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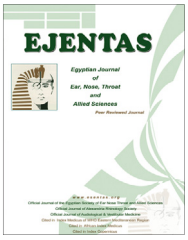


ORIGINAL ARTICLE

# Audiological and otological outcome in Bi-island chondroperichondrial graft type I tympanoplasty


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**KEYWORDS**

Type I tympanoplasty;
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Island technique;
Hearing outcome;
Graft take rate

**Abstract** *Background:* The principal aims of a tympanoplasty operation are to create an intact tympanic membrane and to restore an optimal hearing improvement. Many surgeons have used cartilage for grafting due to its increased stability and resistance to negative pressure. Cartilage has been criticized because of concerns regarding hearing results.

*Objectives:* The aim of this study is to present the experience of using cartilage for grafting central perforations in type I tympanoplasty procedure with some novel modifications and evaluate its take rate and audiologic results.

*Methods:* This is a prospective study including 40 patients (45 ears) who underwent type I cartilage tympanoplasty. All patients are primary cases of chronic suppurative otitis media of tubo-tympanic type. The following parameters were evaluated at least after 3 months from surgery: graft take and change between the pre- and post-operative pure-tone average air-bone gap (PTA-ABG).

*Results:* Thirty-nine patients included in the study underwent 45 cartilage tympanoplasty type I operations. The mean age of the patients was 24.9 ± 9.5 years (range, 15–51 years). The mean follow up period was 6.2 months (range, 3–9 months). All perforations were found to be closed with a 100% graft take rate. The overall mean pre-operative PTA-ABG was 26.0 ± 4.4 dB, whereas the postoperative PTA-ABG was 13.8 ± 5 dB ($p < 0.0001$) which is highly significant. The percent of reduction of PTA-ABG was about 46.6%.

*Conclusion:* Bi-island chondroperichondrial type I tympanoplasty is an effective and reliable technique with a high success rate and minimal complications.



## 1. Introduction

To date, temporalis fascia remains the most commonly employed material for tympanic membrane reconstruction with a success rate of 93–97% in primary tympanoplasties.[1]

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According to Wullstein's classification; type I tympanoplasty is synonymous to myringoplasty and refers to the repair of perforated TM without altering the ossicular system. All three ossicles are present and mobile, the procedure includes exploration of middle ear to inspect and ensure normality of ossicles.[2]

Many surgeons have used cartilage as a grafting material on account of its increased stability and resistance to negative middle ear pressure, even in cases with chronic eustachian tube dysfunction.[3]

For cases at high risk for failure, such as recurrent perforations, total perforations, and severely atelectatic tympanic membranes, many surgeons have used cartilage as a grafting material.[4]

Fascia and perichondrium need a new vascular supply but cartilage is supplied by diffusion. Cartilage also seems to offer high resistance both to the lack of vascularization and to infections.[5]

There are many described techniques for cartilage tympanoplasty such as cartilage butterfly inlay technique, cartilage palisade technique, perichondrium cartilage island technique, cartilage mosaic technique and cartilage reinforcement technique.[6]

This grafting material is easy to harvest from the conchal bowl or tragus and is well tolerated in the middle ear. Cartilage material has been criticized because of concerns regarding hearing results and postoperative middle ear surveillance in cholesteatoma cases also is blamed for the increased complication risk if acute otitis media occurs later on.[7]

The aim of this study is to present the experience of using cartilage for grafting central perforations in type I tympanoplasty procedure with bi-island chondroperichondrial modifications and evaluate its take-rate and audiologic results.

## 2. Materials and methods

This is a prospective study including a total number of 40 patients (45 ears) who underwent bi-island chondroperichondrial type I cartilage tympanoplasty (intact ossicular chain) between January 2011 and January 2013 at the Department of Otolaryngology–Head and Neck Surgery, Ain Shams University Hospitals. Six patients underwent bilateral tympanoplasty with a period of 6 months interval between the 2 operations. One patient was excluded from the study because of less than 3 months follow-up postoperatively. All operations included in this study are done by the same surgical team (the authors) using the same technique.

