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RESEARCH ARTICLE

THE STUDY OF EUSTACHIAN TUBE FUNCTION IN SAFE OTITIS MEDIA

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ABSTRACT

Introduction: Eustachian tube maintains equilibrium between middle ear and atmosphere, protects against nasopharyngeal pressure variations, ascending secretions and microorganisms. Patent and functioning Eustachian tube is the foremost requirement for success of tympanoplasty. The reason behind graftfailure is abnormal function of Eustachian tube, which is the main pathology behind chronic suppurative otitis media.

Objectives: The Eustachian tube patency is assessed here with various tubal function tests in all cases of safe otitis media.

Materials and Methods: A random sample of 100 patients were screened and tubal function of each of them was assessed through simple, reliable and cost effective and those which can be daily applicable Eustachian tube function tests,and each test was compared with the other individually and results were drawn accordingly.

Results: Among all 100 patients assessed, impression drawn were in terms of success rates : On Valsalva- 84%, Siegalisation- 86%, Ear drops- 87%, Nasopharyngoscopy- 80%, Tympanometry- in 75% pressure could not be built up and rest 25% were subjected to Toynbee's test, of which 64% showed "step-ladder" graph and 36% showed "flat" graph.

Conclusions: Of all the tests mentioned above that mainly comment on patency of the Eustachian tube, Toynbee's maneuveris the only test which tells about function of Eustachian tube, opening and closing mechanism for equalisation of middle ear pressure.

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INTRODUCTION

Eustachian tube is a complex organ that forms a vital bridge between middle ear and nasopharynx and has the following 3 vital functions that is ventilatory, protective and mucociliary function. Multifactorial causes that can lead to abnormal Eustachian tube function as a result of middle ear infections are sinus and upper respiratory tract infections, nasopharyngeal mass. Otitis media is one of the most commonotological conditions encountered in our Otorhinolaryngology practice and abnormal Eustachian tube function being the prime etiology. Though there are many factors that influence graft uptake rate, a good preoperative tubal function is one of the prerequisite for high rate of success rates in terms of graft uptake following tympanoplasty. With the aid of many diagnostic procedures, it has now become easy, cost effective, consistent and convenient to find the cause behind graft failure. Hence, this topic was chosen for study and the prime objectives are-to assess patency of Eustachian tube in cases of safe otitis media, to analyse utility of different methods used to assess tube patency and to find out accurate method of assessing Eustachian tube function. Various studies have inferred their own pros and consregarding this topic chosen for the study. Though majority of the studies as mentioned in detail below have opted in for Tympanometry as their choice for Eustachian tube function assessment, while Valsalva comes second in the row; but only one single study in literature has commented on Toynbee maneuver as the diagnostic test of choice for assessment of Eustachian tube function which is having resemblance to this study in terms of results arrived. Hence, due to rarity of literature available in this context, this age old, very basic Following confirmation of thtopic was considered apt for the study.

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MATERIALS AND METHODS

A cross sectional study was conducted among randomly selected 100 patients who were screened on outpatient basis with discharging ear and decreased hearing. Following confirmation of the ear disease, tests were conducted on

them – Valsalva test, Siegalisation, Ear drops test, Nasopharyngoscopy, Tympanometry with Toynbee maneuver. The criteria included in the study were of all age groups including children. Patients with enlarged adenoids, cleft palate and nasopharyngeal mass were come across. Also patients complaining of repeated and recurrent episodes of sinus and upper respiratory tract infections- allergic rhinitis, chronic sinusitis were considered. All cases of mucosal chronic suppurative otitis media with discharge were treated conservatively. The criteria excluded in the study were all traumatic, postoperative cases and atticoantral diseases.

Procedures

Valsalva maneuver: Mouth is closed tightly with nose pinched and air is blown out forcibly and air leak appreciation is confirmed.

