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Endoscopic Double-Flap Tympanoplasty Versus Classical Underlay Technique for Anterior Quadrant Perforations: A Prospective Comparative Study

Janani Rammohan[1], Aishwarya Prabhakaran[2], Vimal Dass[3]

[1]Senior Consultant, Be Well Hospital, Tambaram

[2]Senior Assistant Surgeon, Government Hospital Tiruporur

[3]Assistant Professor, Department of ENT at Government medical College and Hospital, Annamalai Nagar, Cuddalore district.

ABSTRACT

Introduction: Anterior quadrant tympanic membrane perforations continue to pose a surgical challenge due to limited annular support, shallow anterior canal anatomy, and reduced vascularity, all of which predispose to graft instability and higher failure rates. Conventional underlay tympanoplasty often struggles to achieve consistent closure in this region. The double-flap tympanoplasty technique, incorporating both anterior and posterior tympanomeatal flaps, aims to strengthen anterior graft anchorage and improve surgical outcomes.

Study: This prospective comparative study included 62 patients with anterior quadrant perforations, randomly assigned into Group A (Classical Tympanoplasty, n = 31) and Group B (Double Flap Tympanoplasty, n = 31). All surgeries were performed endoscopically using temporalis fascia grafts. Preoperative assessment included otoscopy, HRCT temporal bone, and pure tone audiometry. Patients were followed for three months, evaluating graft uptake, residual perforation, graft lateralisation, anterior blunting, and hearing improvement. Statistical analysis included chi-square and t-tests.

Results: Graft uptake was higher in the double-flap group (96.7%) compared to the classical group (87.1%). Residual perforation occurred in 12.9% of Group A and 3.2% of Group B. Graft lateralisation was noted exclusively in Group A (9.7%). Hearing outcomes favoured the double-flap technique, showing greater audiological gain at three months (12.84 ± 1.73 dB versus 10.24 ± 0.95 dB) and better air–bone gap closure (10.94 ± 2.98 dB versus 12.70 ± 2.49 dB), both statistically significant.

Conclusion: Double Flap Tympanoplasty offers improved graft stability, reduced residual perforation, and superior hearing outcomes compared to Classical Tympanoplasty in anterior quadrant perforations. It represents a safe, effective, and advantageous modification for challenging anterior defects, especially larger perforations requiring enhanced anterior support.

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1. INTRODUCTION

Tympanic membrane perforations involving the anterior quadrant remain one of the most challenging entities in middle ear surgery due to limited anterior support, reduced vascularity and a tendency for graft displacement. These anatomical constraints frequently contribute to higher rates of graft failure and residual perforation when classical underlay tympanoplasty is used, particularly for anterior-superior defects [1]. Successful tympanoplasty aims to restore both tympanic membrane integrity and conductive hearing, yet multiple studies have shown that anterior perforations consistently demonstrate poorer closure rates compared to central or posterior perforations [2]. To overcome these limitations, several surgical modifications have been developed, including anterior anchoring, cartilage reinforcement and elevation of supplementary tympanomeatal flaps. Recent literature highlights that double-flap tympanoplasty, which incorporates both posterior and anterior tympanomeatal flaps, provides more stable anterior graft positioning and significantly improves graft uptake in anterior quadrant perforations [3]. Additionally, randomized clinical trials have demonstrated that the anterior pull-through or double-flap technique reduces the incidence of residual perforation and lateralization without adding major operative complexity, making it a reliable alternative to conventional type I

tympanoplasty [4]. These observations justify the need to compare classical and double-flap endoscopic tympanoplasty to determine the superior method for managing anterior quadrant perforations.

