

Tympanometric Assessment of Eustachian Tube Function Before and After Tympanoplasty

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Abstract:

Objective: Evaluation of eustachian tube function before and after tympanoplasty and to determine whether there is improvement in either the eustachian tube function or the hearing as a result of tympanoplasty.

Materials & methods: A prospective study of 50 cases with chronic otitis media – mucosal disease were admitted to YENEPLOYA HOSPITAL for surgery from October 2011 to October 2013 were included in the study. Preoperative PTA and eustachian tube function tests were taken. Patients were then subjected to ear surgery. Postoperatively 2 follow ups were done at 3 months and 6 months.

Results: Majority of patients were from the mean age group of 27.18 ± 11.65 years. Mean preoperative PTA average of the patients was $30.693 \text{ dB} \pm 13.997 \text{ dB}$. Mean PTA average at 3 months was $24.84 \pm 10.09 \text{ dB}$ and at 6 months was $25.37 \pm 10.52 \text{ dB}$. Impedance audiometry for Eustachian tube showed that of the 50 cases, 68% of patients, were patent and 32% patients were obstructed. 62.5% cases with obstructed eustachian tube had successful graft uptake and 37.5% patients had reperforation after 6 months.

Conclusion: The study shows that good Eustachian tube functions is a required for obtaining a good outcome during tympanoplasty.

Keywords: Eustachian tube function, Impedance audiometry, Tympanoplasty, Cortical mastoidectomy

I. Introduction

The reconstruction of the hearing mechanism in otological surgeries is essential for proper rehabilitation of the patient's hearing, due to the patient's improvement in hearing and absence of symptoms in patient post-surgery. Eustachian tube dysfunction has been considered as one of the factors of tympanoplasty failure both primarily due to middle ear pressure dynamics and secondarily via recurrent otitis. Hence, assessment of Eustachian tube function is of prime importance before undertaking any surgical procedure for chronic otitis media. The modern impedance audiometer helps us to assess the physiological functioning of the Eustachian tube when the tympanic membrane is intact as well as in the presence of perforation.

II. Materials & Methods

A Prospective study of 50 cases of chronic otitis media (mucosal disease), who visited the ENT outpatient department and were admitted for ear surgery from October 2011 to July 2013 was conducted. Patients with tubotympanic type of chronic suppurative otitis media with central perforation and who are undergoing tympanoplasty/ cortical mastoidectomy were subjected to the study.

Inclusion criteria

1. Patients who presented with chronic otitis media – both active and inactive mucosal disease.
2. Patients having more than 40 dB hearing loss on pure tone audiometry
3. Patients with good cochlear reserve.

Exclusion criteria

1. Patients with other ENT disorders (apart from chronic suppurative otitis media)
2. Cases having Atticoantral type of CSOM.
3. Patients with poor cochlear reserve
4. Cases who are not medically fit for surgery.

Patients having chronic otitis media (mucosal disease) with central type of perforation and in whom Tympanoplasty with/without Cortical Mastoidectomy was planned were subjected to the study. A thorough clinical ENT examination was done and evidence of any other ENT conditions were ruled out.

A pure tone audiometry was done with INTERACOUSTICS AC40 AUDIOMETER, followed by Eustachian tube evaluation with the INTERACOUSTICS TITAN SERIES IMPEDANCE AUDIOMETER in all the patients. The opening pressure and the residual pressure of the test ears were measured. Patients having

residual pressure more than 50 daPa were termed as poor Eustachian tube function; those having less than 50 daPa were termed as good Eustachian tube function. Tympanoplasty was performed on all patients, whether they underwent Cortical mastoidectomy or not. Following the surgery, the patients were recalled after 3 months for their first visit, and a second set of PTA and Eustachian tube function tests was done. Patients in whom the graft failed to take up and had retraction or perforation were assessed accordingly, i.e. Toynbee's test procedure. The procedure was repeated again after 6 months.

