ORIGINAL RESEARCH PAPER

Otorhinolaryngology

KEY WORDS: Cartilage Shield Tympanoplasty, Revision Tympanoplasty, Myringoplasty Failure.

PRESERVING HEARING: THE ADVANCEMENTS OF CARTILAGE SHIELD TYMPANOPLASTY

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ABSTRACT

Background: Cartilage Shield Tympanoplasty (CST) is an emerging as a preferred technique for revision surgery in myringoplasty failures. The rigidity of cartilage helps resist retraction, though concerns about hearing outcomes and follow-up surveillance remain. **Aim:** To evaluate the advacements of cartilage shield tympanoplasty in revision cases. **Methods:** A prospective study at our tertiary institute involved 100 patients (ages 18-50) with one or more failed tympanoplasties with duration of study from January 2023 to June 2024. Pre and post-operative audiograms were obtained, with follow-ups to assess graft uptake and hearing outcomes. **Results:** The mean pre-operative pure tone air-bone gap (PTA-ABG) was 26.08±8.10 dB, while the mean post-operative PTA-ABG was 14.45±5.17 dB. One case (4%) showed residual perforation, which was addressed with fat myringoplasty. The graft take rate was 96%, and the mean post-operative gain in PTA-ABG was 11.63 ±7.10 dB. **Conclusions:** CST is recommended for revision tympanoplasty cases.

INTRODUCTION

Reconstructing the hearing mechanism through surgery, either with or without tympanic membrane perforation restoration, is known as tympanoplasty. Duckert et al. published the first literature report on cartilage shield tympanoplasty in 1995. Tympanic membrane perforations can cause significant hearing loss, recurrent infections, and complications such as cholesteatoma.[1] Traditional tympanoplasty techniques using numerous graft materials, including skin, fascia lata, temporalis fascia, vein, perichondrium, and dura mater, have been employed for the closure of the faulty membrane since Zoellner and Wullstein introduced tympanoplasty in the 1950s which have yielded favourable outcomes but are sometimes inadequate, especially for extensive perforations or recurrent perforations following myringoplasty. Cartilage Shield Tympanoplasty (CST) leverages the unique properties of cartilage to address these limitations effectively[2]. When it comes to draining ears, adhesive otitis media, retraction pockets, perforations involving all or more of the quadrants of tympanic membrane, and revision tympanoplasty cases, cartilage grafts are typically the recommended treatment option as it also has the property of more stable and resitant to negative middle ear pressure. The two primary approaches in cartilage tympanoplasty are the island graft and palisade techniques[3].

Literature Review

CST involves using the cartilage, typically from the tragus or conchal bowl, to reconstruct the tympanic membrane. Studies have shown that cartilage offers superior durability and resistance to retraction compared to traditional grafting materials[4]. The use of cartilage in tympanoplasty was first popularized by Zahnert et al. (2000), demonstrating its effectiveness in reducing graft failure rates. Subsequent studies, including those by Dornhoffer (2003) and Gerber et al. (2008), have corroborated these findings, highlighting the resilience and biocompatibility of cartilage in middle ear surgeries.

METHODS

A prospective study comprising of 100 patients of either sexes, aged between 18-50 years, who had one or more failed tympanoplasties and all the cases operated between the period of January 2023 to June 2024 in the Department of Otorhinolaryngology – Head and Neck Surgery, Santosh Medical College, Ghaziabad, a tertiary care hospital in western Uttar Pradesh . Pre- and post-operative audiograms were obtained to assess hearing outcomes. The surgical procedure involved harvesting cartilage from the tragus or conchal bowl, shaping it into a shield, and grafting it onto the tympanic membrane. Data were analyzed using the Student t-test for quantitative data and the chi-square test for qualitative data.

Inclusion Criteria

1) Age between 18-50 years.
2) One or more failed tympanoplasties of same ear.
3) Patients having only conductive hearing loss.
4) Dry same ear for atleast 3 months.

Exclusion Criteria

1) Active discharge.
2) Sensorineural or mixed hearing loss.
3) Weak immune status like HIV, TB, uncontrolled DM etc.
4) Congenital hearing loss.
5) Cholesteatoma or marginal perforation.

