

Muco-Ciliary Function of Eustachian Tube in Patients with Tubo Tympanic Disease and its Impact on Surgery

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ABSTRACT

Eustachian tube dysfunction is one of the familiar factors foremost to progress of chronic suppurative otitis media. Tube mucociliary transport is chief for removal of the inflammation products from the middle ear enabling recovery of the affected mucosa of the middle ear, local circulation and renewal of normal air pressure in the middle ear. To assess the mucociliary function of the Eustachian tube in patients with tubo tympanic type of chronic suppurative otitis media. To correlate the surgical outcome of chronic suppurative otitis media with Eustachian tube after 3 months of post-operative period. To correlate if any relationship between the mucociliary function of Eustachian tube with nasal allergy. To correlate if any relationship between the mucociliary function of Eustachian tube in patients with tubo tympanic type of chronic suppurative otitis Media with respect to site of perforation and also between the site of perforation and the surgical outcome in patients with chronic suppurative otitis media (Tubo tympanic type).

Keywords:

Eustachian tube, Inflammation, Mucociliary, Otitis

1. Introduction

The meticulous preoperative examination is the method by which one is warned of and armed for the problems involved in the surgery of the chronic ear diseases. This is especially true when Tympano- mastoidectomy procedures are performed. The function of Eustachian tube is an important factor in deciding the prognosis of the middle ear disease and hence surgical outcome [1-5]. Successful treatment of Chronic Suppurative Otitis Media (Tubotympanic type) requires an understanding of the principles of Eustachian tube function [6-9].

Eustachian tube has at least 3 important functions with respect to the middle ear [10,17].

1. The secretions from the middle ear drains into the nasopharynx [11].
2. Ventilation of the middle ear to equilibrate air pressure between the Middle ear and atmospheric pressure and to replenish oxygen has been absorbed [15].
3. Protection from nasopharyngeal sound pressure and secretions [10].

Along with mechanical factors like gravity and air pressure gradient, clearance of secretions from middle ear is influenced by [18]

- a) The mucociliary system of Eustachian tube.
- b) Active tubal opening.
- c) Surface tension factors.

The ventilatory function is important since a malfunctioning Eustachian tube hampers the function of the middle ear cleft and leads to middle ear effusion. Various studies have proven the positive correlation between ventilatory tubal function and middle ear disease [15].

Though the ventilatory function is of paramount importance in determining the outcome of surgery for the middle ear, the clearance function is no less important since adequate clearance of the middle ear hastens healing of the mucosal epithelium, poor drainage yields poor results⁹. In Chronic Suppurative Otitis Media, mucociliary function of the Eustachian tube is impaired due to

ciliary dysfunction and middle ear drainage can be maintained only by muscular clearance function (active tubal opening)[15].

The dye installation test mainly evaluates the mucociliary function of Eustachian tube [16]. Despite pressure regulation function being the most important of the three physiologic functions of the Eustachian tube for maintenance of optimal hearing, the protective and clearance functions are also important in maintaining the physiologic state. The clearance and drainage functions of the Eustachian tube have been assessed by several of methods in the past. By means of radiographic techniques, the flow of contrast media from the middle ear (tympanic membrane not intact) into the nasopharynx has been assessed [24]. Instillation of fluorescein solution into the middle ear and assessment of the clearance function of the Eustachian tube by subsequently examining the nasopharynx with an ultraviolet light [24]. Radioisotopic techniques were used to monitor the flow of saline solution down the Eustachiantube[26].

Muco ciliary clearance can be assessed by observing Methylene blue in the Nasopharynx after it had been instilled into the middle ear [27]. Mucociliary flow was evaluated by determining the time that elapsed after saccharin had been placed on the mucous membrane of the middle ear until the subject reported tasting it⁷⁶. The common reason for middle ear surgical failure has been attributed to Eustachian tube dysfunction if one rules out infection and poor surgical techniques. Hence, effective pre operative and post operative tubal function is highly important for good surgical outcome for the middle ear reconstructive surgeries. Thus it becomes apparent that Eustachian tube assessment should begin early in the disease. Also, Eustachian tube dysfunction hampers the muco ciliary transport leading to chronicity of middle ear pathologies and contributes to a major reason for the surgical failures.

This study emphasizes that it is mandatory to evaluate mucociliary transport mechanism of Eustachian tube prior to cortical Mastoidectomy with Tympanoplasty [1, 16] and before starting any mode of surgical treatment in patients with Chronic Suppurative Otitis Media.(Tubo tympanic disease)

2. Materials And Methods

Source of data

Patients attending with ear symptoms Department of Oto-rhino- laryngology & Head and Neck surgery, Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry from January 2015 to June 2016 who had fulfilled the inclusion criteria and exclusion criteria.

Sample size of the study:

All patients as per inclusion criteria were recruited into the study with a number restricted to 75 cases and subjected to detailed evaluation and further surgical procedure.

Design of the study:

This is a Prospective clinical study conducted in our institute.

Methods of Data Collection:

Cases selected for the study were subjected to detailed history and thorough clinical examination and detailed questionnaire, explaining them the protocols being followed and consent for the procedure taken. The following investigations were also done:

1. DyeTest

In this procedure examination of the ear was done to assess the condition of the middle ear mucosa. Based on the findings the middle ear mucosa was classified into three categories.

