Eustachian Tube Function test: a new dimension in the management of CSOM

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Abstract

Poor eustachian tube function is a major cause of both failure of tympanoplasty as well as the persistence of otorrhoea in chronic suppurative otiis media. In this study, Eustachian tube function tests were carried out on 631 ears of CSOM using an impedance audiometer and the results were analysed. The study showed that impaired tubal function is not only the major cause of persistent/recurrent otorrhoea in CSOM but is also an important contributory factor for failure of tympanoplasty: The results of tympanoplasty were found to be significantly poor when carried out in ears having poor tubal function as compared to ears with normal tubal function.

Key words :- *Eustachian tube function test, Toynbee's test. William's test, Impedance Audiometry, CSOM.*

Introduction

Dysfunction of the Eustachian tube plays a very important role in the pathogenesis of both suppurative and non-suppurative otitis media. The results of treatment, as well as the long term prognosis of both types of otitis media is dependent upon the proper functioning of the Eustachian tube. Adequate tubal function is a pre-requisite for the success of middle ear reconstructive surgery. Hence, assessment of Eustachian tube function is of paramount importance not only before embarking on any surgery for suppurative otitis media, but also for establishing its etiological basis. Unfortunately however, the assessment of Eustachian tube function has not been popularised as much as it warrants. The natural outcome of this has been poor success in spite of competent surgery in well-equipped microsurgical set-ups. Though there are some reports of over 90% success in middle ear reconstructive surgery in the published literature, this is not the general experience. The average results are usually in the range of 75-80%. Black, Hickey, & Wormald (1995) have reported graft take-up rate of 75.3% in a large study of myringoplasty in children. Foggia and McCabe (1990) of the University of Iowa have reported a take-rate of only 76% in a reasonably large study. Prof. A.F. John of Columbia University, New York has opined that there is a common factor inherent in all failures and if infection and poor surgical technique are ruled-out, it is poor eustachian tube function - which is the cause of most failures. Though many otologists routinely

carry out tests for anatomical patency of the Eustachian tube prior to surgery (either by passing a nylon thread or some dye into the middle

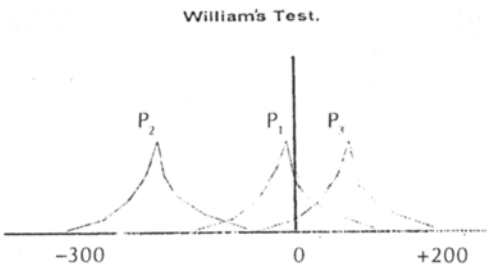


Fig. 1A - Diagramatic depiction of Willian'a test of eustachian tube function in subjects with intact tympanic membrane. 3 tympanograms are done to measure the middle ear pressure P1, P2, P3 (peak of the tympanograms) under 3 different conditions (see text). P1- ambient pressure, P2- pressure after swallowing P3- pressure after valsalva.

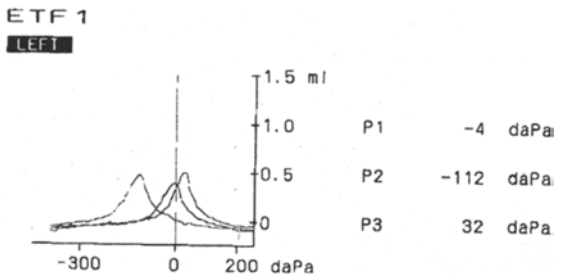


Fig. 1B- The William's test printout of an ear with normal ETF obtained from the AZ—26 impedance audiometer. The ambient middle ear pressure (P1) is 4daPa, the middle pressure after swallowing (P2) is —112daPa and the middle ear pressure after valsalva (P3) is+32daPa.

