ORIGINAL ARTICLE

Have We Found an Ideal Grafting Material for Tympanoplasty? Cartilage Island Graft!

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Abstract

The study was carried out to find out the ideal graft material by comparing the audiological outcome after tympanoplasty by using three different types of grafts: tragal cartilage, temporalis fascia, and cartilage island. The study included ninety patients, 30 in each group of tympanoplasty using temporalis fascia, tragal cartilage, and cartilage island by underlay technique. The patients were followed up for a period of 6 months, and hearing outcomes were compared by using pure-tone audiometry. The outcomes were analyzed in terms of residual perforation (graft uptake) and preoperative and postoperative hearing air–bone gap. Using statistical analysis, the cartilage island graft was found to be far superior to temporalis fascia and tragal cartilage grafts. The hearing outcome was improved in all groups but was statistically significant in the cartilage island group when compared to both the other groups (p <0.001). Hearing results of temporalis tympanoplasty and tragal cartilage tympanoplasty were similar and statistically insignificant ($p = 1$). Graft uptake of cartilage island was the best with no failures in our limited series. Graft uptake of temporalis fascia and tragal cartilage were also good, with slightly better results in the temporalis fascia group than in the tragal cartilage graft group (statistically insignificant $p = 1$). Overall, cartilage island graft is much superior to either the temporalis fascia or the whole cartilage graft as far as both graft uptake and hearing results are concerned. Although it is a more skillful job as far as the technique is concerned, the superior results make it worth following by every otology surgeon.

Keywords: Cartilage, Grafts, Island, Methods, Trends, Tympanoplasty.

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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. TM perforations significantly impair the quality of life of millions of patients. There are a number of materials for closure of TM perforations, like skin, perichondrium, vein, temporalis fascia, dura, and cartilage. The most frequently used technique for the repair of TM perforations is underlay grafting of temporalis fascia. However, long-term use of this graft has not proved satisfactory in cases of subtotal perforations, atelectatic ear, retraction pockets, ossiculoplasty, or mastoid surgery. It shows a higher chance of re-perforation, atrophy, and retraction.

To overcome these fallacies, cartilage grafts with or without perichondrium were used. It was used in the repair of large perforations, scutum defects, ossiculoplasty, atelectatic TM, eustachian tube dysfunction cases, and revision cases. The advantages of cartilage graft are minimal inflammatory tissue reaction, very low metabolic rate, nutrition by diffusion, resistance to pressure deformations, and its easy pliable and easy to harvest nature. It also provides firm support, thus avoiding future retractions. However, being thick and stiff, it mechanically reduces the vibratory pattern of the TM, contributing to some impairment in the functional results, especially in the higher tones. Being opaque, it may lead to the failure of recognition of a hidden cholesteatoma.

Tympanoplasty with cartilage island as graft material is a new technique that combines the benefits of both fascia and cartilage. The tensile strength of perichondrium along with the low metabolic rate of cartilage contributes to the higher graft uptake and hearing improvement.

This study was undertaken to state the merits of the cartilage island grafting method in tympanoplasty over other grafting materials.

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Method

This prospective study was carried out from August 1, 2014 to September 1, 2016, on patients attending the ENT Outpatient Department of BJ Government Medical College and Sassoon Hospital, Pune. The approval and permission from the Ethics Committee and Authority were obtained prior to starting the study. Informed written consents were obtained from all patients undergoing the surgery according to the protocol approved by the Ethics Committee of our institution.

Patient Selection

Sample Collection

This study included a sample of ninety patients attending the ENT Outpatient Department over a period of 2 years. The following criteria were used for the selection of cases:

Inclusion Criteria

- Patients with CSOM tubo-tympanic type with ear dry, moderate, large, and subtotal sizes.
- Age above 16 years and below 60 years.

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Exclusion Criteria

- CSOM attico-antral disease.
- CSOM tubo-tympanic disease active stage.
- Age below 16 years and above 60 years.
- Tympanic perforation of small size.
- Patients with previous ear surgery done.

Pure-tone audiometry was done at 1.5, 3, and 6 months postoperatively, and average air–bone gap was calculated using the values of three frequencies, 500, 1000, and 2000 Hz.

