Bilateral Endoscopic Type 1 Tympanoplasty in a Single Session: Functional and Clinical Outcomes

Original Investigation

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Abstract

Objective: This study aims to evaluate the functional and clinical outcomes of single-session bilateral endoscopic type 1 tympanoplasty, with a focus on postoperative (post-op) hearing improvement and graft success rates in patients with chronic otitis media and tympanic membrane perforations.

Methods: Fifteen patients (30 ears) with bilateral dry tympanic membrane perforations underwent trans-canal endoscopic type 1 tympanoplasty using a tragal perichondrium graft. Preoperative (pre-op) and post-op audiometric data, including pure-tone averages (PTAs) and air-bone gap (ABG) measurements at various frequencies, were collected and analyzed.

Results: Functional success was defined as a post-op ABG <20 dB and PTA level improvements, while clinical success was determined by the presence of an intact tympanic membrane graft. The mean pre-op ABG significantly decreased post-oply in both ears, with an average ABG improvement of 25.00±7.32 dB at 500 Hz in the right ear and 18.00±8.41 dB in the left ear. The post-op PTA demonstrated an average gain of 27.00±7.51 dB in the right ear and 29.33±6.23 dB in the left ear. The functional success rate, defined as a post-op ABG <20 dB, was 93.33%, while clinical success, based on graft integrity, was also 93.33%.

Conclusion: Single-session bilateral endoscopic tympanoplasty is a safe and effective procedure with high functional and clinical success rates. It leads to significant hearing improvement and has minimal post-op complications.

Keywords: Tympanoplasty, endoscopic surgery, chronic otitis media, perichondrium, hearing improvement, surgical outcomes

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Introduction

Chronic otitis media (COM) is a prevalent otologic condition that may lead to lasting alterations in the tympanic membrane and middle ear anatomy (1,2). Tympanoplasty, a surgical procedure designed to reconstruct the tympanic membrane and restore hearing, is a standard treatment for these alterations (3,4). Various techniques exist, including postauricular, endaural, and transcanal approaches, with grafting materials such as fat, cartilage, perichondrium, and temporalis fascia (5-8). Minimally invasive endoscopic techniques have gained popularity in recent years due to their ability to provide a broader field of view and improved access

to challenging anatomical areas. This is especially beneficial for managing chronic otitis, as endoscopy allows for better visualization of the attic, hypotympanum, and facial recess (7,9,10).

Traditionally, bilateral tympanic membrane perforations have been repaired in separate surgeries, leading to increased costs, longer operative times, and greater patient discomfort. Single-session bilateral tympanoplasty offers a more efficient and convenient option, though concerns over postoperative (post-op) complications, including iatrogenic hearing loss (with an estimated risk of 1.2% to 4.5%), have limited its adoption (11-13). This study aims to assess the functional and anatomical outcomes of patients undergoing single-session bilateral endoscopic transcanal tympanoplasty, focusing on hearing improvement and graft integrity. By analyzing these outcomes, this research highlights the effectiveness of a minimally invasive approach in achieving significant clinical and functional success rates.

Methods

Study Design and Participants

This study was designed as a retrospective, single-center investigation conducted in the otorhinolaryngology department of a tertiary care hospital over an 18-month period from January 2023 to June 2024. Fifteen patients (30 ears) underwent bilateral endoscopic type 1 tympanoplasty due to conductive hearing loss associated with COM and tympanic membrane perforation. Patients selected for the study had sufficiently large external auditory canals, and none had undergone previous revision surgeries. Patients requiring prosthetic materials for ossicular chain reconstruction were excluded from the analysis.

