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Research Article

EFFECT ON MIDDLE EAR MECHANISM FOLLOWING COCHLEAR IMPLANTATION MEASURED USING MULTIFREQUENCY TYMPANOMETRY

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ABSTRACT

Objectives: Present study aimed to evaluate the effect of cochlear implantation on mechano-acoustical property of ME by studying resonant frequency using MFT.
Design: Cross sectional study**.**
Study Sample: Total of 30 candidates participated in study, were divided into two groups. Group I included 15 cochlear implant recipients with age range of 3.5 to 10 years and group II included cochlear implant candidates with age range of 3 to 8 years.
Results: Descriptive analysis was carried out to find out the mean and standard deviation for resonant frequency (f0) in both groups. In present study, the resonance frequency of middle ear was increased significantly in implant ear compare to all three non implanted ear i.e. non-implanted ears of group I and both the non-implanted ears of group II.
Conclusion: The findings of the present study should be interpreted cautiously as it has been done on a small data. Further grouping of patients according to the duration of cochlear implant use and type of electrode array would enable to look for any correlation between them and the resonance frequency will provide a better picture for implementation of information in cochlear implant population.

INTRODUCTION

Profoundly deaf adults and children who did not derive any benefit from conventional hearing aids, the introduction of cochlear implants have made it possible to successfully rehabilitate these groups. Cochlear implants may help provide hearing in patients who are deaf because of damage to sensory hair cells in their cochleas. A cochlear implant (CI) is a surgically implanted electronic device that provides a sense of sound to a person who is profoundly deaf or severely hard of hearing. Research has shown that preoperative residual hearing is a positive predictor of good performance with a cochlear implant (Rubinstein JT et. al, 1999; NIH consensus conference, 1961; Gantz BJ *et.al*., 1993).

Preservation of residual low frequency hearing with addition of electrical speech processing can even improve the speech perception abilities of cochlear implant users. Preservation of low frequency hearing requires an intact middle-ear conductive mechanism in addition to intact inner-ear mechanisms. There are different techniques that has been used for implantation i.e. insertion of electrode array in cochlea.

Studies indicated, post implantation changes of the machano-acoustical properties of the middle ear (Donnelly *et.al*., 2009; Guzevicius *et.al*., 2010) and also apart from ME the mobility of round window as well as intra cochlear hydrodynamics may be affected, observed in some patient (Mynatt *et.al*., 2006) due to presence of electrode array on and around the basilar membrane and leakage of perilymph from bony labyrinth of cochlear partition, due to surgical procedure. The concept of 'soft surgery' for cochlear implantation has been introduced by Lehnhardr (1993) to avoid as much damage as possible in the inner and studies indicated that 'soft surgery' led to preservation of residual hearing in more than about 70% of the patients after cochlear implantation (Fraysse B *et al*,2006. James CJ *et al*, 2006. Gstoettner W *et al*, 2004. Gstoettner WK. *et al*, 2006; Balkany TJ *et al*, 2006; James C *et al*, 2005; Kiefer J *et al*, 2004).

In study done by Doneelly (2009) used, laser Doppler vibrometry to see the effect of cochlear implant electrode insertion on middle-ear function as measured by intra-operatively, where stapes displacement had been studied in

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response to electrode insertion. In the study variable effect on stapes displacement has been observed and results showed that insertion of electrode led to increased stapes displacement in two third patients where in one third patient stapes footplate movement was found to be reduced in displacement. This variability may reflect alteration of cochlear impedance, possibly due to differing loss of perilymph associated with the electrode insertion. But little is known about the effect of a cochlear implant electrode on middle-ear function.

The study of changes in middle ear mechano-acoustical property can be done using tympanometry. The stiffness and mass component of middle ear facilitates the study of ME status using different parameters in tympanometry. It can be hypothesized that the resonance frequency of the ME could be changed, reflects the changes in the sound propagation properties in the ME, which can be evaluated by Multi Frequency Tympanometry (MFT) due to insertion of electrode array.

Need of the study

Low frequency residual hearing is important for CI patient to perceive environmental sounds, music and low frequency speech sound. If there is changes occur in the ME acoustical property due to electrode insertion, it's important to understand the change in nature of sound propagation accordingly and using this information while selection of management options like bimodal fitting etc. for maximizing the use of residual hearing along with cochlear implant.

