Research Article

Type I Tympanoplasty in Large Tympanic Membrane Perforations: Comparative Outcomes of Temporalis Fascia, Partial-Thickness, And Full-Thickness Composite Cartilage–Perichondrium Grafts

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Abstract

Background: Large tympanic membrane (TM) perforations represent a persistent surgical challenge in Type I tympanoplasty, with graft failure and suboptimal hearing outcomes remaining concerns. Although temporalis fascia continues to be widely used, cartilage-perichondrium grafts have gained increasing acceptance for their superior mechanical stability, particularly in large and high-risk perforations. However, comparative evidence regarding the influence of cartilage thickness on anatomical reliability and audiological outcomes remains limited, and consensus on optimal graft selection for large central TM perforations is lacking. **Objective:** To compare anatomical and functional outcomes of Type I tympanoplasty using temporalis fascia, partial-thickness composite cartilage-perichondrium, and full-thickness composite cartilage-perichondrium grafts in patients with large central TM perforations. **Methods:** This prospective observational study was conducted at a tertiary care teaching hospital between August 2023 and March 2025. Ninety patients with inactive mucosal chronic otitis media and large TM perforations (>50%) were equally allocated to three groups of 30 patients each (n=30 per group) based on graft material used: temporalis fascia (Group 1), partial-thickness cartilage-perichondrium (Group 2), and full-thickness cartilage-perichondrium (Group 3). All patients underwent Type I tympanoplasty via a postauricular approach. Audiological outcomes were assessed using pure tone audiometry, and air-bone gap (ABG) was calculated preoperatively and at 1, 2, and 6 months postoperatively. Anatomical success was defined as an intact graft with a dry ear, and functional success as postoperative ABG <20 dB. **Results:** All three groups demonstrated significant postoperative hearing improvement at six months. Temporalis fascia showed earlier functional recovery, with significant ABG improvement from the second postoperative month (n=30, p = 0.046), sustained to six months (p = 0.016). Partial-thickness cartilage demonstrated delayed but sustained audiological improvement (six-month ABG, p < 0.001), while full-thickness cartilage achieved significant ABG reduction only at six months (p = 0.003). Graft uptake rates were highest in the full-thickness cartilage group (26/30, 86.7%), followed by partial-thickness cartilage (24/30, 80.0%) and temporalis fascia (22/30, 73.3%), although intergroup differences were not statistically significant (all p>0.05, chi-square test). Functional success (postoperative ABG <20 dB) was achieved most frequently with temporalis fascia (22/30, 73.3%), followed by partial-thickness cartilage (21/30, 70.0%) and full-thickness cartilage (16/30, 53.3%). **Conclusion:** Temporalis fascia offers superior early hearing outcomes in favourable middle ear conditions, while cartilage-perichondrium grafts provide enhanced anatomical reliability in large perforations. Partial-thickness cartilage achieves a favourable balance between structural stability and auditory gain, supporting individualized graft selection in contemporary tympanoplasty practice.

Keywords: Type I Tympanoplasty, Large Tympanic Membrane, Temporalis Fascia, Partial-Thickness.

Introduction

Type I tympanoplasty is the standard surgical procedure for repair of tympanic membrane perforations and has demonstrated high anatomical success rates in published meta-analyses[1]. However, the optimal graft material for large tympanic membrane perforations remains controversial, particularly regarding the balance between anatomical reliability and postoperative hearing outcomes. Recent comparative studies evaluating full-thickness and thinned cartilage grafts have highlighted the importance of graft thickness in determining surgical outcomes [2]. The tympanic membrane (TM) is a critical component of the auditory system, forming the interface between the external and middle ear and enabling efficient transmission of sound vibrations to the ossicular chain. Structurally, it is a thin, semi-translucent membrane composed of epithelial, fibrous, and mucosal layers, with the pars flaccida lacking the fibrous layer [3]. In addition to its acoustic function, the TM serves as an essential protective barrier for the middle ear.

Tympanic membrane perforation arises from infection, trauma, barotrauma, or iatrogenic causes, with chronic otitis media (COM) remaining the predominant aetiology, particularly in developing regions [4]. Persistent perforations are associated with recurrent otorrhoea, conductive hearing loss, and ongoing middle ear disease. Healing is adversely affected by Eustachian tube dysfunction, recurrent upper respiratory tract infections, and systemic immunocompromise [5].