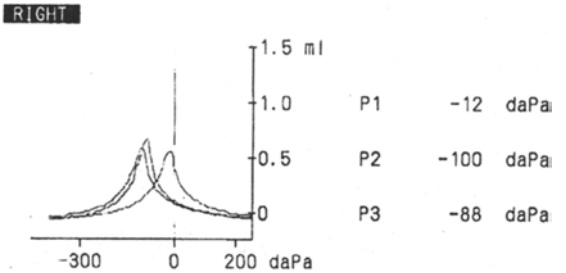


Fig. 2A - William's test printout in a patient with intact TM showing an ambient middle pressure (P1) of -12daPa which has become negative —100daPa on swallowing (P2) but has not become significantly positive - 88daPa on valsalva (P3). Partially impaired tubal function.

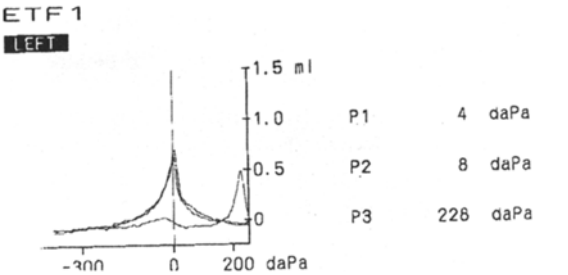


Fig. 2B-ETF test in a patient with intact TM in whom the William's test has shown a partially impaired tubal function. The ambient pressure (P1) of 4daPa has not become negative on swallowing (P2) but has become positive (P3) on valsalva.

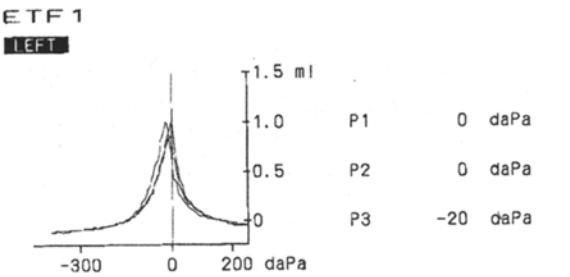


Fig. 2C - William's test printout of an ear showing grossly impaired tubal function.

ear), yet these tests do not serve the purpose for which they are undertaken. These techniques merely tell us whether the Eustachian tube is anatomically patent or not. The purpose of undertaking the Eustachian tube function tests is to assess its physiological profile. It is the physiologically functioning and not anatomical patency of the eustachian tube that is required for maintaining the normal function of the middle ear. The modern impedance audiometers offer us the facility of ascertaining the physiological function of the eustachian tube not only when the tympanic membrane is intact but also in presence of a perforation. Two types of Eustachian tube function tests are possible in these newer generation impedance audiometers viz. - William's test for patients having an intact ear-drum, and Toynbee's test for patients having a perforated ear-drum. In the William's test, the impedance audiometer is programmed to measure the middle ear pressure in 3 conditions viz. the middle ear pres-

sure at the start of the test (resting pressure), after the patient swallows (with the nose and mouth closed), and finally after performing valsalva. Normally, the ambient (i.e. resting) middle ear pressure should be at or near the environmental, i.e. atmospheric air pressure (i.e. approx. O mm of water pressure), the pressure should become negative on swallowing and positive on performing valsalva (Fig. 1A and 1B). Any deviation from this is considered abnormal. If the ambient middle ear pressure becomes negative on swallowing but does not become positive on valsalva or vice versa the function is considered to be partially impaired (Fig. 2A and 2B). If the middle ear pressure does not change at all either on swallowing or on valsalva, the eustachian tube function is considered grossly impaired (Fig. 2C). In the Toynbee's test (done in patients of perforated ear-drum), the impedance audiometer is programmed to artificially increase or decrease the air-pressure at the middle ear and then record the change of air pressure in the middle ear each time the patient swallows. The test is carried out for a fixed duration of time e.g.