Pneumatic otoscopy/Siegalisation: The speculum is connected to the side tube which is attached to a rubber bulb. The rubber bulb is passed and released to alter the pressure in the ear canal. The system is then made air-tight by making the speculum snugly fit into the ear canal. The pathology of the ear is then examined by pressing the rubber bulb. A magnified view of the tympanic membrane as well as the pathology and the mobility of tympanic membrane are assessed.

Ear drops test: In cases with perforated tympanic membrane, on topical use of ear drops whether or not bitter sensation is felt in the throat is evaluated.

Tympanometry: All the patients were subjected to Tympanometry. The patients, in whom the middle ear pressure was built up, were subjected to Toynbee's test.

Toynbee test: The subject is asked to swallow when the nose is pinched. If the Eustachian tube opens during the test, the middle-ear pressure changes is determined by the timing of the tubal opening and the nasopharyngeal pressure gradient and is documented by means of graphical representation.

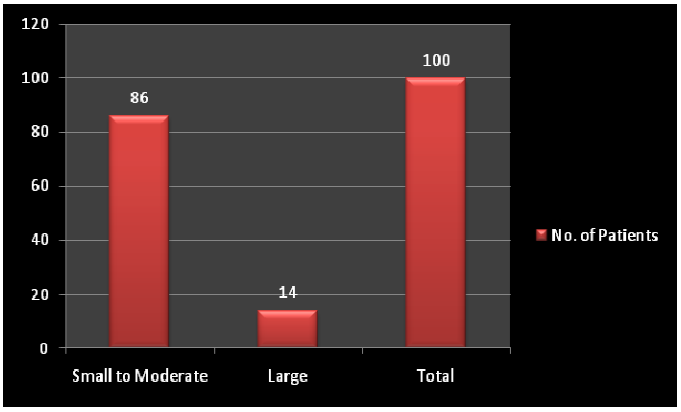
Nasopharyngoscopy: Nasopharyngoscopy is done keeping the patient nil by mouth for 3 hours. Nose is sprayed with 10% lignocaine spray and then packed with cotton patties saturated with 4% lignocaine solution. Patient is made to sit in an upright position with head supported. Cotton patties are removed and the scope is passed through from a roomy nasal cavity and made stationary into the nasopharynx. The patient is asked to swallow and Valsalva maneuver is done and then the opening of the Eustachian tube is visualized and also other pathologies in surrounding area are noted.

RESULTS

Among 100 patients, 52 were male and the rest 48 were female. Among them 7 were children and the rest were adults.

Table 1. Distribution based on size of perforation

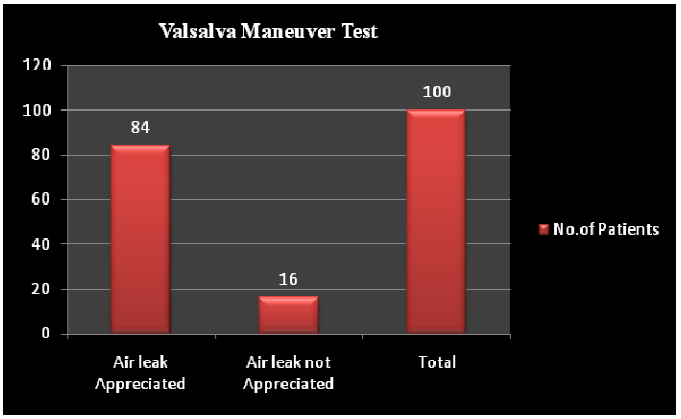
Size of Perforation	Number of Patients
Small to Moderate (SM)	86 (Y)
Large (L)	14 (N)
Total	100



Graph 1. The size of perforation among sample size varied from small to moderate in 86 and large perforation in 14 patients

Table 2. ValsalvaManeuver

Test	Observation	Number of Patients
Valsalva Maneuver	Air leak appreciated	84 (Y)
	Air leak not appreciated	16 (N)
	Total	100