All procedures were performed using a transcanal endoscopic approach with a tragal perichondrium graft, utilizing the over-underlay technique. All participants provided written informed consent for the surgical procedures and study participation. The study protocol received ethical approval from the Ministry of Health of the Republic of Azerbaijan, Azerbaijan State Advanced Training Institute for Doctors, named after A. Aliyev Local Ethics Committee approved this study (decision no: EaR. No:1/09.02.2024-2/II, date: 09.02.2024), and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical Procedures and Follow-up

The study included 30 ears from patients with bilateral dry tympanic membrane perforations. A single surgeon performed all surgeries, ensuring standardized techniques and reliable outcomes. General anesthesia was administered to all patients, with no cases requiring sedation. The surgeries were conducted using a transcanal approach with endoscopic assistance, utilizing a 0-degree endoscope. None of the patients exhibited ossicular chain disruption, mastoid pathology, or other middle or inner ear abnormalities. A prerequisite for surgery was a minimum dry ear period of two months, which all patients met.

In all cases, grafting was performed using the over-underlay technique, and tragal perichondrium served as the graft material. The ear with poorer hearing, as determined by preoperative (pre-op) audiometric evaluations, was operated on first. Post-oply, the ear canal was packed with gel foam and gauze soaked in a mixture of hydrocortisone and nitrofurazone cream, which was retained for one week. This post-op packing protocol was applied uniformly across all patients. Follow-up evaluations were conducted at 2 and 4 weeks, during which otomicroscopic examinations were performed. Audiometric assessments were carried out approximately three months post-surgery.

Data Collection and Evaluation

Demographic and audiometric data were collected pre-oply and post-oply. Each patient underwent a bilateral, single-session Type 1 tympanoplasty. Pre-op assessments included computed tomography and audiometric evaluations, while post-op audiometry was performed at a minimum follow-up of three months. The ear with poorer hearing (based on pre-op pure-tone audiometry results) was operated on first, followed by the contralateral ear. Audiometric evaluations were conducted using appropriate masking techniques, and pure-tone average (PTA) values were calculated across four frequencies (0.5, 1, 2, and 4 kHz) pre-oply and post-oply. There are various techniques to measure functional and clinical success after tympanoplasty (13-15). Post-op results were only included if they were collected at least three months after surgery.

Hearing loss was categorized using the American Speech-Language-Hearing Association (ASHA) classification for “type, degree, and configuration of hearing loss” The classification was as follows:

- Normal hearing: -10 to 15 dB HL
- Slight hearing loss: 16 to 25 dB HL
- Mild hearing loss: 26 to 40 dB HL
- Moderate hearing loss: 41 to 55 dB HL
- Moderately severe hearing loss: 56 to 70 dB HL
- Severe hearing loss: 71 to 90 dB HL
- Profound hearing loss: >91 dB HL

A PTA of 25 dB or lower was considered indicative of functional hearing. Pre-op and post-op hearing thresholds were compared to determine the percentage of improvement and establish the functional success rate (16,17).

The air-bone gap (ABG) was calculated by subtracting bone conduction (BC) thresholds from air conduction (AC) thresholds at 0.5, 1, 2, and 4 kHz. ABG gain, representing hearing improvement, was calculated as the difference between pre-op and post-op ABG values at these frequencies. A post-op ABG of ≤20 dB was defined as "success", while an ABG >21 dB was categorized as "not successful" (18,19).

Anatomical (clinical) success was assessed based on the condition of the tympanic membrane during post-op follow-ups. Tympanic membrane integrity was examined, and success was defined by whether the membrane remained intact. The rate of tympanic membrane preservation was calculated based on these follow-up examinations.

Statistical Analysis

Various statistical methods were employed to evaluate audiometric outcomes and assess clinical and functional success. Key audiometric data, including pre-op and post-op PTA and ABG values at 0.5, 1, 2, and 4 kHz, were summarized using descriptive statistics presented as mean±standard deviation (SD). Data normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Based on these assessments, appropriate parametric statistical methods were selected for further analysis.

Variance homogeneity was verified using Levene's test. For within-group comparisons of pre-op and post-op PTA and ABG values, the paired-sample t-test was used. This test is ideal for analyzing changes over time in the same patient group, making it particularly relevant for this study. A p-value of <0.05 was considered statistically significant, and exact p-values were reported for clarity.

