A Comparison of Tympanometric Outcomes following Type 1 Tympanoplasty versus Type 1 Tympanoplasty with Cortical Mastoidectomy

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ABSTRACT

Introduction

Type 1 Tympanoplasty and Type 1 tympanoplasty with Cortical Mastoidectomy are two well accepted approaches for treatment of Chronic Otitis Media. Mastoid air cells are considered as buffer system of middle ear and exenteration of the same may have effects on middle ear function. This study aims to assess the difference in middle ear function in terms of tympanometry between Type 1 Tympanoplasty and Type 1 tympanoplasty with Cortical Mastoidectomy.

Materials and Methods

102 patients of Chronic Otitis Media with normal middle ear mucosa were randomly divided into two groups. One group underwent Type 1 Tympanoplasty and another group underwent Type 1 Tympanoplasty with Cortical Mastoidectomy. Tympanometry was done preoperatively and 6 months after surgery. The results were assessed in terms of type of tympanogram, ear canal volume, static compliance, peak pressure of middle ear and pressure gradient.

Results

The mean values of all variables were slightly higher with the cortical mastoidectomy group as compared to the tympanoplasty group. However, the p value was >0.05, hence the results were statistically insignificant.

Conclusion

There are no statistically significant tympanometric differences between Type 1 Tympanoplasty as compared to Type 1 Tympanoplasty with Cortical Mastoidectomy. However, tympanometry can be an effective tool in assessment of response to particular surgery by the comparison of preoperative and postoperative changes.

Keywords

Tympanoplasty; Mastoidectomy; Tympanometry; Chronic Otitis Media

The chronic otitis media (COM) is a longstanding infection of the middle ear cavity causing abnormality of pars tensa/ pars flaccida, usually following an acute otitis media, eustachian tube dysfunction or otitis media with effusion. COM being a very common disease among the Indian population with a prevalence of 6%,[1] affecting the quality of life of majority of the patients and causing hearing disability in many, any lack of clarity regarding the management of the same should be appropriately addressed.

The surgical methods used in treatment of COM have come a long way since 1953 when tympanoplasty was introduced by Wullstein with split thickness graft.[2,3] The mastoidectomy procedures were introduced later on for a complete eradication of the disease. Although cortical mastoidectomy was done earlier, it became popular after 1958 by the concept that an unoccluded mastoid antrum would invite ingrowth of squamous epithelium.[4,5] The concept of cortical mastoidectomy became more widely accepted after the study in 1975 by Holmquist and Bergstorn stating that a well aerated mastoid is a prerequisite for long lasting result in COM postoperatively.[4,6]

A cortical mastoidectomy if performed eradicates the disease and gains access to the antrum, attic or middle

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ear. It thus increases the air containing space in continuity with the middle ear, allowing the middle ear to better accommodate changes in pressure without tympanic membrane retraction. Thus, it acts as the buffer system for maintaining air pressure equilibrium in the middle ear and this is assumed to have some role to play in the maintenance of normal middle ear function. Also, it is well accepted that the extent of mastoid pneumatization and the presence of inflammatory disease in the mastoid are contributing to the success of any surgery done for eradication of COM. The cortical mastoidectomy therefore may have some role in replenishing the normal function of middle ear and thus, the popular school of thought came into place suggesting that cortical mastoidectomy has an added benefit in patients with inactive mucosal COM with normal middle ear mucosa. However this is still unproven due to the lack of conclusive evidence and thorough research is essential to put light into this dilemma.

Tympanometry is a useful tool in assessing the middle ear function in terms of peak pressure and pressure gradient of the middle ear along with the static compliance which depends on the acoustic energy absorbed by the middle ear. In COM, all the parameters of tympanometry get affected as the tympanic membrane has a perforation or abnormality which affects the compliance as well as the pressure gradient. In cases with normal middle ear mucosa, the change in tympanometry is primarily attributed to the presence of perforation in the tympanic membrane causing pressure and volume changes and thereby poor compliance.

