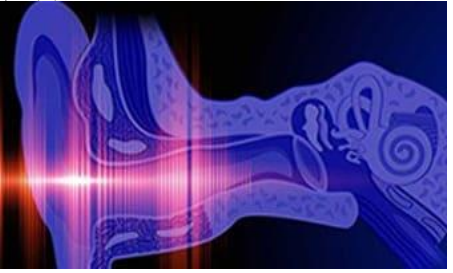


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## Comparison of Eustachian tube function by impedance audiometry and correlation results with tympanoplasty

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### Abstract

**Background:** The Eustachian tube (ET) is a connecting tube between the tympanic cavity and the nasopharynx, which has three main functions: maintaining middle ear pressure, draining middle ear secretions through mucociliary clearance, and protecting the middle ear from nasopharynx sound and pathogen reflux. The success of tympanoplasty depends on many factors, one of which is the proper functioning of the Eustachian tube. To find out the evaluation of Eustachian tube function using impedance audiometry and comparison of surgical outcomes in terms of graft incorporation in normal and abnormal Eustachian tube function.

**Methods:** A prospective study included 100 patients with chronic suppurative otitis media with central perforation (CSOM) who visited the Department of Otolaryngology-Head and Neck Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January to December 2023. The study included 100 patients diagnosed with mucosal-type chronic suppurative otitis media in the quiet or inactive phase. A detailed medical history was collected for all patients, an ENT examination was performed, and radiological examinations were performed. Eustachian tube function was assessed using impedance audiometry. Preoperative and postoperative results of Eustachian tube function were compared, and the results were analyzed.

**Results:** Out of 100 patients between age group of 17 to 45 years with mucosal type of CSOM, either in inactive or quiescent stage were included in study. All cases were of unilateral ear disease. 40% patients (40/100) were in the age group of 17-20 years. Male to female ratio was 1:1.5. Otorrhoea was the main complaint in all cases with 52% patients (52/100) having duration of discharge between 1-10yrs. Majority of patients were seen in quiescent stage of the disease i.e 65% (65/100) during first visit. On impedance audiometry 60% patients had normal Eustachian tube function and 40% had impaired function. Overall graft takes up rate was 91.0% and failure rate was 9.0%. Tympanoplasty was successful in 93.3% patients with normal Eustachian tube function and in 87.5% with impaired function and difference was not statistically significant ( $P > 0.05$ ). Hearing improvement in terms of air-bone gap closure (AB gap < 20db) was more in patients with normal Eustachian tube function (60%).

**Conclusion:** Impedance audiometry is a simple and direct method to assess Eustachian tube function. Not only the anatomical patency but also the physiological function of the Eustachian tube is evaluated. The outcome of tympanoplasty is successful if the Eustachian tube is functioning normally, but Eustachian tube dysfunction is not a reason to refuse the procedure.

**Keywords:** Tubotympanic disease, type-i tympanoplasty, impedance audiometry

### Introduction

The Eustachian tube (ET) is a connecting tube between the tympanic membrane and the nasopharynx, with three main functions: maintaining pressure in the middle ear, draining middle ear secretions through mucociliary clearance, and protecting the middle ear from sound and pathogen reflux in the nasopharynx<sup>[1]</sup>. The success of tympanoplasty depends on many factors, one of which is the proper functioning of the Eustachian tube. Tubal dysfunction is considered one of the most important factors in tympanoplasty failure<sup>[2]</sup>. Over time, many methods have been developed to evaluate the ETF. These include sonotubometry, radiological studies and photoelectric methods to measure patency, evaluation of the ventilation ability of the Eustachian tube in a soundproof room, and the use of fluorescein or saccharin to measure mucociliary clearance. However, all these methods are very complicated and the corresponding facilities are not available in many places. The new generation of impedance audiometers offers the possibility to evaluate ET in a simpler, more