The study population is not selected according to sex. All patients are primary cases of chronic suppurative otitis media (CSOM) of tubotympanic type. The main symptom of complaining was recurrent attacks of otorrhea that have been stopped for at least 3 months prior to surgery. All the patients have tympanic membrane central, kidney shaped perforation (perforation of > 50% of the whole TM area) with normal middle ear mucosa.

Patients with ossicular chain defects, cholesteatoma, otorrhea, middle ear granulation, history of previous middle ear surgery or massive tympanosclerosis were not included in the study. Also patients younger than 15 years of age were excluded from the study.

All the patients were assessed through a clinical history, general and otorhinolaryngological physical examination, imaging is done routinely in the form of temporal bone CT scan. Each patient underwent preoperative audiological evaluation including speech reception threshold and speech discrimination testing.

The following parameters were evaluated at least after 3 months from surgery: graft take and change between the pre- and post-operative pure-tone average air-bone gap (PTA-ABG). Other post operative complications were evaluated such as reperforation, sensorineural hearing loss, retraction pockets, facial nerve injury and tinnitus.

Postoperatively, the patients are observed regularly at the clinic on the postoperative day 10 (for the removal of the external gauze and sutures), at 1 month for otoscopic evaluation and at 3 months (for endoscopic ear examination and audiometry). A third endoscopic evaluation is performed at 6 to 9 months. Successful graft take was defined as having no perforation (within at least 3 months after surgery), retraction, lateralization or graft granulation (Fig. 5).

Audiological evaluation was made among the patients for whom complete tympanic membrane closure was achieved. The PTA-ABG for each audiogram was evaluated by calculating the mean air-bone gap at 500, 1000, 2000, 4000, and 8000 Hz. Pre- and post-operative PTA-ABG were compared using the Independent-Sample $T$ Test and Chi-Square test.

The collected data were revised, coded, tabulated and introduced to a PC using the Statistical package for Social Science (SPSS 15.0 for windows; SPSS Inc., Chicago, IL, 2001). Data were presented and suitable analysis was done according to the type of data obtained for each parameter. A $p$ value of less than 0.05 was considered statistically significant.

Institutional Review Board approval and patients' consent were obtained.

## 3. Modification in bi-island chondroperichondrial technique

The edges of the perforation was freshened and followed by dissection of the posterior canal wall skin and the tympanic membrane remnant from the malleus. The meatal skin, the posterior part of the tympanic membrane and annulus were cut and separated as a free flap, then the meatal skin was put in saline after marking the lateral, medial, superior and inferior edges.

The bone was drilled (canaloplasty) till the perforation and the annulus could be seen in the whole circumference. Also drilling was done posteriorly to expose the incudostapedial joint.

The cartilage graft was harvested from the tragus and the cartilage–perichondrium graft was prepared by removing the perichondrium from one side of the cartilage while maintaining its attachment on the other side. A midline cartilage strip (not including perichondrium) was removed from the cartilage island till two semicircles of cartilage connected by perichondrium were formed (bi-island) (Fig. 1).

Inspection of the ossicular chain was included, as mentioned previously, chain continuity, chain fixation, and inspection of the attic for hidden cholesteatoma that may change the treatment plane and also the eustachian tube were endoscopically assessed.

The reconstruction of the tympanic membrane perforation was started, the anterior island was tucked under the annulus and the bare perichondrium area in the middle of the graft is tucked below the handle of malleus (sometimes excision of the umbo was done to avoid medialization of the graft). The posterior cartilage island was placed over the incudostapedial joint to repair the posterior part of the tympanic membrane perforation. After repairing the tympanic membrane with this cartilaginous graft, it acquires a funnel shape (Figs. 2 and 3).

The meatal skin was returned to its original position but we prefer to move the skin flap a little bit anteriorly to cover the posterior third of the graft (Fig. 4). Pledgets of Gelfoam are placed over the graft for stabilization.

Postoperative treatment was given for 10 days in the form of amoxicillin and clavulinic acid for 10 days and NSAIDS (non steroidal anti inflammatory drugs).