Graph 2. Valsalva test when performed among 100 patients, in 84 patients air leak was appreciated indicating Eustachian tube is patent. In the remaining 16 patients air leak was not appreciated as the Eustachian tube was blocked at the time of the test

Table 3. Siegalisation test

Test	Observation	Number of Patients
Siegalisation	Tympanic membrane mobile	86 (Y)
	Tympanic membrane not mobile	14 (N)
	Total	100

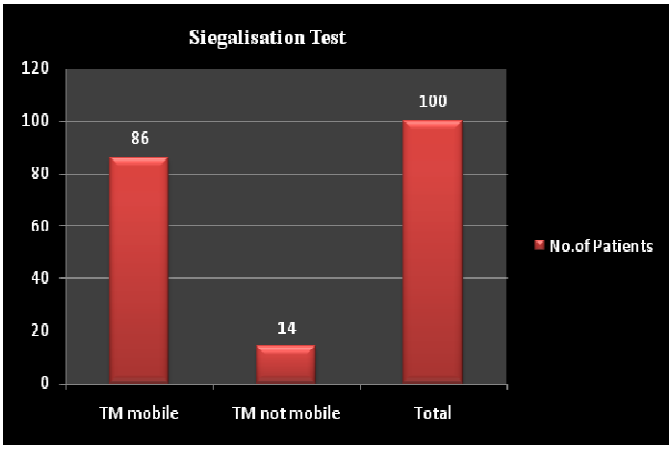
Table 4. Ear Drops Test

Test	Observation	Number of patients
Ear Drops Test	Drops felt in Throat	87 (Y)
	Drops not felt in Throat	13 (N)
	Total	100

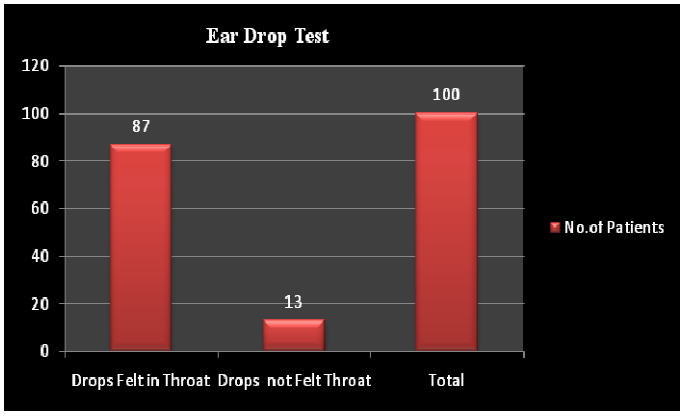
Table 5. Tympanometry

Table 5a.

Test	Observation	Number of Patients
Tympanometry	Pressure could not be built up	75 (Y)
	Pressure could be built up	25 (N)
	Total	**100**



Graph 3. Siegalisation test when performed in 100 patients, in 86 patients there was active mobility of the tympanic membrane as they have small to moderate sized perforation indicating good patency of the Eustachian tube. In 14 patients, tympanic membrane did not move with pneumatic otoscopy. This was either due to Eustachian tube blockage or inability to assess the tympanic membrane mobility due to large perforation. Actively mobile tympanic membrane suggests that Eustachian tube is patent



Graph 4. Ear drops test when performed in 11 patients, following instillation of ear drops, 87 patients felt the bitter sensation in the throat, within few minutes indicating patent Eustachian tube. The remaining 13 patients did not feel the presence of drops in the throat due to the blockage in the Eustachian tube