- a. Healthy –Dry
- b. Edematous – Moist
- c. Polypoidal

The patient was asked to swallow 10 times before the test to ensure open nasopharyngeal orifice of the tube. Then in supine position the head was turned to the side opposite to the ear being tested (i.e.,) the test ear was kept upwards. Two to three drops of sterile Methylene blue (Product: Nice^R -Methylene Blue solution-10% water soluble Methylene blue with aqueous base) was instilled with spinal needle (25G) into the middle ear close to the Eustachian tube orifice through the perforation into the tympanic membrane using 0° Hopkins rigid 4mm endoscope as the guide all the while asking the patient to refrain from swallowing.

The nasopharyngeal end of the tube was watched for the appearance of the dye using nasal endoscope after pre packing the nose on the side of test being performed.

A note of the time lapsed from the instillation of the dye to appearance of the dye at nasopharyngeal end was noted. The results of this test were classified into three groups as follows:

Eustachian tubal function	Methylene blue clearance time
Normal	Less than 10minutes
Partial dysfunction	10-20 minutes
Gross dysfunction	More than 20minutes

2. Diagnostic NasalEndoscopy

The diagnostic nasal endoscopy was done using 30° Hopkins rigid 4mm Nasal endoscope. Nose was packed with pledges soaked in a mixture of 4% Xylocaine (10ml) and 10 drops nasal decongestant (Xylometazoline).

I pass II pass III pass

3. Pure tone Audiometry

This was done to record the type of hearing loss and degree of hearing loss with Diagnostic Audiometer (Make- Resonance, Model R-37A-TDH 39).

4. X-Ray Mastoids

X-ray mastoids- lateral oblique view (Laws view) was taken and the radiological features were noted (whether Diploic, Sclerosed or Pneumatic) with specification of 60Kv, 45mAs and 10X8cm film.

5. Blood Investigations

Routine Haemogram (HB,BT,CT,TC,DC), Random Blood Sugar, Blood urea and serum creatinine, urine routine and microscopy, viral serology markers, X-Ray chest PA view, ECG were all done as a part of routine pre-operative work up.

Pre-operative preparations for patients were prepared in following protocols for ear surgeries. Patients were operated both under General anesthesia and Local anesthesia depending upon the age of the patient and also by clinically assessing their co- operation for the procedure under local anesthesia. All 75 patients underwent to the following surgical procedures.

Patients were started on suitable inject able antibiotics which were given for one week along with analgesics, antacids, anti histamine and multivitamins. In cases of suspected post operative wound infections, antibiotics were continued up to 2 weeks.

Patients were reviewed after 4 weeks of post surgery and then reviewed again after 3 months. Patients were evaluated post operatively using otoscopy on outpatient visits and Pure Tone Audiometry was done at end of 3-4th month after surgery. However hearing results were not used as an outcome measure.

3. Results And Discussions

The factors influencing Eustachian tubal function and hence the success of Cortical Mastoidectomy with Tympanoplasty were analyzed and following results were noted.

In our study the age of patients ranged from 15 years to 45 years and majority of them were found to be in age group of 21-30 years (42.7%).

The Mean age was of 29.49 years and median age found to be 31 years in our study group.

Figure 1 **Distribution of patients according to Age**

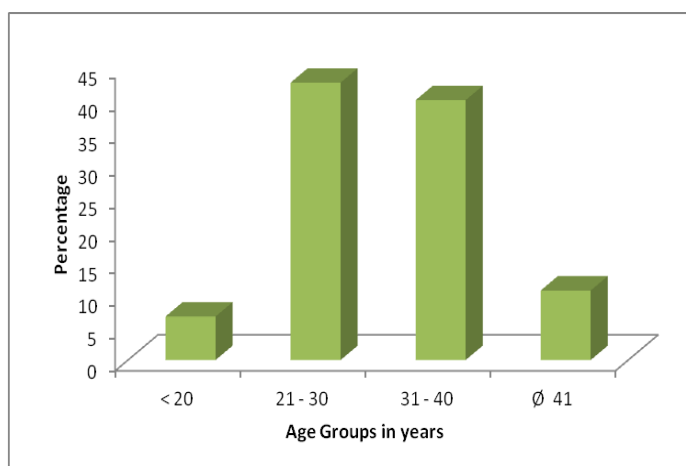


Figure 2 **Distribution of patients according to sex**

In our study sex distribution was studied and males (61.3%) outnumber females (38.7%) in presentation.

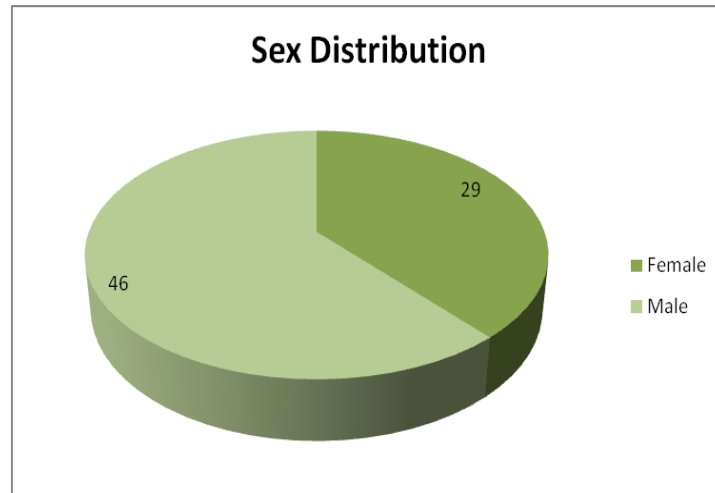


Figure 3 Distribution of patients according socio economic status

In our study socioeconomic majority of patient fall in middle socioeconomic strata (88.4%).