direct and user-friendly way. ET dysfunction plays an important role in the development of otitis media and therefore in the success rate of tympanoplasty. Therefore, the assessment of ET function has become the focus of many studies [3]. Impedance audiometry helps to assess the physiological function of Eustachian tube which is much more important than mere assessment of anatomical patency of the tube. The present study was undertaken to assess the ETF by impedance audiometry in patients with Chronic Suppurative Otitis Media - mucosal type with reference to its treatment outcome. There is conflict between authors about role of ET in success rate of tympanoplasty; some concluded that ET dysfunction has no effect on the outcome of tympanoplasty, while others insisted on its important role [4]. This lack of consensus may be due to absence of a single gold standard test that can measure the ET function accurately and its relation to tympanoplasty [5]. Thus, combination of the ET function tests may be helpful in minimizing this conflict and predicting possible surgery failure. The present study aims to evaluate ET function and its impact on surgical outcomes in tympanoplasty patients.

### Materials and Methods

The prospective study comprised of 100 patients of Chronic Suppurative otitis media (CSOM) with central perforation attending at Department of Otolaryngology-Head & Neck Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January to December 2023. Inclusion criteria: Patients in the age group of 18-45 years, with Tubotympanic type of CSOM, having no source of active infection in ear, nose and throat and having good cochlear reserve were included in the study. Exclusion criteria: Patients with Atticoantral CSOM, revision tympanoplasty, associated with any other source of infection in ENT, those with SNHL were excluded from the study.

All patients were evaluated with detailed history, ENT and systemic examination, otomicroscopy and radiological investigations like x-ray mastoid schuller's view and paranasal sinuses. Pure tone audiometry was done with ALPS - Advanced Digital Audiometer AD-2000 in a sound treated room. Preoperative ETF was tested with AZ-26 of Interacoustic impedance audiometer.

The impedance audiometer was programmed to artificially increase or decrease the air pressure in the middle ear and record the change in pressure in the middle ear every time the patient swallowed. The air pressure at the middle ear end of the Eustachian tube initially changed by +250 or -250 mm H<sub>2</sub>O (daPa). The patient was then instructed to swallow repeatedly to determine whether the positive or negative pressure was partially neutralized with each swallow. The air pressure in the middle ear was monitored using impedance audiometry and recorded graphically. As the patient swallowed, the middle ear pressure rapidly changed. Normally, the positive or negative pressure in the middle ear is partially neutralized with each swallow, and after 3 to 5 swallows, the pressure in the middle ear is completely equalized. The value should be 1.0 mm H<sub>2</sub>O. Any deviation from this is considered abnormal. If pressure remains after 5 swallows, tubal function is considered impaired. All patients underwent either retroauricular or intraauricular type I tympanoplasty. The graft was placed using the underlay technique. Temporal fascia was selected as the graft material.

Follow-up examinations were performed at 1, 2, 4, 6, and 8 weeks. After successful closure of the perforation, a tone hearing test was performed 8 weeks postoperatively.

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 21). The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Qualitative data were described using number and percent. Continuous variables were presented as mean  $\pm$  SD (standard deviation) for normally distributed data. Monte carlo test is used to compare qualitative variables when expected count less than 5. Paired t test is used to compare quantitative data preoperatively and postoperatively.

### Results

Out of 100 patients between age group of 17 to 45 years with mucosal type of CSOM, either in inactive or quiescent stage were included in study. All cases were of unilateral ear disease. 40% patients (40/100) were in the age group of 17-20 years. Male to female ratio was 1:1.5. Otorrhoea was the main complaint in all cases with 52% patients (52/100) having duration of discharge between 1-10yrs. Majority of patients were seen in quiescent stage of the disease i.e 65% (65/100) during first visit.

