Cartilage Support for Fascia Graft in Type I Tympanoplasty

Shreeya Kulkarni · Vinay Kulkarni ·
Kiran Burse · Vandana Sancheti · Gaurav Roy

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Abstract To evaluate the success rate, in terms of anatomical and functional results, in our technique of cartilage support for fascia graft in type I tympanoplasty. Retrospective study of tragal cartilage support for fascia graft in tympanoplasty for large central perforation in 748 patients was carried at an academic institution during January 2004 to March 2012. Patients' age ranged from 11 to 65 years. 325 (43.4 %) male and 423 (56.6 %) female patients were operated and mean post-operative follow up was of 24 months (range 6–48 months). The inclusion criteria were large central or subtotal perforation, anterior quadrant perforation, anterior tympanosclerotic patch with perforation and revision myringoplasty. Small central perforation, posterior perforations, traumatic perforations and Ossiculoplasty were excluded from this study. In this technique, a piece of tragal cartilage carved in semi lunar shape is inserted medial to anterior remnant of tympanic membrane. Temporalis fascia graft is sandwiched between cartilage and anterior remnant of tympanic membrane. Post-operative closure of perforation was noted. Pure-tone average

pre and post-operative air-bone gap in dB at 250, 500, 1000, 2000, and 4,000 Hz were compared. The overall success rate of our technique was 98.3 % in terms of graft uptake and within 13.35 ± 5.22 dB of air bone gap closure in terms of hearing improvement. This study reveals that cartilage support for fascia graft in type I tympanoplasty is a highly reliable technique and gives significant improvement in graft take-up and hearing status.

Keywords Tragal cartilage · Large, subtotal perforation · Temporalis fascia · Narrow anterior rim

Abbreviations

CSOM	Chronic suppurative otitis media
TM	Tympanic membrane
Fig	Figure
Ant	Anterior
Post	Posterior
Std dev	Standard deviation
Pre op	Pre operative
Post op	Post operative
CI	Confidence interval
k	Thousand

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The paper received RAF Cooper Best Paper Award in the State.

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S. Kulkarni · V. Kulkarni · K. Burse · V. Sancheti · G. Roy
Dr Vasantrao Pawar Medical College Hospital and Research
Center, Adgaon, Nashik 422003, Maharashtra, India

S. Kulkarni (✉)
21 Durvankur, Shastrinagar So., Indiranagar, Nashik 422009,
Maharashtra, India
e-mail: kshreeya@hotmail.com

Introduction

Chronic suppurative otitis media (CSOM) tubotympanic type is the most common infective condition of ear. Tympanoplasty has been well established since decades as surgery of choice for CSOM. The promotion of Tympanoplasty by Zollner in 1951 [1] and Wullstein in 1952 [2] started new era in the history of otology. From its initial

days, tympanoplasty has been modified by many authors in terms of approach, technique and materials used for grafting the tympanic membrane [3–5]. Each had its merits and demerits, but whatever is the technique, subtotal perforation has always posed a challenge to otologists [6]. Subtotal perforation with very small anterior remnant of tympanic membrane and anterior bony overhang are more prone to failure after tympanoplasty [7]. Though various methods are practiced for placement of graft in tympanoplasty for Subtotal perforation, failure of perforation to close is seen in 10 % of cases [7, 19]. The reasons of residual perforations are poor adaptation of graft, displacement of graft which may sink medially or may shift posteriorly or may shrink. When the graft is supported medially only by gelfoam (abgel), failure is seen in large number of cases [7].

To overcome this problem, we have introduced a novel technique in which a small semilunar shaped piece of tragal cartilage is placed medial to the narrow anterior rim in case of a large or subtotal perforation. The temporalis fascia graft is placed lateral to this cartilage support and medial to the thin anterior rim. This cartilage splays and stays in place and provides firm support to the fascia graft medially. It prevents sinking or shrinking of the graft. The success rate of this technique is very good and there is significant hearing improvement in all frequencies. Cartilage evokes minimal inflammatory tissue reaction and provides firm support. 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 [6, 8, 9].

Materials and Methods

The present study was conducted at Dr Vasantrao Pawar Medical College Hospital and Research center, Adgaon, Nashik and Bhaskar ENT Hospital Nashik. The study protocol and consent forms were approved by the research review committee. A total of 748 cases from age group 11 to 65 were operated from January 2004 to April 2012. Out of these 326 (44 %) patients were operated under general anesthesia and rest 422 (56 %) were operated under local anesthesia. 325 (43.4 %) patients were males and 423 (56.6 %) were females. This technique is basically designed for perforations with very narrow anterior rim (Diagram 1 in Supplementary material).