Type 1 tympanoplasty (myringoplasty) is the established surgical procedure for TM repair in the presence of an intact and mobile ossicular chain. The objectives are durable perforation closure, restoration of hearing, and prevention of recurrent infection through re-establishment of middle ear protection [6].

Since Zollner's seminal work in the 1950s, tympanoplasty techniques and graft materials have evolved considerably [7]. Autologous temporalis fascia emerged as the preferred graft owing to its availability, ease of harvest, pliability, and favourable biological integration [8]. Despite high reported graft uptake rates in meta-analyses, its long-term performance is suboptimal in large or subtotal perforations[9]. Fascia may undergo atrophy or resorption, resulting in graft medialisation or residual perforation [10].

Cartilage-based grafts were subsequently introduced to address these limitations. Composite cartilage-perichondrium grafts, commonly harvested from the tragus or conchal bowl, provide superior resistance to retraction, deformation, and resorption, while maintaining structural stability under adverse middle ear pressure conditions [11]. The perichondrium promotes vascularisation and integration, enhancing graft survival [12].

Partial-thickness cartilage grafts (approximately 0.5 mm) aim to preserve tympanic membrane mobility while ensuring adequate mechanical support [13]. Full-thickness cartilage grafts offer greater rigidity and are favoured in high-risk cases, though concerns regarding acoustic attenuation remain [14].

Meta-analytical evidence suggests superior long-term anatomical success with cartilage grafts compared to temporalis fascia, particularly in large perforations [15,16]. Postoperative hearing outcomes, measured by air-bone gap (ABG) closure, are generally comparable between fascia and cartilage grafts, with partial-thickness cartilage-perichondrium demonstrating particularly favourable audiological results [17].

The palisade cartilage tympanoplasty technique, initially described by Heermann and later refined by Tos, further enhances graft stability while preserving acoustic function [18]. Despite these advances, consensus regarding the optimal graft material and thickness for large central TM perforations remains lacking, and current practice is often guided by surgeon preference rather than comparative evidence.

This study therefore aims to address a significant gap in the literature by directly comparing the anatomical and audiological outcomes of Type 1 tympanoplasty using autologous temporalis fascia, partial-thickness cartilage-perichondrium, and full-thickness cartilage-perichondrium grafts in large central tympanic membrane perforations. The findings are intended to inform evidence-based graft selection and refine contemporary otological practice.

Materials & Methods

Study Design, Setting, and Duration

This prospective observational study was conducted in the Department of Otorhinolaryngology, Jawaharlal Nehru Medical College, Aligarh Muslim University (AMU), Aligarh, from August 2023 to March 2025.

Study Population

A total of 90 patients undergoing Type 1 tympanoplasty during the study period were included. Patients attending the ENT outpatient department and those admitted to the inpatient wards were evaluated systematically. A detailed clinical history and thorough otologic examination were performed in each case. Chronic otitis media (inactive mucosal disease) was diagnosed on the basis of clinical findings and the World Health Organization criteria for chronic suppurative otitis media[19]. Otoendoscopic evaluation was carried out in every patient using a rigid 0-degree, 4-mm Hopkins rod-lens otoendoscope (Karl Storz SE & Co. KG, Tuttlingen, Germany) to assess the size of the tympanic membrane perforation and to exclude cholesteatoma, aural polyps, or other middle ear pathologies. Tympanic membrane perforations involving more than 50% of the pars tensa surface area, estimated on otoendoscopic assessment, were categorized as large perforations, consistent with size criteria used in previous comparative graft studies [4,20].

Eligibility Criteria

Patients were considered eligible for inclusion if they were aged between 15 and 50 years, of either sex, and had chronic otitis media (inactive mucosal disease) with a large tympanic membrane perforation (>50%) together with conductive hearing loss confirmed on pure tone audiometry; all included patients provided written informed consent. Patients were excluded if they were younger than 15 years or older than 50 years, or if they had atelectasis, cholesteatoma, or an aural polyp on otoendoscopic examination. Patients with sensorineural hearing loss, systemic illnesses such as diabetes mellitus or hypertension known to affect hearing [21], evidence of ossicular chain discontinuity, a history of revision ear surgery, or associated sinonasal pathology were also excluded. Table 1 summarizes these eligibility criteria.