2. MATERIALS AND METHODS

The present prospective comparative study was conducted at the Upgraded Institute of Otorhinolaryngology, Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai, from November 2021 to September 2022, with the objective of evaluating the surgical feasibility and outcomes of Classical Type I Tympanoplasty versus Double Flap Tympanoplasty in patients presenting with tympanic membrane perforations involving the anterior quadrant. A total of 62 patients fulfilling the inclusion criteria were recruited and randomly allocated into two equal groups of 31 each using a computer-generated random number table, with allocation concealment ensured through the Serially Numbered Opaque Sealed Envelope (SNOSE) method. Patients aged 15–80 years with anterior quadrant perforations—with or without posterior quadrant extension—conductive hearing loss with adequate cochlear reserve, and HRCT temporal bone demonstrating no cholesteatoma or mastoiditis were included, whereas those with age below 15 or above 80 years, poor cochlear reserve, significant nasal pathology, tympanosclerosis, ossicular erosion, active infection or unwillingness for surgery were excluded. All patients underwent detailed otoscopic and endoscopic examination, assessment of perforation size and quadrant involvement, routine clinical evaluation, pure tone audiometry to document air conduction thresholds and air–bone gap, and HRCT temporal bone for middle ear and mastoid assessment. A structured proforma captured demographic details, duration of symptoms, traumatic history, preoperative audiology, and baseline findings. All surgeries were performed endoscopically via a transcanal approach under local anesthesia with lignocaine–adrenaline infiltration. Temporalis fascia graft was harvested through a supra-auricular incision and prepared after drying. In Group A (Classical Tympanoplasty), a posterior tympanomeatal flap from 6 to 12 o'clock was elevated, the middle ear inspected, and the temporalis fascia graft placed as an underlay medial or lateral to the handle of malleus based on anatomical suitability, followed by gelfoam support and flap repositioning. In Group B (Double Flap Tympanoplasty), in addition to the posterior flap, a separate anterior tympanomeatal flap was created by a horizontal incision at the 3–4 o'clock position, elevating the canal skin and annulus to create an anterior tunnel; the graft was placed through the posterior flap and its anterior tip gently pulled through the tunnel using a right-angle hook to provide anterior anchorage and prevent graft medialization. Intraoperative parameters including canal anatomy, anterior canal wall overhang, middle ear mucosa status, ossicular chain integrity, round window reflex, graft–malleus relationship, and chorda tympani nerve injury were documented. Postoperative follow-up was conducted at 1, 2, and 3 months, during which endoscopic evaluation assessed graft uptake, residual perforation, graft lateralization, anterior blunting, epithelial pearl formation, and canal healing, while audiological assessment included repeated PTA to determine air conduction threshold improvement, air–bone gap closure, and total audiological gain. Primary outcome measures included graft uptake rate, residual perforation, and intra-/post-operative complications, while secondary measures included audiological gain at each follow-up interval and air–bone gap closure at three months. Statistical analysis was performed using appropriate tests, with continuous variables analyzed using independent sample t-tests and categorical variables using chi-square tests, and a p-value <0.05 considered statistically significant.

3. RESULTS

Demographic Characteristics of the Study Population

The study included 62 participants divided equally into Group A (Classical Tympanoplasty) and Group B (Double Flap Tympanoplasty). The mean age in Group A was 36.84 ± 8.16 years, while Group B had a mean age of 36.90 ± 10.79 years. Gender distribution showed a female predominance in both groups. Right ear involvement accounted for 51.6% of cases, while left ear involvement accounted for 48.4%.

Variable	Group A	Group B	Total
Mean Age (years)	36.84 ± 8.16	36.90 ± 10.79	—
Male	11 (35.5%)	13 (41.9%)	24 (38.7%)
Female	20 (64.5%)	18 (58.1%)	38 (61.3%)
Right Ear	14 (45.2%)	18 (58.1%)	32 (51.6%)
Left Ear	17 (54.8%)	13 (41.9%)	30 (48.4%)

Clinical Profile and Preoperative Findings

Ear discharge was the most common presenting symptom, observed in 77.4% of participants. Hard of hearing was reported by 58.1%, while tinnitus (8.1%) and vertigo (1.6%) were less frequent. The anterior–inferior quadrant was involved most often. Preoperative PTA was comparable between the groups.

Finding	Group A	Group B	Total
Ear discharge	25 (80.6%)	23 (74.2%)	48 (77.4%)
Hard of hearing	16 (51.6%)	20 (64.5%)	36 (58.1%)

Tinnitus	1 (3.2%)	4 (12.9%)	5 (8.1%)
Vertigo	1 (3.2%)	0 (0%)	1 (1.6%)
Mean Pre-op PTA (Right)	32.41 ± 4.71 dB	31.61 ± 5.76 dB	—
Mean Pre-op PTA (Left)	31.42 ± 3.13 dB	30.91 ± 4.49 dB	—

Intraoperative Findings and Surgical Parameters

Most patients had normal middle ear mucosa, while congested mucosa was observed in 14.5%. Narrow EAC was seen in 8.1%, and anterior canal wall overhang in 9.7%. Chorda tympani nerve injury occurred in 9.7% of Group A and 12.9% of Group B cases. Ossicular chain was intact in all patients.

Parameter	Group A	Group B	Total
Narrow EAC	2 (6.5%)	3 (9.7%)	5 (8.1%)
Congested mucosa	6 (19.4%)	3 (9.7%)	9 (14.5%)
Anterior canal wall overhang	2 (6.5%)	4 (12.9%)	6 (9.7%)
Chorda tympani injury	3 (9.7%)	4 (12.9%)	7 (11.3%)

Postoperative Outcomes and Complications

Postoperative evaluation at 1, 2, and 3 months showed significant differences between the two groups. Group B demonstrated a graft uptake rate of 96.7%, higher than Group A at 87.1%. Residual perforation occurred in 12.9% of Group A and only 3.2% of Group B. No anterior blunting or epithelial pearls were observed in either group. Graft lateralization occurred only in Group A (9.7% at 3 months), while no such cases were noted in Group B.