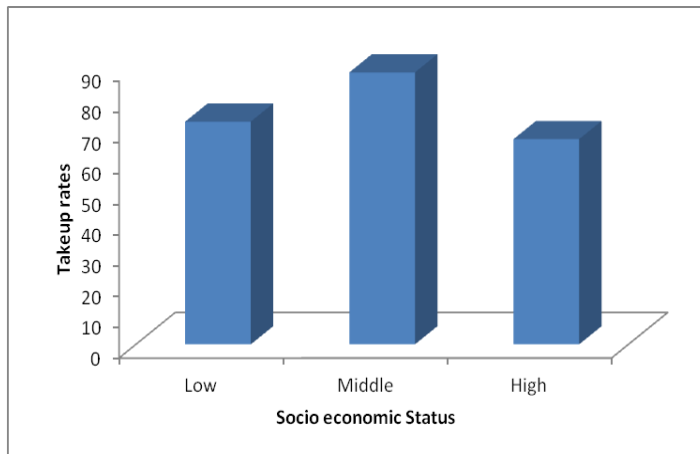


Figure 4 Distribution of patients according to size of perforation

In our study medium sized perforation was majority (38.7%) presentation as examination finding.

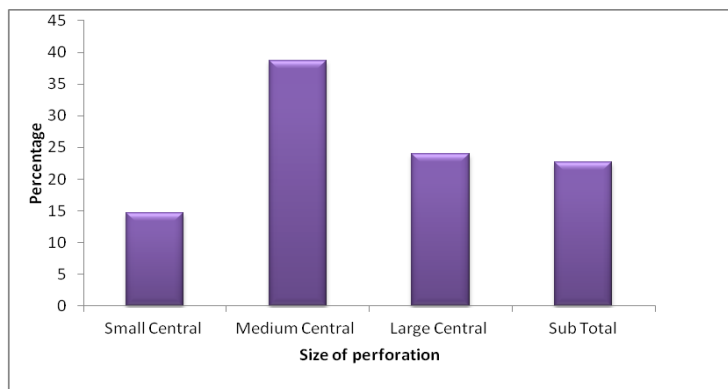


Figure 5 Distribution of patients according to site of perforation

In our study anterior perforation (40%) has maximum presentation followed by subtotal (38.7%) and posterior perforation (21.3%) after taking into account the maximum involved quadrant of the tympanic membrane.

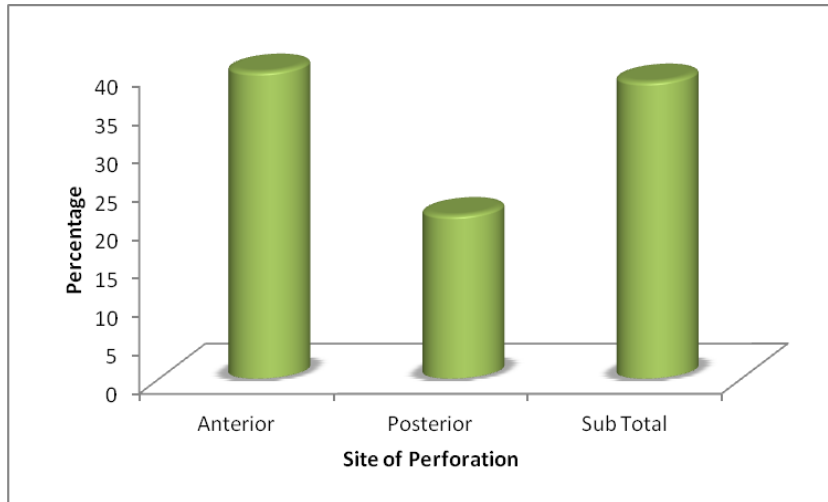


Figure 6 Correlation of Eustachian tube function with the site of perforation

In our study normal Eustachian tubal function was observed in 53 patients (of which 22 had anterior quadrant, 11 had posterior quadrant and 20 subtotal perforation), while partial dysfunction was seen in 20 patients (8 with anterior quadrant, 4 with posterior quadrant and 8 with subtotal perforation) and 2 with gross dysfunction (involving subtotal and posterior quadrant one each). On applying Chi Square test and finding p value it was found p value >0.01 and hence the results are statistically insignificant.