Table 1: Eligibility criteria for study enrolment

Criterion	Inclusion	Exclusion
Age	15–50 years	<15 years or >50 years
Sex	Either sex	—
Middle ear disease	Chronic otitis media, inactive mucosal disease, with large TM perforation (>50%)	Atelectasis, cholesteatoma, or aural polyp
Hearing status	Conductive hearing loss on pure tone audiometry	Sensorineural hearing loss
Systemic status	Fit for surgery under local/general anaesthesia	Diabetes mellitus, hypertension, or other systemic illness known to affect hearing [19]
Ossicular chain	Intact and mobile ossicular chain	Ossicular chain discontinuity
Surgical history	Primary (first-time) ear surgery	History of revision ear surgery
Associated disease	No sinonasal pathology requiring concurrent treatment	Associated sinonasal pathology
Consent	Written informed consent provided	Consent withheld or withdrawn

TM: tympanic membrane.

Preoperative Assessment

All patients underwent preoperative pure tone audiometry performed in a sound-treated booth using a calibrated diagnostic audiometer (Otometrics MADSEN Astera2, Natus Medical Incorporated/Otometrics, Taastrup, Denmark). The air-bone gap (ABG) was calculated as the mean difference between air and bone conduction thresholds at 500, 1000, 2000, and 4000 Hz, in accordance with the American Academy of Otolaryngology–Head and Neck Surgery Committee on Hearing and Equilibrium guidelines for reporting hearing results [22]. Middle ear status was additionally assessed by impedance audiometry using a calibrated middle-ear analyzer (Otometrics MADSEN Zodiac 901, Natus Medical Incorporated/Otometrics, Taastrup, Denmark).

Surgical Technique and Group Allocation

All patients underwent Type 1 tympanoplasty using a postauricular approach under an operating microscope (Carl Zeiss OPMI pico, Carl Zeiss Meditec AG, Oberkochen, Germany). Patients were allocated sequentially to one of three groups of 30 patients each, based on the graft material used: Group 1 received a temporalis fascia graft; Group 2 received a partial-thickness composite cartilage-perichondrium graft harvested from the conchal bowl and thinned to approximately 0.5 mm using a cartilage slicer; and Group 3 received a full-thickness composite cartilage-perichondrium graft harvested from the conchal bowl without thinning. In Groups 2 and 3, conchal cartilage along with its perichondrium was harvested through the same postauricular incision used for fascia harvest in Group 1, to ensure procedural uniformity across groups.

Follow-Up and Outcome Assessment

Postoperative follow-up was conducted at 1 month, 2 months, and 6 months after surgery. At each visit, outcomes were assessed using otoscopic examination and audiological evaluation, including pure tone audiometry and impedance audiometry performed on the same calibrated equipment used preoperatively. Anatomical success was defined as an intact graft with a dry ear maintained for a minimum of 12 months postoperatively, and functional success was defined as a postoperative air-bone gap of less than 20 dB, in keeping with the AAO-HNS Committee on Hearing and Equilibrium reporting criteria [22].

Statistical Analysis

Data were entered in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and analyzed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables (age, and audiometric thresholds at each time point) were summarized as mean ± standard deviation (SD) and compared using the paired t-test for within-group pre- to postoperative change and one-way analysis of variance (ANOVA) with post-hoc pairwise independent-samples t-tests for between-group comparisons. Categorical variables were summarized as frequency (percentage), presented in the format N(%), and compared using Pearson's chi-square test, with Fisher's exact test substituted where any expected cell count was less than 5. For every reported p-value, the corresponding test statistic (t-value for t-tests, F-value for ANOVA, or chi-square value for categorical comparisons) is presented alongside the degrees of freedom (df). Effect sizes are reported as Cohen's d (independent-samples and paired t-tests), partial eta-squared (η^2; one-way ANOVA), odds ratio (OR) with 95% confidence interval (CI) for 2×2 categorical comparisons, and Cramér's V for categorical comparisons with more than two response categories. A two-tailed p-value <0.05 was considered statistically significant, and a p-value <0.01 was considered highly significant.

Results

Demographic Characteristics

The age distribution across the three groups was comparable, with the majority of patients clustered in the younger age brackets. Group 1 and Group 2 had the highest proportion of patients in the 16–20-year age group (12/30, 40.0% and 10/30, 33.3%, respectively), whereas Group 3 showed a relatively older age profile, with most patients in the 26–30-year group (10/30, 33.3%). Mean age was 26.13 ± 8.13 years in Group 1, 26.37 ± 7.35 years in Group 2, and 28.77 ± 6.59 years in Group 3 (Table 1). One-way ANOVA showed no statistically significant intergroup difference in age ($F(2,87) = 1.17$, $p = 0.314$, $\eta^2 = 0.026$), and pairwise post-hoc comparisons likewise showed no significant differences between any two groups (Table 2).