The inclusion criteria for this study were:

1. Large Central perforation
2. Subtotal perforation
3. Anterior quadrant perforation

4. Anterior tympanosclerotic patch with perforation
5. Revision myringoplasty.

The cases excluded from this study were:

1. Small central perforation
2. Perforation in posterior quadrant.
3. Traumatic perforation.
4. Ossiculoplasty
5. Perforation with cholesteatoma

In all the cases the ear was dry at the time of surgery. Pre operative audiograms were done noting air and bone conduction thresholds at 250, 500, 1k, 2k and 4k.

Operative Technique

Tragal area is infiltrated with 2 % xylocaine with 1:200,000 adrenaline [10]. Incision is taken at the medial margin, so that the normal contour of tragus is preserved and scar is not visible [11]. Tragal cartilage is harvested. The perichondrium over the tragal cartilage is separated. This tragal cartilage is ideal as it is thin, flat, with some elasticity, so when it is placed medial to the anterior rim, it splays and stays in the place [10]. It can be molded while inserting. Post auricular Wilde's incision is taken. Temporalis fascia graft is harvested. Then tympanomeatal flap is raised and meatotomy is done about 6–8 mm from annulus (Diagram 2 in Supplementary material). Margins of perforation are freshened up. At the level of annulus, de-epithelization is done till posterior margin of the perforation is reached. Fibro-mucosal layer is cut, up to annulus, at 6 o'clock position. Superiorly de-epithelization is done by denuding short process as well as handle of malleus. A sharp cut is taken anterior to handle of malleus on fibrous layer. (This is done for perfect placement of fascia graft later on.) The cartilage is carved in a semi lunar shape (Fig. 1). Its dimensions are supero inferiorly approximately 6–8 mm and antero-posteriorly approximately 3–4 mm. (It may vary with amount of middle ear space). It is placed gently medial to the anterior rim margin in such a way that the superior tapering end goes anterior to malleus and inferior tapering end goes in hypo tympanum (Diagram 3 in Supplementary material.) The antero-posterior curvature of the cartilage fits and merges with the curvature of the anterior mesotympanum. It is ensured that the cartilage and anterior rim margin of TM are in contact with each other. Gelfoam is placed in the middle ear medial to the cartilage to ensure this contact. Then temporalis fascia graft is placed anteriorly between the rim and the cartilage (Diagram 4 in Supplementary material). It is positioned as inlay graft anterior to malleus handle superiorly and at 6 o'clock position inferiorly (where fibro-mucous layer was cut). Posteriorly it stays over the fibrous layer to become on lay

Fig. 1 **a** Semilunar shaped cartilage. **b** Post operative microscopic photograph

Table 1 Demographic and clinical data

Data	Value
Number of patients	748
Mean age at surgery (range)	33 years (11–65 years)
Sex ratio: male/female	0.75:1
Type of cases	
Large central perforation	232 (31 %)
Subtotal perforation	172 (23 %)
Anterior quadrant perforation	165 (22 %)
Tympanosclerosis patch anterior to handle of malleus	105 (14 %)
Revision myringoplasty	74 (10 %)
Anesthesia	
Local	422 (56 %)
General	326 (44 %)
Follow up-average (range)	24 (6–48 months)
Hearing loss	
Pre-op	32.6 (23–54 db)
Post-op	19.25 (11–41 db)

graft and extends over the bony canal. Then posterior tympanomeatal flap is repositioned back (Diagram 5 in Supplementary material). Gel foam is kept on the graft. Closure is done.

Post operatively they were given antibiotic cover for 1 week and ear drops for 3 weeks. The patients were followed up for minimum 2 months to maximum 3 years. Post operative audiograms were done. A successful anatomical outcome was considered to comprise full intact healing of graft without perforation for at least one year postoperatively (Fig. 1). A successful functional outcome

was good hearing improvement. air-bone gap with closure in dB at 250, 500, 1000, 2000, and 4,000 Hz were compared.