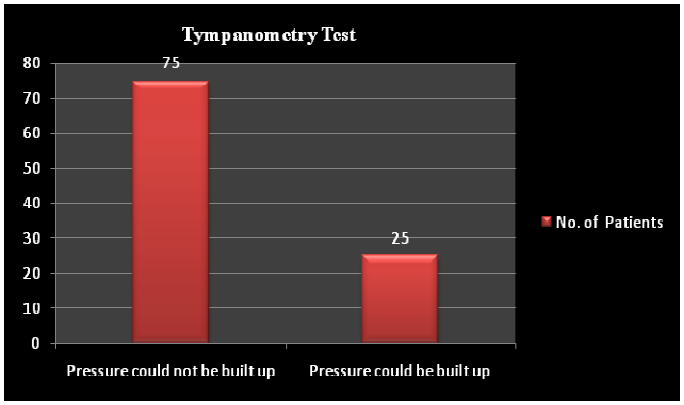
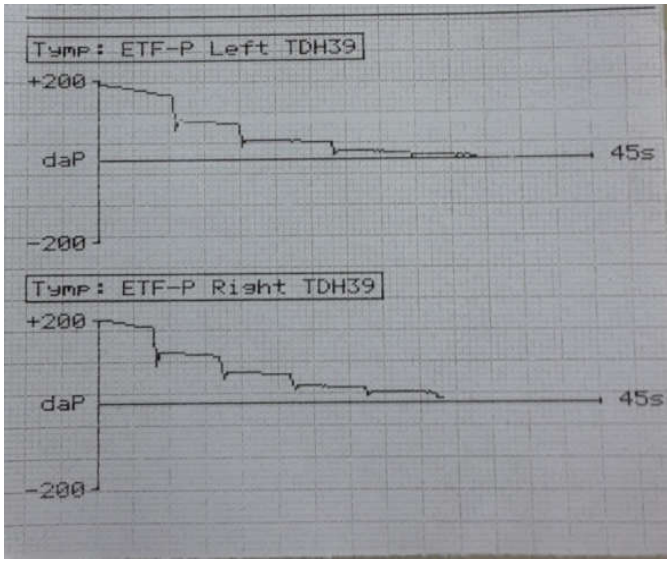
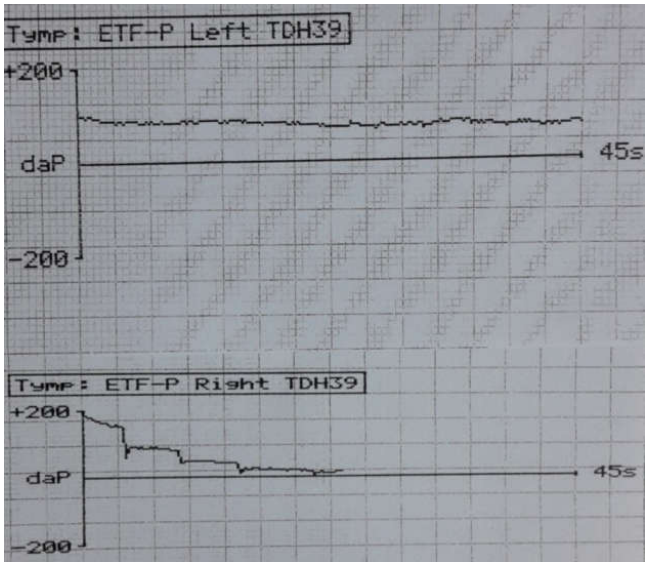


Table 5b.

Test	Observation	Number of patients
Toynbee test	Step ladder pattern present	16 (Y)
	No step ladder pattern	09 (N)
	Total	25



Graph A:

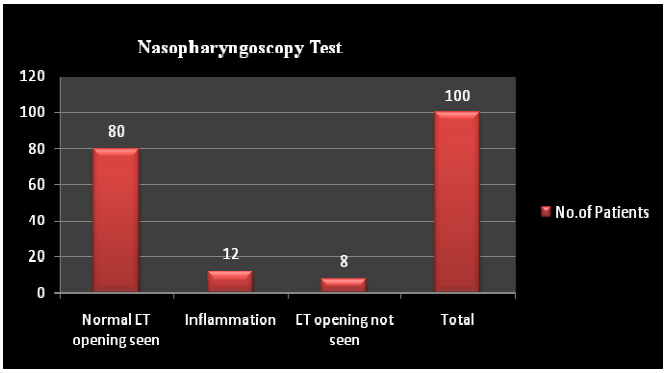


Graph B:

When all 100 patients were subjected to tympanometry test (Table 7a). In 75 patients, pressure could not be built up hence suggesting patent Eustachian tube. But pressure was built up in the rest 25 patients suggesting blocked Eustachian tube. So, Toynbee's test (Table 7b) was done on these 25 patients and among them 16 patients showed "step-ladder" type of graph (Graph A) suggesting normal Eustachian tube function. While the rest 9 showed a "flat" graph (Graph B) indicating temporary Eustachian tube block due to allergic rhinitis (1 case), enlarged adenoids (5 cases), cleft palate (2 cases), nasopharyngeal mass (1 case).

Table 6. Nasopharyngoscopy

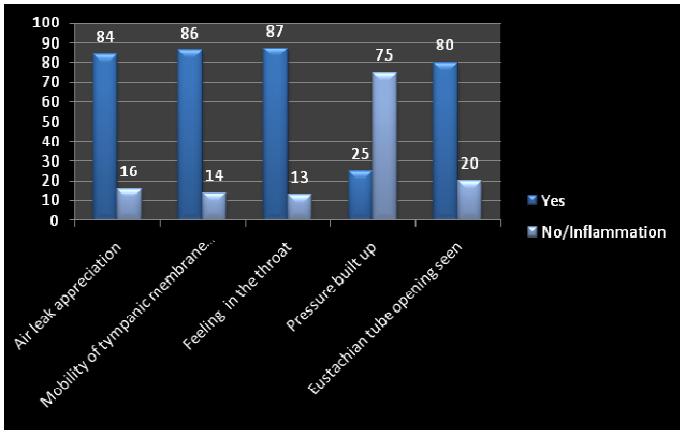
Test	Observation	Number of Patients
Nasopharyngoscopy	Normal Eustachian tube opening seen	80 (Y)
	Inflammation	12 (I)
	Eustachian tube opening not seen	08 (N)
	Total	100



Graph 6. While performing the test, 30^0 angulated scope is graduated up to the nasopharyngeal end of the Eustachian tube to visualize its opening and when the patient was asked to swallow, active opening of the tube was noted in 80 patients, indicating good Eustachian tube function. While in 12 patients due to allergic rhinitis and chronic sinusitis, inflammation was seen around the Eustachian tube opening. In the remaining 8 cases with enlarged adenoids, cleft palate, soft tissue mass in the nasopharynx, obstruction was noted at the nasopharyngeal end of the tube indicating poor Eustachian tube function

Table 7. Tests performed on 100 patients

Test	Observation	Number of patients	
		Yes	No/Inflammation
ValsalvaManouvre	Air leak appreciation	84	16
Siegalisation	Mobility of tympanic membrane visualisation	86	14
Ear Drop Test	Feeling in the throat	87	13
Tympanometry	Pressure built up	25	75
Nasopharyngoscopy	Eustachian tube opening	80	20