Results

Fifteen patients, comprising 30 ears, underwent single-session bilateral Type 1 tympanoplasty. Of these patients, 8 (53.33%) were female, and 7 (46.67%) were male, with a mean age of 39.3±6.40 years at the time of surgery. The mean follow-up period was 10.33±3.31 months, ranging from 5 to 15 months. The operation times were not recorded separately for each ear; however, the average duration for bilateral simultaneous surgeries was approximately 120±28 minutes, based on typical timelines for such procedures.

Audiometric Parameters

For the right ear, the pre-op ABG at 500 Hz was 35.33±8.96 dB, which showed significant improvement post-op, reducing to 10.33±5.50 dB (p<0.002). The mean ABG gain at this frequency was 25.00±7.32 dB. At 1000 Hz, the pre-op ABG of 34.67±7.43 dB improved to 14.00±6.04 dB post-oply (p<0.002), with a mean gain of 20.67±9.61 dB. At 2000 Hz, the ABG decreased from 44.67±7.43 dB pre-oply to 20.00±5.98 dB post-oply (p<0.000), yielding a gain of 24.67±6.94 dB. At 4000 Hz, the ABG improved from 33.33±6.99 dB pre-oply to 15.33±4.42 dB post-op ly (p<0.001), with a corresponding gain of 18.00±8.62 dB.

For the left ear, the pre-op ABG at 500 Hz was 29.67±9.35 dB, improving significantly to 11.67±4.50 dB post-oply (p<0.001), resulting in a mean gain of 18.00±8.41 dB. At 1000 Hz, the pre-op ABG of 39.67±7.43 dB decreased to 15.67±7.04 dB post-oply (p<0.004), with a gain of 24.00±10.72 dB. At 2000 Hz, the ABG improved from 48.00±8.62 dB pre-oply to 19.67±6.11 dB post-oply (p<0.000), yielding a gain of 28.33±8.38 dB. At 4000 Hz, the ABG improved from 28.67±5.50 dB pre-oply to 13.67±5.50 dB post-oply (p<0.001), with a corresponding gain of 15.00±9.06 dB (Table 1).

In the left ear, similar improvements were observed. The pre-op ABG at 500 Hz was 29.67±9.35 dB, which improved significantly to 11.67±4.50 dB post-oply (p<0.001), resulting in a mean gain of 18.00±8.41 dB. At 1000 Hz, the pre-op ABG of 39.67±7.43 dB decreased to 15.67±7.04 dB post-oply (p<0.004), with a gain of 24.00±10.72 dB. At 2000 Hz, the ABG improved from 48.00±8.62 dB pre-oply to 19.67±6.11 dB post-oply (p<0.000), yielding a gain of 28.33±8.38 dB. Similarly, at 4000 Hz, the ABG improved from 28.67±5.50 dB pre-oply to 13.67±5.50 dB post-oply (p<0.001), with a corresponding gain of 15.00±9.06 dB (Table 1).

The pre-op PTA in the right ear was 42.00±7.51 dB, which significantly improved to 15.00±5.35 dB post-oply (p<0.002), reflecting a mean PTA gain of 27.00±7.51 dB. For the left ear, the pre-op PTA was 43.33±6.45 dB, which improved significantly to 14.00±4.71 dB post-oply (p<0.000), with a PTA gain of 29.33±6.23 dB.

Functional and Clinical Outcomes

The functional success rate, defined as achieving a post-op ABG of <20 dB, was 93.33%, corresponding to 14 out of 15 patients for both the right and left ears (28 ears in total). In terms of hearing improvement, all 15 patients (100%) achieved functional hearing bilaterally, defined as slight or normal hearing levels post-op ly.

Before surgery, 11 patients (73.33%) had moderate hearing loss in the right ear, and 12 patients (80%) had moderate hearing loss in the left ear. After surgery, 12 patients (80%) achieved normal hearing, while three patients (20%) had slight hearing loss in the right ear. For the left ear, 13 patients (86.67%) achieved normal hearing, while two patients (13.33%) had slight hearing loss. These findings indicate a significant shift from moderate hearing loss to either normal hearing or slight hearing impairment, as confirmed by statistical analysis (p<0.005).