Every patient who fulfilled the inclusion and exclusion criteria received a thorough assessment based on their medical history, a comprehensive physical examination, and systemic examination of ear, nose, and throat including the tuning fork tests. The detailed examination of the affected as well as opposite ear was done using otoscope pre-operatively to identify the perforation type and its size, condition of handle of malleus, middle ear mucosa and the leftover tympanic membrane whether free or sticking to the middle ear mucosa. The otoscopic findings were confirmed by EUM i.e examination under microscope followed by Pure Tone Audiometry test between the range of 500 Hz to 8000 Hz of frequency to evaluate the type and degree of hearing loss of the affected ear as well as the hearing status of the opposite ear. Patients were asked to sign an informed consent form outlining the benefits, drawbacks, and complications of the proposed course. After the all routine investigations and pre-anaesthetic check ups patients were taken up for surgery under general anaesthesia and results were recorded.

Before taking the patient in for surgery xylocaine sensitivity test using 2% xylocaine interadermally and antibiotic sensitivity test was done.

Surgical Procedure

After patient's positioning, painting and draping with sterility, the sites pre-auricular, post auricular , external auditory canal and temporal region were infiltrated with 2% xylocaine in 1:100000 adrenaline, followed by post auricular or William wildes incision along with vascular strips incision and temporalis fascia graft was harvested. The margins of the perforations were freshened and tympanosclerotic plaques were removed if present. The status of ossicular chain was determined and a cartilage around 8mm to 10 mm in diameter, round in shape taken from cymba conchae area. To make space for the manubrium, a V shaped wedge of cartilage was removed and the perichondrium was removed

from both sides. Using a right-angle hook, the cartilage graft was positioned behind the manubrium, and fixed the graft like lock and key method for its acoustic gain ,showcasing its convex medial surface. The cartilage graft's periphery was positioned medial to the fibrous annulus or the remains of the tympanic membrane. In patients with problem of malleus medialization, the tensor tympani tendon was divided for the placement of graft medially by lateralizing the malleus and then covering the cartilage by previously harvested temporalis fascia. No space is left between the posterior canal wall and newly placed tympanic membrane to prevent the formation of cholesteatoma. The canal was then filled with gelfoam soaked in antibiotic. Post auricular area sutured , hemostasis achieved and mastoid dressing done.

Post- Operative Managemnt

Pateints were given antibiotics, antihistamine and non-steroidal anti-inflammatory drugs for 7 days and were discharged after keeping under close observation for 24 hrs. While discharging the patients, they were clearly instructed to take certain precautions like keeping the ear dry, avoiding straining and lifting any heavy weights followed by follow ups on OPD basis at 1 week, 6 weeks and 3 months. Sutures were removed on day 10 post operative along with ear pack. Patients were instructed to take further oral and topical antibiotics. Audiograms were performed 3 months after surgery, followed by regular ear otoscopic examination on 6 months and thereafter every 1 year.

Data Management and Analysis

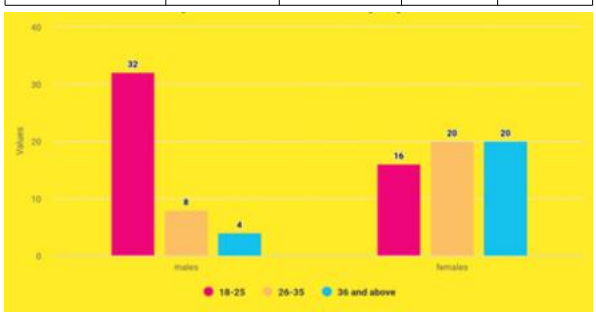
A Version 26.0 of SPSS (Statistical Package for Social Studies) for Windows was used to conduct the analysis. Student t-test analysis was used to examine the data. We utilized the chi-square test for qualitative data. The means and standard deviation of normally distributed data were shown. The significance level for each test was set at 5%.Therefore, if the p value was less than 0.05, a relationship was considered significant.

RESULTS

Males constituted the majority in the 18–25 years age group, whereas the females were equally dispersed throughout the three age groups (Table 1).

Table 1: Age And Sex Distribution Of Patients Undergoing Cartilage Shield Tympanoplasty.

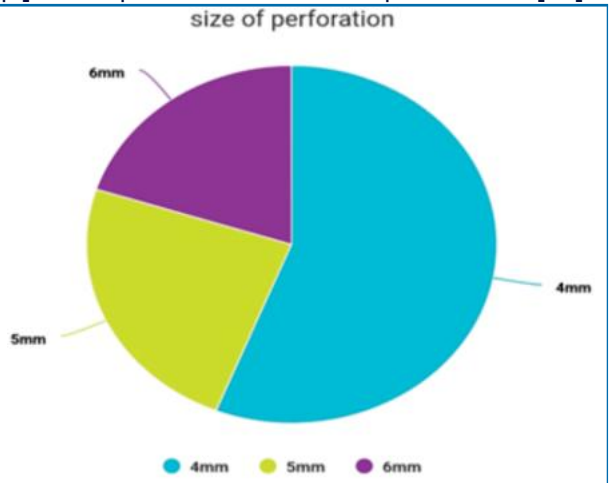
Age (years)	Males	Females	Total	%
18-25	32	16	48	48
26-35	8	20	28	28
36 and above	4	20	24	24
Total	44	56	100	100



On the basis of sizes of perforation, majority of patients had 4mm and 5mm and rest had 6mm. (Table 2).

