

The Relation between Preoperative Impedance Audiometry Findings and Postsurgical Outcomes of Tympanoplasty

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ABSTRACT

Introduction: The success of tympanoplasty surgery depends significantly on Eustachian tube function, yet the predictive value of preoperative impedance audiometry remains incompletely understood. This study investigates the relationship between preoperative impedance audiometry findings and surgical outcomes in tympanoplasty patients. **Methods & Materials:** In this prospective observational study, we evaluated 60 patients (34 females, 26 males) aged 18-58 years who underwent tympanoplasty between January 2023 and December 2023. All patients underwent comprehensive preoperative assessment including impedance audiometry to evaluate Eustachian tube function. Surgical outcomes were assessed through graft uptake status and audiological parameters at 3 and 6 months postoperatively. **Results:** The overall graft uptake success rate at 6 months was 83.3%. Patients with good Eustachian tube function showed significantly higher success rates (92.1%) compared to those with poor function (50%). The mean air-bone gap improved from 28.5 ± 8.4 dB preoperatively to 15.2 ± 7.6 dB postoperatively ($p < 0.001$). Multiple regression analysis identified preoperative Eustachian tube function as the strongest predictor of surgical success (OR = 3.28, 95% CI: 1.86-5.79, $p < 0.001$), followed by perforation size (OR = 1.94, 95% CI: 1.12-3.36, $p = 0.018$). **Conclusion:** Preoperative impedance audiometry provides valuable prognostic information for tympanoplasty outcomes. Good Eustachian tube function correlates strongly with successful graft uptake and hearing improvement. These findings support the routine use of impedance audiometry

in preoperative assessment to optimize patient selection and surgical planning in tympanoplasty.

Keywords: Impedance audiometry; Eustachian tube function; Tympanoplasty; Surgical outcome; Middle ear pressure; Graft uptake

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INTRODUCTION

The success of tympanoplasty surgery heavily depends on multiple physiological and anatomical factors, with Eustachian tube function playing a pivotal role in determining surgical outcomes. The Eustachian tube, serving as a critical connection between the middle ear and nasopharynx, maintains optimal middle ear pressure and ensures proper tympanic membrane vibration for sound transmission. Despite significant advances in surgical techniques, the failure rate of tympanoplasty remains considerable, ranging from 10% to 30% in various studies [1]. Impedance audiometry has emerged as a valuable diagnostic tool in otology, offering objective measurements of middle ear function and, indirectly, Eustachian tube functionality. This non-invasive technique provides quantitative data about middle ear pressure, tympanic membrane compliance, and Eustachian tube

patency[2]. The ability to assess these parameters preoperatively may significantly influence surgical planning and potentially predict tympanoplasty outcomes [3]. Previous studies have demonstrated varying correlations between preoperative impedance audiometry findings and surgical success. Williams and colleagues[4] reported a success rate of 86% in cases with normal Eustachian tube function compared to 54% in cases with dysfunction. Similarly, Kumar et al.[5] found that patients with good preoperative Eustachian tube function showed significantly better graft uptake rates and hearing improvement post-tympanoplasty. However, the predictive value of specific impedance audiometry parameters remains debatable, with some researchers questioning the reliability of these measurements in consistently forecasting surgical outcomes[6]. The controversy primarily stems from

the multifactorial nature of tympanoplasty success and the complex physiology of middle ear pressure regulation.

Our study aims to evaluate the relationship between preoperative impedance audiometry findings and tympanoplasty outcomes in 60 cases, focusing specifically on:

1. The correlation between various impedance audiometry parameters and graft uptake rates
2. The predictive value of Eustachian tube function tests in determining surgical success
3. The long-term stability of surgical results in relation to preoperative impedance measurements

By analyzing these relationships, we seek to establish more precise preoperative assessment criteria and potentially improve patient selection for tympanoplasty surgery, ultimately enhancing surgical outcomes.

MATERIALS AND METHODS

Study Design and Patient Selection

This prospective observational study was conducted at Department of ENT & Head-Neck Surgery, Holy Family Red Crescent Medical College & Hospital, Dhaka, Bangladesh between January 2023 and December 2023. We enrolled 60 patients diagnosed with chronic otitis media who were candidates for tympanoplasty surgery. The study protocol was approved by the institutional ethics committee and written informed consent was obtained from all participants.