Graph 7. Results of all the tests together depicted in the graph

DISCUSSION

According to the study by Yusuf *et al*. in 2011, he has said that, Valsalva maneuver is the technique for middle ear pressure equalization and is considered highly sensitive and specific test. It also indicates patency of the Eustachian tube. In the study done by Ding *et al*. in 1998, Valsalva maneuver is easy and convenient test and does not need expensive instrument. It evaluates Eustachian tube function in accuracy, which is fit for basic level hospital. In 2000 Bunne *et al*. has mentioned in his study that, Valsalva maneuver's efficiency when performed single for assessment of Eustachian tube opening and closing functions is of less prognostic value and yields good success rates when it is combined with Toynbee maneuver, as it shares a common physiological basis. As per Dhingra, failure of the test does not prove blockage of the tube because in only about 65%, subjects can successfully perform this test. According to study by Uzun *et al*. in 2004, Valsalva maneuver always gives good results when performed both preoperatively and postoperatively in cases of otitis media following surgery in order to assess tubal function irrespective of the graft material used and surgery performed. Pre-operatively, results of this test on assessment of tubal function were 30%. According to the study by Yusuf *et al*. in 2011, Valsalva maneuver is highly sensitive and specific for the middle ear pressure equalization. Doyle *et al*. conducted the study in 2013, Valsalva maneuver is the best reliable tool among all tests for Eustachian tube function to evaluate qualitatively and quantitatively the pressure opening and closing functions of the Eustachian tube. As per Doyle in another study has said that, in cleft palate children ability to alter middle ear pressure is deranged. As a result they have high prevalence of developing middle ear disease. So, one of the reasons for functional obstruction of the Eustachian tube is this anatomical abnormality. As cases of mucosal chronic otitis media are more common in our set up, we clinically evaluated all 100 patients with perforated tympanic membrane to look for tubal patency by Valsalva test. In this study, 84 % showed good results in terms of air leak appreciation. The results as per the study were better compared to the study done by Uzun *et al*. Even in the study there were two cases of cleft palate which correlates with the study as quoted by Doyle *et al*. Marshall *et al*. conducted a study in 1984, otitis media and otitis media with effusion are common disorders of childhood. Tube dysfunction plays an important role in otitis media. Pneumatic otoscopy is used to evaluate tubal function in cases with otitis media.

Based on the study conducted by Bluestone *et al*. in 1974, a normal appearance of tympanic membrane is not necessarily indicating a normally functioning tube but normal tympanic membrane mobility on Siegalization indicates good patency of the Eustachian tube. Any middle-ear disease, presence of high negative middle- ear pressure, or both determined by a pneumatic otoscope gives presumptive evidence of the Eustachian tube dysfunction. In the study, 86% showed movement of tympanic membrane with small to moderate perforation indicating good tubal patency. In the remaining, who had large central perforation, mobility of tympanic membrane could not be assessed. According to studies conducted by Prasad *et al*. 2009, Nishant *et al*. 2012 and Shreyas *et al* (2012), ear drops test is done to look for patency of the Eustachian tube. It is one of the simplest, cost effective and valuable diagnostic tool to assess the mucociliary function of the tube and hence assess the tubal patency. When ear drop test was conducted among 100 patients, 84 patients could feel the bitter sensation in the throat as they were having dry ear, 3 patients had a delayed response and the rest could not feel the drops in the throat. As in these 84 patients, the travel of the drop was fast and the rest either had blocked tube or could not make out the response or had a delayed response. Depending on the condition of the middle ear mucosa, patients with dry ear felt the bitter sensation in the throat comparatively earlier

than in those with wet ear. While compared to the study done by Shreyas *et al*. 87.5%, patients had good Eustachian tube function with dry ear which very well matches with this study. Virton *et al*. in his study in 1982 has mentioned that, this test is used to assess Eustachian tube function. A good tubal function is when middle ear pressure is between 0 to -250mm H2O as majority of the tubes open during swallow, but a reduced tubal opening is noted as middle ear pressure decreased from 0 to -200mm H2O and this fluctuation of negative middle ear pressure is evaluated accurately by tympanometry. Shift in the peak pressure point in tympanogram between + /- 200 mm to +/- 400 mm H2O indicates relative efficiency of measurement of the Eustachian tube function by tympanometry and implies that Eustachian tube opens and equalizes middle ear air pressure. According to the study by Bylander *et al*. in 1983, impedance audiometry is a reliable tool to evaluate qualitatively and quantitatively the pressure opening and closing functions of the Eustachian tube. Based on the study conducted by Takahashi *et al*. in 1991, the tube function was analysed by tympanometry and in the case of dysfunction of the tube, altered tympanogram with overlapping pressure peaks are obtained and this indicates that ineffectively operating tube shows changes in the middle ear pressure suggesting that the tube is temporarily or permanently blocked.