Table2: Distribution Of Patients On The Basis Of Size Of Perforation

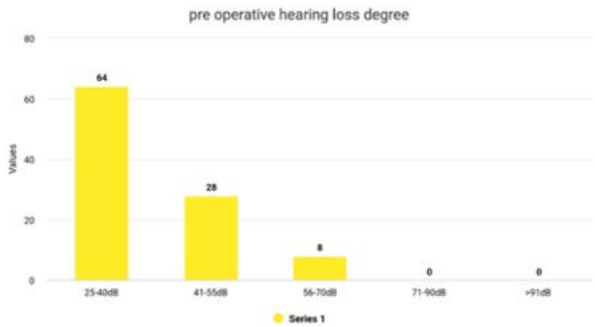
Size of perforation(mm)	No of patients(%)
4mm	56 (56)
5mm	24 (24)
6mm	20 (20)
Total	100 (100)



PTA of patients were done pre- operatively and post-operatively including the failed cases. Out of 100 patients 64 had hearing threshold of 25-40 dB, whereas 36 patients had hearing threshold of 41-55 dB. (Table 3). Pre- operatively.

Table 3: Pre-operative Hearing Loss Degree.

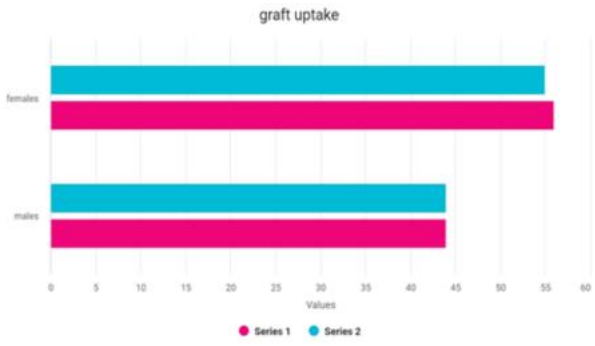
Degree of hearing loss	Hearing threshold (dB)	Total number of patients
Mild	25-40	64
Moderate	41-55	28
Moderate-severe	56-70	08
Severe	71-90	00
Profound	>91	00



Post- operatively out of 100 patients 99 had intact tympanic membrane accounting for 96% success rate at the end of 14th week in which all 44 males had intact TM giving 100% success whereas 55 females out of 56 gave outcome of 98.21 %. (Table 4).

Table 4: Graft Uptake

Gender	No of patients	Patients with graft uptake	%
Males	44	44	100
Females	56	55	98.21
total	100	99	99

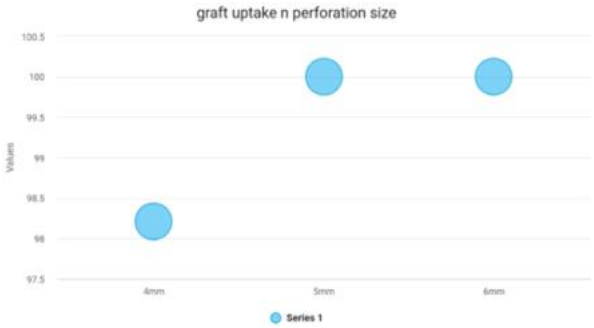


Cases with perforation measuring 5mm and 6mm had 100% uptake rate with failure of uptake in 1 case with perforation measuring 4mm. (Table 5).

Table 5 : Graft Uptake and Perforation Size Relationship

Perforation	No. of patients	Graft uptake	%
4mm	56	55	98.21
5mm	24	24	100
6mm	20	20	100

No correlation was found between the graft uptake rate (p > 0.05) and the size of perforation.



Patients with bilateral COM who suited the inclusion criteria for revision surgery got 1 ear operated had 100% graft uptake whereas patients with unilateral COM had 94.4 % of graft uptake. (Table 6).

Table 6 : Graft Uptake in B/L COM and U/L COM.