As mastoid air cells have been found as the air pressure buffer system for the middle ear, cortical mastoidectomy that offers a patent aditus might have an effect on the tympanometry variables which are based on the middle ear air pressure and compliance. Also mastoid air cells which can act as the nidus of inflammation in COM, if exenterated will be affecting the healing of the ear postoperatively. Thus, the change in tympanometry variables can be a useful predictor for the efficacy of cortical mastoidectomy in inactive mucosal COM with normal middle ear mucosa.

The change in individual parameters of tympanometry preoperatively and postoperatively in COM patients hasn't been explored yet. Due to the closure of perforation, exenteration of mastoid air cells, maintenance of pressure gradient across the tympanic membrane and due to the recovery of middle ear mucosa from inflammation, the tympanogram is expected to change after the successful management of COM. The area needs further research and analysis for reaching a valid conclusion.

Our study attempts to identify the tympanometric changes in patients who underwent tympanoplasty with cortical mastoidectomy as opposed to Tympanoplasty alone.

Materials and Methods

An institute based ambispective analytical study was done in a tertiary health care center in West Bengal, India. The study was conducted from June 2022 to May 2024. Patients of chronic otitis media who presented in the ENT Outpatient department who satisfied the inclusion and exclusion criteria and consented for participation in the surgery were selected as the study sample. All selected patients were assessed clinically and documented according to the criteria, a detailed history was taken and a proper and thorough clinical examination was done. Furthermore, audiological assessment by pure tone audiometry and tympanometry was done thereafter.

Inclusion Criteria:

- Age group: 18 to 50 years
- Central perforation
- Mild to moderate conductive hearing loss
- Normal middle ear mucosa on radiology
- Intact ossicular chain
- Dry ear for at least four weeks before surgery

Exclusion Criteria:

- Healed COM
- Cholesteatoma
- Previous surgery of ear
- Any source of distant infection (Nose, PNS, Pharynx)
- Unwilling to participate in the study

Study Variables:

- Type of Tympanogram
- Ear canal volume
- Static compliance
- Peak pressure of middle ear
- Pressure gradient

A total of 110 patients were randomly assigned into two groups, however, 8 patients had a failure of surgery leading to residual perforation and therefore were excluded from the study. Out of 8 patients, 5 patients were from the Type 1 Tympanoplasty with cortical mastoidectomy group while 3 patients were from the Type 1 Tympanoplasty alone group. Those who underwent successful surgery were followed up till 6 months and a late tympanometry at 6 months was documented.

Results

102 patients were included in the study out of which 57 patients underwent Type 1 Tympanoplasty whereas 45 patients underwent Type 1 tympanoplasty along with cortical mastoidectomy.

The study population belonged to an age ranging from 18 years to 49 years with mean age of 33.5 ± 7.85 years. Majority of the patients (60.8%) belonged to the age group of 25-40 years. No gender preponderance was seen in the population (male: female = 1:1.02).

The most common presentation was unilateral mucoid discharge associated with hearing loss (68.6%) while 31% patients presented with discharge alone. 16.7% patients had bilateral discharge at the time of presentation and the worst ear was operated on in such cases. Most of the patients had symptoms for many years, as high as 27 years. The minimum duration of illness noted was 6 months. The mean duration of illness was 9.05 years with a median of 7 years.

Audiometric evaluation of the patients showed that 91.1% patients had mild conductive hearing loss while 8.8% patients had moderate conductive hearing loss at the time of presentation. The contralateral side essentially showed a normal audiogram except in bilateral cases.Out of the bilateral cases, 15 cases presented with mild conductive hearing loss and 2 cases presented with moderate conductive hearing loss in the contralateral ear.

The tympanometric assessment was done preoperatively and postoperatively (after 6 months of surgery) in all patients. The mean preoperative values of the affected ear were compared with that of the postoperative results in the study population.