Results

In this study age group wise distribution indicated that the maximum number of patients were from age group 21–40 (57 %), followed by 41–60 years (20 %), then teenagers (18 %), and above 61 elderly with least number (5 %). 56 % cases were operated under local anesthesia and 44 % under general anesthesia. The present study showed case wise distribution as follows (Table 1). Cases of large central perforation were 31 %, subtotal perforation were 23 %, only anterior quadrant perforation 22 %, anterior tympanosclerotic patch with perforation 14 %, revision cases 10 %. Large central perforation was a perforation occupying more than two quadrants of tympanic membrane with invariably narrow anterior rim of the membrane. In subtotal perforation a very thin rim was seen all around. In only anterior quadrant perforation, and in anterior tympanosclerotic patch patients after the tympanosclerotic patch was removed, the remaining rim was very narrow. In revision cases also there was large perforation. Out of these 10 % of revision cases, all cases were previously operated by some other technique, except only one case which was operated by this same technique. In that case the Tragal cartilage was used previously, so we harvested conchal cartilage [12]. After revision there was complete closure of perforation and hearing improvement. The overall success rate in terms of closure of perforation in this study was 98.3 %, i.e. 13 patients out of 748 had a residual perforation (Fig. 2). In most of them it was due to upper

Percent of Closure of perforation **Fig. 2** Percent closure of perforation**Table 2** Proportion of closure of perforation

Binomial test ^a				
Closure perforation	N	Observed prop.	Test prop.	Asymp. sig. (2-tailed)
Yes	735	0.98	0.5	0.0001 ^b
No	13	0.02		
	748	1		

^a Based on Z approximation^b Highly significant

respiratory tract infection or inadequate post operative antibiotic therapy. Proportion of closure of perforation was done by Binomial test, based on Z approximation showed highly significant results (Table 2). In this study, we observed that there was significant air-bone gap closure in postoperative audiograms as compared to preoperative audiograms. The paired mean difference between pre and post operative AB Gap was 13.36 ± 5.22 dB was highly significant at $p = 0.000$ (Table 3). The hearing improvement was seen in all frequencies, i.e. 250, 500, 1000, 2000, 4000 Hz. The AB Gap closure at 250 Hz was 21.3 dB; at 500 Hz it was 19.6; at 1,000 Hz it was 15.9; at 2,000 Hz it was 11.8 and at 4,000 Hz it was 2.9 dB (Fig. 3). There was peculiar observation that, the improvement in hearing was statistically significant at all frequencies where as at 4,000 Hz, the improvement was comparatively less. Paired t test showed that mean difference was gradually decreasing and highly significant at $p = 0.000$. It was also observed that the mean difference between pre and post

Table 3 Pre op ABG–Post op ABG

Paired differences between	Mean	Std. dev	Std. error mean	95 % CI of the difference				Significant p value (2-tailed)
				Lower	Upper	t test	df	
Pre op ABG–post op ABG	13.36	5.22	0.19	12.98	13.73	70.05	747	0.000 ^a

Statistical inference: in the above table, mean difference between pre op ABG and post op ABG was highly significant at $p = 0.000$

^a Highly significant difference**AB Gap closure (mean difference bet pre and post op) in dB** **Fig. 3** AB gap closure

operative 4,000 Hz had least significance among all variables. The 95 % CI showed lower and upper bound of mean significant difference (Table 4).

Discussion

Historically various graft materials have been used to reconstruct tympanic membrane including skin, fascia, vein, perichondrium, dura and cartilage [14]. At present the most common material used for tympanoplasty is temporalis fascia followed by tragal perichondrium [6]. The success rate of the intervention in terms of closure of perforation with fascia is estimated to be around 80–90 % for primary tympanoplasty [14, 15]. However these results decrease in some specific cases, such as large or subtotal perforations, anterior perforations, revision tympanoplasty. Larger perforation is associated with significant low rate (56 vs 74 %) [16]. Temporalis fascia has its own advantages like a common incision for approach, large amount of graft material is available and more so that its basal metabolic rate is low, its thickness is similar to normal tympanic membrane and embryo logically it develops from mesoderm which is same as normal tympanic membrane [6, 17, 18]. But temporalis fascia can suffer atrophy or vascularisation, causing posterior shrinkage or sinking in middle ear, ultimately causing failure of closure of the perforation in such cases [19, 20]. Cartilage has been used with great success to reconstruct TM. Cartilage can be used in the form of several parallel, full-thickness strips (palisade technique) or in plates of different sizes and shapes; in