Results

In this study, seventy four patients were operated using the postauricular approach and 16 using the endaural approach of tympanoplasty. A total of 49 were operated under general anesthesia and 41 under local anesthesia. Majority (46.6%) of the patients belonged to the age-group of 21–30 years, 36.7% patients were in the age-group of 31–60 years, while only 16.7% patients were between 16 and 20 years of age. This distribution was statistically insignificant with respect to the graft material used.

As presented in Table 1, preoperatively, 48% cases had slight hearing loss, 37% cases had mild hearing level, and 14% cases had moderate hearing loss.

The postoperative analysis of hearing indicates that 56% of the patients showed closure of air–bone gap up to 0–10 dB level and that 42% showed closure till 11–20 dB of air–bone gap. A total of 30% of patients operated using temporalis fascia graft showed air–bone gap in the range of 0–10 dB, 40% of patients operated with tragal cartilage showed air–bone gap in the range of 0–10 dB, and 96% of patients operated with cartilage island showed air–bone gap in the range of 0–10 dB. There was no statistically significant difference ($p = 1$) between the temporalis fascia group and the tragal cartilage group. However, there was statistically significant difference ($p < 0.001$) between the tragal cartilage group and the cartilage island group. Similarly, there was statistical significant difference ($p < 0.0001$) between the temporalis fascia group and the cartilage island group.

In our study, overall, 92.2% cases had a successful closure without any residual perforation, out of which 100% cases of cartilage island had successful closure, while 90 and 86.7% cases of temporalis fascia and tragal cartilage showed successful closure, respectively.

Even though there is no statistical significant difference ($p = 0.133$) between the three study groups, which might be due to the small sample size, the success rate of cartilage island graft was superior to the temporalis fascia group and the tragal cartilage group.

As presented in Table 2, the mean postoperative improvement in hearing levels was 17.7 dB for the cartilage island group, while it was 9.3 and 9.2 dB for the temporalis fascia and the tragal cartilage groups, respectively.

Discussion

The purpose of our study was to emphasize the merits of cartilage island tympanoplasty over other grafting methods due to the lack of existing studies on cartilage island tympanoplasty.

Hearing Results

Overall, 92% of patients among all the study groups in our study showed an improvement in their hearing levels, while 8% showed no improvement, deterioration, or meager improvement in their hearing levels postoperatively at 6 months of follow-up period. In total, 96% cases of cartilage island tympanoplasty showed a postoperative air–bone gap of less than 10 dB, while the comparable figures in the groups of temporalis fascia and tragal cartilage were only 30 and 40%, respectively.

The mean postoperative air–bone gap in hearing using temporalis fascia, tragal cartilage, and cartilage island were 15.1, 15.4, and 5.6 dB, respectively. There was no statistical significance ($p = 1$) between postoperative hearing levels of the temporalis fascia and the tragal cartilage groups. Our results of using fascia and tragal cartilage compare well with the reports given by Gerber et al.[1] and

Table 1: Distribution of patients as per preoperative and postoperative hearing levels

Air–bone gap (dB)	*Temporalis fascia no. (%)*		*Tragal cartilage no. (%)*		*Cartilage island no. (%)*		*Total no. (%)*	
	Preoperative	*Postoperative*	*Preoperative*	*Postoperative*	*Preoperative*	*Postoperative*	*Preoperative*	*Postoperative*
0–10	1 (3.3)	9 (30.0)	1 (3.3)	12 (40.0)	2 (6.7)	29 (96.7)	4 (4.44)	50 (55.6)
11–20	14 (46.7)	18 (60.0)	13 (43.3)	14 (46.7)	13 (43.3)	1 (3.3)	40 (44.4)	33 (36.7)
21–30	11 (36.7)	2 (6.7)	12 (40.0)	4 (13.3)	10 (33.3)	0 (0)	33 (36.7)	6 (6.7)
>31	4 (13.3)	1 (3.3)	4 (13.3)	0 (0)	5 (16.7)	0 (0)	13 (14.4)	1 (1.3)
Total	30 (33.3)	30 (33.3)	30 (33.3)	30 (33.3)	30 (33.3)	30 (33.3)	90 (100.0)	90 (100.0)
Mean ± SD	24.4 ± 7.3	15.1 ± 7.3	24.7 ± 7.2	15.4 ± 6.9	23.5 ± 9.0	5.6 ± 2.7		