All the patients who underwent Type 1 Tympanoplasty alone had preoperative tympanometry curve of 'B' type which got converted into 'A' type postoperatively in 42.1 % (24/57) cases whereas the rest of the cases had 'B' type curve postoperatively.The preoperative canal volume ranged from 0.8 to 2.1 cc with a mean volume of 1.44 ± 0.31 cc which changed into 1.11 ± 0.23 cc postoperatively. The minimum volume postoperatively was 0.61 cc and maximum volume was 1.58 cc which is near to the normal range of ear canal volume. The static compliance also shows a similar trend where preoperative compliance ranged from 0 to 0.04 cc with a mean of 0.01 cc which changed into 0.32 ± 0.10 cc postoperatively. The minimum and maximum values post operatively were 0.13 to 0.55 cc respectively. The peak middle ear pressure was -369 ± 130 daPa preoperatively (range: -638 to -164 daPa) which increased to -19 ± 27 daPa postoperatively. The minimum value postoperatively was measured to be -62 daPa and maximum value was noted as +40 daPa.The pressure gradient preoperatively showed an average of 0.02 ±0.01 daPa with a range of 0.01 to 0.05 daPa. This increased postoperatively to 0.21 ± 0.08 daPa with a minimum gradient of 0.09 to a maximum gradient of 0.39 daPa.

All the patients who underwent Type 1 Tympanoplasty with cortical mastoidectomy also had preoperative tympanometry curve of 'B' type. This was converted into 'A' type postoperatively in 44.4 % (20/45) cases whereas the rest of the cases had 'B' type curve postoperatively. The canal volume of the patients who underwent cortical mastoidectomy with tympanoplasty ranged preoperatively from a minimum of 0.83 cc to maximum of 1.94 cc with a mean of 1.57 ± 0.29 cc. This value postoperatively decreased to 1.23 ± 0.21cc with a range of minimum 0.71 cc to maximum 1.58 cc. The static

compliance of this group preoperatively ranged from 0 to 0.04 cc with a mean of 0.01 cc. Postoperatively, this increased to a mean value of 0.34 ± 0.12 cc ranging from a minimum of 0.16cc to a maximum of 0.83 cc. The peak middle ear pressure preoperatively ranged from -625 to -197 daPa with a mean of -388 ± 112 daPa. Postoperatively, the pressure reduced to -57 to 27 daPa with a range of -23 ± 22 daPa. Meanwhile the pressure gradient also showed an upward trend from a mean value of 0.02 ± 0.01 daPa preoperatively to 0.22 ± 0.09 daPa postoperatively. The range preoperatively was 0.01 to 0.05 daPa which increased to 0.09 to 0.42 daPa postoperatively.

Thus it was observed that the mean values of all variables were slightly higher with the cortical mastoidectomy group as compared to the tympanoplasty group. On comparison of mean values between two groups, the p value for ear canal volume was 0.06, that of static compliance was 0.405, that of peak middle ear pressure was 0.430 and that of pressure gradient was 0.744. Thus the results were statistically insignificant as $p > 0.05$ for a confidence interval of 95%.

Table I: Comparison of mean tympanometry values of different groups

	MEAN PREOPERATIVE TYMPANOMETRY VALUES	POSTOPERATIVE TYMPANOMETRY VALUES OF TYMPANOPLASTY GROUP	POSTOPERATIVE TYMPANOMETRY VALUES OF CORTICAL MASTOIDECTOMY GROUP
TYPE OF CURVE	B type (100%)	A type (42.1%)	A type (44.4%)
CANAL VOLUME	1.44 ± 0.31 cc	1.11 ± 0.23 cc	1.23 ± 0.21 cc
STATIC COMPLIANCE	0.01 cc	0.32 ± 0.10 cc	0.34 ± 0.12 cc
PEAK MIDDLE EAR PRESSURE	-369 ± 130 daPa	-19 ± 27 daPa	-23 ± 22 daPa
PRESSURE GRADIENT	0.02 ± 0.01 daPa	0.21 ± 0.08 daPa	0.22 ± 0.09 daPa

Discussion

It is accepted that mastoid plays an important role in the middle ear aeration and pressure regulation by acting as a reservoir and thereby decreasing the pressure variations inside the middle ear.[7] This helps in preventing chronic inflammation of the middle ear. Saying that, the cause and effect relationship between mastoid air cells and COM has still not been established as in whether the disease causes a disturbed pneumatization of mastoid or if the small mastoid air cells predisposes to the disease.[8,9,10,11] The lack of proper aeration at the time of initial tympanoplasty has been shown by some studies to be a significant source of failure in non cholesteatomatous COM.[4,12] Thus, finding a cause-effect relationship between mastoid aeration and disease can be done by repneumatizing the cells by cortical mastoidectomy.