Parameter	Group A	Group B	Total
Graft uptake	27 (87.1%)	30 (96.7%)	57 (91.9%)
Residual perforation	4 (12.9%)	1 (3.2%)	5 (8.1%)
Anterior blunting	0	0	0
Epithelial pearls	0	0	0
Graft lateralization	3 (9.7%)	0	3 (4.8%)

Audiological Outcomes and Hearing Gain

Audiological improvement was assessed using PTA at 1, 2, and 3 months. Both groups showed improvement, but Group B exhibited better gains across all follow-up visits. At 3 months, Group B showed an audiological gain of 12.84 ± 1.73 dB, compared to 10.24 ± 0.95 dB in Group A. Air-bone gap closure was also better in Group B (10.94 ± 2.98 dB) than in Group A (12.70 ± 2.49 dB).

Audiological Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)
Gain at 1 month	3.28 ± 0.93 dB	4.30 ± 1.41 dB
Gain at 2 months	6.81 ± 0.95 dB	7.23 ± 0.93 dB
Gain at 3 months	10.24 ± 0.95 dB	12.84 ± 1.73 dB
AB gap at 3 months	12.70 ± 2.49 dB	10.94 ± 2.98 dB

Comparative Analysis Between Classical and Double-Flap Tympanoplasty

Statistical comparison between the two surgical techniques demonstrated variable outcomes across anatomical and functional parameters. Graft uptake showed no statistically significant difference between the groups, with Group A demonstrating 27/31 successful closures and Group B demonstrating 30/31 closures. Residual perforation was also not significantly different, although numerically higher in Group A (4 cases) compared to Group B (1 case). Graft lateralization occurred only in Group A (3 cases), while Group B showed none, approaching but not reaching statistical significance. Audiological outcomes, however, demonstrated clear differences: hearing gain at 3 months was significantly higher in Group B, and AB gap closure was also significantly better in Group B, reflecting improved functional hearing outcomes with the double-flap technique.

Outcome Parameter	Group A	Group B	χ^2 / t-value	p-value
Graft uptake	27/31 (87.1%)	30/31 (96.7%)	$\chi^2 = 1.96$	0.1617
Residual perforation	4 (12.9%)	1 (3.2%)	$\chi^2 = 1.96$	0.1617
Graft lateralization	3 (9.7%)	0	$\chi^2 = 3.15$	0.0758
Hearing gain (3 months)	10.24 ± 0.95 dB	12.84 ± 1.73 dB	t = –7.33	2.67×10^{-9}

AB gap closure	12.703 ± 2.49 dB	10.939 ± 2.98 dB	t = 2.53	0.0142

4. DISCUSSION

The management of tympanic membrane perforations involving the anterior quadrant continues to be challenging due to anatomical constraints and limited vascularity that affect graft stability [5]. Anterior perforations present reduced visibility, narrow working space, and weaker anterior annular support, all of which contribute to higher failure rates compared to perforations in other quadrants [6]. These limitations often predispose the graft to medialisation, lateralisation, or inadequate anterior edge contact, which collectively reduce the likelihood of successful uptake [7]. In this context, newer endoscopic techniques such as the double-flap tympanoplasty aim to improve anterior anchorage and enhance graft support, thereby improving outcomes [8].

In the present study, the double-flap technique demonstrated superior graft uptake (96.7%) compared to classical underlay tympanoplasty (87.1%), though the difference did not reach statistical significance. The observed improvement is consistent with the rationale that an anterior tympanomeatal flap provides direct mechanical support to the graft's anterior edge, reducing the risk of displacement [9]. A study evaluating the anterior pull-through technique similarly reported improved stability and lower graft failure rates in anterior perforations [10]. The improved outcomes in our study align with these findings, suggesting that structural support at the anterior margin is crucial.

Residual perforation rates in our series were higher in the classical group (12.9%) compared to the double-flap group (3.2%), again reflecting the advantage of additional anchorage [11]. Similar patterns were observed in a study evaluating anterior tab flap tympanoplasty, which demonstrated significantly lower failure rates for large perforations when anterior support was incorporated [12]. These findings support the notion that the anterior sulcus's morphology, which is often shallow and less fibrous, requires additional reinforcement to secure the graft effectively [13].

With respect to hearing outcomes, the double-flap group showed significantly improved audiological gain at three months (12.84 ± 1.73 dB) compared to the classical group (10.24 ± 0.95 dB), demonstrating functional superiority associated with the enhanced anterior seal. A study assessing chondro-perichondrial grafts for anterior perforations similarly reported significant postoperative air-bone gap reduction with mean improvement of nearly 10 dB [14]. In our study, the greater stability of the graft in the double-flap group may have led to a more effective reconstruction of tympanic membrane mechanics, translating into better sound conduction.