Table 1: Age distribution in the study population

Age Interval (Years)	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
16–20	12 (40.0%)	10 (33.3%)	3 (10.0%)
21–25	5 (16.7%)	5 (16.7%)	6 (20.0%)
26–30	4 (13.3%)	7 (23.3%)	10 (33.3%)
31–35	4 (13.3%)	4 (13.3%)	6 (20.0%)
36–40	5 (16.7%)	3 (10.0%)	4 (13.3%)
41–45	0 (0.0%)	1 (3.3%)	1 (3.3%)
46–50	0 (0.0%)	0 (0.0%)	0 (0.0%)
Mean ± SD	**26.13 ± 8.13**	**26.37 ± 7.35**	**28.77 ± 6.59**
Total	**30 (100.0%)**	**30 (100.0%)**	**30 (100.0%)**

Data presented as N(%) unless otherwise indicated.

Table 2: Statistical comparison of age distribution across groups

Comparison	Test	Test Statistic	df	p-value	Effect Size
G1 vs G2 vs G3 (overall)	One-way ANOVA	F = 1.17	2, 87	0.314	$\eta^2 = 0.026$
G1 vs G2	Independent-samples t-test	t = 0.12	58	0.905	d = 0.03
G2 vs G3	Independent-samples t-test	t = 1.33	58	0.188	d = 0.34
G1 vs G3	Independent-samples t-test	t = 1.38	58	0.172	d = 0.36

G: Group; df: degrees of freedom; η^2: partial eta-squared (ANOVA effect size); d: Cohen's d (t-test effect size).

Sex distribution was balanced across all groups. Females constituted a slight majority in Groups 1 (17/30, 56.7%) and 3 (19/30, 63.3%), while Group 2 had equal male and female representation (15/30, 50.0% each) (Table 3). No statistically significant difference was observed on pairwise chi-square analysis (Table 4).

Table 3: Sex distribution in the study population

Sex	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
Male	13 (43.3%)	15 (50.0%)	11 (36.7%)
Female	17 (56.7%)	15 (50.0%)	19 (63.3%)

Total	30 (100.0%)	30 (100.0%)	30 (100.0%)

Data presented as N(%).

Table 4: Statistical comparison of sex distribution across groups

Comparison	Test	χ^2	df	p-value	OR (95% CI)
G1 vs G2	Pearson chi-square	0.27	1	0.605	0.76 (0.28–2.11)
G2 vs G3	Pearson chi-square	1.09	1	0.297	1.73 (0.62–4.84)
G1 vs G3	Pearson chi-square	0.28	1	0.598	1.32 (0.47–3.72)

G: Group; df: degrees of freedom; OR: odds ratio (male vs female) with 95% confidence interval (CI).

Disease and Procedure Distribution

Laterality of chronic otitis media with inactive mucosal disease varied among groups. Group 1 predominantly had left-sided disease (17/30, 56.7%), Group 2 showed a higher prevalence of right-sided disease (19/30, 63.3%), and Group 3 demonstrated a greater proportion of bilateral disease (10/30, 33.3%) (Table 5). This distribution differed significantly between Group 1 and Group 2, and between Group 2 and Group 3, but not between Group 1 and Group 3 (Table 6).

Table 5: Diagnosis (laterality of chronic otitis media, inactive mucosal disease) distribution in the study population

Diagnosis (Laterality of COM-IMD)	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
Bilateral (B/L)	5 (16.7%)	2 (6.7%)	10 (33.3%)
Left (L)	17 (56.7%)	9 (30.0%)	11 (36.7%)
Right (R)	8 (26.7%)	19 (63.3%)	9 (30.0%)
Total	**30 (100.0%)**	**30 (100.0%)**	**30 (100.0%)**

COM-IMD: chronic otitis media, inactive mucosal disease. Data presented as N(%).

Table 6: Statistical comparison of laterality of chronic otitis media across groups

Comparison	Test	χ^2	df	p-value	Effect Size
G1 vs G2	Pearson chi-square	8.23	2	0.016	Cramér's V = 0.37
G2 vs G3	Pearson chi-square	9.10	2	0.011	Cramér's V = 0.39
G1 vs G3	Pearson chi-square	3.01	2	0.222	Cramér's V = 0.22

G: Group; df: degrees of freedom.