Aims and objectives

The present study aimed to see the effect of cochlear implantation on mechano-acoustical property of ME by studying resonant frequency using MFT.

METHOD

Patient selection

Thirty patients were initially recruited for the study, 16 male children and 14 female children. These 30 children were then divided into two groups based on cochlear implantation. Group-I included cochlear implant recipients, 15 children with age range of 3.5 to 10 years (Mean:6.03 SD:1.63) received implant in one ear for minimum of 6 months back. All the subjects included in this group had unilateral cochlear implantation and were implanted with Medel. In Group-II 15 children with age range of 3 to 8 years (Mean: 5.46 SD: 1.30) were included were cochlear implant candidates selected for cochlear implant surgery. The inclusion criterion for the study was simply the requirement for a cochlear implant. The patients selected were 'traditional' cochlear implant patients with severe to profound sensorineural hearing loss. The aetiology of their hearing loss included congenital hearing loss and idiopathic causes. Informed consent was obtained in all cases.

Exclusion criterion

In present study candidates with the history of previous middle ear discharge, surgery, head trauma, exposure of any kind of middle ear disease, Menier's disease, confirmed middle ear pathology(e.g.: otitis media, cholesteatoma, otosclarosisetc); abnormal otoscopic findings, middle ear pressure less than -100 dapa, i.e. negative middle ear pressure, and abnormal surgical findings in CI recipients'(intra operative exposure and damage of the tympanic annulus, cochlear obliteration/ ossification)were excluded from present study. In short exclusion criterion for the study was middle-ear disease, as determined by history, otoscopy, tympanometry and intra-operative findings. None of the patients recruited were subsequently excluded.

Instrumentation

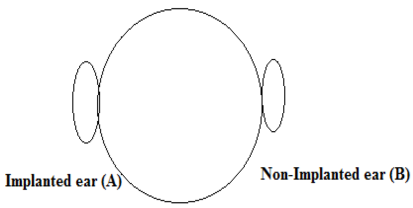
A Garson StadlerTympStar instrument was used for MFT measurement.

Procedure

For both the groups' complete clinical examination including otoscopic examination, shape of single component tympanometry and middle ear pressure were evaluated before proceeding to MFT measurements.

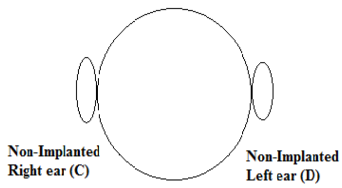
Resonant frequency was defined automatically for both the ears for both the groups. Inter –aural difference Δf0 was calculated as f0Right – f0Left for cochlear implant candidate i.e. group II, where as for group I cochlear implant recipients, Δf0 were calculated for Implant ear-Nonimplant ear. Mean value and standard deviation (SD) were calculated for f0Right, f0Left and Δf0 of both measurements for both the groups. The statistical Package for Social sciences (SPSS) version 20.0 software was used for statistical processing.

Group-I



Cochlear Implant Recipients

Group-II



Cochlear Implant Candidates

RESULTS

The statistical Package for Social sciences (SPSS) version 20.0 software was used for statistical processing. Descriptive analysis was carried out to find out the mean and standard deviation for resonant frequency in both groups. The details are given in table below.

The findings of descriptive value indicated higher mean value for implanted ear resonance frequency (f0) in comparison to nonimplated ear for group I and both the nonimplanted ear for group II. Subsequently Paired T-test was carried out to compare the mean values of within and between groups for resonant frequencies i.e. Inter-aural difference (Δf0), resonant frequency for right ear (f0Right) and resonant frequency of left ear (f0Left) were measured. Mean value and standard deviation (SD) for all three, Δf0, f0implantear/Right ear and f0 nonimplant/Left ear for both the groups tabulated below in detail.

Table 1 Resonance frequency (f0) of both ears in two groups.

Group	components	Range Minimum	Maximum	Mean	SD
Group-I	Age	3.5	10	6.0333	1.63080
Cochlear implant	f0 Implant ear	250.00	1450.00	1006.6667	369.78115
recipients N- 15	f0 Non-implant ear	550.00	950.00	733.3333	135.83954
Group- II	Age	3.00	8.00	5.4667	1.30201
Cochlear implant	f0 Implant ear	350.00	900.00	623.3333	178.15189
candidate N- 15	f0 Non-implant ear	350.00	950.00	593.3333	164.60631

N: indicates total number of participants, SD: standard Deviation.