On otoscopy, 58 patients (58.0%) had large central perforation whereas 36 (36%) had moderate and 6 patients (6%) had small perforation. 52.0% (52/100) patients had preoperative air bone (AB) gap between 30-45 dB whereas 46% (46/100) patients had AB gap between 15-30dB and 2.0 (2/100) patient had more than 45 dB. On impedance audiometry it was found that 60% (60/100) patients had normal Eustachian tube function and 40% (40/100) patients had impaired ETF. All patients underwent type I Tympanoplasty. Follow up were done at 2<sup>nd</sup>, 4<sup>th</sup>, 6<sup>th</sup> and 8<sup>th</sup> weeks. Graft take up was assessed at each visit and hearing improvement was evaluated at 8<sup>th</sup> week by pure tone audiometry. Association between Eustachian tube function and graft take up was studied. In the normal Eustachian tube function group, out of 60, graft take up was seen in 56 cases (93.3%) and rejection in 4 cases (6.7%). In impaired ETF group, out of 4 cases, graft take up was seen in 35 cases (87.5%) and rejection in 5 cases (12.5%) (Table-1). Postoperatively, the air bone gap at 2 months follow up was reduced to less than 10 dB in 16(16%) cases with normal tubal function and 4 (4%) case of impaired tubal function. Air bone gap of >30 dB was seen in 2 (2%) case of normal and 3 (3%) case of impaired tubal function (Table-2).

**Table 1:** Relationship between preoperative Eustachian tube function and graft take-up.

Preoperative tubal function	Total no of patients	Graft take up	Failure
Normal	60	56(93.3%)	4(6.7%)
Impaired	40	35(87.5%)	5(12.5%)
Total	100	91(91.0%)	9(9.0%)

**Table 2:** Relationship between Eustachian tube function and closure of air bone (AB) gap at 2 months.

Eustachian tube function	< 10dB	11-20dB	21-30dB	>30dB	Total
Normal	16(16%)	40(40%)	2(2%)	2(2%)	60(60%)
Impaired	4(2%)	30(30%)	3(3%)	3(3%)	40(40%)

**Table 3:** Correlation of Eustachian tube function and tympanoplasty outcome

Authors	Success rate in Normal ETF	Success rate in Impaired ETF
Cohn <i>et al.</i> 1979 (22)	95%	75%
Sen <i>et al.</i> 1998 (23)	80%	80%
Priya <i>et al.</i> 2012 (24)	100%	98%
Present study	93.3%	87.5%

**Table 4:** Relationship between Eustachian tube function and closure of air bone (AB) gap at 2 months

Eustachian tube function	< 10dB	11-20dB	21-30dB	>30dB	Total
Normal ETF	16	40	2	2	60
Impaired ETF	4	30	3	3	40

## Discussion

In all patients, ET function was tested by saccharin test, methylene blue test, and pressure equalization test (PET), followed by microscopic retroauricular tympanoplasty. Demographic and basic data are shown in the table. ETF is thought to play an important role in the development of otitis media and ventilation of the middle ear cavity, and has been noted as a prognostic factor. ETF is the most important factor for the surgical outcome in patients with CSOM (canalotympanoplasty type) [6]. A properly functioning Eustachian tube is an essential component of a normally functioning middle ear, and the presence of good mucociliary drainage of the Eustachian tube and tympanic membrane represents a good prognostic factor for the outcome of tympanoplasty [7]. ETF is responsible for the failure of tympanoplasty primarily due to pressure dynamics in the middle ear and secondarily due to recurrent middle ear infections.<sup>[8]</sup> Therefore, preoperative testing of tubal function is of great interest, especially if it can be used to estimate the likelihood of a satisfactory outcome of tympanoplasty. The age range of the patients in this study was 17 to 45 years, with a mean age of 25.8 years. A study conducted by Shiromany *et al.* had patients in age range from 12 to 64 years and mean age was  $26.7 \pm 10.18$  years<sup>[9]</sup>. The mean age of patients in the present study was comparable with the other studies<sup>[10-12]</sup>. Maximum patients i.e. 40% (40/100) were in age range of 17-20 years. As second decade of life is the most active time of one's life more people seek medical advice for discharging ear. In the present study male to female ratio was 1:1.5. Holmquist in his study of 72 cases also showed female preponderance with 31 males and 41 females<sup>[13]</sup>. Literature does not show any predilection for females<sup>[14-17]</sup>. The duration of otorrhea indicates that CSOM patients, who are usually pain-free, do not seek medical attention even if their discharge lasts for more than 10 years. In this study, impedance audiometry was used to test Eustachian tube function. Physiologically, neutralization of negative pressure in the middle ear is achieved by temporarily opening the Eustachian tube to allow air to pass through, bringing the air pressure in the middle ear cavity to a level approximately equal to atmospheric pressure. These muscles contract when swallowing. Therefore, to evaluate Eustachian tube function, it is necessary to determine whether an artificially increased or decreased middle ear pressure can be neutralized by swallowing and returned to ambient pressure. Eustachian tube patency test showed that out of 100 cases, 60 (60%) were having normal ETF and 40 (40%) were having impaired function. Study carried by different authors showed a variation in the percentage of Eustachian tube