The management of inactive mucosal variety of COM with normal middle ear mucosa has been an area of research from as early as 1970s after the study in 1978 by Holmquist and Bergstorn stating that a well aerated mastoid is a prerequisite for long lasting result in COM postoperatively.[4,6] Those who support the school of thought that cortical mastoidectomy is beneficial argue that cortical mastoidectomy increases the air reservoir in the mastoid and also help in achieving the patency of aditus. A poorly pneumatized air cell system lacks buffering capacity and is therefore more prone to chronic inflammatory conditions in the middle ear. Those who don't support this argument suggest the possibility of an

unoccluded antrum allowing the ingrowth of squamous epithelium. They also believe that the potential for injury to the inner ear structures and facial nerve during mastoid surgery outweighs the beneficial effects on tympanic membrane healing.

The studies conducted previously regarding the association of mastoidectomy with effective management in COM were mainly based on the postoperative uptake of the graft, hearing improvement, rate of recurrence of ear discharge etc. In most of the studies, no additional benefit of mastoidectomy was found whereas those which found a better outcome with mastoidectomy had statistically insignificant results except for a few.

It was Jackler and Schindler[13] in their study way back in 1984, who first found that simple mastoidectomy can be a safe and useful adjunct to myringoplasty in selected cases of chronic otitis media with perforation. Thereafter many studies showed similar results. In the study done by Sharma et al,[14] in the management of safe COM, Type I tympanoplasty with cortical mastoidectomy was found to have a better graft uptake and post-operative A–B gap closure as compared to without mastoidectomy with p value < 0.05. They concluded that tympano-mastoidectomy had an added benefit when combined with tympanoplasty in management of these cases. A similar result was found in a study by Ruhl et al[7] in the management of non cholesteatomatous COM cases. Meanwhile, Garg et al[8] recommends opening of the mastoid only if on inspection of the middle ear, one finds mucoid type of discharge as there are more chances to find disease in the mastoid in these cases. Nayak et al[15] also compared the results in dry tubotympanic COM and they reached a conclusion that cortical mastoidectomy when combined with tympanoplasty is more effective in terms of graft uptake and hearing gain especially in those with small mastoids.

Kaur et al[16] who did a comparative evaluation of surgical and audiological outcomes in patients of chronic suppurative otitis media with dry ear treated by myringoplasty with or without simple mastoidectomy suggested that hypocellularity of the mastoid process has a strong correlation with the tubotympanic type of CSOM. However they found no statistically significant results while doing cortical mastoidectomy in such patients. Krishnan et al[17] and Toros et al[18] also could not find any significant difference in results of graft success and final functional hearing rates between the two groups ($p > 0.05$) in similar studies. Balyan et al[19] in their study on non cholesteatomatous ear found that Tympanoplasty without mastoidectomy yields comparable results of graft success and final functional hearing rates between dry and discharging ears ($p > 0.05$) which were statistically insignificant when compared to tympanoplasty results. Mishiro et al[20] in their study on long term outcomes in COM cases found that mastoidectomy was not a significant factor and therefore an avoidable surgical procedure in tympanoplasty for perforated COM, even if the ear is infected. Mastoidectomy performed in non-cholesteatomatous COM in the study by Tawab et al[21] gave no statistically significant benefit over simple myringoplasty in regards with graft success rate and dryness of the middle ear with comparable hearing outcome. Agrawal et al[4] and Jaseetha et al[22] also concluded the same in similar studies conducted on mucosal variety of COM patients.