## 4. Results

Thirty-nine patients included in the study underwent 45 cartilage tympanoplasty type I operations. The mean age of the patients was 24.9 ± 9.5 years (range, 15–51 years). There were 26 females (66.6%) and 13 males (33.4%). Twenty-seven operations were done on the right ear while 18 on the left. Thirty-three patients had a unilateral pathology while 6 patients underwent bilateral operation.

The mean follow up period was 6.2 months (range, 3–9 months). All perforations were found to be closed regardless of their size with a 100% graft take rate. There were no immediate post-operative complications such as wound infection, hematoma or facial nerve injury. Three cases complained from tinnitus postoperatively which decreased in intensity by time. Three cases presented postoperatively with a posterior canal granulations on the edges of the free flap which responded to local treatment. One patient had a mild sensorineural hearing loss (SNHL) of 5 dB.

**Figure 1** The bi-island cartilage graft after removing a cartilage strip from its center.

**Figure 2** The bi-island cartilage graft is put in its proper place.

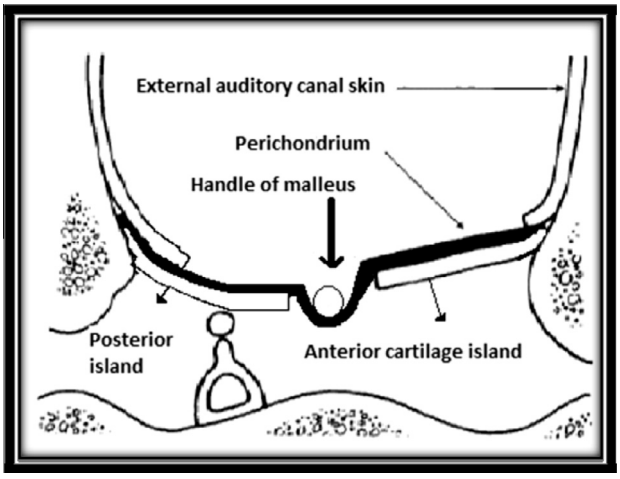


**Figure 3** This diagram shows the proper placement of the graft.

**Figure 4** The final step after returning the free posterior wall meatal skin flap to its original position with a little bit anterior displacement to cover the posterior third of the flap.

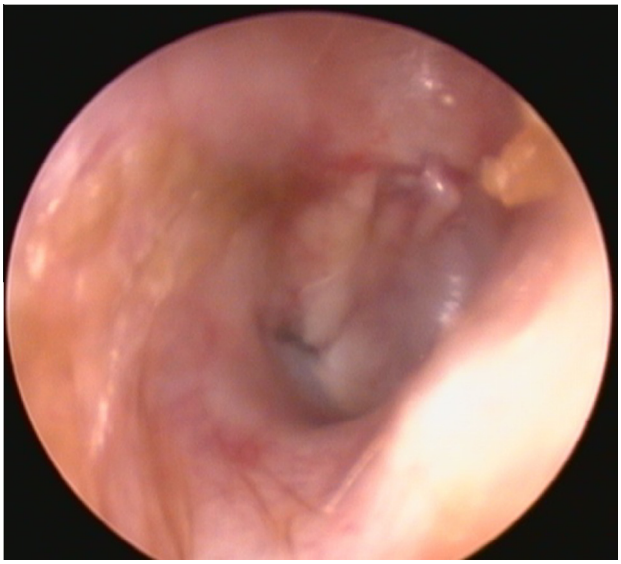

**Figure 5** Postoperative endoscopic view 3 months after surgery.

In all patients a pure tone audiogram from 250 Hz to 8 kHz was obtained preoperatively which is compared to a postoperative pure tone audiogram done at third month after surgery. During analysis of the results of pure tone audiogram for each patient; the frequencies were grouped into a low and high frequency. The overall mean pre-operative PTA-ABG was 26.0 ± 4.4 dB, whereas the post-operative (3 months after surgery) PTA-ABG was 13.8 ± 5 dB ($p < 0.0001$) which is statistically highly significant. The percent of reduction of PTA-ABG was about 46.6% (Table 1 and Fig. 6).

The results of the Speech discrimination scores (SDS) and the speech reception threshold (SRT) were compared pre and post operatively. There was a statistically non-significant difference ($p$ value of 0.03) regarding SDS while SRT was improved with a statistically significant difference ($p$ value < 0.001) (Table 2).