Table 4 Paired *t* test

Paired differences between	Pre op mean	Post op mean	Mean	Std. deviation	Std. error mean	95 % CI of the difference				Significant <i>p</i> value (2-tailed)
						Lower	Upper	<i>t</i> test	df	
Pre op 250–post op 250	36.67	15.37	21.3	16.6	0.6	20.1	22.5	35.2	747	0.000 ^a
Pre op 500–post op 500	35.70	16.10	19.6	8.2	0.3	19.0	20.2	65.6	747	0.000 ^a
Pre op 1k–post op 1k	32.42	16.43	15.9	6.2	0.2	15.4	16.3	69.6	747	0.000 ^a
Pre op 2k–post op 2k	27.58	15.76	11.8	6.6	0.2	11.3	12.3	49.2	747	0.000 ^a
Pre op 4k–post op 4k	28.40	25.50	2.9	4.0	0.1	2.6	3.1	19.7	747	0.000 ^a

Statistical inference: in the above table, mean difference of each variable was gradually decreasing and highly significant at $p = 0.000$ i.e. It was also observed that the mean difference between pre and post operative 4k had least significance among all variables. The 95 % CI showed lower and upper bound of mean significant difference

^a Highly significant difference

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 [17, 21, 22]. Cartilage has been shown to be well tolerated by middle ear. Long term survival is achieved since cartilage grafts are nourished largely by diffusion and not by neo vascularization. It maintains its rigid quality and resists resorption and retraction [16, 23]. The cartilage is a satisfactory grafting material because it is easily accessible, easy to adapt, resistant to negative middle ear pressures, stable, elastic, well tolerated by the middle ear, resistant to resorption. Due to its characteristic rigidity and thickness, there has been controversy regarding audiological aspect; however, various studies have demonstrated that audiological results are good [8, 13, 24].

In this study we have utilised the best of both things. We are using temporalis fascia graft and reinforcing it with small piece of tragal cartilage for support so that the closure of perforation is certain. In our study, out of 748 patients 735 patients had complete closure of perforation. i.e. The success rate of anatomical closure of perforation is 98.3 %. There was significant improvement in hearing as suggested by the statistical tests. A good amount air bone gap closure was seen in all frequencies 250, 500, 1k, 2k, 4k. At 4k the closure was minimum. The exact reason behind this observation is not understood but the speculation may be as follows. Perichondrium and cartilage share with fascia the quality of being mesenchymal tissue, 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 [6]. The tympanic membrane is attached from all over at annulus and at handle of malleus. Posteriorly there is ossicular chain and anteriorly there is eustachian tube. In our technique we are placing the cartilage in anterior most portion of the tympanic membrane. Though it does not hamper the aeration through eustachian tube, it might be restricting the movement on tympanic membrane

at 4k. Cartilage has lower compliance than fascia and hence, sudden pressure variations may not be well regulated with a more rigid tympanic membrane [6, 25]. 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. Using laboratory models, some researchers investigated the acoustic transfer characteristics of cartilage plates and their resistance to pressure changes. Zahnert et al. [25] 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. [25] noted that a cartilage plate with a thickness of less than 0.5 mm gave the least acoustic transfer loss. This may require further study and analysis. Nonetheless, the hearing improvement was highly significant as average air-bone gap closure was within 13.35 ± 5.22 dB at $p = 0.000$.

Conclusion

In tympanoplasty for anterior, subtotal or large central perforation, use of semilunar piece of tragal cartilage, medial to anterior rim has certain advantages. It gives good support for temporalis fascia graft. The effective anterior margin increases. Graft does not sink down in the middle ear. Graft does not retract backwards if temporalis fascia graft is sufficiently tucked in. Only 1–2 mm of tympanic membrane is supported anteriorly. So it does not hamper the mobility of TM. Normal eustachian tube function is preserved. Tragal scar is not very obvious. Narrow anterior

rim is a commonly encountered difficulty in tympanoplasty for anterior, large or subtotal perforation. This can be taken care of by creating a cartilage support. This technique has good results in terms of closure of perforation as well as hearing improvement. This technique is working well and can be considered as good alternative method in tympanoplasty for large or subtotal central perforations.

Statistical Analysis

In the above study, the following statistical methods were used. For quantitative data, descriptive statistics was presented by *N*, mean, standard deviation and range and for qualitative data, frequency count *N* and percentage were put in a tabular or graphical manner. To analyze data, appropriate statistical tests were applied such as, comparison between means of paired groups, paired *t* test was applied; to test the proportion of closure of perforation, binomial test was used and other data displayed by various tables and figures. All statistical analysis was done by using statistical software SPSS (version 16.0).

Conflict of interest None.