In the study conducted by Lazo *et al*. in 2005 he has mentioned that, tympanometry is readily available procedure that may be useful in patients to prevent chronic middle-ear disease. As per the study done by Pelikan *et al*. in 2009, otitis media and otitis media with effusion are common disorders of childhood. Frequent relapses of middle ear infection is due to anatomic and craniofacial abnormalities, enlarged adenoids, previous episodes of acute otitis media, allergic rhinitis, chronic sinusitis, all these contribute to Eustachian tube dysfunction. Diagnostic evaluation by tympanometry has a pivotal role that has proved to be more efficient than other air equalisation methods in assessing the course and prognosis of otitis media and also to evaluate tubal function.

According to the study by Renata *et al*. in 2010, Tympanometry is based on acoustic immittance that measures positive and negative air pressure variations produced in the external acoustic meatus that leads to changes in physical properties in the middle ear and tympanic membrane. Immittance tests are also used to study ventilatory function of the Eustachian tube and hence this pressure equalization swallow test is accurate to assess the tube dysfunction. Shreyas *et al*. in his study in 2012 has mentioned that, a modern impedance audiometer offers facility to ascertain the physiological function of Eustachian tube not only in the intact tympanic membrane but also in the presence of perforation. Its advantages are that it is quick, non-invasive, patients compliance is not required, accurate and inexpensive and it offers the best means of assessing the Eustachian tube function. The results of the tympanometric assessment in their study were 80%. As per study done by Kanagamuthu *et al*. in 2013, the Eustachian tube function is related to duration, type and location of tympanic membrane perforation in chronic suppurative otitis media. Impedance audiometry is a simple, invasion-free method to evaluate the Eustachian tube function. There is a strong association between tube functions and graft uptake and is proven by Toynbee test whether the tube is patent or not. This suggests that Eustachian tube plays a major role in the success of tympanoplasty. When all 100 patients in the study, with perforated drum were subjected to tympanometry, in 75 patients pressure could not be built up indicating patent Eustachian tube. In the rest 25 patients, pressure was built up suggesting blocked Eustachian tube. So, Toynbee's test was done in 25 patients, and among them 16 patients showed, "step-ladder" type of graph suggesting normal Eustachian tube function while the rest 9 showed, a "flat" graph indicating temporary Eustachian tube block due to allergic rhinitis, cleft palate, enlarged adenoids and nasopharyngeal mass. Our study also shows good results (75%) which are almost similar to the study conducted by Shreyas *et al*.

According to the study by El-Guindy *et al*. in 1998, normal endoscopic results indicate good tubal function, while abnormal results indicate organic tubal obstruction which is correctable. Any inflammation around the tubal opening due to the presence of recurrent episodes of otitis media, upper respiratory infections, chronic and occult sinusitis, presence of hypertrophied adenoids and craniofacial deformity such as cleft palate and nasopharyngeal mass all that can make the opening of the tube blocked and non-visualisable. Hence, Nasopharyngoscope has been a diagnostic tool in these cases. In this study, 1 case of allergic rhinitis, 2 cases of cleft palate, 5cases of adenoid hypertrophy and 1 case of nasopharyngeal mass have ben come across. Based on the study conducted by Yuan *et al*. in 2007, morphological changes of pharyngeal ostium of the eustachian tube plays an important role in the genesis and development of otitis media. Hence, Nasopharyngoscope is a very useful tool in the diagnosis and treatment of otitis media. As per the study done by Skotnica *et al*. in 2007, Eustachian tube dysfunction plays an important role in the development, persistence and recurrence of otitis media with effusion and chronic otitis media. Evaluation of the type of obstruction in the cartilagenous portion of the tube is important for decision concerning methods for treatment and prognosis of surgical outcome. To identify the characteristics of the dynamic function of the pharyngeal orifice of the tube in children, transnasal endoscopic examination of the nasopharyngeal opening of the tube with Nasopharyngoscope is done.