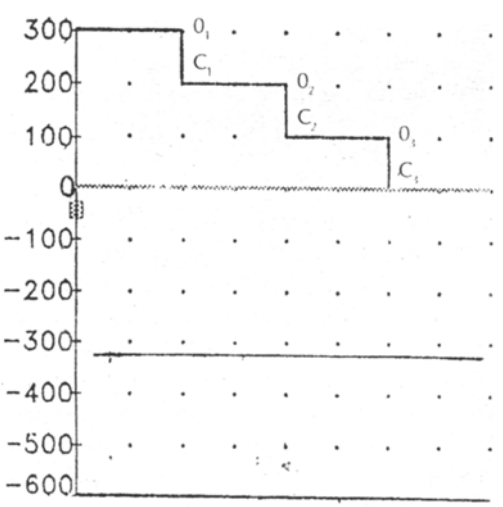
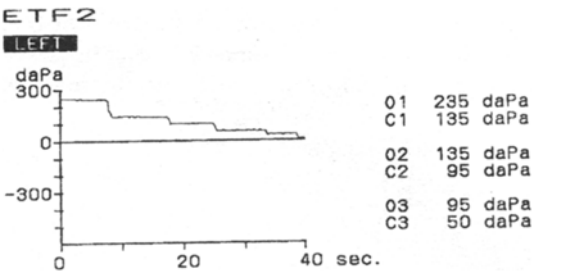


Fig. 3- Diagrammatic depiction of Toynbee's test of eustachian tube function in a subject with perforated tympanic membrane. O1/O2/O3 are the pressures at which the eustachian tube opened and C1 /C2/C3 are the pressures at which the eustachian tube closed.



Dig. 3A - Toynbee's test print-out in a patient of CSOM showing normal tubal function. The positive pressure of + 250daPa has been totally neutralised after swallowing 5 times.

40secs (min.) or 160secs (max). In Toynbee's test, the air pressure at the middle ear end of the Eustachian tube is first changed either to -250 or +250mm of water pressure (daPa) and the patient is then asked to swallow repeatedly to ascertain whether the positive or negative pressure is being partially neutralised with each swallow. The air pressure of the middle

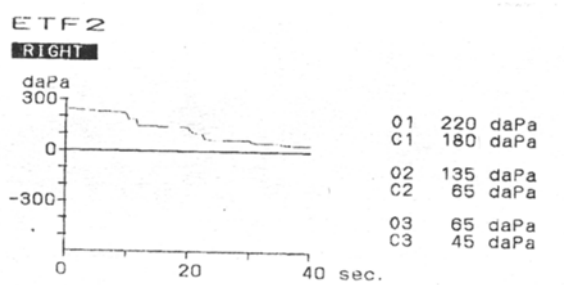


Fig. 4- Toynbee's test done on a patient of CSOM with slightly impaired tubal function. The positive pressure has not been totally neutralised even after swallowing several times. A residual pressure of 45 daPa is persisting.

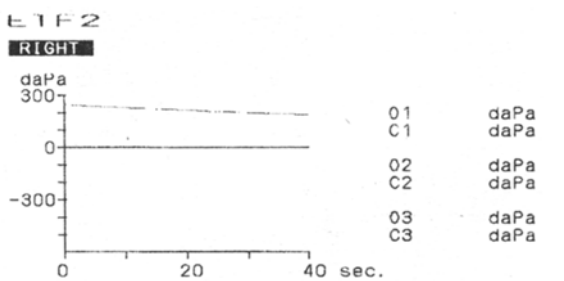


Fig. 5- Toynbee's test done on a patient of CSOM showing grossly impaired tubal function. In spite of swallowing several times over a duration of 40secs. the pressure has not been neutralised at all.

ear is monitored and recorded gràphically by the impedance audiometer. Any change of pressure during swallowing is recorded as a step-ladder type of graph (Fig. 3). Normally the positive or negative middle ear pressure should be partially neutralised with each swallow and in 3 or 4 swallows the pressure should totally neutralise, i.e. it should reach 0 mm of water pressure (OdaPa). Any deviation from this is considered abnormal. If some residual pressure persists even after 5 swallows, the tubal function is considered to be partially impaired (Fig. 4). If the positive or negative pressure built up by the impedance audiometer cannot be neutralised at all by repeated swallowing, then the Eustachian tube function is considered to be grossly impaired (Fig. 5).