Table 2 f0 differences within group

Group	Mean	SD	95% interval lower	Upper	correlation	P
Group-I (A-B)	273.33333	431.71860	34.25554	512.41113	2.452	.028
Group-II (C-D)	30.00000	198.02597	-79.66313	139.66313	.587	.567

Note: A: implanted ear of group I, B: non-implanted ear of group I, C: non-implanted right ear of group II, D: non-implanted left ear of group II.

The findings of paired T-test depicts higher f0 for group I which was statistically significant (p value= 0.028), but there is no significant difference for f0 within group II (p value= 0.567) seen (table 2).

Table 3 f0 differences between groups.

Group-I vs. Group-II	Mean	SD	95% interval lower	Upper	correlation	P
A-C	383.33333	391.27387	166.65309	600.01358	3.794	0.002
A-D	413.33333	415.53179	183.21950	643.44717	3.852	0.002
B-C	110.00000	212.30033	-7.56800	227.56800	2.007	0.064
B-D	140.00000	142.92855	60.84881	219.15119	3.794	0.062

Note :A: implanted ear of group I, B: non-implanted ear of group I, C: non-implanted right ear of group II, D: non-implanted left ear of group II.

Between group f0 findings revealed statistically significant for implanted ear of group I when compared with both the non-implanted ear of group II (p value< 0.05) from table 3. On comparison of Δf0 between two groups there was no statistical significant difference (table 4) was obtained (p value> 0.05).

Table 4 Δf0 comparison between group-I and group-II.

Group	Mean	SD	95% interval lower	Upper	correlation	P
I vs II	183.33333	489.41170	-87.69383	454.36050	1.451	0.169

DISCUSSION

Overall there was increase in resonance frequency f0 observed for implanted ear when compared to non-implanted ear in group I which was statistically significant (p value=0.002), where as there is no significant changes observed between two ears of group II. When implanted ear f0 of group I was compared with right and left ear f0 of group II separately, the p value (0.002) showed significant increase in f0 for implanted ear. On comparison of intra-aural differences of Δf0 between groups I and Group II there was no significant difference observed. In present study, the resonance frequency of middle ear was increased significantly in implant ear compare to all three non implanted ear i.e. non-implanted ears of group I and both the non-implanted ears of group II. The larger shift of resonance frequency could be resulted from the post-operative alteration. Multifrequency tympanometry enables decomposition of the admittance into its components i.e. conductance and reactance. The later is the sum of the mass reactance at the level of auditory ossicles and the stiffness reactance at the level of annular ligament. At the resonance frequency, admittance is represented only by conductance, reflecting basically the resistance of the inner ear (Darrouzet *et al*., 2007). Therefore we can hypothesize that any shift in f0 reflects changes of intra-cochlear admittance, induced by the insertion of electrode array. The higher value of f0 could be explained from the point of intra cochlear hydrodynamics. Scarring and stiffening of both the round window and basilar membrane along with subsequent dampening of the scala-tympni (Choi & Oghalai, 2005) that may lead to increased intra cochlear resistance (or decreased admittance), resulting in increased stiffness of the ossicular chain ad higher f0 values. Closure proximity of electrode array to the basilar membrane may compromise pressure waves transmission by interfering with the movement of the cochlear partition.

SUMMARY AND CONCLUSION

Despite the well know fact of great interest to electrode insertion trauma and its effect on intra-cochlear structures, leading to total or significant loss of residual hearing, little attention has been paid on to the possibilities of an effect on middle ear mechanics after cochlear implantation. The significant changes in resonance frequency of implanted ear in cochlear implant patients may serve as an objective measure to explain the changes in sound propagation properties via middle ear due to mechano-acouctical changes in the same, following implantation. This will probably help to measure the preserved low frequency or residual hearing post implantation and using the information for choosing further management in these patients like bimodal or Electro Acoustical Stimulation(EAS) to enhance overall listening. However, the findings of the present study should be interpreted cautiously as it has been done on a small data. Further grouping of patients according to the duration of cochlear implant use and type of electrode array would enable to look for any correlation between them and the resonance frequency will provide a better picture for implementation of information in cochlear implant population.