III. Observations And Results

The study included patients of all ages ranging from 11 to 58 years of age:

The majority of patients were young adults between the age group of 20-29 yrs of age. The mean age group was 27.18 ± 11.65 yrs. Of these patients, 22(44%) were males and 28(56%) were females. The main presenting complaint for these patients was Ear discharge. The duration of symptoms varied from 6 months to years (4 patients give history from childhood). 6 patients presented to the OPD with discharging ears even after taking medical line of treatment and they had to undergo cortical mastoidectomy procedure along with tympanoplasty. Pure tone audiometry evaluation for hearing loss was done during the pre-operative, 3rd month postoperative, and 6th month post-operative period was done to assess the level of hearing loss as well as hearing improvement post-operatively. The mean Preoperative PTA was $31.34 \text{ dB} \pm 10.02 \text{ dB}$. The post-operative PTA at the 3rd month showed that there was significant improvement compared to the Preoperative PTA as shown below; however, the comparison between Postop PTA at 3 months and Postop PTA at 6 months shows no significant change. Mean Post-op PTA at 3 months was $25.35 \pm 10.61 \text{ dB}$ and at 6 months was $25.91 \pm 10.97 \text{ dB}$. The test shows that at 3 months, there is significant improvement (**Table 1**).

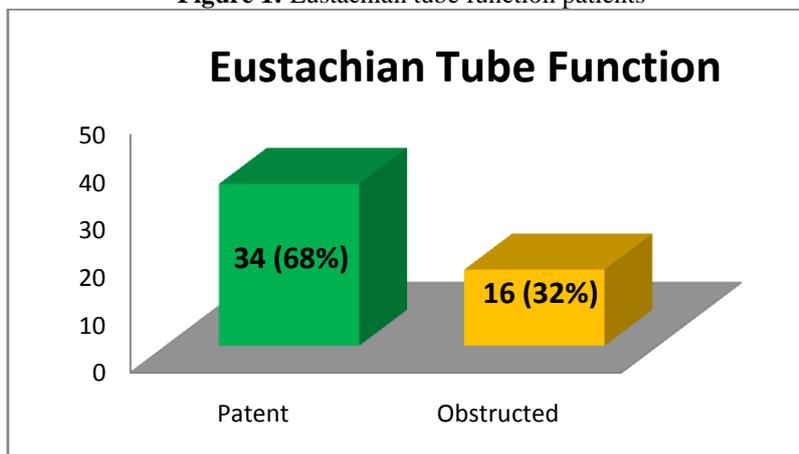
Table 1: Mean PTA average with % change

		Mean difference	Change (%)
Preop PTA	PTA at 3 m	5.991	19.11
	PTA at 6 m	5.431	17.33
PTA at 3 m	PTA at 6 m	-.560	2.21

We found that there is significant difference between the PTA taken at pre-op and at both post-op PTAs at 3 months and 6 months, as the p value < 0.05.

Of the 50 cases, 34 patients (68%), were patent and 16 patients (32%) were obstructed on observing their impedance audiometry findings (Fig. 1).

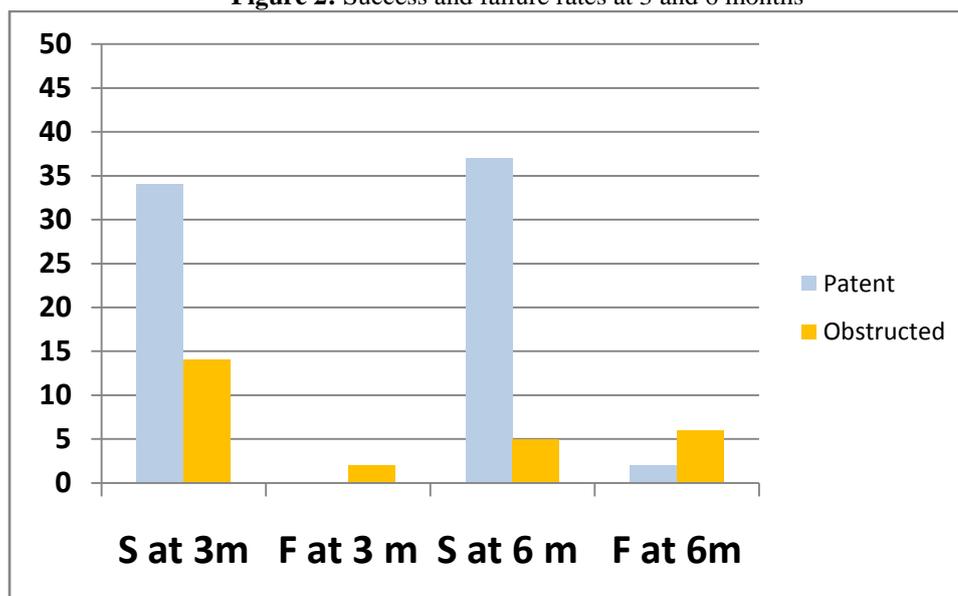
Figure 1: Eustachian tube function patients



Surgical procedures: Overall, most patients underwent Type 1 tympanoplasty (35 patients – 70%). 15 patients underwent other procedures (5 patients (10%) - modified type 3 tympanoplasty; 10 patients (20%) underwent cortical mastoidectomy and Tympanoplasty. Of the patients who underwent Cortical mastoidectomy, 6 patients (60%) underwent Type 1 tympanoplasty while the remaining 4(40%) underwent modified type 3 tympanoplasty).