COM	No.	Graft uptake	%
b/l	28	28	100
u/l	72	71	98.6
total	100	99	99

Hearing levels were checked for 3 months. (Table 7.)

Table 7: Mean Gain in Hearing Threshold

Mean pre-op HT	Mean post-op HT	Mean gain
44.04dB	30.47dB	13.57

The mean A-B gap before surgery was 26.08±8.10 dB and after surgery was 14.45±5.17 dB, giving mean gain of 11.63 ±7.10 dB. (Table 8).

Table 8 : Mean Gain in A-B gap after CST

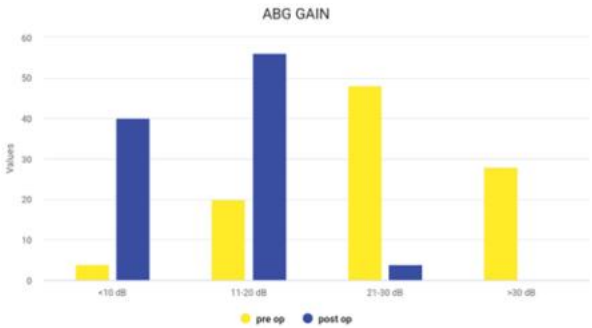
Mean pre-op A-B gap	Mean post-op A-B gap	Mean gain
26.08dB	14.45dB	11.63

On comparing the AB gap on PTA pre- operatively 24 patients were less than 20dB, 48 patients were between 20-30dB and 28 were more than 30dB, whereas post- operatively 40 patients had less than 10dB, 56 in between 11-20dB and 4 patients more than 20dB. (Table 9).

Table 9: ABG Gain in Pre and Post Surgery Patients

ABG (dB)	Pre-op	Post-op
≤10	4	40
11-20	20	56
21-30	48	4
>30	28	0

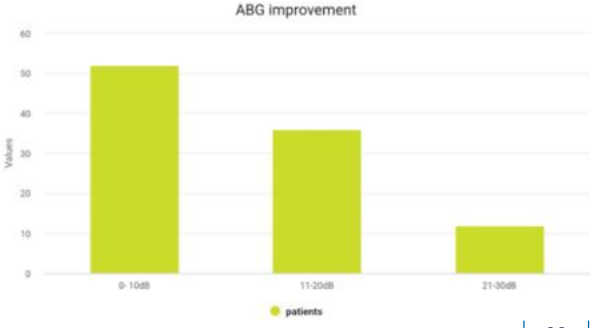
The statistical comparison of the AB gap between pre-operative and postoperative periods revealed a fairly significant difference (p<0.001). ABG significantly improved following surgery.



52 patients experienced a 0–10 dB improvement. 36 patients showed an 11–20 dB improvement in their ABG whereas 12 patients showed improvements of 21–30 dB (Table 10).

Table 10: ABG Improvement

ABG (dB)	No. of pts
0-10	52
11-20	36
21-30	12



A statistical comparison revealed that it was significant. Thus, following surgery, there was a noticeable improvement in hearing. There were no documented post-operative problems.

DISCUSSION

The most often used graft material for tympanoplasty surgery has been temporal muscle fascia[4]. The postoperative parameters of the graft are typically unknown due to the unevenly distributed elastic fibers and fibrous connective tissue that make up the temporal muscle fascia.

The study group from 18 to 50 years were chosen to ensure regular follow ups and to reduce the chances of graft uptake failures because among children the chances of upper respiratory tract infections are higher than compared to other age groups where as presbycusis among the elderly patients is more common. Patients with history of ear discharge were ensured to have dry ears atleast 6 weeks or more prior to the surgery because the possibility of graft uptake in dry ears are more than compared to wet ears. According to one study, cartilage grafts do better in dry ears while middle ear infections have highly adverse effects on chondrocytes.

The overall graft uptake in our study is 99% which concludes that cartilage shield tympanoplasty is a reliable technique as suggested by the results of some of the authors. In fact, the cartilage is nourished mostly by diffusion and becomes well incorporated in the tympanic membrane.

The largest number of patients in our study was 56 (56%) with 4 mm perforations, 24 (24%) with 5 mm perforations, and 20 (20%) with 6 mm perforations. The surgical outcome and the extent of the perforation did not correlate. However, during the 3-months follow-up, all of the patients in our study showed improvement in their hearing, as indicated by a decline in Air - Bone gap on pure tone audiometry. 48 patients (48%) had gains between 0 and 10 dB, 40 patients (40%) had gains between 11 and 20 dB, and 12 patients (12%) had gains between 21 and 30 dB, so 48 patients made up the majority of the patient population gain between 0 -10 dB.

