –underlay technique graft was placed lateral to handle of malleus and medial to tympanic membrane remnant and annulus. This technique is more practically acceptable and is easy to perform. Exposure of middle ear is excellent and ossicles status can be checked. This technique is preferred whenever reconstruction of ossicles is needed. Side effect like anterior blunting is not present with this technique. Various graft material can be used with this technique. Shishegar et al (2012) had used conchal cartilage graft. The perichondrium was removed from one side of the cartilage, and the cartilage was then cut into several slices. Four or five palisades were placed in an over-under fashion in relation to the malleus handle and perichondrium facing laterally. All palisades were supported by the perichondrium to fill the gaps between palisades.¹³

COMBINED TECHNIQUE

In the combined technique two grafts are placed. One graft was placed under the handle of malleus and tympanic membrane remnants. Second graft is placed on the fibrous layer of tympanic membrane. Gupta et al had 86.6% success in his overlay technique.²³ Brown studied Success rate following myringoplasty at the Royal Victoria Eye and Ear Hospital.²⁴ Study shows 74% success in underlay technique and 100% success in overlay technique. Sengupta et al had done study in 2012 was showing success rates among underlay, overlay and combined technique were 81.25, 85.71 and 90% respectively. There was no significant difference between acceptance of graft by any technique as per the study

done by Vartiainen et al, Frank Rizer et al and Sengupta et al.²⁵⁻²⁷

CIRCUMFERENTIAL SUB ANNULAR GRAFT TECHNIQUE

In circumferential sub annular graft technique, the graft is put under the annulus, handle of malleus and anteriorly the graft covers the anterior canal wall. Then the reposition of graft remnant is done. In this technique, graft gets anterior support. Graft gets blood supply from the flap. Circumferential sub annular graft technique gives good graft uptake. Study done by Murugendrappa MA et al had shown 96% success rate. Mokhtarinejad et al reported 95% success in graft uptake by circumferential sub annular graft technique.²⁸ The postoperative mean hearing improvement by circumferential sub annular technique done by Murugendrappa et al had shown hearing improvement by 11 dB and in the same study by conventional underlay technique, hearing improvement was 8 db. Muhammad Rafiq et al and Rahul Kawatra had done conventional underlay technique where graft success rate is 88% and 87% respectively which is much lower than study done by Murugendrappa et al.²⁰

SWING DOOR TECHNIQUE

Swinging door tympanoplasty was described by Palva et al in 1969.²⁹ It is simple technique and can be used by beginners. In this technique, laterally based skin flap is made. Swinging door flaps are made by cutting tympanomeatal flap, the fibrous annulus and the tympanic membrane. Mokhtarinejad et al reported 95% success in graft uptake with this technique. There are different studies done to compare results of cartilage and temporalis fascia graft by Shishegar et al, Mohamad et al etc. Most of the studies were showing slightly better results regarding acceptance of graft which were statistically not significant.

BUTTERFLY AND PALISADE TECHNIQUE CARTILAGE TYMPANOPLASTY

In this technique, cartilage with perichondrium was taken from both sides. Cartilage graft taken is of larger size than the size of perforation. Cartilage is cut in between from periphery and epithelium from edges of the perforation is removed. Edges of the perforation are kept between cartilage perichondrium flaps. Thus the graft is supported from above and below. This technique is commonly used for smaller perforations. Butterfly Cartilage tympanoplasty can be done with the endoscope. Butterfly cartilage tympanoplasty with the use of dermatological punch had shown 92.3% success in the tympanic membrane closure and air bone gap was improved from 27.67 to 20.1.³⁰ Karakullukçu and Eavey had shown high success rate for transcanal butterfly tympanoplasty for non-marginal, small perforations of tympanic membrane perforation closure.^{31,32}

The palisade technique is preferred in cases of cholesteatoma, ossiculoplasty, atelectasis ear and eustachian tube dysfunction. Perichondrium from one side is removed and the cartilage is sliced. Four or five palisades were placed in an over-under on the malleus handle. Cartilage put in such way that perichondrium faces laterally bridging the gaps between cartilage pieces. Shishegar et al (2012) had used conchal cartilage graft in palisade fashion.¹³ Different modifications are done to use cartilage grafts. Borkowski et al had used U shaped conchal cartilage graft with perichondrium. The size of graft taken is reshaped as size of tympanic ring to seal total perforation of tympanic membrane.³³ Demirpehlivan (2011) had shown that cartilage island grafts are giving higher success rates than cartilage palisade technique.¹⁶ There is no difference between functional results of full thickness cartilage and fascia tympanoplasty.⁸

FAT TYMPANOPLASTY

Fat myringoplasty (FGM) is an office procedure in small perforations. It can be used in all small and medium-large sized perforations. There are various studies done to prove success rate of fat tympanoplasty in dry perforations with intact ossicles. Question of debate is on the size of perforation and acceptance of fat graft.