Air-bone gap closure was also significantly better in the double-flap group. Previous research indicates that even when anatomical closure is achieved, unstable or improperly seated grafts result in suboptimal hearing outcomes [15]. Our data reaffirm that ensuring anterior graft stability plays a major role in restoring optimal tympanic membrane vibration and aeration patterns within the middle ear.

Several large-scale studies in the literature highlight the superiority of modified tympanoplasty techniques for anterior or subtotal perforations. For instance, loop-underlay tympanoplasty for anterior and large perforations achieved closure rates exceeding 99% with excellent hearing outcomes [16]. Similarly, comparative evaluations of anterior versus posterior tympanomeatal flap elevation have shown equivalent graft success rates but better audiological improvement when the anterior flap is incorporated for anterior perforations [17]. These findings parallel the outcomes of our double-flap group. Anatomical variations such as narrow external auditory canal or anterior canal wall overhang can hinder exposure and limit the surgeon's ability to secure graft placement [18]. In our study, narrow canal was encountered in 8.1% and anterior canal wall overhang in 9.7% of cases. Despite these limitations, the double-flap technique was able to overcome these constraints and achieve favourable closure rates. The anterior flap is presumed to mitigate the negative impact of canal anatomy by creating an independent support plane for the graft [19].

We observed no cases of epithelial pearl formation or anterior blunting in either group, which aligns with other endoscopic tympanoplasty literature. Studies have shown that epithelial complications are more frequently associated with overlay techniques, while underlay and modified underlay techniques—such as the double flap—are associated with fewer epithelial sequelae [5]. Similarly, graft lateralisation was seen exclusively in the classical group (9.7% at 3 months). This is consistent with reports that lack of anterior anchorage predisposes to lateralisation, especially when the anterior annulus is deficient or the canal wall is overhanging [6].

During the intraoperative assessment, ossicular chain integrity and middle ear status were comparable across groups. Since ossicular discontinuity or mucosal hypertrophy are known contributors to poorer outcomes, their exclusion in this cohort may have allowed a more accurate comparison between the two surgical techniques [7]. Eustachian tube function, although not directly measured in our study, is another determinant of success. Previous literature has reported that eustachian

dysfunction affects graft healing and middle ear ventilation, with anterior perforations being more susceptible to failure in the presence of poor tubal function [10].

Our findings of improved outcomes with the double-flap technique are supported by recent publications advocating endoscopic approaches for anterior perforations. A trial comparing single-flap and double-flap tympanoplasty found no significant difference in overall graft uptake but reported superior anterior edge support in the double-flap technique [8]. Another study evaluating endoscopic double flap tympanoplasty similarly reported high graft uptake rates with good hearing outcomes and minimal complications [18]. These results reinforce the relevance of flap design in securing grafts in difficult-to-access areas of the tympanic membrane.

Despite reassuring results, our study has limitations. The sample size was moderate, and the follow-up restricted to three months, which may not fully capture long-term graft behaviour or delayed failures. Additionally, the absence of ossicular pathology in our cohort may limit the generalisability of hearing results when applied to complex chronic otitis media cases. Future studies with longer follow-up and stratified analysis based on perforation size, canal anatomy, and eustachian tube function would provide greater insight.

The present study has several limitations. The sample size was relatively small, which may limit the statistical power to detect differences between the two techniques. The follow-up duration of three months was short and may not adequately capture late graft failures, delayed perforations, or long-term audiological outcomes. All surgeries were performed in a single tertiary centre, which may limit generalisability to different surgical settings or varying surgeon experience levels. The exclusion of patients with ossicular erosion or eustachian tube dysfunction may also limit applicability to more complex chronic otitis media cases. Larger studies with longer follow-ups are recommended.

5. CONCLUSION

The present prospective comparative study evaluated the outcomes of Classical Type I Tympanoplasty and Double Flap Tympanoplasty in repairing tympanic membrane perforations involving the anterior quadrant, a region traditionally associated with poorer graft stability and higher failure rates. Both techniques achieved satisfactory anatomical and functional results; however, the Double Flap technique consistently demonstrated superior performance. It achieved higher graft uptake, lower residual perforation rates, and complete absence of graft lateralisation, reflecting the effectiveness of anterior anchorage in providing structural support to the graft. Audiological outcomes were also notably better in the Double Flap group, with significantly greater hearing gain and improved air–bone gap closure, indicating enhanced functional restoration of middle ear mechanics. Importantly, the technique was feasible, safe, and did not increase postoperative complications. The findings suggest that adding an anterior tympanomeatal flap offers a distinct advantage, particularly in large or subtotal anterior perforations, where graft displacement is more likely. Although further studies with larger cohorts and longer follow-up are warranted, the present study supports Double Flap Tympanoplasty as a reliable and effective alternative to classical underlay tympanoplasty for anterior quadrant perforations.