As a large number of studies have been conducted on this topic, multiple systematic literature reviews were also done on this topic. A review by Hall et al[23] concluded that tympanoplasty alone may be sufficient for repair of simple and uncomplicated tympanic membrane perforations. Eliades et al[24] in their review suggested lack of evidence for reaching a valid conclusion and proposed the need of large scale multicenter prospective studies for collecting more conclusive evidence. No previous studies have compared the tympanometric variations or middle ear function of patients who underwent cortical mastoidectomy.

In our study, the demographic and clinical parameters of the patients were assessed along with audiometry. The age and gender distribution was found to be similar to other studies on inactive mucosal COM. The mean age was found to be 33.5 ± 7.85 years similar to the studies of Sharma et al[14] and Agarwal et al[4]. No gender preponderance was observed as in the general population. In this study, the most common symptom was discharge associated with hearing loss (68.6%). The duration of

the symptoms was mostly around 7 years and bilateral patterns of symptoms were noticed in 16.7 % cases similar to the study by Sharma et al.[14] In our study, 91.9 % of the patients with hearing loss had mild conductive hearing loss, a result similar to that of Garg et al.[8]

While observing the tympanometric variables preoperatively, the affected side shows a 'B' curve in all patients with larger canal volume, high negative peak pressure and very low static compliance and pressure gradient.

The change in tympanometric variables showed a similar trend in both the groups postoperatively. The canal volume has decreased in both tympanoplasty group (1.11 ± 0.23 cc) as well as cortical mastoidectomy group (1.23 ± 0.21 cc) with a higher value in the second group-statistically insignificant. The high canal volume (1.44 ± 0.31 cc) preoperatively can be explained by the central perforation in the tympanic membrane which allows communication of EAC with middle ear, thus forming a single cavity. The volume assessed is therefore the combination of ear canal volume and middle ear volume. This was found to reduce significantly ($p < 0.01$) postoperatively implying the successful tympanic membrane repair which separated the EAC from middle ear.

The high negative pressure (-369 ± 130 daPa) noted preoperatively showed a positive trend which was approaching zero postoperatively in both the groups (-19 ± 27 daPa in tympanoplasty group and -23 ± 22 daPa in mastoidectomy group). This was also because of the closure of tympanic membrane perforation which enables the maintenance of a peak pressure where both EAC pressure and middle ear pressure becomes equal with maximum compliance. However, the values were found to be slightly higher in the mastoidectomy group although statistically insignificant.

The static compliance (0.01 cc) and pressure gradient (0.02 ± 0.01 daPa) which were too low to measure preoperatively increased significantly in both groups, with cortical mastoidectomy group (0.34 ± 0.12 cc) showing a slightly higher compliance as compared to the tympanoplasty group (0.32 ± 0.10 cc). But, the difference between the two groups was statistically insignificant.

However, the changes in preoperative and postoperative measurements were statistically significant in both the groups showing that both the surgeries were effective in revitalizing the middle ear postoperatively. This implies that tympanometry can be used as a reliable marker for the evaluation of improvement in middle ear function postoperatively.

The decrease in postoperative canal volume is a marker of successful graft uptake and sealing of the perforation which can be used medicolegally by the operating surgeon in proving the presence of a perforation preoperatively which got healed post surgery. Thus, it is suggested that tympanometry should be done preoperatively and postoperatively in all the patients who undergo surgery for COM with tympanic membrane perforations.

Conclusion

The tympanometry findings in chronic otitis media mucosal variety with normal middle ear mucosa treated with Type 1 tympanoplasty alone was similar to those treated with tympanoplasty and cortical mastoidectomy. But the preoperative and postoperative tympanometry findings were statistically significant overall. Hence tympanometry can be used as an effective tool in the postoperative assessment of surgery for chronic otitis media patients by the comparison of preoperative and postoperative changes in different variables. The variations in tympanometry post surgery also can have medicolegal implications which can be favorable for the operating surgeon.

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