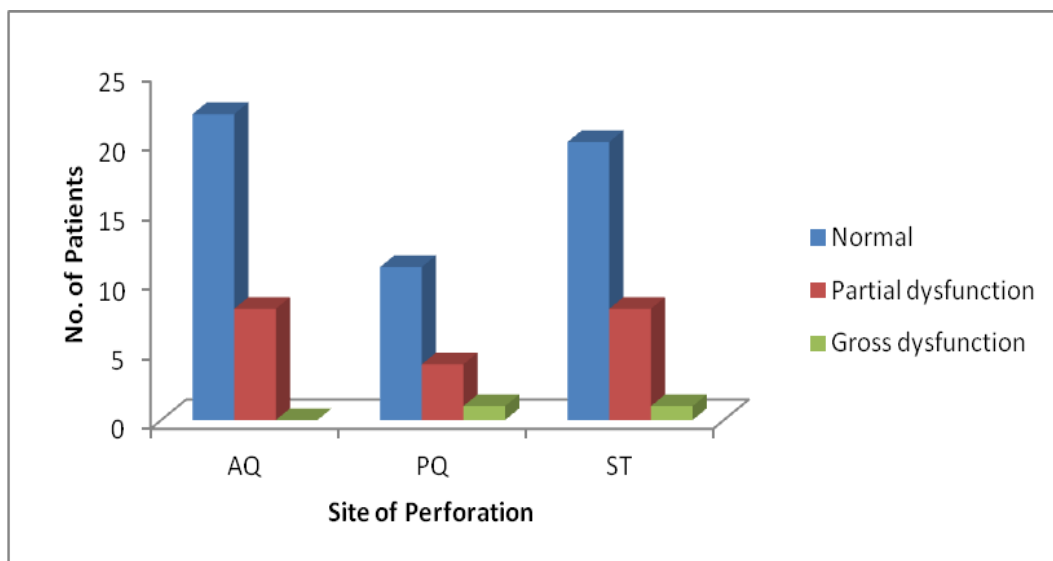


Figure 7 Graft take up rate with regard to site of perforation

Take up rates were maximum in anterior perforations followed by posterior and subtotal perforation in our study of 75 patients. In our study there was no statistical significance between Graft take up and site of perforation($p>0.05$)

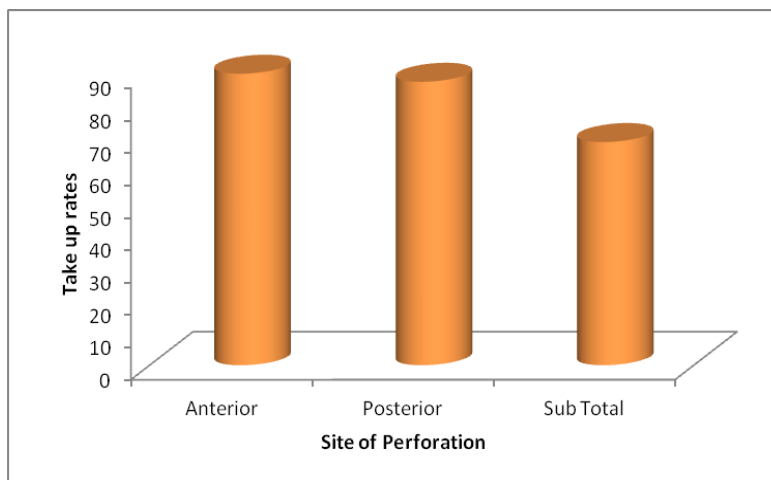


Figure 8 Eustachian tube function in the study group(Dye Test)

In our study 53 patients(70.7%) had normal eustachian tubal function followed by 20 patients (26.7%) with partial dysfunction and 2 patients (2.6%) with gross dysfunction. Statistical analysis by t- test using two independent means and p value ($p<0.00001$) showed the results are statistically significant.

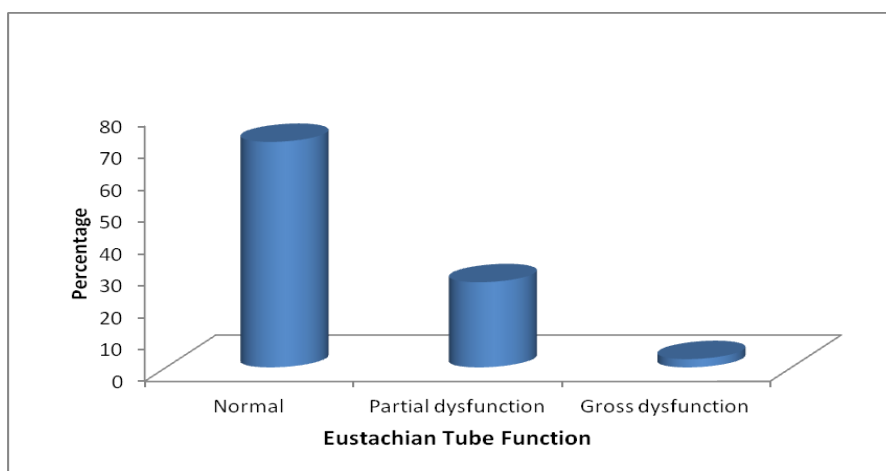


Figure 9 Correlation of Eustachian tube function with outcome of surgery

In our study the graft take up rate was found to be 88.7% in patients with normal Eustachian tubal function and 70% in patients with Partial dysfunction. 2 patients with gross dysfunction showed failure of graft uptake. Statistical analysis by applying Chi-Square test and p value were found to be 12.29 and 0.02 respectively which shows that the results are statistically significant.