## 5. Discussion

Contrary to other materials, cartilage has some physical properties that facilitate its use in tympanoplasties. These grafts are nourished by diffusion and easily incorporated on the tympanic membrane, which has been confirmed in second look tympanoplasties.[1] It is a more robust material, easier to fit on the ear drum perforation site. It is thicker, less prone to resorption and retraction. They have no secretory glands, nor hair follicles as those found in the skin, thus being used as tympanic membrane graft without the risk of causing iatrogenic cholesteatomas.[14] Cartilage minimizes the inflammatory tissue reaction and ensures resistance against infection during the recovery process.[15]

Although the indication of cartilage use in tympanoplasty is numerous, we included only type I tympanoplasty in this series in order to properly assess the impact of this technique on the outcome of surgery by isolating cases with intact and mobile ossicular chain.

In our series; tragal cartilage was used, since 2 mm cartilage strip was left intact in the tragal dome, we have not observed any cosmetic problems related to tragal cartilage harvesting. Preparation of the perichondrium cartilage island graft was easy, and by experience sizing of the cartilage graft and shaping it to fit the circumference of the middle ear were no more a time consuming step.

The tragal cartilage is typically slightly less than 1 mm thick and therefore it can be used as a full-thickness graft. It can be used without any slices as we did but according to Zahnert's experimental study, cartilage slices < 500 μm thick are similar to the tympanic membrane in terms of their acoustic properties.[13] Since our hearing results were good, we recommend full-thickness grafts for cartilage reconstruction of the eardrum.

The overall graft take rate of 100% suggests that our technique is a reliable one. Other studies for different authors showed a success rate ranging from 93.2%,[8] 97%,[9] 97.7%,[10] 98.2[11] to 100%[12] which is in agreement with our results.

The overall mean pre-operative PTA-ABG was 26.0 ± 4.4 dB, whereas the post-operative (3 months after surgery) PTA-ABG was 13.8 ± 5 dB ($p < 0.0001$) which is highly significant. Our results are similar to Dornhoffer's type I cartilage tympanoplasty results (average PTA-ABG improvement of 11.3 ± 9.2 dB).[16] The excellent hearing results obtained in the present study compare favorably with those published by different authors and support the hypothesis that cartilage use has excellent function outcome.

**Table 1** Comparative study between preoperative and postoperative audiometric findings in the studied group. NS (non-significant), HS (highly significant).

| Audiometry | | | Mean | ±SD | $t$ | $P$-value | Sig. |
|---|---|---|---|---|---|---|---|
| Nerve | Low frequency | Preoperative | 15.3 | 4.0 | −1.000 | 0.334 | NS |
| | | Postoperative | 15.7 | 4.2 | | | |
| | High frequency | Preoperative | 17.0 | 7.3 | −1.382 | 0.189 | NS |
| | | Postoperative | 18.0 | 7.0 | | | |
| | Overall | Preoperative | 16.2 | 5.4 | −1.468 | 0.164 | NS |
| | | Postoperative | 16.8 | 5.2 | | | |
| Air bone gap | Low frequency | Preoperative | 28.3 | 7.0 | 8.264 | <0.001 | HS |
| | | Postoperative | 15.7 | 6.2 | | | |
| | High frequency | Preoperative | 23.7 | 5.8 | 6.041 | <0.001 | HS |
| | | Postoperative | 12.0 | 7.0 | | | |
| | Overall | Preoperative | 26.0 | 4.4 | 9.282 | <0.001 | HS |
| | | Postoperative | 13.8 | 5.0 | | | |
| | Percent of reduction of ABG mean (range) % | | 46.6 (83.3–22.2%) | | | | |