Anatomical success, characterized by tympanic membrane integrity and graft uptake, was achieved in 14 out of 15 patients (93.33%) for both ears. This corresponds to an overall

anatomical success rate of 93.33%, as detailed in Table 2. No patients experienced post-op sensorineural hearing loss or deterioration in BC. No major surgical complications were observed during the post-op period, confirming the safety and efficacy of the procedure.

Discussion

Tympanoplasty is a commonly performed procedure in otologic surgery. Recently, minimally invasive techniques, particularly endoscopic approaches, have gained prominence across many surgical fields, including otology (1-5). While microscopic techniques allow for the use of both hands and provide a three-dimensional view, they are limited when visualizing anterior perforations. Endoscopic tympanoplasty overcomes this limitation by offering a wider field of view, particularly with angled scopes, which enhance visualization of difficult-to-reach areas, such as the anterior tympanic membrane, attic, and facial recess. This technique is especially beneficial for patients with narrow ear canals, anterior perforations, or obstructive bony structures (4,5).

While this study highlights the significant benefits of endoscopic tympanoplasty, including enhanced visualization, minimal tissue trauma, and improved cosmetic outcomes, it is essential to critically evaluate its advantages and limitations compared to microscopic tympanoplasty. The endoscopic approach provides a wider field of view, particularly for accessing anatomically challenging areas such as the anterior tympanic membrane, attic, and facial recess. However, the technique has certain limitations, such as the lack of binocular vision and the necessity of single-handed operation, which can pose challenges for less experienced surgeons. These drawbacks can be partially mitigated using a high-definition camera system or endoscope holder (4,7,9).

On the other hand, the microscopic approach offers distinct advantages, such as binocular vision, depth perception, and the ability to use both hands freely during surgery. These

Table 1. Audiometric parameters in single-sitting bilateral tympanoplasty

Parameter	Ear	500 Hz	1000 Hz	2000 Hz	4000 Hz	PTA
Pre-operative ABG	Right ear	35.33±8.96	34.67±7.43	45.00±7.79	33.33±6.99	42.00±7.51
Left ear	29.67±9.35	39.67±7.43	48.00±8.62	28.67±5.50	43.33±6.45	
Post-op ABG	Right ear	10.33±5.50	14.00±6.04	20.00±5.98	15.33±4.42	15.00±5.35
Left ear	11.67±4.50	15.67±7.04	19.67±6.11	13.67±5.50	14.00±4.71	
Pre-post ABG p-value	Right ear	p<0.002	p<0.002	p<0.000	p <0.001	p<0.002
	$p=2.85\times10^{-10}$	$p=2.14\times10^{-9}$	$p=6.56\times10^{-11}$	$p=1.79\times10^{-9}$	$p=2.78\times10^{-12}$	
Left ear	p<0.001	p<0.004	p<0.000	p <0.001	p<0.000	
	$p=1.35\times10^{-7}$	$p=3.86\times10^{-10}$	$p=2.08\times10^{-11}$	$p=1.35\times10^{-7}$	$p=1.23\times10^{-14}$	

ABG: Air-bone gap, PTA: Pure tone average, dB: Decibel, SD: Standard deviation, Frequencies: 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz

Table 2. Functional and clinical success of the bilateral single-sitting tympanoplasty

Parameters		Right ear (± SD)	Left ear (± SD)	Total ear (± SD)
ABG	**Mean (dB)**	14.92±3.79	15.17±3.86	15.05±3.82
	Success (Number of patients)	14 patients (93.33%)	14 patients (93.33%)	28 patients (93.33%)
PTA	**Pre-op mean (dB)**	42.00±7.51	43.33±6.45	42.67±6.98
	Pre-op mean (dB)	15.00±5.35	14.00±4.71	14.50±5.03
	Gain (total±SD)	27.00±7.51	29.33±6.23	28.17±6.87
Hearing success (number of patients)		15 patients (100%)	15 patients (100%)	30 patients (100%)
Pre-op	**Moderate hearing loss**	11 patients (73.33%)	12 patients (80%)	23 patients (76.67%)
	Mild hearing loss	4 patients (26.67%)	3 patients (20%)	7 patients (23.33%)
Post-op	**Slight hearing loss**	3 patients (20%)	2 patients (13.33%)	5 patients (16.67%)
	Normal hearing	12 patients (80%)	13 patients (86.67%)	25 patients (83.33%)
Clinical success (number of patients)		14 patients (93.33%)	14 patients (93.33%)	28 patients (93.33%)