F value = 0.157; *p* value = 0.855 for preoperative analysis; *F* value = 25.252; *p* value = <0.0001, using *Post hoc* test [Bonferroni test] for postoperative hearing loss analysis

Table 2: Distribution of patients as per postoperative improvement in hearing levels

Postoperative improvement in hearing levels (dB)	*Temporalis fascia No. (%)*	*Tragal cartilage No. (%)*	*Cartilage island No. (%)*	*Total No. (%)*
Mean ± SD	9.3 ± 5.8	9.2 ± 4.0	17.7 ± 7.9	
F value		19.12		
p value		<0.0001		
Post hoc test (Bonferroni test)	*p* value = 1 between group I and II *p* value <0.0001 between group I and III *p* value <0.0001 between group II and III			

Group I, temporalis fascia; Group II, tragal cartilage; Group III, cartilage island

Gierek et al.[2] in their comparative studies between tympanoplasty using temporalis fascia and tragal cartilage grafts. However, both of them did study only fascia and tragal cartilage but did not study cartilage island; hence, the significant improvement by using cartilage island could not be compared.

Kalcioglu et al.[3] found a postoperative air–bone gap of 15.42, 11.67, 8.34, 7.36, and 8.61 dB for the frequencies of 250, 500, 1000, 2000, and 4000 Hz, respectively, for tympanoplasty operated using temporalis fascia as graft. All cases showed a postoperative air–bone gap in the range of 7–20 dB, compared to our study having a postoperative air–bone gap of 15.1 dB for temporalis fascia. Vaidya et al.[4] stated an average postoperative air–bone gap to be 17.05 dB for temporalis. In their study, 96% cases showed a postoperative air–bone gap closure of less than 20 dB at 6 months as compared to our study showing 90% cases with a postoperative air–bone gap of less than 20 dB, which is statistically insignificant. The temporalis fascia graft has always given good results with respect to hearing levels as per the data and studies available in the past. Our study also proved the same with satisfactory hearing results postoperatively.

Hartwein[5] observed a postoperative air–bone gap of 18.5, 17.5, 16.5, and 13.5 dB in the frequencies of 500, 1000, 2000, and 4000 Hz using tragal graft, which—when compared to our study having a postoperative air–bone gap of 15.4 dB—is statistically insignificant. Aidonis et al.[6] found the average preoperative and postoperative air–bone gap to be 32.4 ± 14.1 dB and 24 ± 13.7 dB, respectively, for cartilage shield grafts, concluding that the cartilage graft may affect the hearing results due to its thickness and rigid nature. Khan[7] achieved postoperative air–bone gap closure within 7.06 ± 3.39 dB for sliced tragal cartilage. His study on 223 cases gave far superior results to our study, but it is an exception. Vaidya[4] observed an average postoperative air–bone gap of 16.3 dB for cartilage shield tympanoplasty, with 92.30% cases showing a postoperative air–bone gap of less than 20 dB at 6 months as compared to our study with 86.7% cases showing a postoperative air–bone gap of less than 20 dB, which is statistically insignificant. Cartilage being thicker and rigid was considered to affect the acoustic properties. Also, due to it being opaque, the middle ear area cannot be examined as in temporalis fascia, which gives visibility of the middle ear. But with the new techniques and methods being used for cartilage tympanoplasty, like cartilage slicing technique, hearing results have improved over the years, with it being almost equivalent when compared to temporalis fascia graft.

Cartilage island tympanoplasty results in a superior closure of the air–bone gap. Our study gave superior results as the technique used had modifications in the fashioning of the cartilage island. The cartilage was thinned, and the 2-mm strip for accommodating the handle of malleus was not created as in previous studies conducted by others. Only a small portion of cartilage corresponding to the size of the perforation was fashioned as an island with the perichondrium forming the rest of the periphery of the graft (Figs 1 to 3). The tensile strength of the perichondrium along with the low metabolic properties of the cartilage contributed to the higher rate of graft uptake and hearing improvement when compared to temporalis fascia or tragal cartilage individually. Chances of retraction and formation of retraction pockets are also minimal (Fig. 4).