Aims of the study

1) To assess tubal function in patients of safe type of CSOM and in patients of failed tympanoplasties.
2) To ascertain whether Eustachian tube function had any bearing upon the success or failure of tympanoplasty/myringoplasty.

Material and Methods

An impedance audiometer AZ-26 of Interacoustics (Denmark) was used to carry out the Toynbee's test and William's test on 487 patients (631 ears) over a period of 14 months (from April '97 to May '98). The author carried out the study in his private set up in Calcutta.

Break up of patients - (Fig. 6)

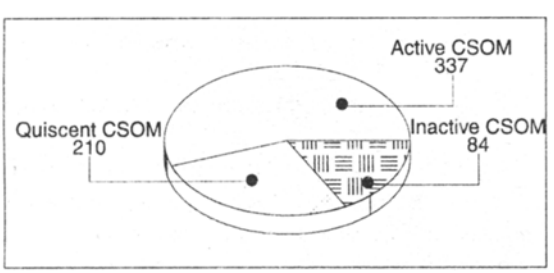


Fig. 6- Pie-chart showing breakup of patients.

The patients of CSOM - (total 631 ears) comprised of 337 ears with central perforation in active (i.e. discharging) stage of CSOM, 210 in quiescent stage and the rest 84 ears in inactive stage. In the ears in which active CSOM was present, the ear was first thoroughly cleaned, and then Toynbee's test was done. Of the 84 ears in the inactive stage, the test was not possible in 33 ears as the air pressure in the middle ear end of the Eustachian tube could not be built up in spite of having a perfect seal in the external meatus. This is because air continued to leak from the nasopharyngeal end of the tube when the pressure was being built-up. A similar phenomenon was observed in 23 of the 210 ears in the quiescent stage. This indicates that the tube is patent anatomically in those patients (since, otherwise the air would not have leaked from the nasopharyngeal end of the tube) but no idea of its physiological function is possible in these 33+23= 56 ears. 59 of these 631 ears of CSOM were failed tympanoplasties. Tympanoplasty/myringoplasty had been done on these ears by competent surgeons before this study was undertaken but the surgery had failed. The Toynbee's test was done in all these 337+187+51 =575 ears (Fig. 6). During the tenure of the study, 103 of these 574 ears had undergone myringoplasty / tympanoplasty by very competent and renowned surgeons in Calcutta. 62 of these 103 ears were available for post operative eustachian tube function assessment. William's test for assessment of tubal function was carried out in those patients in whom the surgery was successful (perfect take-up of graft) and Toynbee's test was carried out post-operatively in those ears in whom the graft did not take-up or a re-perforation had occurred. The findings of the Eustachian tube function tests for these different groups of patients (i.e. these on whom Toynbee's test was done and those on whom William's test was done) were classified into 3 categories (criteria detailed above) viz:-

1) Perfectly normal function.
2) Partilly impaired function

3) Grossly impaired function

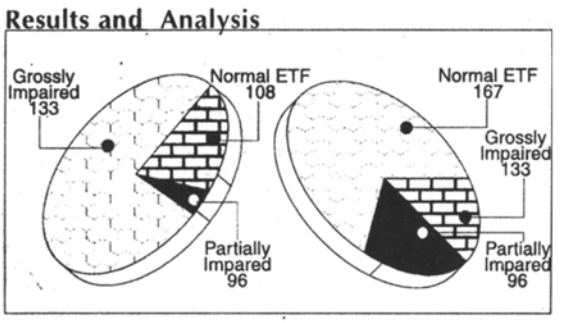


Fig. 7- Pie charts showing ETF results is ears with CSOM. The left chart shows the results in 337 ears with active CSOM and the right chart shows the results in 238 ears with inactive /quiescent CSOM.