The statistical comparison between preoperative and postoperative ABG was found to be significantly significant ($p<0.001$). The outcomes were consistent with the research conducted by Ahmad et al. (2017), who also noted improved hearing following cartilage grafting. After surgery, it was observed a reduction in the ABG mean value to 11.63 dB ($p<0.05$). Research on both humans and animals has revealed that while the cartilage matrix does not break down with time, there are empty spaces in it that indicate chondrocyte degeneration.

Various articles previously in revision type I tympanoplasty, showed, an ABG of less than 10 dB. Assuming that replacing a large portion of the tympanic membrane with cartilage would add stiffness and mass.

Zahnert et al. examined the mechanical deformation and acoustic transmission properties of cartilage with different thicknesses under different ambient pressure variations. There was no significant difference between the conchal and tragal cartilages when they were compared.

When compared to the typical tympanic membrane, the varying thickness of a cartilage produces an acceptable loss of sound transmission. Therefore in CST, we removed the perichondrium from the graft on both sides in order to create a thinner graft.

52 patients underwent cartilage tympanoplasty by Kyrodimos et al., and all of the patients had successful graft take. In 223 ears, Khan et al. performed primary cartilage tympanoplasty with overall success rate of 98.20%. [5-6] Moore stated that the graft took 100%. Mesenchymal tissue gives rise to fascia, cartilage, and perichondrium. Gerber et al. [7] compared the cartilage to fascia in a frequency-specific manner and again no significant difference was observed. Thus, post-operative hearing loss is probably due to the post-operative changes in the middle ear structures, rather than to the material used for reconstruction When the tympanic membrane heals, the graft gets integrated into the middle layer, forming the lamina propria. Compared to fascia, cartilage is easier to work. It provides the scaffolding needed for epithelialiization, the healing process, and later support against recurrent perforations. The cartilage scaffolding secures and stabilizes the perichondrium during healing, preventing it from protruding into the middle ear cavity and causing a failure.[8] The perichondrium's connection to the cartilage reduces its shrinkage as well[9]. In our procedure , the perichondrium was removed on both the sides, and cartilage stops the laterally placed temporalis fascia from retracting.

Temporalis fascia graft failure is a significant concern for patients undergoing revision surgery[9]. Boone et al. performed revision cartilage tympanoplasty on 95 patients, and they found that 94.7% of them had effective closure without perforation[10]. Cartilage is a rigid material which can resist retraction. Its medial to handle of malleus placement and its intrinsic firmness prevents graft failure and medialization of graft. The concha cymba cartilage is easy to harvest, has an average thickness of 0.8 mm and its concave contour resembles that of tympanic membrane. We did not see collapse into the middle ear space or graft lateralization in any of the instances. According to Moore, cartilage can therefore be inserted for graft stability without cutting a groove in the bone annulus. In one failure case there was a small residual perforation antero-inferiorly, which was planned for fat myringoplasty. There was not much pain following the procedure. Without any complications or lasting deformities, the donor site healed. The patients could feel the improvement in their hearing. No post-operative problems occurred.

The current study's findings indicate that cartilage is a good material for grafting because it is readily available, simple to shape, stable (especially in situations without a fibrous annulus), sufficiently elastic for good sound conduction, well tolerated, and resistant to resorption. The graft opacity of this operation may be a disadvantage since it could make it more challenging to identify any developing cholesteatoma in the future. But the fascia is also not much transparent as well[11]. At the end of 6 months patients with ABG less than 20 dB were considered successful.

The key benefit of cartilage tympanoplasty is the possibility of epithelization over the cartilage surface even in the event of anterior graft detachment. [12]Another benefit of this procedure is that it prevents the formation of synechia between the graft and promontory because the graft does not require the use of a sponge in the middle ear to be sustained.

CST has demonstrated superior outcomes in revision tympanoplasty cases, offering a robust solution for tympanic membrane reconstruction. The biocompatibility and resilience of cartilage minimize the risk of retraction and recurrent perforations, which are common with traditional grafting materials. Future research should focus on refining the technique, exploring its application in various clinical scenarios, and leveraging advancements in imaging and biomaterials to enhance surgical precision and outcomes.

CONCLUSION

Cartilage Shield Tympanoplasty represents a significant advancement in otologic surgery, providing a reliable and effective solution for tympanic membrane perforations. The high graft success rate and substantial hearing improvement observed in this study support the recommendation of CST for revision tympanoplasty cases.

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