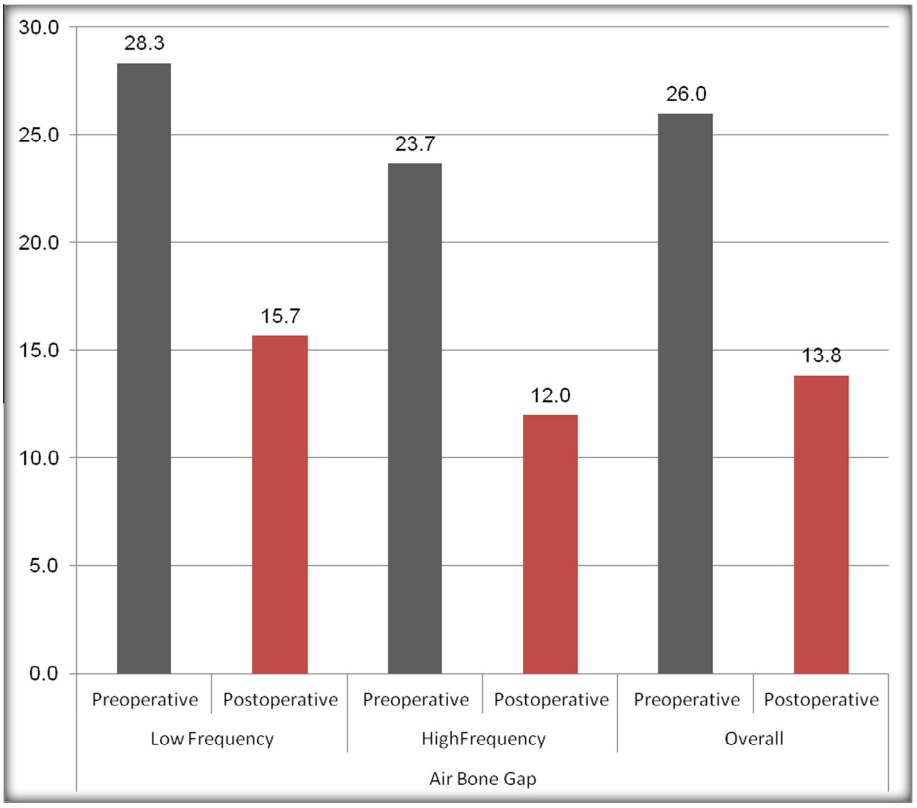


**Figure 6** Preoperative and postoperative audiometry.

**Table 2** Comparative study between preoperative and postoperative SDS and SRT findings in the studied group.

| Audiometry | Pre-operative (mean ± SD) | Post-operative (mean ± SD) | *P* value |
|---|---|---|---|
| SRT | 34.1 ± 10.0 | 19.4 ± 7.8 | <0.001 |
| SDS | 94.1 ± 8.3 | 96.7 ± 6.5 | 0.03 |

In our study, we applied some modifications on the cartilage techniques, to deal with the disadvantages of cartilage tympanoplasty. Cartilage tragal graft was shaped in a bi-island shape and we left the central perichondrium as a bare strip to give the graft these advantages:

1. To avoid entrapment of pus if the ear later on develops acute otitis media, this allows the pus to perforate the central part to minimize the complication that might happen.
2. The presence of perichondrial central strip will allow separate mobility of the anterior and posterior islands.
3. Regardless of the distance between the handle of the malleus and promontory, we could move both islands in a way to avoid medialization because each island moves freely not limited by the position of the other island or malleus position.

We cut the posterior skin meatal free flap and we do not reflect it anteriorly to allow complete visualization of the tympanic membrane remnant and this also allows easy manipulation during graft positioning. Routine canaloplasty is done which allows an optimum visualization of tympanic membrane remnant. According to our series this step has no postoperative complication as skin sloughing, two cases only developed postoperative external canal granulation which is treated simply applying an antibiotic and steroid cream.

Our results have a very high success rate of graft taking (100%) with no failures and this gives an idea that our modification of cartilage tympanoplasty is effective and reliable.

Three cases developed postoperative tinnitus: one of these cases was high frequency resistant tinnitus and this could be explained by the development of mild SNHL. The other two cases develop clicking tinnitus and this could be explained by the movement of the cartilaginous islands and friction with the surrounding and was improved within 3 months.

## 6. Conclusion

Bi-island chondroperichondrial type I tympanoplasty is an effective and reliable technique with a high success rate and minimal complications.

## Conflict of interest

There is no conflict of interest and no financial disclosures.

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