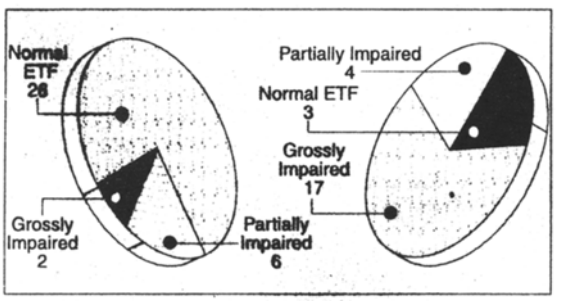


Fig. 8- Pie charts showing post-operative ETF results in 62 ears on whom tympanoplasty had been done during the tenure of the study. The Left chart shows the results in 34 ears in which the tympanoplasty was successful and the right chart shows the results in 24 ears in whom tympanoplasty was unsuccessful. William's test has been done on the successful cases (intact TM) and Toynbee's test has been done on the unsuccessful cases (perforated TM).

A) Of the 575 ears with central perforation, the results were as follows (Fig. 7). In the 337 ears with central perforation in which the ear was discharging, the Toynbee's tests showed—

1. Perfectly normal function - 32.04% (108 ears)
2. Partially impaired function - 28.48% (96 ears)
3. Grossly impaired function - 39.46% (133 ears)

In the (187+51)=238 ears which had a central perforation but was not actively discharging the Toynbee's test showed-

1) Perfectly normal function - 70.16% (167 ears)
2) Partially impaired function- 6.72% (16 ears)
3) Grossly impaired function - 23.19% (55 ears)

B) Of the 62 cases which came for post-operative follow-up 2-5 months after surgery (myringoplasty/tympanoplasty), 24 had failed tympanoplasties but in the rest 38 (i.e. 59.37%), the graft had taken-up well. But in 4 of these 38 patients, the graft had undergone medialisation with adhesive changes and hence these cases were excluded from the study because tubal function tests are not possible in the absence of air in middle ear. In the rest 34 ears, the William's test (since the ear-drum was now intact) of tubal function was carried out. In these 34 ears the results were as follows (Fig. 8).

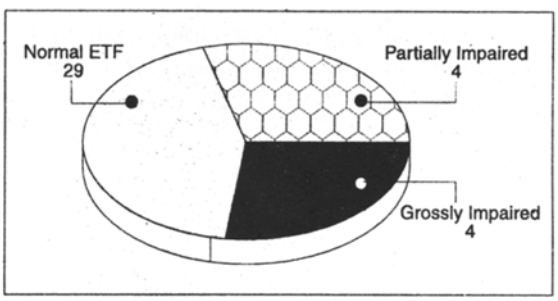


Fig. 9- Pie chart showing the pre-operative ETF result in the 34 patients in whom the tympanoplasty was successful.

1) Perfectly normal function - 76.47% (26 ears)
2. Partially impaired function- 17.64% (6 ears)
3. Grossly Impaired function- 5.88% (2 ears)

Of the 24 ears in whom the graft had not taken up or a re-perforation had occurred (within 5 months) or localised retraction pockets with no hearing improvement was found, the results of tubal function tests were as follows (Fig. 8)

1) Perfectly normal function- 12.5% (3 ears)
2) Partially impaired function- 16.66% (4 ears)
3) Grossly impaired function-70.83% (17 ears)

The 24 ears, in which the tympanoplasty had failed, the pre-operative Toynbee's test results were as follows-

1) Perfectly normal function- 29.16% (7 ears)
2) Partially impaired function- 8.33% (2 ears)
3) Grossly impaired function- 62.5% (17 ears)

Whereas in those 34 ears in whom the graft took-up well and there was no retraction and hearing improvement was satisfactory, the pre-operative Toynbee's results (Fig. 9) were as follows-

1) Perfectly normal function- 79.41% (27 ears)
2) Partially impaired function- 8.82% (3 ears)
3) Grossly impaired function- 11.76% (4 ears)