Success rate: -The success and failure was noted by the graft uptake and the appearance of the tympanic membrane at 3 months and at 6 months (Fig. 2).

Figure 2: Success and failure rates at 3 and 6 months

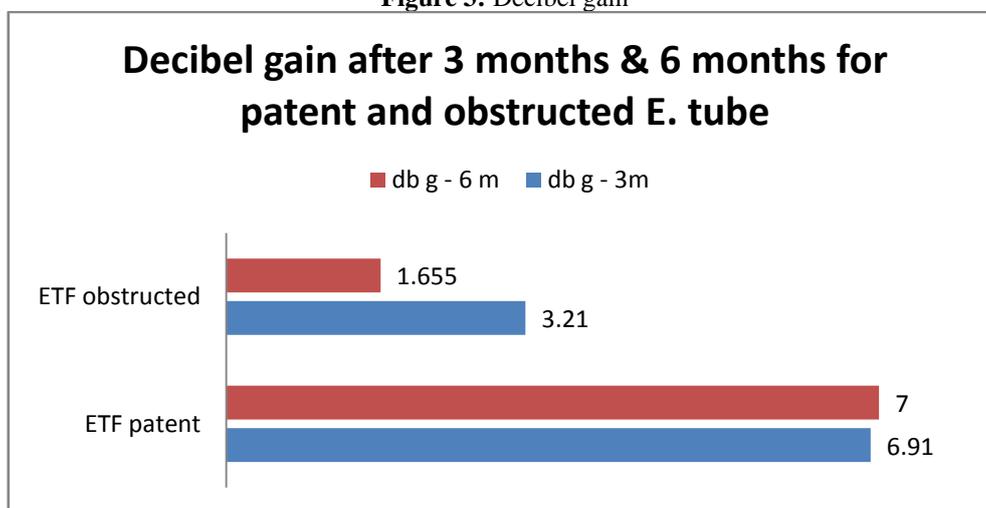


1.) Eustachian tube function compared with success of surgery:-

- a. **Patent Eustachian tube** – Out of the 34 cases of patent Eustachian tube, 32 cases (94.1%) had successful graft uptake, while 2 cases (5.9%) had reperforation; the two cases were 11 and 13 years of age and reperforation occurred due to repeated Upper respiratory tract infections within the 6 months follow up.
- b. **Obstructed Eustachian tube** – 16 patients had obstructed Eustachian tube, of which 10 cases had successful graft uptake (62.5%) and 6 patients had reperforation after 6 months (37.5%).
- c. **Eustachian tube function at 3 & 6 months** –Eustachian tube function at 3 and 6 months showed little improvement except for 5 cases with subtotal perforation, whose Eustachian tube had become patent after 3 months of surgery.

Decibel gain: -The decibel gain was measured between patients having Patent Eustachian tube and obstructed Eustachian tube. Patent Eustachian tube patients showed a mean improvement of $6.91 \text{ dB} \pm 4.20$ at 3 months and the obstructed Eustachian tube patients showed $3.21 \text{ dB} \pm 3.12$ at 3 months. At 6 months, the gain was less as compared to the gain at 3 months but was still significant compared to pre-operative Eustachian tube function (Fig. 3).

Figure 3: Decibel gain



Eustachian Tube function in relation to size of perforation

On comparing the size of perforation and the Eustachian tube, 4 cases had Small central perforation, all of whom had patent Eustachian tube; 14 patients had Medium central perforation, of which 13 had patent and 1 case had obstructed Eustachian tube. Of the cases having large central perforation, 17 cases had patent and 10 cases had obstructed Eustachian tube. Finally, 5 cases of Subtotal perforation were seen, all of whom had obstructed Eustachian tube. Using chi square test, we found that the p value for Eustachian tube function and size of perforation was 0.0007 (< 0.05).