Implication of the study

The present study add on the information in literature in regard to mechno-acoustical changes in middle ear, post-implantation which will further help in order to choose hearing aids with appropriate frequency range for EAS in bimodal selection.

Reference

1. Balkany, T.J., Connell, S.S., Hodges, A.V., Payne, S.L., Telischi, F.F., Eshraghi, A.A.,2006, Conservation of residual acoustic hearing after cochlear implantation, *OtolNeurotol,*vol 27,pp 1083-1088.
2. Choi, C.H., & Oghalai, J.S., 2005, Predicting the effect of post-implant cochlear fibrosis on residual hearing. *Hearing Research*, vol 205, pp 193-200.
3. Darrouzet, V., Dulon, D., franco-Vidal, V., 2007, Multifrequency immittancemetry in experimentally

induces stapes, round window and cochlear lesion, *Audiol Neurotol*, vol 12, pp 85-100.

4. Donnlly, N., Bibas, A., Jiang, D., Bamiou, D.E., Santulli, C., Jeronimidis, G., Fitzgerald O'Connor, A., 2009, Effect of cochlear implant electrode insertion on middle ear function as measured by intra-operative laser Doppler Vibrometry, *Journal of LaryngolOtology* , vol 123,pp 723-9.
5. Fraysse, B., Macias, A.R., Sterkers, O., Burdo, S., Ramsden, R., Deguine, O., 2006, Residual hearing conservation and electroacoustic stimulation with the nucleus 24 contour advance cochlear implant, *OtolNeurotol*, vol27, pp 624-633.
6. Gantz, B.J., Woodworth, G.G., Knutson, J.F., Abbas, P.J., Tyler, R.S., 1993, Multivariate predictors of audiological success with multichannel cochlear implants, *Ann OtolRhinolLaryngol*, vol 102, pp 909-916.
7. Gstoettner, W., Kiefer, J., Baumgartner, W.D., Pok, S., Peters, S., Adunka, O., 2004, Hearing preservation in cochlear implantation for electric acoustic stimulation, *ActaOtolaryngol*, vol 124, pp 348-352.
8. Gstoettner, W.K., Helbig, S., Maier, N., Kiefer, J., Radeloff, A., Adunka, O.F., 2006, Ipsilateral electric acoustic stimulation of the auditory system: results of long-term hearing preservation, *AudiolNeurootol*, vol 11 *Suppl* 1, pp 49-56.
9. Guzevicus, D., Bibas, A., Jiang, FittzgeraldO'Connor, A., 2010, The effect of cochlear implantation on the resonant Frequency of the middle ear.
10. James, C.J., Fraysse, B., Deguine, O., Lenarz, T., Mawman, D., Ramos, A., 2006, Combined electroacoustic stimulation in conventional candidates for cochlear implantation, *AudiolNeurootol*, vol 11 Suppl 1, pp 57- 62.
11. James, C., Albegger, K., Battmer, R., BurdoS, Deggouj, N., Deguine, O., 2005, Preservation of residual hearing with cochlear implantation: how and why, *ActaOtolaryngol*, vol 125, pp 481-491
12. Kiefer, J., Gstoettner, W., Baumgartner, W., Pok, S.M., Tillein, J., Ye, Q., 2004, Conservation of low-frequency hearing in cochlear implantation, *ActaOtolaryngol*, vol 124, pp 272-280.
13. Lehnhardt, E., 1993, Intracochlear placement of cochlear implant electrodes in soft surgery technique. HNO, vol 41, pp 356-359.
14. Mynatt, R., Hale, S.A., Gill, R.M., Plontke, S.K., Salt, A.N., 2006, Demonstration of a longitudinal contraction gradient along scala tympani by sequential sampling of perilymph from the cochlear apex, *J Assoc Res Otolaryngol*, vol 7, pp 182-93.
15. NIH consensus conference, 1995, Cochlear implants in adults and children, *JAMA, vol* 274, pp 1955-1961.
16. Rubinstein, J.T., Parkinson, W.S., Tyler, R.S., Gantz, B.J., 1999, Residual speech recognition and cochlear implant performance: effects of implantation criteria, *Am J Otol*, vol 20, pp 445- 452.

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