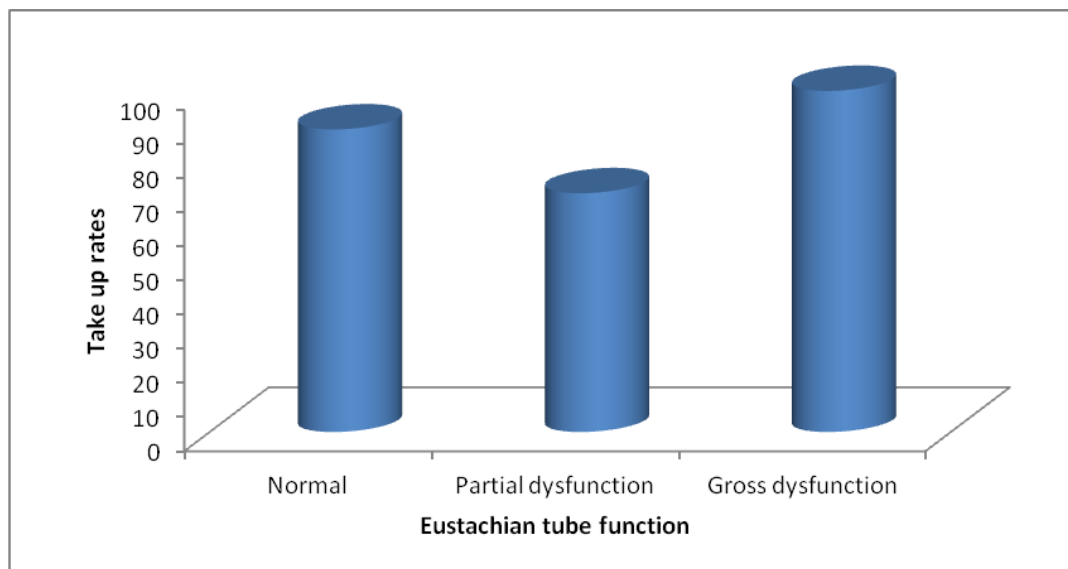


Figure 10 Correlation of Eustachian tube function with smoking

In our study of 75 patients, 15 patients were found to be smokers and 60 of them were non smokers.

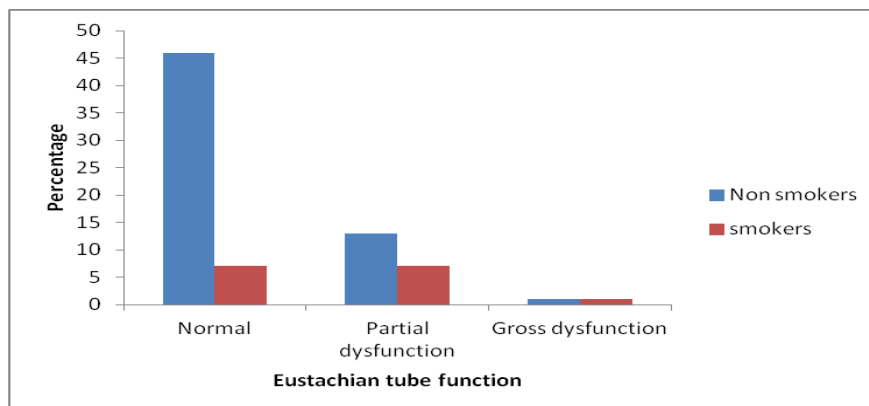


Figure 11 Distribution of patients according to side of perforation

Out Of the 75 patients 38 were presented with right side perforation (50%) and 36 with left ear perforation (48%) and one patient with B/L perforation.

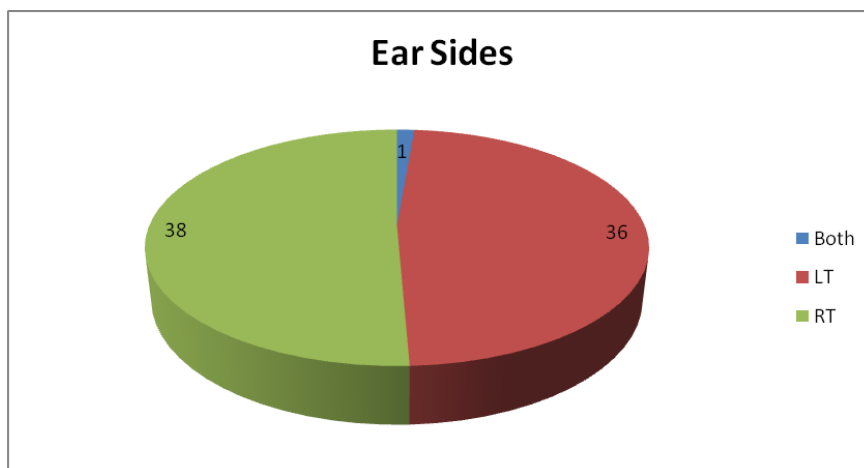


Figure 12 Correlation of Nasal allergy and Eustachian tubal function

In our study 22.7% patients (17) had history of nasal allergy.