References

1. Zoellner F (1955) The principles of plastic surgery of the sound-conducting apparatus. *J Laryngol Otol* 69:567–569
2. Wullstein HL (1952) Functional operations in the middle ear with split-thickness skin graft. *Arch Otorhinolaryngol* 161:422–435
3. Heermann H (1960) Tympanic membrane plastic with temporal fascia. *Hals Nas Ohren* 9:136–139
4. Cavalier M, Mottola G, Rondinelli M, Iemma M (2009) Tragal cartilage in tympanoplasty: anatomic and functional results in 306 cases. *Acta Otorhinolaryngol Ital* 29:27–32
5. Amedee RG, Mann WJ, Riechelmann H (1989) Cartilage palisade tympanoplasty. *Am J Otol* 10:447–450
6. Vaidya S, Sharma H, Cartilage tympanoplasty for management of TM perforation: review of literature [internet]. 2012. URL: <http://www.waent.org/archives/2012/Vol5-1/20120120-cartilage-tympanoplasty/type-1-tympanoplasty.htm>. Accessed 20 Jan 2012
7. Finerman Wilmore B (1964) Causes of failure in tympanoplasty. *J Natl Med Assoc* 56:136–138
8. Dornhoffer J (2003) Cartilage tympanoplasty: indications, techniques and outcomes in 1000 patient series. *Laryngoscope* 113:1844–1856
9. Heermann J, Heermann H, Kopstein E (1970) Fascia and cartilage palisade tympanoplasty. *Arch Otolaryngol* 91:228–241
10. Nemade S (2011) Cartilage shield tympanoplasty: effect of thickness of graft on postoperative hearing results. *Odisha J Otorhinolaryngol Head Neck Surg* 5:1–8
11. Li H-E, Sun J-J, Lin Y-S (2007) Preserving the natural shape of the tragus and the pretragal depression during making cartilage perichondrium composite graft in tympanoplasty. *Zhonghua er bi yan hou tou jing wai ke za zhi Chin J Otorhinolaryngol Head Neck Surg* 42:152–153
12. Puls T (2003) Tympanoplasty using conchal cartilage. *Acta Otorhinolaryngol Belg* 57:187–191
13. Gerber MJ, Mason JC, Lempert PR (2000) Hearing results after primary cartilage tympanoplasty. *Laryngoscope* 110:1994–1999
14. Murbe D, Zahnert T, Bornitz M, Huttenbrink KB (2002) Acoustic properties of different cartilage reconstruction techniques of tympanic membrane. *Laryngoscope* 112:1769–1776
15. Altuna X, Navarro JJ, Martinez Z et al (2010) Island cartilage myringoplasty: anatomical and functional results in 122 cases. *Acta Otorhinolaryngol Esp* 61:100–105
16. Aidonis Ioannis, Robertson Thomas C, Sismanis Aristides (2005) Cartilage shield tympanoplasty: a reliable technique. *Otol Neurotol* 26:838–841
17. Giersek T, Slaska-Kaspera A, Majzel K, Klimczak-Goław L (2004) Results of myringoplasty and type I tympanoplasty with the use of fascia, cartilage and perichondrium grafts. *Otolaryngologia polska Polish Otolaryngol* 58(3):529–533
18. Nichlani SS, Jagade MV, Ganeshan A (2010) Reconstruction of the tympanic membrane with partial tragal cartilage graft versus temporalis fascia graft. *Bombay Hosp J* 52:197–201
19. Dabholkar JP, Vora K, Sikdar A (2007) Comparative study of underlay tympanoplasty with temporalis fascia and tragal perichondrium. *Indian J Otolaryngol Head Neck Surg* 59:116–119. doi:10.1007/s12070-007-0035-0
20. Shadyev Kh D, Vishnyakov VV (1997) Tragus perichondrium and cartilage, temporal fascia in tympanoplasty. *Vestn Otorinolaringol* 4:46–47
21. Heermann J (1978) Auricular cartilage palisade tympano-epi-tympano- antrum- and mastoid-plasties. *Clin Otolaryngol* 3:443–446
22. Kazikdas KC, Onal K, Boyraz I, Karabulut E (2007) Palisade cartilage tympanoplasty for management of subtotal perforations: a comparison with the temporalis fascia technique. *Eur Arch Otorhinolaryngol* 264:985–989
23. Arriaga MA (2010) Cartilage tympanoplasty: classifications of methods—techniques-results. *Otol Neurotol* 31:861–1012. doi:10.1097/MAO.0b013e3181e40a89
24. Dornhoffer JL (1997) Hearing results with cartilage tympanoplasty. *Laryngoscope* 107:1094–1099
25. Zahnert T, Huttenbrink K-B, Murbe D, Bornitz M (2000) Experimental investigations of the use of cartilage in tympanic membrane reconstruction. *Am J Otol* 21:322–328