Chhapola[8] emphasized that incorporation of cartilage in perichondrium as a composite would counteract negative middle ear pressure, which is of paramount importance in eustachian tube dysfunction cases. Moreover, the appropriate cartilage thickness would not hamper conduction of sound and protect graft from retraction or re-perforation. Desarda[9] achieved 96% success rate

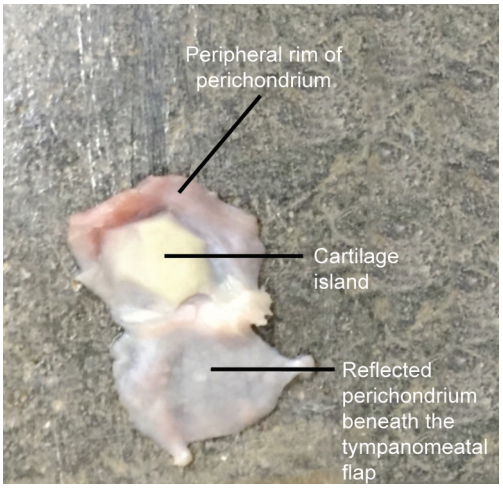

Fig. 1: Harvested cartilage island graft

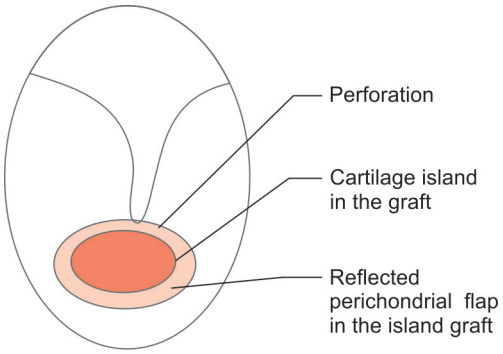

Fig. 2: Cartilage island graft

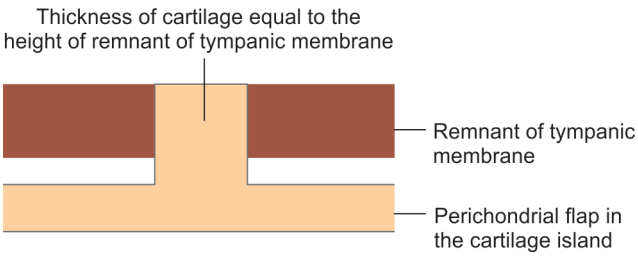

Fig. 3: Cross-section of cartilage island graft

using tragal cartilage with perichondrium as a composite graft for myringoplasty, stating it to be the best material for reconstructive tympanoplasty.

Kalcioglu[3] found frequency-specific postoperative air–bone gap to be 15.42, 11.67, 8.34, 7.36 and 8.61 dB for the frequencies of 250, 500, 1000, 2000, and 4000 Hz for cartilage island grafts. Karaman[10] found postoperative air–bone gap closure of 20.2, 23.58, 22.23, and 24.79 dB at 500, 1000, 2000, and 4000 Hz for cartilage island graft, which as compared to our study was superior. Yurttas et al.[11] achieved 93% success rate of cartilage island tympanoplasty. No graft lateralization or displacement into the middle ear occurred. The overall average pre- and postoperative air–bone gap was 37.27 ± 12.35 and 27.58 ± 9.84 dB, respectively. They concluded that if cartilage graft is prepared and placed properly, then the cartilage island grafting method of tympanoplasty appears to provide better success rates and hearing results. Genc[12] also had a