In comparison with size of the perforation and the Eustachian tube function, we found that cases having both Medium Central perforation and Subtotal perforation had success rate of 100% at 3 months. 4 cases of the 50 had small central perforation, out of which 2 of the cases (50%) had successful graft uptake, and 2 case (50%) experienced failure of graft by 6 months. In cases having large central perforation, 20 cases (74.07%) had successful graft uptake and 7 cases (25.93%) had failure of graft at 6 month period. In this case, there is no significance as the p value was > 0.05 , on using chi square test.

IV. Discussion

Current developments in middle ear reconstructive surgery have given more information regarding the study of the Eustachian tube and its effects in the course of reconstructive middle ear surgery.

Tos¹ and Biswas² have emphasized the importance of Eustachian tube function in middle ear surgery. The Eustachian tube function has been responsible for failure in some cases of tympanoplasty due to both middle ear pressure dynamics and recurrent otitis³.

Adequate functioning of the Eustachian tube is also considered as one of the prerequisites for re-establishing a closed, aerated tympanic cavity in tympanoplasty⁴. Many otologists routinely carry out tests for anatomical patency of the Eustachian tube prior to surgery (by passing some dye into the middle ear or a nylon thread). Hasan M Mustafa et al⁵ used a regular sphygmomanometer to which they attached a T-shaped tube situated between a rubber pump and the manometer. The 3rd limb ended in an ear piece, which fitted tightly into the external auditory canal by creating an airtight seal. The air pressure was slowly raised while the surgeon observed the manometer until there was a sudden fall as the Eustachian tube opened up. Most surgeons evaluate the tubal function clinically by observing the Valsalva response⁵. The impedance bridge can also be used in cases with perforated ear drums by raising the pressure in the external meatus and measuring the tubal opening pressure⁵.

Alberti and Kristenson⁶ used the acoustic impedance bridge in 1970 to estimate tubal function with an intact drum. In order to maintain normal function of the middle ear, the physiological functioning of the Eustachian tube is important. A modern impedance audiometer offers us the facility of ascertaining the physiological function of the Eustachian tube not only when the tympanic membrane is intact but in the presence of perforated ear drum as well². In this study, we used impedance audiometry. Impedance audiometry is advantageous because:

- a. Can be used in the presence of a perforated tympanic membrane
- b. Quick and non-invasive
- c. Accurate
- d. Inexpensive

Although according to published literature there are reports of over 90% success in middle ear reconstructive surgery, the general experience is not exactly so. The average results are usually in the range of 75% to 80% - Foggia reported a take rate of only 76% in a reasonably large study⁷. Assessment of Eustachian tube function should be considered mandatory before undertaking any surgery for treatment of patients having chronic otitis media.

Comparative studies of surgical success & Obstructed Eustachian tube

In our study, the overall success rate after 6 months was 84 %. 62.5 % cases (10 patients out of 16) with obstructed Eustachian tube had success mainly because of 2 reasons: at 6 months, though the tympanic membrane was retracted, the graft had taken up in 5 cases. In the other 5 cases, the patients had subtotal perforations, and showed improvement in both the graft uptake as well as Eustachian tube function. This may suggest that the Eustachian tube dysfunction was because of exposure of the middle ear mucosa to the external environment, due to irritation leading to mucosal oedema. In a study done by Mackinnon et al⁸, the success rate was 29% in obstructed Eustachian tube; Another study, by Fateen et al⁹, the success of surgery in negative postoperative cases was 42.8 %.

Our study had a higher success rate because 5 cases were noted to have retracted TM, while 5 cases who had successful uptake were subtotal perforations that healed after 3 months and showed normal TM.

Comparing the data given by Sato et al¹⁰(Table 2), a similar outcome in patients having poor eustachian tube function is seen, while patients having good eustachian tube function have a slightly less occurrence of surgical failure in our study.

Table 2: Comparative studies of surgical failures (SATO et al vs. Present study)

E.T.F (Eustachian tube function)	GOOD	POOR
P.P.E.T (Positive pressure equalisation test)	14.1 %	35%
N.P.E.T (Negative pressure equalisation test)	13.5%	27.5%
C.T. (Clearance test)	10.9%	32.3%
Present study	5.9%	37.5%

This study shows that Patent eustachian tube always carries a better prognosis than obstructed eustachian tube cases in the outcome of tympanoplasty¹¹. Of the 34 cases with preoperatively patent eustachian tube, there was failure in only 2 cases. The patients had recurrent attacks of Upper respiratory tract infections, and both were in the adolescent age group (11years and 13 years). Warren, Adkins M.D. et al¹² had shown similar failure rates.