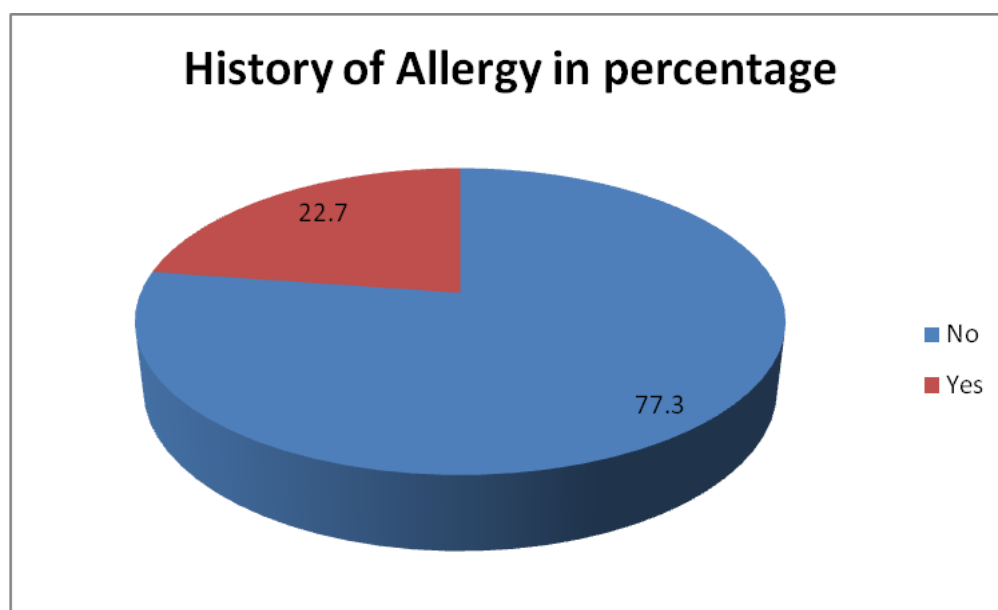


Figure 13 Percentage distribution of Middle ear mucosal status

Out of 75 patients, 36 patients (48%) had dry middle ear mucosa while 24 patients (32%) had moist middle ear mucosa and 15 patients (20%) had polypoidal middle ear mucosa.

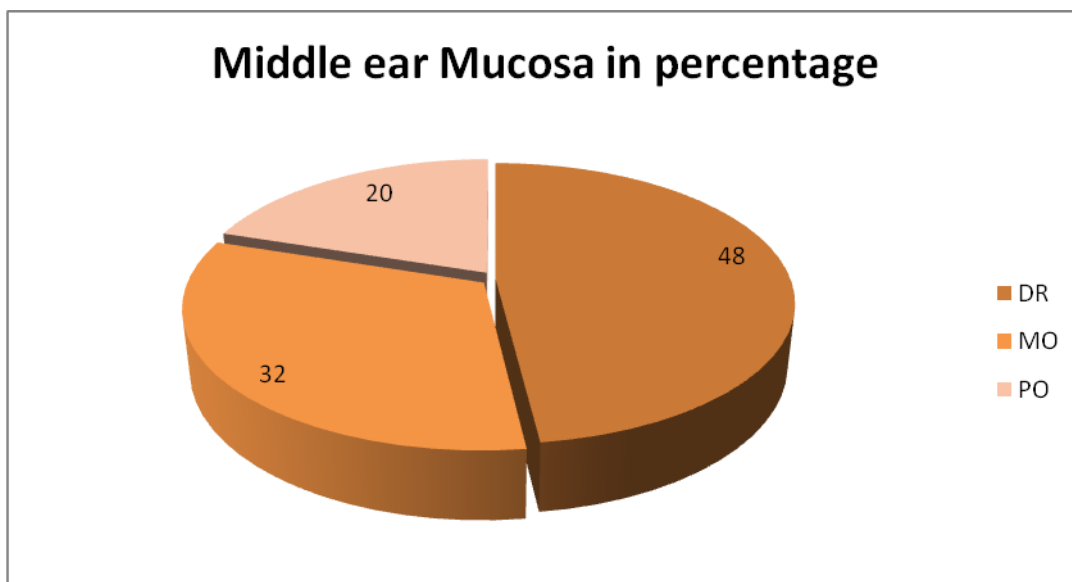
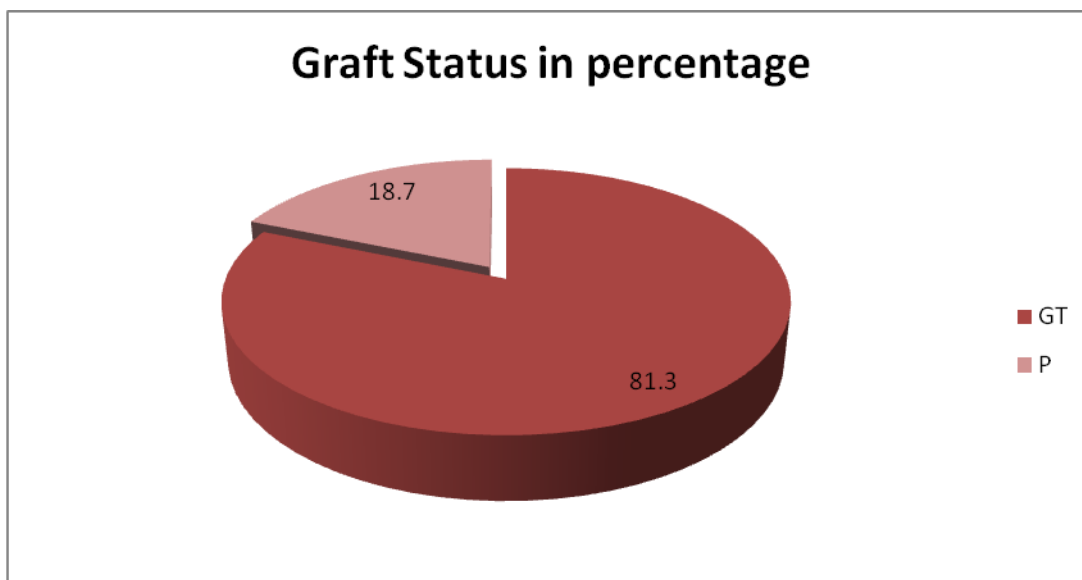


Figure 10 Percentage distribution of graft uptake status

In our study the graft take up rate was found to be 81.3% and 18.7% had failure of graft up take. Statistical analysis using Yates Chi-square and Yates p value were found to be 6.639 and 0.036 which were statistically significant.