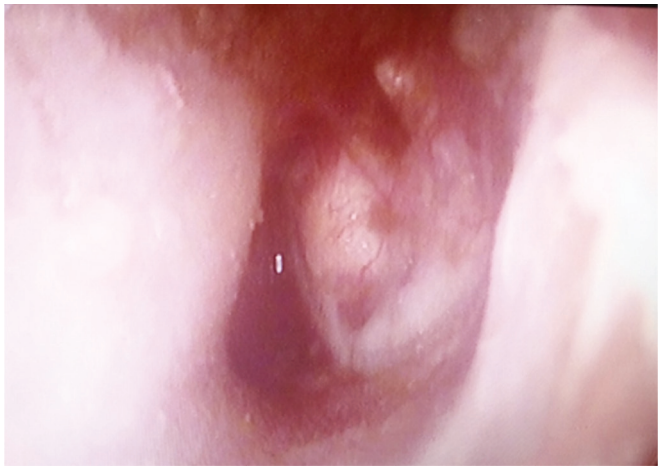

Fig. 4: Neotympanum after cartilage island tympanoplasty

similar study with cartilage island with the average postoperative air–bone closure of more than 19 dB.

Tyagi[13] observed a closure of air–bone gap within 0–30 dB in 94.55% cartilage island tympanoplasty: 32.72% had closure within 10 dB, 36.36% within 20 dB, 25.45% within 30 dB, and 5.45%, >30 dB. The main advantage of the cartilage island graft was observed to be its very low metabolic rate, other advantages being its nutrition by diffusion, pliability—making it easy to work with, and its resistance to deformation from pressure variations. However, it has the opaque nature of TM, potentially hiding residual cholesteatoma as the main disadvantage. Graft uptake rate was found to be 96.36%, and audio-logical outcomes with closure of 94.55% air–bone gap within 0–30 dB were achieved.

Graft Uptake Rate

The graft uptake rate in terms of the absence of residual perforation was 92% at the end of 6 months of follow-up. There were in total 8% cases of residual perforation postoperatively.

Kalcioglu[3] found graft survival rates to be 86.1 and 95% in the temporalis fascia and cartilage island groups comparable to our results of 90 and 100%. Similarly, Karaman et al.[11] found 97.29% of graft uptake rate of cartilage island tympanoplasty.

Reddy[14] compared the results of temporalis fascia with cartilage perichondrium tympanoplasty. At 6 months postoperatively, there was 95.77% success of graft uptake with 4.22% re-perforation cases with temporalis, while with cartilage perichondrium, 98.36% cases showed successful graft uptake with only 1.63% cases of re-perforation. After 2 years, 84.5% cases were successful, with 9.85 and 7.04% cases showing re-perforation and retraction pocket formation with temporalis fascia, while the results with cartilage perichondrium were consistent as before.

Most of the graft failures were due to infection in the postoperative period either along the eustachian tube or via the external auditory canal. Most of the patients belonged to low socio-economic strata, poor personal hygiene and care also being one of the factors responsible for failure.

The cartilage island graft has proved superior to both the whole cartilage and temporalis fascia graft in a way that graft uptake rate is 100% and hearing results are much better. It combines the stability and strength of cartilage and the resilience of perichondrium together. The island of cartilage just helps to plug the perforation, and remaining perichondrium which underlays the rest of the TM gives strength to the TM. That is why, we see 100% graft uptake in a group of thirty patients, even though in a very large group it may fall slightly. Surprisingly, even for us, the hearing results of cartilage island graft was far superior to the other two groups. One reason could be, as the island of cartilage is just of the size of the perforation, it is not adding to the mass of the handle of malleus and impeding the movement of the handle of malleus. The whole cartilage, on the contrary, which extends from one perimeter to other perimeter catching the handle of malleus in between, not only will add bulk to the whole TM and the handle of malleus but also could impede the movement of the handle of malleus. By this particular cartilage island graft, the issue of weakness associated with the temporalis fascia has also been taken care of.

As regards the ease of technique, we do agree that the technique is little more difficult than temporalis fascia and whole tragal cartilage. It requires a certain degree of exposure and competence in otology surgery before one can embark on cartilage island tympanoplasty. Carving an exact island of cartilage, at the same time not injuring the remaining perichondrium on which the cartilage is sliced, is a skillful job. Placing the graft is however very easy. Hence, although this is not a surgery for the newcomer, all the middle-level surgeons should be able to perform this very easily.