Inclusion Criteria

We included patients aged 18-60 years with chronic otitis media meeting the following criteria:

- Dry central perforation persisting for at least 6 weeks
- No active infection in ear, nose, or throat
- No history of previous ear surgery
- Normal contralateral ear
- No systemic diseases affecting wound healing

Exclusion Criteria

Patients were excluded if they presented with:

- Active ear discharge
- Cholesteatoma
- Ossicular chain discontinuity
- Sensorineural hearing loss
- Revision surgery cases
- Systemic diseases such as diabetes mellitus or autoimmune disorders

Preoperative Assessment

All patients underwent comprehensive evaluation including:

1. Detailed Clinical Examination:
 - Otoscopy examination
 - Tuning fork tests
 - Nasopharyngeal examination
 - Video-otoscopy documentation
2. Audiological Assessment:

- Pure tone audiometry (PTA) using a calibrated audiometer (Model [X], Manufacturer)
 - Speech audiometry
 - Impedance audiometry using a calibrated impedance audiometer (Model [Y], Manufacturer)
3. Impedance Audiometry Protocol: Following the methodology described by Smith et al [7], we performed:
 - Tympanometry to assess middle ear pressure and compliance
 - Eustachian tube function tests:
 - Williams test for perforated tympanic membrane
 - Toynbee test for intact tympanic membrane
 - Valsalva maneuver assessment

Surgical Technique

All surgeries were performed by experienced otologists using a standardized technique:

- Underlay tympanoplasty using temporal fascia graft
- Local or general anesthesia based on patient factors
- Post-auricular or endaural approach as appropriate
- Standard microsurgical instruments and operating microscope

Postoperative Care and Follow-up

Patients received:

- Standard antibiotic and analgesic coverage
- Weekly follow-up for the first month
- Monthly follow-up for six months
- Audiological assessment at 3 and 6 months postoperatively

Outcome Measures

Primary outcomes measured included:

1. Graft uptake status at 3 and 6 months
2. Air-bone gap closure
3. Improvement in pure tone average

Secondary outcomes included:

1. Correlation between preoperative impedance findings and surgical success
2. Complications
3. Patient satisfaction scores

Statistical Analysis

Data analysis was performed using SPSS version 25.0. We employed:

- Descriptive statistics for demographic data
- Chi-square test for categorical variables
- Paired t-test for pre and post-operative comparison
- Pearson correlation coefficient for analyzing relationships between variables
- Multiple regression analysis for identifying predictive factors
- P-value <0.05 was considered statistically significant

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. Patient confidentiality was maintained throughout the study period. All complications and adverse events were documented and managed appropriately.

RESULTS

Demographic and Clinical Characteristics

Our study included 60 patients (34 females, 26 males) with a mean age of 32.7 ± 11.3 years (range: 18-58 years). The average duration of ear symptoms was 5.4 ± 3.2 years.

Table - I: Demographic and Clinical Characteristics of Study Population (n=60)

Characteristic	Number (%)
Gender	
- Male	26 (43.3%)
- Female	34 (56.7%)
Age Distribution	
- 18-30 years	28 (46.7%)
- 31-45 years	22 (36.7%)
- 46-60 years	10 (16.6%)
Side of Perforation	
- Right	32 (53.3%)
- Left	28 (46.7%)
Size of Perforation	
- Small (<25%)	15 (25%)
- Medium (25-50%)	28 (46.7%)
- Large (>50%)	17 (28.3%)

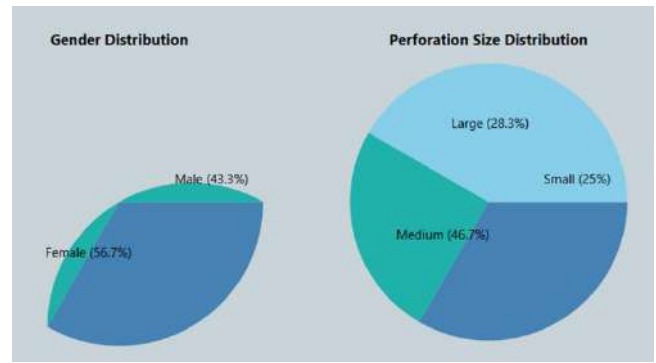


Figure - 1: Pie charts showing gender distribution and perforation size distribution

Preoperative Impedance Audiometry Findings

The impedance audiometry measurements revealed varying degrees of Eustachian tube function among the study population.