Of the 4 patients who had medialisation of the graft with adhesive changes, 2 had grossly impaired tubal function prior to the surgery. As previously stated, 59 of the 575 ears in whom the Toynbee's test was done, already had failed tympanoplasty before the study was undertaken. The preoperative Eustachian tube status of these 59 patients could not be ascertained (as their tympanoplasties had already been performed before undertaking this study). The results of Toynbee's test in these 59 failed tympanoplasty ears were as follows-

1) Perfectly normal function - 11.86% (7 ears)
2) Partially impaired function - 18.74% (11 ears)
3) Grossly impaired function - 69.49% (41 ears)

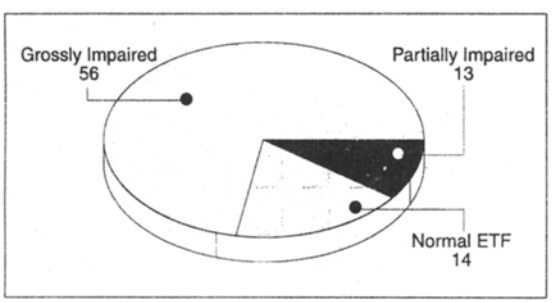


Fig. 10- Pie chart showing post-operative ETF results in 83 patients of failed tympanoplasty.

Hence, in the 59 (surgery before the study was undertaken +24 (surgery after the study was undertaken) i.e. 83 ears of failed tympanoplasties covered in this study, the Eustachian tube function was normal in only 7+7 = 14 (16.86%) ears, the tubal function was partially impaired in 11+2=13 (i.e. 15.66%) ears and function was grossly impaired in 41+15=56 (67.46%) ears (Fig. 10).

Discussion

This study demonstrates the value of assessing the physiological function of the Eustachian tube in the management of tubotympanic (i.e. safe) type of CSOM. The unsafe types of CSOM (attic and posterior marginal) were excluded from the study. The author found the Toynbee's ETF tests to be somewhat unreliable in attic / posterior-marginal perforation.

Though many methods have been described for determining eustachian tube function in the past, they are all very cumbersome and not suitable for our daily practice. These methods include sonotubometry (*Pavla* et al 1987 and Murti KG et al 1980), radiological studies (Bluestone CD et al-1972), photoelectric method to measure patency (Yagi et al 1987), assessment of the ventilatory capacity of the eustachian tube using a sound proof-chamber (Kodamma et al 1994) and the use of fluorescien/ saccharine to measure mucociliary clearance time. The modern method of ascertaining the physiological function of the Eustachian tube by means of the newer impedance audiometers very easily is hence a boon and is a very helpful diagnostic tool to the practicing otologist (Riedel et al 1987).

Physiologically the neuralisation of the negative middle ear pressure is brought about by intermittently opening the Eustachian tube and allowing air to pass through it such that the air pressure within the middle ear cavity is brought back more or less to the same level as that of

the atmospheric air pressure. The intermittent opening of the Eustachian tube is caused by contraction of the tensor palatini and partially the levetor veli palatini muscles. These muscles contract during swallowing. Hence for assessment of Eustachian tube function, it has to be essentially ascertained whether an artificially increased or decreased middle ear pressure can be neutralised and brought back to ambient pressure by swallowing. Increase of pressure in the middle ear (measurable by the impedance audiometer) on performance of valsalva indicates that the Eustachian tube is opening on active pressure, but the former, (i.e. whether the changed pressure is being neurtalised on swallowing) is a better and a more reliable way of assessing tubal function. The newer generation of impedance audiometers allow us to monitor and document whether swallowing and valsalva respectively decrease or increase the middle ear pressure and thereby test the eustachian tube function very precisely and effectively. It has been established that the monitoring of the opening of the eustachian tube and the resultant neutralisation of the middle ear pressure on swallowing is much more accurate when the Toynbee's test is carried out in a pressure differential (Perlman 1967, Ingelstedt 1967). Performance of the Toynbee's test in a pressure differential is possible only by using the impedance audiometer. The impedance audiometer builds up a positive or negative pressure at the middle ear end of tube whereas the pressure at the nasopharyngeal end of the tube remains at OdaPa (atmosphere pressure). Without this pressure differential, the test is positive in only one third of the patients who have normal function, which means that without this pressure differential the false negative rate is very high. Herein lies the importance of functional assessment of Eustachian tube using the impedance audiometer. The information obtained from these tests of assessment of Eustachian tube function both for perforated as well as for intact ear drums is very helpful to the otologist who can then select the line of management on a more scientific and logical basis.