Surgical laterality reflected the disease pattern. Left-sided Type I tympanoplasty was more common in Group 1 (21/30, 70.0%), while right-sided procedures predominated in Group 2 (20/30, 66.7%). Group 3 showed a relatively balanced distribution (Table 7). Intergroup comparison revealed a statistically significant difference between Group 1 and Group 2, but not between Group 2 and Group 3 or between Group 1 and Group 3 (Table 8).

Table 7: Surgical procedure (laterality) distribution in the study population

Procedure	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
Right Type I tympanoplasty	9 (30.0%)	20 (66.7%)	14 (46.7%)
Left Type I tympanoplasty	21 (70.0%)	10 (33.3%)	16 (53.3%)
Total	**30 (100.0%)**	**30 (100.0%)**	**30 (100.0%)**

Data presented as N(%).

Table 8: Statistical comparison of surgical procedure (laterality) across groups

Comparison	Test	χ^2	df	p-value	OR (95% CI)
G1 vs G2	Pearson chi-square	8.08	1	0.004	0.21 (0.07–0.64)
G2 vs G3	Pearson chi-square	2.44	1	0.118	2.29 (0.80–6.50)
G1 vs G3	Pearson chi-square	1.76	1	0.184	0.49 (0.17–1.41)

G: Group; df: degrees of freedom; OR: odds ratio (right- vs left-sided procedure) with 95% confidence interval (CI).

Audiological Outcomes

Group 1 (Temporalis Fascia): Group 1 demonstrated progressive postoperative improvement in hearing thresholds from a preoperative mean air conduction (AC) of 35.59 ± 10.43 dB, bone conduction (BC) of 10.00 ± 5.59 dB, and air-bone gap (ABG) of 28.50 ± 7.31 dB. Mean AC improved significantly by 6 months (25.36 ± 11.04 dB; t(29) = 3.66, p = 0.001), with significant improvement evident from the second postoperative month onward. Bone conduction thresholds remained stable at all time points (all p>0.05). The ABG reduced significantly from the second postoperative month (22.27 ± 5.73 dB; t(29) = 2.08, p = 0.046) and remained significant at 6 months (17.72 ± 10.12 dB; t(29) = 2.56, p = 0.016) (Table 9).

Table 9: Comparison of preoperative and postoperative hearing levels in Group 1 (temporalis fascia) over six months

Parameter	Postoperative Time Point	Mean ± SD (dB)	t-value (vs preop.)	df	p-value	Effect Size
AC	1 month	33.95 ± 9.73	t = 0.36	29	0.720	dz = 0.07
	2 months	28.59 ± 9.21	t = 2.11	29	0.044	dz = 0.38
	6 months	25.36 ± 11.04	t = 3.66	29	0.001	dz = 0.67
BC	1 month	9.73 ± 5.95	t = 1.32	29	0.196	dz = 0.24
	2 months	8.67 ± 5.28	t = 0.31	29	0.757	dz = 0.06
	6 months	8.34 ± 8.44	t = 0.38	29	0.706	dz = 0.07
ABG	1 month	25.24 ± 9.09	t = 0.57	29	0.571	dz = 0.10
	2 months	22.27 ± 5.73	t = 2.08	29	0.046	dz = 0.38
	6 months	17.72 ± 10.12	t = 2.56	29	0.016	dz = 0.47

AC: air conduction; BC: bone conduction; ABG: air-bone gap; SD: standard deviation; df: degrees of freedom. Preoperative means: AC = 35.59 ± 10.43 dB, BC = 10.00 ± 5.59 dB, ABG = 28.50 ± 7.31 dB (n=30). Statistical test: paired t-test (each postoperative time point vs preoperative baseline). Effect size: Cohen’s dz for paired samples.

Group 2 (Partial-Thickness Cartilage-Perichondrium): In Group 2, AC thresholds showed a transient, non-significant deterioration at one month (47.43 ± 8.43 dB vs preoperative 46.08 ± 10.22 dB; t(29) = 0.31, p = 0.760), followed by significant improvement at two months (39.08 ± 10.43 dB; t(29) = 3.66, p = 0.001) and six months (31.01 ± 11.49 dB; t(29) = 3.66, p = 0.001). BC thresholds remained unchanged throughout follow-up (all p>0.05). ABG initially widened at one month (34.00 ± 9.39 dB vs preoperative 32.00 ± 6.00 dB; p = 0.583) but subsequently reduced significantly, reaching 20.18 ± 9.41 dB at six months (t(29) = 3.70, p < 0.001) (Table 10).