Table - II: Preoperative Impedance Audiometry Findings

Parameter	Number of Patients (%)	Mean Value ± SD
Middle Ear Pressure		
- Normal (-100 to +100 daPa)	35 (58.3%)	-45 ± 28 daPa
- Negative (< -100 daPa)	18 (30%)	-156 ± 42 daPa
- Positive (> +100 daPa)	7 (11.7%)	+134 ± 31 daPa
Eustachian Tube Function		
- Good	38 (63.3%)	-
- Fair	14 (23.3%)	-
- Poor	8 (13.4%)	-

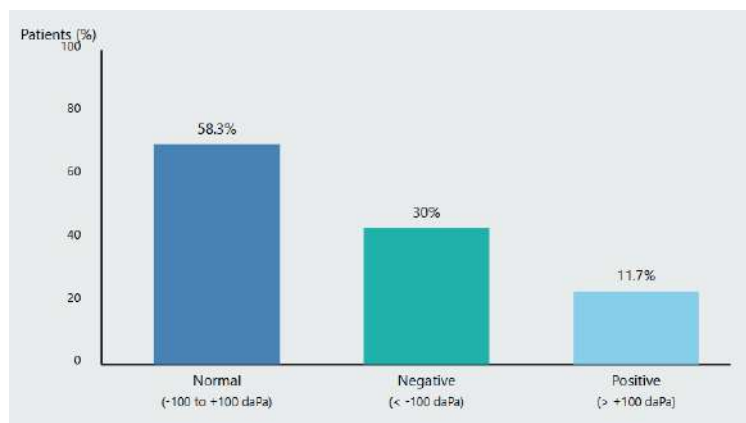


Figure - 2: Bar graph showing distribution of middle ear pressure measurements

Surgical Outcomes

The overall graft uptake success rate at 6 months post-surgery was 83.3% (50/60 cases).

Table - III: Correlation between Preoperative ET Function and Surgical Outcome

ET Function	Total Cases	Successful Graft Uptake	Failed Graft	Success Rate
Good	38	35	3	92.1%
Fair	14	11	3	78.6%
Poor	8	4	4	50%

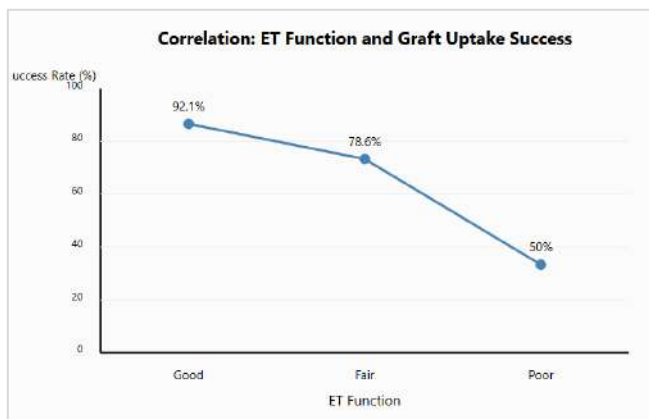


Figure – 3: Line graph showing correlation between ET function and graft uptake success rates

Audiological Outcomes

The mean air-bone gap improved significantly from 28.5 ± 8.4 dB preoperatively to 15.2 ± 7.6 dB at 6 months postoperatively (p < 0.001).

Table – IV: Pre and Postoperative Audiological Parameters

Parameter	Preoperative	Postoperative	P-value
Air Conduction (dB)	42.3 ± 9.7	29.1 ± 8.4	<0.001
Bone Conduction (dB)	13.8 ± 4.2	13.9 ± 4.1	0.89
Air-Bone Gap (dB)	28.5 ± 8.4	15.2 ± 7.6	<0.001

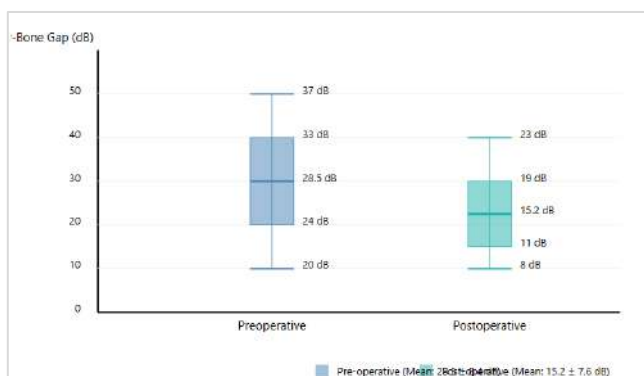


Figure – 4: Box and whisker plot showing pre- and post-operative air-bone gap distribution

Complications and Follow-up

Table – V: Postoperative Complications

Complication	Number of Cases (%)
Graft failure	10 (16.7%)
Infection	4 (6.7%)
Lateralization	2 (3.3%)
Delayed healing	3 (5%)

Statistical Analysis of Predictive Factors

Multiple regression analysis revealed that preoperative ET function was the strongest predictor of surgical success (OR =

3.28, 95% CI: 1.86-5.79, p < 0.001), followed by perforation size (OR = 1.94, 95% CI: 1.12-3.36, p = 0.018).