A study by VIRTANEN et al¹³ showed a success rate of 80 % in patients who had normal pre-operative tubal function (Table 3).

Table 3: Comparison of surgical success in patients with patent Eustachian tube

	VIRTANEN et al ¹³	PRESENT STUDY
No. of cases	87	50
Patent Eustachian tube	78	34
Success	63 (80%)	32 (94.11%)

In a study conducted by Fadl A. Fadl¹⁴, it was seen that when comparing the outcome of surgery with size of the perforation, the smaller the perforation, the better the result. In our study, we found that the medium central perforations and the subtotal perforations had 100% success rate, while the small perforations had a 50% success rate, and large central perforation had a 74% success rate (Table 4).

Table 4: Comparison of surgical success with size of perforation

Size of perforation	FADL A. FADL ¹⁴	PRESENT STUDY
Small Central Perforation	50%	50%
Moderate central perforation	92.3%	100%
Subtotal	84.1%	100%

In our study, 5 subtotal cases showed improvement after surgery in both the uptake of the graft as well as in eustachian tube function. This may be due to the fact that infection from the external environment has been prevented by the graft, allowing the middle ear mucosal edema to subside and the eustachian tube function to return to normal. We have found no comparative study with regards to improvement of eustachian tube function following tympanoplasty.

V. Conclusion

The impedance audiometer offers the best means of assessing the Eustachian tube function, as measures function in both intact as well as in perforated tympanic membranes. The prognosis of middle ear surgery has a direct correlation with the Eustachian tube functions, i.e. good Eustachian tube functions is essential for obtaining a good prognostic value and vice versa. Cases of Obstructed Eustachian tube are ideal candidates for Cartilage tympanoplasty; Patent Eustachian tube cases can be cured with standard Temporalis fascia Tympanoplasty

Bibliography

- [1]. Tos M. Importance of eustachian tube function in middle ear surgery. *Ear, nose, & throat journal*. 1998;77(9):744.
- [2]. Biswas A. Eustachian tube function test: a new dimension in the management of CSOM. *Indian Journal of Otolaryngology and Head & Neck Surgery*. 1999;51(2):14-22.
- [3]. Schuknecht HF, Kerr AG. Pathology of the eustachian tube. *Archives of Otolaryngology*. 1967;86(5):497-502.
- [4]. Manning SC, Cantekin EI, Kenna MA, Bluestone CD. Prognostic value of eustachian tube function in pediatric tympanoplasty. *The Laryngoscope*. 1987;97(9):1012-6.
- [5]. Moustafa HM, Abdel-Latif SM, Shaaban B. A simple apparatus for the assessment of Eustachian tube patency before myringoplasty. *J Laryngol Otol*. 1979;93:39-42.
- [6]. Alberti P, Kristensen R. The clinical application of impedance audiometry: A preliminary appraisal of an electro-acoustic impedance bridge. *The Laryngoscope*. 1970;80(5):735-46.
- [7]. Foggia D, McCabe B. Homograft tympanoplasty: the Iowa experience. *Otology & Neurotology*. 1990; 11(5):307-9.
- [8]. MacKinnon D. Relationship of pre-operative eustachian tube function to myringoplasty. *Acta Oto-Laryngologica*. 1970;69(1-6):100-6.

- [9]. Fateen A, Soliman T, Issa T, Handosa A, Zohdy I, Raafat S. Myringoplasty with mastoidectomy in Eustachian tube dysfunction. Med J Cairo Univ.1994; 62:179-84
- [10]. Sato H, Nakamura H, Honjo I, Hayashi M. Eustachian tube function in tympanoplasty. ActaOto-Laryngologica. 1990;110(S471):9-12.
- [11]. Cohn AM, Schwaber M, Anthony LS, Jerger JF. Eustachian tube function and tympanoplasty. The Annals of otology, rhinology, and laryngology. 1979;88(3 Pt 1):339.
- [12]. Warren Y., Adkins, White B. Type 1 tympanoplasty: Influencing factors. Laryngoscope1984; 94(7):916-8.
- [13]. Virtanen H, Palva T, Jauhiainen T. The prognostic value of Eustachian tube function measurements in tympanoplastic surgery. ActaOto-Laryngologica. 1980;90(1-6):317-23.
- [14]. Fadl FA. Outcome of type-1 tympanoplasty. Saudi medical journal. 2003;24(1):58-61.