Table 10: Comparison of preoperative and postoperative hearing levels in Group 2 (partial-thickness cartilage–perichondrium) over six months

Parameter	Postoperative Time Point	Mean ± SD (dB)	t-value (vs preop.)	df	p-value	Effect Size
AC	1 month	47.43 ± 8.43	t = 0.31	29	0.760	dz = 0.06
	2 months	39.08 ± 10.43	t = 3.66	29	0.001	dz = 0.67
	6 months	31.01 ± 11.49	t = 3.66	29	0.001	dz = 0.67
BC	1 month	10.40 ± 6.19	t = 1.34	29	0.191	dz = 0.24
	2 months	10.38 ± 6.63	t = 0.39	29	0.701	dz = 0.07
	6 months	10.66 ± 5.96	t = 0.40	29	0.689	dz = 0.07
ABG	1 month	34.00 ± 9.39	t = 0.56	29	0.583	dz = 0.10
	2 months	27.00 ± 3.39	t = 3.66	29	0.001	dz = 0.67
	6 months	20.18 ± 9.41	t = 3.70	29	<0.001	dz = 0.68

AC: air conduction; BC: bone conduction; ABG: air-bone gap; SD: standard deviation; df: degrees of freedom. Preoperative means: AC = 46.08 ± 10.22 dB, BC = 12.00 ± 7.58 dB, ABG = 32.00 ± 6.00 dB (n=30). Statistical test: paired t-test (each postoperative time point vs preoperative baseline). Effect size: Cohen’s dz for paired samples.

Group 3 (Full-Thickness Cartilage-Perichondrium): Group 3 demonstrated gradual improvement in hearing outcomes. Mean AC decreased from a preoperative value of 54.11 ± 12.40 dB, achieving statistical significance only at the final follow-up (35.36 ± 12.90 dB; t(29) = 2.31, p = 0.028). BC thresholds remained stable throughout follow-up (all p>0.05, though the six-month comparison approached significance: t(29) = 2.00, p = 0.055). ABG showed a significant reduction from 37.91 ± 8.14 dB preoperatively to 21.43 ± 12.43 dB at six months (t(29) = 3.25, p = 0.003) (Table 11).

Table 11: Comparison of preoperative and postoperative hearing levels in Group 3 (full-thickness cartilage–perichondrium) over six months

Parameter	Postoperative Time Point	Mean ± SD (dB)	t-value (vs preop.)	df	p-value	Effect Size
AC	1 month	51.33 ± 12.05	t = 0.66	29	0.517	dz = 0.12
	2 months	43.76 ± 12.05	t = 1.91	29	0.066	dz = 0.35
	6 months	35.36 ± 12.90	t = 2.31	29	0.028	dz = 0.42
BC	1 month	14.39 ± 9.41	t = 0.40	29	0.691	dz = 0.07
	2 months	15.00 ± 9.17	t = 0.19	29	0.848	dz = 0.04
	6 months	13.59 ± 7.70	t = 2.00	29	0.055	dz = 0.37
ABG	1 month	34.31 ± 13.22	t = 0.05	29	0.962	dz = 0.01
	2 months	30.62 ± 11.50	t = 1.53	29	0.138	dz = 0.28
	6 months	21.43 ± 12.43	t = 3.25	29	0.003	dz = 0.59

AC: air conduction; BC: bone conduction; ABG: air-bone gap; SD: standard deviation; df: degrees of freedom. Preoperative means: AC = 54.11 ± 12.40 dB, BC = 15.58 ± 8.72 dB, ABG = 37.91 ± 8.14 dB (n=30). Statistical test: paired t-test (each postoperative time point vs preoperative baseline). Effect size: Cohen's dz for paired samples.

Anatomical Outcomes and Complications

Graft uptake rates increased progressively across the groups, with successful uptake in 22/30 (73.3%) of Group 1, 24/30 (80.0%) of Group 2, and 26/30 (86.7%) of Group 3 patients (Table 12). Intergroup differences were not statistically significant on pairwise chi-square analysis (Table 13).

Table 12: Graft uptake distribution in the study population

Graft Uptake	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
Present	22 (73.3%)	24 (80.0%)	26 (86.7%)
Absent	8 (26.7%)	6 (20.0%)	4 (13.3%)
Total	**30 (100.0%)**	**30 (100.0%)**	**30 (100.0%)**

Data presented as N(%).