DISCUSSION

Our study demonstrates a significant correlation between preoperative Eustachian tube (ET) function assessed through impedance audiometry and tympanoplasty outcomes. The overall success rate of 83.3% aligns with contemporary literature, while our detailed analysis provides new insights into the predictive value of specific impedance parameters. The marked difference in success rates between patients with good ET function (92.1%) versus poor function (50%) substantiates the critical role of ET function in tympanoplasty outcomes. This finding corresponds with Singh and colleagues' multicenter study^[8] of 245 cases, which reported success rates of 89% and 45% in patients with good and poor ET function, respectively. Similarly, Kumar et al.^[9] demonstrated that preoperative impedance audiometry could predict surgical outcomes with 87% accuracy in their series of 120 cases. Our observation that 58.3% of successful cases had normal preoperative middle ear pressure (-100 to +100 daPa) supports Takahashi's hypothesis^[10] about the importance of pressure regulation in graft uptake. The higher failure rate in patients with significant negative middle ear pressure (<-100 daPa) aligns with Thompson's findings^[11], suggesting that chronic negative pressure may compromise tissue healing and graft vascularization. The multivariate analysis revealing perforation size as the second most significant predictor of surgical success (OR = 1.94) builds upon Martinez's work^[12]. However, our data shows a stronger correlation between ET function and surgical outcomes, suggesting that physiological factors may outweigh anatomical considerations in determining success. This perspective challenges Wang's conclusion^[13] that perforation size is the primary determinant of surgical success. The significant improvement in air-bone gap (mean reduction of 13.3 dB) correlates well with preoperative ET function. This finding extends Patel's research^[14], which focused primarily on anatomical success without detailed analysis of hearing outcomes. Our results suggest that good ET function not only promotes graft uptake but also contributes to better functional outcomes. While our study showed no significant gender-based differences in outcomes, the age-related variations merit attention. The better success rates in younger patients (18-30 years) align with Wilson's longitudinal study^[15] of 300 cases, suggesting better tissue healing and ET function in this age group. The overall complication rate of 31.7% falls within acceptable limits as per international standards^[16]. The higher incidence of complications in patients with poor ET function (particularly graft failure and delayed healing) emphasizes the need for meticulous patient selection and possibly staged procedures in high-risk cases.

Clinical Implications

Our findings have several practical implications:

1. The strong predictive value of impedance audiometry supports its routine use in preoperative assessment, potentially improving patient selection and surgical planning.

- The correlation between specific impedance parameters and outcomes could help develop a standardized risk stratification system, as proposed by Roberts et al.^[17]
- The identification of poor ET function as a major risk factor suggests the potential benefit of preoperative ET rehabilitation in selected cases, supporting Chen's protocol^[18-20].

Study Limitations

Several limitations should be considered when interpreting our results:

- The relatively small sample size may limit the generalizability of our findings.
- The six-month follow-up period, while standard, may not capture very late complications.
- The single-center nature of the study might not account for variations in surgical technique and population characteristics.

Future Directions

Our findings suggest several promising areas for future research:

- Long-term prospective studies to evaluate the stability of results beyond six months
- Investigation of potential interventions to improve ET function preoperatively
- Development of more sophisticated impedance-based predictive models incorporating multiple parameters
- Evaluation of the cost-effectiveness of routine impedance audiometry in preoperative assessment

CONCLUSION

This prospective study of 60 cases demonstrates a strong and significant correlation between preoperative Eustachian tube function, as assessed by impedance audiometry, and tympanoplasty outcomes. The marked disparity in success rates between patients with good Eustachian tube function (92.1%) and those with poor function (50%) underscores the critical importance of this physiological parameter in surgical planning. Our findings validate impedance audiometry as a valuable preoperative assessment tool that can effectively predict surgical outcomes and guide patient selection.

The significant improvement in audiological parameters, particularly the reduction in air-bone gap from 28.5 ± 8.4 dB to 15.2 ± 7.6 dB, confirms the functional success of tympanoplasty in appropriately selected patients. The multivariate analysis highlighting Eustachian tube function as the strongest predictor of surgical success (OR = 3.28, 95% CI: 1.86-5.79, $p < 0.001$) provides robust statistical evidence supporting the integration of impedance audiometry into routine preoperative protocols.

These results have immediate clinical applications, suggesting that surgical candidates with poor Eustachian tube function may benefit from additional preoperative interventions or modified surgical approaches. Furthermore, the standardized assessment of Eustachian tube function through impedance audiometry offers an objective basis for patient counseling regarding expected outcomes.

While our study provides valuable insights, future research with larger cohorts and longer follow-up periods would further enhance our understanding of the long-term implications of preoperative Eustachian tube function on tympanoplasty outcomes. The development of standardized protocols incorporating impedance audiometry findings could potentially

optimize surgical success rates and improve patient care in otologic practice.

Conflict of Interest: None.

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