As per the study conducted by Marseglia *et al*. in 2011, Nasopharyngoscope is an indispensable and diagnostic tool in localizing and treating the hidden lesions responsible for obstruction. In this study, similar results where noted. In 80 patients the tube opening was normal and visualised suggesting good Eustachian tube function. But in the remaining 20 patients, inflammatory changes were noted around the tube opening in 12 patients due to allergic rhinitis and chronic sinusitis. In the rest 8 patients, tubal opening was not visualised due to presence of enlarged adenoids, cleft palate and nasopharyngeal mass, indicating poor tube function. As per studies done by Gimenez *et al*. in 1993, Xiao *et al*. in 2006 and Nishant Kumar *et al*. in 2012, Eustachian tube function is related to duration, type and location of tympanic perforation in chronic suppurative otitis media. In this study, majority of them were having small perforation and mainly in antero-

inferior quadrant. Doyle *et al*. in his study in 1980 has concluded that, cleft palate has a high prevalence of chronic otitis media due to limited ability of the tensor velipalatini muscle to dilate the tube actively on swallowing, which is the cause for functional obstruction of the Eustachian tube. In this study, 2 children with cleft palate have come across.

Conclusion

Valsalva test provides accurate results in 84% patients. However it is still felt that, this test was biased to some extent and depends on patient's response. Siegalisation test provides correct status of the Eustachian tube in 86% patients having small to moderate perforation on tympanic membrane. This test does not hold good for cases with large central perforation because appreciation of the mobility of the tympanic membrane is difficult. Ear drops test yields good results and provides accurate status of the Eustachian tube function in 87% patients. Despite of good results, the duration of result varies depending on the size and site of the perforation on the tympanic membrane. Hence, delayed response is arrived at. Nasopharyngoscopy is an accurate, non-invasive test. In our study 80% patients, had normal tube opening while in the rest tubal opening was not visualized due to nasopharyngeal pathology and partially visualized due to inflammation. Tympanometry is a practical and easy test. In 75% patients, as patients were having perforated tympanic membrane, pressure could not be built indicating patency of the Eustachian tube. The remaining 25% patients were subjected to Toynbee test. Amongst them, Eustachian tube was patent and functioning in 64% of the patients showing a "step ladder" graph. A "flat type" of graph was noted in the remaining 36% patients with blocked tube at the time of the test. Thus, all 91% patients had a patent Eustachian tube.

All the above tests indicate patency of the Eustachian tube, while Toynbee test is the only test which gives idea of functioning of the Eustachian tube that is opening and closing mechanism for equalisation of pressure in middle ear. Among all the above mentioned tests, there were some or the other cons, but only Toynbee's test gave accurate and reliable results.Hence, Toynbee's maneuver was considered an ideal test of choice for assessment of Eustachian tube function. This test must be preferably preformed in all the patients who are wanting and willing for tympanoplasty in order to attain effective success results following surgery.

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PROFORMA

Name:
Age:
Sex:
Religion:
Ward:
OPD / IPD no:
Socioeconomic status:
DOA:
DOD:
Address:
Occupation:
Chief complaints:
History of presenting complaints:
Past history:
Family history:
Personal history:
General Examination:
Systemic Examination:
Local Examination:

Examination of Ear: Right Left

1.Pre-auricular region
2.Post-auricular region
3.Pinna
4.External auditory canal
5.Otoscopic examination of tympanic membrane

Tuning fork tests:

512Hz (Rinne's test, Weber's test, Absolute bone conduction test)
Otoneurological examination-
Facial nerve examination-
Examination of Eustachian tube patency:

1.By ear drops method-
2.Valsalvamanouver-
3.Siegalisation-
4.Nasopharyngoscopy-
5.Tympanometry-

Examination of Nose:

Examination of Throat:

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