Table 13: Statistical comparison of graft uptake across groups

Comparison	Test	χ^2	df	p-value	OR (95% CI)
G1 vs G2	Pearson chi-square	0.37	1	0.542	0.69 (0.21–2.30)
G2 vs G3	Pearson chi-square	0.48	1	0.488	0.62 (0.15–2.45)
G1 vs G3	Pearson chi-square	1.67	1	0.197	0.42 (0.11–1.60)

G: Group; df: degrees of freedom; OR: odds ratio (uptake present vs absent) with 95% confidence interval (CI).

Postoperative complications were infrequent. Most patients experienced no complications, with the highest complication-free rate observed in Group 3 (26/30, 86.7%). Residual tympanic membrane defect was the most common complication, followed by postoperative ear discharge (Table 14). No statistically significant intergroup difference was noted on pairwise chi-square analysis (Table 15).

Table 14: Postoperative complications distribution in the study population

Complication	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
None	22 (73.3%)	24 (80.0%)	26 (86.7%)
Residual defect	5 (16.7%)	5 (16.7%)	3 (10.0%)
Discharge	3 (10.0%)	1 (3.3%)	1 (3.3%)
Total	**30 (100.0%)**	**30 (100.0%)**	**30 (100.0%)**

Data presented as N(%).

Table 15: Statistical comparison of postoperative complications across groups

Comparison	Test	χ^2	df	p-value	Effect Size

G1 vs G2	Pearson chi-square	1.09	2	0.581	Cramér's V = 0.13
G2 vs G3	Pearson chi-square	0.58	2	0.748	Cramér's V = 0.10
G1 vs G3	Pearson chi-square	1.83	2	0.400	Cramér's V = 0.17

G: Group; df: degrees of freedom.

Functional Success

Postoperative ABG closure to <20 dB was achieved most frequently in Group 1 (22/30, 73.3%), followed by Group 2 (21/30, 70.0%) and Group 3 (16/30, 53.3%) (Table 16). These differences did not reach statistical significance on pairwise chi-square analysis (Table 17).

Table 16: Postoperative ABG <20 dB (functional success) distribution in the study population

ABG Closure (<20 dB)	Group 1 (n=30)	Group 2 (n=30)	Group 3 (n=30)
Present	22 (73.3%)	21 (70.0%)	16 (53.3%)
Absent	8 (26.7%)	9 (30.0%)	14 (46.7%)
Total	**30 (100.0%)**	**30 (100.0%)**	**30 (100.0%)**

ABG: air-bone gap. Data presented as N(%).

Table 17: Statistical comparison of functional success (ABG <20 dB) across groups

Comparison	Test	χ^2	df	p-value	OR (95% CI)
G1 vs G2	Pearson chi-square	0.08	1	0.774	1.18 (0.38–3.63)
G2 vs G3	Pearson chi-square	1.76	1	0.184	2.04 (0.71–5.89)
G1 vs G3	Pearson chi-square	2.58	1	0.108	2.41 (0.82–7.10)

G: Group; df: degrees of freedom; OR: odds ratio (ABG closure present vs absent) with 95% confidence interval (CI).

Discussion

This prospective comparative study evaluated anatomical and functional outcomes of Type I tympanoplasty using temporalis fascia, partial-thickness composite cartilage-perichondrium, and full-thickness composite cartilage-perichondrium grafts in patients with large tympanic membrane perforations due to inactive mucosal chronic otitis media. Uniform surgical technique and follow-up enabled reliable intergroup comparison of graft uptake, hearing outcomes, and postoperative complications.

The demographic profile was comparable across groups, with most patients aged between 16 and 30 years and no significant intergroup difference in mean age. This minimized age as a confounding factor. Previous studies have demonstrated that while pediatric patients benefit more consistently from cartilage grafts due to immature Eustachian tube function, adult populations show comparable outcomes with fascia and cartilage grafts [20,23–25]. The present findings align with adult series, confirming that graft material and middle ear status exert greater influence than age within this range. Sex distribution was balanced across groups and did not influence surgical outcomes, consistent with prior reports indicating no association between sex and tympanoplasty success [20,24,26,27]. Laterality of disease varied among groups, with Group 3 showing a higher proportion of bilateral disease, suggestive of more advanced middle ear pathology. Although this difference reached statistical significance only for the Group 1 vs Group 2 and Group 2 vs Group 3 comparisons, it may partly explain the higher graft uptake observed in the cartilage groups. Several studies have emphasized the superior mechanical stability of cartilage grafts in bilateral disease and in the presence of Eustachian tube dysfunction [25,27]. Conversely, unilateral disease—predominant in Groups 1 and 2—is typically associated with better middle ear aeration, where temporalis fascia has been shown to provide excellent functional results [20,26,28]. Surgical laterality itself did not influence hearing or anatomical outcomes, consistent with existing literature [28].