Conclusion

Cartilage island graft is a better graft material than temporalis fascia and tragal cartilage for tympanoplasty. Hearing results are superior with cartilage island tympanoplasty, and statistically significant difference is found between it and tragal cartilage and temporalis fascia individually. Hearing results of temporalis tympanoplasty and tragal cartilage tympanoplasty are similar and statistically insignificant ($p = 1$).

Graft uptake of cartilage island is best with no failures in our limited series. Graft uptake of temporalis fascia and tragal cartilage is also good, with slightly better results of temporalis fascia than those of tragal cartilage graft statistically insignificant ($p = 1$).

Overall, cartilage island graft is much superior to either the temporalis fascia or the whole cartilage graft as far as both graft uptake and hearing results are concerned. Although it is a more skillful job as far as the technique is concerned, the superior results make it worth following by every otology surgeon.

References

1. Gerber MJ, Mason JC, Lambert PR. Hearing results after primary cartilage tympanoplasty. Laryngoscope 2000;110(12):1994–1999. DOI: 10.1097/00005537-200012000-00002.
2. Gierek T, Slaska-Kaspera A, Majezal K, et al. Results of myringoplasty and type–I tympanoplasty with use of fascia, cartilage and perichondrium graft. Otolaryngol Pol 2004;18(3):529–533. PMID: 15311598.
3. Kalcioglu T, Firat Y, Selimoglu E. Cartilage tympanoplasty with island technique: a comparison with the temporalis muscle fascia technique. Int Adv Otol 2009;5:45–50.
4. Vaidya S, Parikh V, Shah S, et al. Comparison of modified cartilage shield tympanoplasty with tympanoplasty using temporalis fascia only: retrospective analysis of 142 cases. Scientifica (Cairo) 2016;2016:8092328. DOI: 10.1155/2016/8092328.
5. Hartwein J. "Crown–cork tympanoplasty" a method complete reconstruction of tympanic membrane. Laryngor–Hinootogies 1992;71(2):102–105. Pubmed ID:1571054.

6. Aidonis I, Robertson TC, Sismanis A. Cartilage shield tympanoplasty: a reliable technique. Otol Neurotol 2005;26(5):838–841. DOI: 10.1097/01.mao.0000185046.38900.1f.
7. Khan MM, Parab SR. Primary cartilage tympanoplasty: our technique and results. Am J Otolaryngol 2011;32(5):381–387. DOI: 10.1016/j.amjoto.2010.07.010.
8. Chhapola S, Matta I. Cartilage–perichondrium: an ideal graft material? Indian J Otolaryngol Head Neck Surg 2012;64(3):208–213. DOI: 10.1007/s12070-011-0306-7.
9. Desarda KK, Bhisegaonkar DA, Gill S. Tragal perichondrium and cartilage in reconstructive tympanoplasty. Indian J Otolaryngol Head Neck Surg 2005;57(1):9–12. DOI: 10.1007/BF02907617.
10. Karaman E, Duman C, Isildak H, et al. Composite cartilage island grafts in type I tympanoplasty: audiological and otological outcomes. J Craniofac Surg 2010;21(1):37–39. DOI: 10.1097/SCS.0b013e3181c36283.
11. Yurttas V, Yakut F, Kutluhan A, et al. Preparation and placement of cartilage island graft in tympanoplasty. Braz J Otorhinolaryngol 2014;80(6):522. DOI: 10.1016/j.bjorl.2014.08.007.
12. Genc S. A different cartilage graft technique: perichondrium–preserved palisade island graft in tympanoplasty. J Craniofac Surg 2016;27(2):e166–e170. DOI: 10.1097/SCS.0000000000002411.
13. Tyagi BS, Tyagi S, Srivastava M, et al. Is cartilage-perichondrium composite graft tympanoplasty the ideal treatment for revision tympanoplasty? Int J Otorhinolaryngol Head Neck Surg 2017;3(1):91–94. DOI: 10.18203/issn.2454-5929.ijohns20164807.
14. Reddy R. Comparative study of results of cartilage-perichondrium vs temporalis fascia grafting in active tubotympanic type of chronic suppurative otitis media. J Evol Med Dent Sci 2014;3(24):6714–6720. DOI: 10.14260/jemds/2014/2809.