A functioning Eustachian tube is an integral part of normal middle ear and is thus an essential requirement for optimum results in tympano- mastoid surgeries[1,75]. A preoperative test of tubal function therefore is of great interest, especially if such a test provides a possibility of estimating the chances of achieving a satisfactory result of Tympanoplasty.

Earlier technique of Politzeration studies which mainly assess Eustachian tubal function is insensitive and difficult to quantitate [37]. Flisberg et al [29] in 1963 worked out quantitative methods for measuring preoperative tubal function in patients with tympanic membrane

perforation. These methods have subsequently been used by a number of authors [30-35]. These tests were based upon the capability of the Eustachian tube to equilibrate and induce negative or positive pressure in the middle ear by means of deglutition. However these methods do not evaluate the drainage function of Eustachian tube which may be impaired even though the tube is anatomically open.

Sade in 1966 studied the middle ear mucosa systemically in autopsy material and reported that clearance of the middle ear is an active process and clearly related to its ciliary activity. The significance of ciliary activity is underlined by the fact that Eustachian tube leaves the tympanic cavity superiorly sloping downwards in the direction of the nasopharynx. He demonstrated a physiological escalator in the middle ear comprising a mucous blanket which is carried by cilia. Foreign materials introduced into the middle ear are evacuated through Eustachian tube to the nasopharynx within minutes at a speed which correspond the known capability of cilia. The cilia are normally found embedded in a mucous layer of the middle ear, on the inner layer of tympanic membrane and in parts of the Eustachian tube. It is logical to assume that in disease states such as otitis media, the cilia help partly in evacuating the fluid that accumulates in the middle ear. In certain pathological conditions of the middle ear especially when its secretory activity is increased, decrease in the number of cilia bearing cells occurs. Hence, measurement of the time required for ciliary transport would help to estimate pathological changes in the mucous membrane [32]. Sade in 1967 reported qualitative studies on the mucociliary function of the Eustachian tube. He disclosed the mucous pathways from the middle ear cavity to the Eustachian tube by using visible foreign charcoal particles, glass beads and dried black ink. Since then middle ear mucosa has been accepted to be active part of the upper respiratory mucosa.

Several studies have evaluated Eustachian Tubal function by using saccharin. The saccharin test seems to provide adequate information of the mucociliary function and patency of the Eustachian tube. This test is considered a valuable supplement to other existing tests for tubal function.

Methods Used to Assess Mucociliary Clearance Function of the Middle Ear Eustachian tube System in Humans and Animals Gimenez et al studied the mucociliary function of the Eustachian tube using 5 percent sodium saccharinate in 58 ears with dry central perforation of the tympanic membrane. According to the Saccharin Perception Time, they classified patients into three groups: group 1, normal function; time less than 20 minutes; group 2, partial dysfunction; time 20 to 90 minutes; group 3, gross dysfunction; time more than 90 minutes. Srivastav et al [22] reported mucociliary function of the ET by mean of the saccharin test using a Sweetex tablet; they divided patients into two groups: 1) Saccharin Perception Time 45 minutes, which indicates a patent Eustachian tube; 2) Saccharin Perception Time 45 minutes, which indicates a blocked Eustachian tube.

Dye studies to evaluate mucociliary function of Eustachian tube in dry perforation are few in numbers. Rogers et al, used fluorescent dye and found that dye when injected in middle ear can reach nasopharynx in ten minutes or less. Elbrond et al suggested that the dye, owing to its liquid form, gravitates through the Eustachian tube to the nasopharynx rather than being actively transported. So the principal objective of the dye is to establish the anatomical presence or absence of tube patency. The disadvantage of the dye test is that it requires an endoscope. Both tests described here also have the additional difficulty of keeping the patient in a given position during the tests.

Megerian suggested the idea of evaluation of tubal function using instilled otologic drops into ear canal and found may be helpful in older child and adolescent patients. According to Manning et al⁷³, patients under 20 years of age are to be under risk for tympanoplasty as tubal function as tubal function matures to adult by 20 years.

Methylene blue dye testing to assess the mucociliary function of Eustachian tube has been adopted by various authors in their studies[1, 16, 25,27]henceinourstudyweattemptedtoevaluateEustachiantubal function by Methylene blue. Addition of rigid endoscope while performing the dye test improves the accuracy of instillation of Methylene blue dye into the middle ear and hence more accurate chances of detecting the mucociliary activity of the Eustachian tube⁽⁸⁷⁾.

In our study the age of patients ranged from 15years to 45 years and majority of them were found to be in age group of 21-30years (42.7%). The Mean age was of 29.49 years and median age found to be 31years in our study group. Among the 5 patients in younger age group(less than 20yrs) 4 patients were with normal Eustachian tubal function and one with partial dysfunction and none with gross dysfunction. Three patients in the normal group had success rate while one success in the other group. Since the study sample for this age group is small the conclusion could not be arrived in present study. Larger sample studies are needed to comment on the use of this evaluation technique in younger agegroup.

In the case of normal Methylene blue clearance time in our study the mean time was found to be 7.66 minutes with Standard Deviation 1.47 while the mean of partial and gross dysfunction was found to be 13.09 minutes with Standard Deviation of 2.53. The overall mean was found to be 9.25 minutes which was well in accordance with otherstudied. Attempts have been made to correlate the state of the mucociliary transport system with the results of reconstructive surgery of the middle ear.