Gun et al had shown that patients with small perforations had better audiological outcome than medium-large perforations.³⁴ Konstantinidis et al had shown significantly decreased success with perforation size more than 30% of the pars tensa when fat graft used for tympanic membrane perforation.³⁵ Landsberg had done prospective case series study and concluded that Fat graft myringoplasty had long term durability and it is useful in small and medium sized perforations.³⁶ Koc et al had shown 90% success rate irrespective of size of perforation.³⁷ Kwong et al had shown 100% success rate in fat graft tympanoplasty.³⁸

HYALURONIC ACID FAT GRAFT

Hyaluronic acid fat graft technique is nonsurgical technique for myringoplasty. This procedure can be done in clinic without indoor admission. Other office based surgical techniques used are paper patch technique, myringoplasty, fat myringoplasty and topical application of trichloroacetic acid myringoplasty, etc. The reported success rate of closure of the perforation with hyaluronic acid fat graft technique was 81%, with hearing improvement up to 17 db. Santa Maria had shown that the success rate is irrespective of site of perforation.³⁹ Studies had done to compare different techniques of office based myringoplasties. Also comparison between success of fat and hyuronic acid fat myringoplasty had done by Saliba et al. Saliba et al had shown high success rate of hyaluronic acid fat graft myringoplasty than fat myringoplasty.⁴⁰ Saliba et al had also shown hyaluronic acid fat graft myringoplasty gives equally good results for myringoplasty as that of underlay and overlay

technique.⁴¹ All office-based myringoplasty techniques are equally good. Multiple settings are required for topical application of trichloroacetic acid to achieve complete closure.

CHONDRO-PERICHONDRIAL CARTILAGE GRAFT

Chondroperichondrial cartilage grafts were used by Dundar et al in 2014 for tympanoplasty. Dundar et al had shown 93% graft acceptance with air bone gap less than 10 db.⁴² Dundar et al had used Boomerang-shaped chondroperichondrial graft in the pediatric chronic otitis media cases with higher grade of graft success rate.⁴³

CARTILAGE SHIELD TYMPANOPLASTY

During the Cartilage shield tympanoplasty perichondrium from both sides of cartilage is removed and notch is made on the cartilage to accommodate malleus. Reshaped cartilage is kept at malleus level through underlay technique and the perichondrium is kept lateral to cartilage graft and medial to tympanic membrane perforation. Advantages of this technique are

- As perichondrium covers posterior canal wall, there is no chance of cholesteatoma and retraction pocket formation.
- It gives better stability to the graft.
- Middle ear space is not reduced.

THE BUTTON GRAFT TECHNIQUE

Tympanic membrane perforations of small can be sealed with button cartilage graft technique. Button cartilage graft can be used through transcanal route. Abdelghany had used cartilage-perichondrium button graft for tympanic membrane perforations of size less than 25% of the tympanic membrane and success rate in the tympanoplasty surgery is compared to underlay and overlay technique. The anatomical success rates were 98.5%, 97% and 98.5% for underlay, overlay and button graft technique respectively. Hearing improvement achieved was 10.18 (± 5.4) dB, 8.5 ($+6.5$) dB and 9.1 ($+5.1$) dB for underlay, overlay and button graft technique respectively. The mean durations of the operative procedure were 35 ± 8.4 , 42 ± 6.8 , and 23 ± 6.3 min for underlay, overlay and button graft technique. Tympanic membrane retraction and cholesteatoma pearls formation were side effects of the underlay and overlay techniques which was not seen in the button graft technique tympanoplasty.⁴⁴

CARTILAGE TYMPANOPLASTY WITH ISLAND TECHNIQUE

Cartilage tympanoplasty is done in many ways, considering its rigidity question is arising on its resilience and audiological outcome. Ulkü had compared temporalis fascia with cartilage grafts. Anatomic closure rates of the

tympenic membrane perforation for perichondrium-cartilage and fascia group were 91.3% and 88.2%, respectively. PTA gain of 12.3 dB for the cartilage-perichondrium group and 12.7 dB for the fascia group.¹⁷ Demirpehlivan IA had shown cartilage island flap is giving good results.¹⁶ Dornhoffer had shown that cartilage island flap is used in high risk of reperforation cases.⁴⁵

ENDOSCOPIC VERSUS MICROSCOPIC TYMPANOPLASTY

Comparative studies were done to prove advantage of endoscope and microscope in the success of tympanoplasty. A major limit of endoscopic ear surgery is bleeding. It is difficult to handle bleeding issues in the small space like ear with one hand is with endoscope but in ear surgery like tympanoplasty there are less bleeding issues so endoscopic tympanoplasty technique is still preferred method of tympanoplasty.⁴⁶ With use of endoscope operative time is reduced.³⁹ Also it gives better comfort in paediatric patients.

CONCLUSION

Tympanoplasty is day to day surgery done by ENT surgeons. Site of perforation, size of perforation, ossicular status, audiogram, Eustachian tube dysfunction, status of middle ear mucosa, etc. are the factors make surgeon to decide which technique has to apply to give best anatomical and functional results of surgeries. Among the grafts used for tympanoplasty, cartilage grafts are slightly better to give anatomical and functional outcomes. Temporalis fascia grafts are giving high success rates when used with modified techniques such as circumferential sub annular and anterior pull through techniques. Endoscopic tympanoplasty gives comfort to the patient during surgeries and are time saving, cosmetic, when done under local anaesthesia by endaural approach.

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