function. Normal ETF was observed as 51% by Holmquist<sup>[13]</sup>. Sidentop showed 16%<sup>[18]</sup>, Sharp 7.5%<sup>[19]</sup> and Dutta 26%<sup>[20]</sup>. This difference may be because the different authors used different methods to evaluate the Eustachian tube function and at different time of disease activity. The newer generation of impedance audiometers allow us to monitor and document whether swallowing balances the middle ear pressure and thereby test the Eustachian tube function very precisely and effectively. Monitoring the Eustachian tube opening and the resulting neutralization of pressure in the middle ear during swallowing has been shown to be much more accurate in the presence of a pressure difference<sup>[21, 22]</sup>. Without this pressure difference, only one third of patients with normal function would test positive, meaning that without this pressure difference the rate of false negative results would be very high. This is the importance of assessing Eustachian tube function with an impedance audiometer. In the normal Eustachian tube function group, out of 60, graft take up was seen in 56 cases (93.3%) and rejection in 4 cases (6.7%). In impaired ETF group, out of 40 cases, graft take up was seen in 35 cases (87.5%) and rejection in 5 cases (12.5%). The results of present study are comparable with Mackinnon<sup>[19]</sup>. Who observed 81% success rate in patients with normal ETF and 40% in patients with impaired ETF. Study results were compared with other studies in table-3<sup>[23-27]</sup>. After applying the tests of significance it was found that there is no significant association between Eustachian tube function and successful graft take up ( $P > 0.05$ ). Other authors like Sheehy and Glasscock<sup>[28]</sup>, Sharp<sup>[19]</sup>, Ekvall<sup>[29]</sup>, Bluestone<sup>[30]</sup>, Anderson<sup>[31]</sup>, too observed poor correlation between Eustachian tube function and Tympanoplasty results. They observed more than 70% success rate in patients with poor tubal function. In the present study, we have found hearing improvement more in patients with normal Eustachian tube function with reduction in air bone gap less than 10 dB in 16(16%) cases with normal tubal function and 4 (4%) case of impaired tubal function. Air bone gap of >30 dB was seen in 2 (2%) case of normal and 3 (3%) case of impaired tubal function. Holmquist<sup>[13]</sup>. States that the results were almost same in both, normal and impaired function group. According to Anirban Biswas<sup>[32]</sup>, the incidence of failure of tympanoplasty was much higher amongst patients having poor Eustachian tube function (71%) prior to the surgery. On the contrary, it was found that the success rate in tympanoplasty (i.e. perfect uptake of graft without retraction or post-operative adhesions and post-operative air bone gap of less than 30dB) was much higher (76.0%) in ears which had normal tubal function prior to the surgery. In the present study, statistical evidence showed that Eustachian tube function does not play a much significant role in graft take up. However, to be too dogmatic, a large series study for prolonged period is needed.

## Conclusion

A properly functioning Eustachian tube, as an excellent channel for ventilation and pressure equalization of the middle ear, plays a key role in the success of the implantation and the improvement of hearing during tympanoplasty. However, this does not mean that damage to the Eustachian tube is a reason to reject tympanoplasty. Therefore, the impedance audiometer is an invaluable tool in the diagnostic armamentarium of the otologist.

## Author's Contribution

Not available

**Conflict of Interest**

Not available

**Financial Support**

Not available

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