<i>Function of ET</i>	<i>Success rate</i>		
	Gimenz et al.	Pochbroto et al.	Our study
Normal	75%	80%	88.7%
Partial dysfunction	69%	66%	70%
Gross dysfunction	50%	46%	0.00%

Results of various studies

As shown in the above table our results were in accordance with other authors. Since we had only 2 cases of gross dysfunction we were not able to comment on the effect of gross tubal dysfunction on Tympanoplasty. Good Eustachian tubal function was shown to predict the outcome of Tympanoplasty which was consistent with other studies. But poor tubal function was not a helpful predictor in the outcome of Tympanoplasty.

In our study the graft take up rate was found to be 88.7% in patients with normal Eustachian tubal function and 70% in patients with Partial dysfunction. 2 patients with gross dysfunction showed failure of graft uptake. Statistical analysis by applying Chi-Square test and p value were found to be 12.29 and 0.02 respectively which shows that the results are statistically significant. In our

study the graft take up rate was found to be 81.3% and 18.7% had failure. Statistical analysis using Yates Chi-square and Yates p value were found to be 6.639 and 0.036 which were statistically significant.

Prasad KC et al¹ studies revealed use of Methylene blue dye as test for Eustachian tubal function is statistically significant and our study is in accordance with the same with statistical p value of 0.0024.

Takahashi et al[23], also reported normal Eustachian tube clearance to be within 10minutes. Das et al in their study found average Methylene blue clearance time of 7.62minutes. In our study 71% of them had clearance time less than 10minutes which is considered as normal tubal function and application of t test of statistical significance gave result of $p < 0.0001$ showing the results are significant.

In our study the correlation between nasal allergy and the Eustachian tubal function was statistically analyzed using a T test which showed a p value > 0.05 thus proving to be statistically insignificant. So association between nasal allergy and Eustachian tubal function was not clearly established in our study. Our study results are in accordance with Wilson et al⁸⁴ which showed innumerable children with nasal allergies but they have complete freedom from middle ear disease in adulthood. Also, Allergic Rhinitis more commonly develops before the age 20 years [29-31].

Chronic suppurative otitis media is a condition with different possible etiologies. Using a prospective design we could not show a significant difference in the prevalence of Allergic Rhinitis in the affected adults. Although there is a higher rate of Allergic Rhinitis among Chronic Suppurative Otitis Media, the difference was not statistically significant. One of the differences of our study was the case group; our cases were adults whereas the previous studies [32-35] selected children. We know most of the Chronic Suppurative Otitis Media initiate during childhood (when Allergic Rhinitis is more prevalent than adulthood [36-37], but it may present years later in the adulthood; therefore, in our survey there might be some recall bias during history taking for Allergic Rhinitis. It is to note that indoor allergens were more prevalent in the Chronic Suppurative Otitis Media cases although it did not affect our results; it could be concluded that long-term exposure to such allergens might have a role in the development of this condition. In our study since we had only few (5) patients less than 20years of age relationship can't be statistically proven.

The relationship between time of transport and site of perforation was studied by Gimenez et al. They found muco ciliary function to be best in ears with anterior perforations. The function was worst among posterior perforations and subtotal perforations showed intermediate results. Prasad KC et al in their study found Posterior and subtotal perforations had a higher relationship with partial or gross Eustachian tube dysfunction than anterior perforations. Valles et al in their study found results in contrast to the above one. Their best results corresponded to posterior perforations where as worst cases were subtotal perforations. They also observed no important differences between the sites of perforation. Our study results were very similar to Valles et al showing no relationship between site of perforation and appearance of dye. The relationship between the site of perforation and appearance of the dye at nasopharyngeal end was statistically analyzed by T test and the p value ($p > 0.01$) which is statistically insignificant. Thus the varying topography of the perforation didn't influence the integrity of the muco ciliary system, or else the better or the worse condition of the latter would not influence the appearance of the dye in one type of perforation or the other.

Take up rates were maximum in anterior perforations followed by posterior and subtotal perforation in our study of 75 patients. It was also found, perforations which were involving all quadrants are having maximum residual perforations after the surgery. In our study there was no statistical significance between Graft take up and site of perforation ($p>0.05$). Various studies have shown that site of perforation does have relevance with graft take up [37,38].

The influence of socio economic status in graft take up has not been studied in detail. In our study, there was a 72% success rate in the higher socio economic group compared to a 67% in the lower socio economic group. It has been proven that socio economic factors such as poor living conditions, overcrowding, poor hygiene and poor nutrition are predisposing factors for Chronic Suppurative Otitis Media. In our series the same factors may have been responsible for higher failure rate in the lower socio economic group.

On analyzing the correlation between smoking and Eustachian tubal function by T test in our study. The statistical significance was $p>0.05$ thus proving that smoking is not a significant factor for Eustachian tubal dysfunction in our study. These results were similar to Bakshae et al [39].

4. Conclusion

The dye instillation test is a simple method, easy to perform, cost effective and useful diagnostic tool to assess the mucociliary clearance function of the Eustachian tube. The existence of normal mucociliary clearance of Eustachian tube is a favorable prognostic factor in the outcome of reconstructive surgery in the middle ear. But poor tubal function is not a helpful predictor in the outcome of middle ear surgery. Mucociliary function of the Eustachian tube is not affected by nasal allergy. The mucociliary function of the Eustachian tube does not have impact on site of perforation in chronic suppurative otitis media of tubo tympanic type. The surgical outcome in case of chronic suppurative otitis media tubo tympanic type is not affected by the site of perforation.

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Ethical approval: The study was approved by the Institutional Ethics Committee

Conflict Of Interest

The authors declare no conflict of interest.

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