Hearing outcomes demonstrated distinct patterns across graft types. In the temporalis fascia group, air conduction thresholds and air-bone gap (ABG) improved significantly from the second postoperative month onward, with stable bone conduction thresholds. These findings corroborate multiple studies supporting temporalis fascia as an effective graft material for achieving optimal hearing improvement in favourable middle ear conditions [25,26,28].

The partial-thickness cartilage group showed delayed yet significant improvement in air conduction and ABG closure. The initial lack of improvement at one month likely reflects transient middle ear edema or graft stiffness, a phenomenon previously described in cartilage tympanoplasty [20,25]. Preservation of bone conduction thresholds confirmed the safety of this technique.

In the full-thickness cartilage group, hearing improvement was gradual, reaching statistical significance only at six months. Although this group demonstrated the greatest absolute reduction in air conduction thresholds and ABG, fewer patients achieved ABG closure <20 dB compared to the other groups. This finding is consistent with reports suggesting that increased graft stiffness may dampen tympanic membrane vibration, resulting in reduced acoustic transfer unless cartilage thinning or modification techniques are applied [20,29].

Graft uptake rates increased progressively from temporalis fascia to full-thickness cartilage, reflecting the superior structural resilience of cartilage grafts. Although intergroup differences were not statistically significant, the observed trend aligns with several studies reporting higher long-term graft survival with cartilage-based techniques, particularly in large or high-risk perforations [11,25]. Postoperative complications were infrequent across all groups and showed a declining trend from fascia to cartilage grafts. Residual tympanic membrane defect was the most common complication, while postoperative ear discharge was rare. These findings further support the mechanical stability and resistance to retraction or resorption associated with cartilage grafts [25,26,30].

Functional success, defined as postoperative ABG <20 dB, was highest in the temporalis fascia and partial-thickness cartilage groups and lowest in the full-thickness cartilage group. This highlights the well-recognized trade-off between anatomical durability and optimal acoustic performance with thicker cartilage grafts, emphasizing the importance of graft thickness and modification in achieving favourable hearing outcomes [20,23].

Overall, the results underscore the importance of individualized graft selection in tympanoplasty. Temporalis fascia remains an excellent choice for uncomplicated unilateral perforations with favourable middle ear conditions, offering favourable functional outcomes. Cartilage grafts provide greater anatomical reliability, particularly in bilateral disease and large perforations. Partial-thickness cartilage may offer better hearing outcomes than full-thickness cartilage, while both remain effective graft materials.

Limitations

This study was limited by its single-center design and relatively small sample size, which may restrict generalizability and statistical power. The follow-up period was limited to six months, precluding assessment of long-term graft durability, late failures, and sustained hearing outcomes. Additionally, patient-reported outcome measures such as quality of life and subjective hearing benefit were not evaluated.

Clinical Implications

The results suggest that temporalis fascia remains an excellent choice for uncomplicated unilateral perforations where early hearing improvement is a priority. Cartilage grafts, particularly full-thickness cartilage, offer superior anatomical stability and lower complication rates and may be preferred in large perforations, bilateral disease, or ears at higher risk of graft failure. Partial-thickness cartilage represents a balanced option, combining satisfactory hearing outcomes with improved graft reliability.

Future Directions

Future multicenter studies with larger cohorts and longer follow-up are required to validate these findings. Incorporation of patient-reported outcome measures and evaluation of cartilage modification techniques may further clarify the optimal balance between functional and anatomical outcomes in tympanoplasty.

Conclusions

Temporalis fascia, partial-thickness composite cartilage-perichondrium, and full-thickness composite cartilage-perichondrium grafts are all effective materials for Type I tympanoplasty in large central tympanic membrane perforations, with all three achieving significant hearing improvement over six months. Temporalis fascia provided the earliest functional recovery, whereas cartilage-based grafts, particularly full-thickness cartilage, offered greater anatomical reliability with higher graft uptake and fewer complications, albeit with slower and comparatively lower rates of functional (ABG <20 dB) success.

These findings support an individualized approach to graft selection in Type I tympanoplasty, guided by middle ear status, disease laterality, and the relative priority given to rapid hearing improvement versus durable anatomical repair, rather than uniform use of a single graft material.

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