Conclusion

The study consisted of Eustachian tube function tests in 2 groups of patients - (A) 575 ears which had a central perforation in the tympanic membrane (B) 62 ears of tympanoplasty on whom both pre and post-operative eustachian tube function tests were done.

Eustachian tube function was observed to be normal in only 32.04% of discharging ears but in 70.16% of dry ears. This indicates that persistence of discharge in safe type of CSOM is related to tubal dysfunction. The incidence (67.94%) of impaired tubal function (28.48% partially impaired and 39.46% grossly impaired) was found to be higher (67.94%) in the discharging ears as compared to the dry ears in which the incidence (29.82%) of impaired tubal function (6.72% partially impaired and 23.10% grossly impaired) was significantly lesser.

In failed tympanoplasties (83 pts.), the Toynbee's test showed impaired tubal function in a very high percentage (83.12%) o, ears. Of this 83.12% ears of failed tympanoplasties, the Eustachian tube function was partially impaired in 15.66% and grossly impaired in 67.46% ears. The Eustachian tube function was normal in only 16.87% ears in this sub-group. This suggests that *tubal dysfunction is a very major cause of failure of tympanoplasty.* The small number of patients (16.87%) who had normal tubal function but, yet had failure of the tympanoplasty is probably attributable to poor surgical technique, improper post-operative care or other unidentified causes.

In the second group of 62 ears in whom both pre and post-operative Eustachian tube function assessment was possible, it was found that the incidence of failure of tympanoplasty was much higher amongst patients having poor Eustachian tube function (70.84%) 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 (76.31%) in ears which had normal tubal function prior to the surgery. If the 4 ears in whom the graft had taken up well but had post-operatively undergone adhesive changes are excluded from this study, the success rate of tympanoplasty in the ears which had normal tubal function prior to the surgery is still higher i.e. 85.29%. This implies that *the success rate of tympanoplasty is significantly higher, if patients with normal tube function are chosen for surgery*. The results in this group of patients compares very well with that of El-Guindy (1993) who has reported a 95% success rate of myringoplasty in patients with normal tubal function, a 90% success rate in patients who had tubal dysfunction initially but which could be corrected pre-operatively by treating nasal and peri-tubal pathology, and a poor success rate of only 68% in patients who had poor tubal function which was not adequately corrected before the surgery.

A pre-operative assessment of tubal function is no longer a cumbersome process and is hence mandatory before any reconstructive middle ear surgery. If the tubal function is found deranged pre-operatively, there are many methods both medical as well as surgical which can be employed not only to correct the tubal function prior to surgery but also for the maintenance of a perfect ventilation of the middle ear even after the surgery in refractory cases (Jahn 1993, Yung 1998) so that a reperforation or post-operative retraction /adhesion is prevented. It has been postulated by many otologists (A.F. Jahn- 1996) that most cases of delayed failure of tympanoplasty / myringoplasty are related to faulty tubal function. While Giminez et al (1993) found that mucociliary clearance time has prognostic significance in tympanoplasty, most others have found that the ventilatory function of the eustachian tube is much more important for the success of reconstructive middle ear surgery. The ventilatory function of the eustachian tube is reliably measured by the modern impedance audiometers (e.g. AZ-26 Interacoustics, 775 of Amplaid etc) without any difficulty. (Morimitsu et al 1981). The simplicity of the eustachan tube function test as carried out by the impediance audiometers and the advantages this test provides makes this a very valuable tool in the otologist's diagnostic armamentarium.

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