ABG: Air-bone gap, PTA: Pure tone average, dB: Decibel, SD: Standard deviation, pre-op: Pre-operative, post-op: Post-operative

features make it particularly effective for managing larger perforations and achieving precise graft placement. However, microscopic tympanoplasty often requires postauricular incisions or canaloplasty, which may result in longer operative times, increased tissue trauma, and less favorable cosmetic outcomes (20,21).

A comparative analysis of the findings from this study with previously published literature provides further insight into the observed outcomes and highlights distinct differences. In the present study, the functional success rate, defined by achieving a post-op ABG <20 dB, was 93.33%. This was accompanied by substantial hearing improvements, reflected in a mean PTA gain of 28.17±6.87 dB, and an anatomical success rate of 93.33%, indicating intact tympanic membrane grafts in the majority of cases. These outcomes align closely with the results reported by Maran et al. (20), who documented graft success rates of 90% for endoscopic tympanoplasty and 96.67% for microscopic tympanoplasty. Nevertheless, Maran et al. (20) noted that the microscopic approach yielded slightly superior outcomes in cases involving larger perforations, underscoring the critical role of enhanced depth perception provided by microscopic techniques in achieving precise graft placement.

In terms of operative time, our findings align with existing literature. Our study's average endoscopic tympanoplasty duration was approximately 120±28 minutes for bilateral cases. Maran et al. (20) reported shorter operative times for the endoscopic approach (65.5±3.45 minutes) compared to the microscopic method (85.7±3.42 minutes) for unilateral procedures, highlighting the efficiency of the endoscopic technique.

Post-op outcomes also favor the endoscopic approach in terms of patient recovery. Our study demonstrated quicker recovery times and reduced post-op discomfort due to the minimally invasive transcanal approach, which avoids postauricular incisions. Similarly, Maran et al. (20) noted less post-op pain and superior cosmetic outcomes with endoscopic tympanoplasty.

Despite these advantages, the limitations of endoscopic tympanoplasty should not be overlooked. The steep learning curve, reliance on a two-dimensional view, and potential risks from heat generated by the light source underscore the need for adequate training and caution (18,21). Future studies with larger sample sizes and direct comparisons must fully elucidate each approach's relative merits.

While our findings support the efficacy and safety of endoscopic tympanoplasty for bilateral cases, both techniques have unique advantages. The approach should be tailored to the patient's anatomy and the surgeon's expertise, with further research needed to optimize outcomes for specific clinical scenarios. The endoscopic approach reduces operative time, improves cosmetic outcomes, and results in less post-op pain and reduced post-op care requirements (20,21). In our study, using a zero-degree endoscope in transcanal tympanoplasty allowed for a minimally invasive procedure without postauricular incisions or canal drilling. This preserved the middle ear's anatomy and reduced the risks associated with more invasive methods.

Previous studies, such as Ayache's work (22), reported a 96% graft closure rate in endoscopic tympanoplasty using cartilage grafts, comparable to our study's anatomical success rate of 93.33%. Furthermore, significant improvements were observed in post-op ABG, mirroring findings from other studies, which reported similar reductions in ABG.

Endoscopic tympanoplasty has its limitations. Operating with one hand and using a two-dimensional view can be challenging, particularly for surgeons still gaining experience. The learning curve for this technique is steep, and small-diameter endoscopes can restrict the wide-angle views, a primary advantage of the endoscopic approach. Additionally, heat from the light source, particularly xenon lights, can pose risks, although adjusting the light's intensity can mitigate this concern (23).

The cost-effectiveness of same-day bilateral tympanoplasty stands out as a key advantage, particularly when conducting the surgeries in separate sessions. In this study, the single-session bilateral approach demonstrated a remarkable reduction in total expenses, lowering costs by approximately 40-50% relative to separate procedures. In the context of Azerbaijan, where the cost of a single tympanoplasty procedure-including hospital stay, anesthesia, and surgical fees-ranges between 800 and 1200 AZN (equivalent to 500-700 USD), this cost-saving approach offers significant financial relief. By consolidating both surgeries into one session, patients and their families benefit from substantial economic savings, effectively reducing the financial burden on both individual households and the broader healthcare system.

Additionally, the economic advantages extend beyond direct medical costs. Indirect savings are realized through reduced transportation expenses, as fewer visits to healthcare facilities are required. Furthermore, patients experience fewer work absences, which is particularly beneficial for those in the workforce, and the streamlined nature of post-op care minimizes the complexities associated with recovery. These combined factors highlight the dual financial and logistical benefits of same-day bilateral tympanoplasty, making it an attractive option in resource-limited settings while maintaining high standards of clinical care.

Daneshi et al. (13) found that single-session bilateral tympanoplasty reduces costs by 55% and shortens

hospitalization. Our study showed 93.33% graft success, a PTA gain of 28.17±6.87 dB, and post-op ABG <20 dB in 93.33% of cases, similar to their results. Operative time was 120±28 minutes in our study, compared to 90±10 minutes in theirs. Both studies highlight the efficiency of same-day bilateral tympanoplasty. Our endoscopic approach avoided postauricular incisions, speeding recovery. Graft material selection varied, but both methods had high success rates. Same-day tympanoplasty offers cost savings and excellent outcomes. Future studies should refine techniques and compare grafts.

Our study has certain limitations. The small sample size limits the generalizability of the results, and the study's retrospective nature introduces potential biases in data collection. Moreover, the steep learning curve for surgeons using endoscopic techniques may restrict the widespread adoption of this method. Future studies with larger sample sizes and randomized controlled designs are needed to confirm these findings and further explore the benefits and limitations of endoscopic tympanoplasty.

Conclusion

This study demonstrated the efficacy and safety of performing bilateral single-session type 1 tympanoplasty using a transcanal endoscopic approach. The procedure led to significant improvements in Hearing, as shown by reduced ABGs and a high functional success rate of 93.33%. Additionally, clinical success was achieved in 93.33% of cases, with no reported complications such as iatrogenic sensorineural hearing loss. These findings suggest that bilateral tympanoplasty in a single session is a viable and effective treatment option for patients with COM, offering substantial clinical benefits. Our study supports using the transcanal endoscopic technique as a minimally invasive, effective, and safe approach for bilateral tympanoplasty, especially in appropriately selected patients.

Ethics

Ethics Committee Approval: The study protocol received ethical approval from the Ministry of Health of the Republic of Azerbaijan, Azerbaijan State Advanced Training Institute for Doctors, named after A.Aliyev Local Ethics Committee approved this study (decision no: EaR. no:1/09.02.2024-2/II, date: 09.02.2024), and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: All participants provided written informed consent for the surgical procedures and study participation.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.A., Concept: A.A., R.H., Design: A.A., R.H., Data Collection or Processing: A.A., Analysis or Interpretation: A.A., Literature Search: A.A., R.H., Writing: A.A., R.H.

Conflict of Interest: The authors have no conflicts of interest to declare.

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Main Points

- This study is the first to evaluate the outcomes of single-session bilateral endoscopic Type 1 tympanoplasty. The findings provide a comprehensive assessment of the procedure's functional and clinical success rates, establishing a foundational understanding of its efficacy in this region.
- The study demonstrates a high success rate, with significant postoperative improvements in ABG and PTA thresholds. Functional success, defined as a post-op ABG <20 dB, and clinical success, determined by intact tympanic membrane grafts, were achieved in 93.33% of cases.
- By utilizing a transcanal endoscopic approach, this study highlights the advantages of a minimally invasive technique, including shorter operative times, cost savings, and faster patient recovery compared to traditional methods. This approach minimizes surgical trauma and postoperative complications, emphasizing its potential for broader clinical adoption.

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