ORIGINAL RESEARCH PAPER

Volume - 15 | Issue - 02 | February - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A PROSPECTIVE STUDY ON EFFECT OF MASTOID DRILLING IN EAR SURGERIES, ON FUNCTIONING OF NORMAL CONTRALATERAL EAR BY OAE.

Otorhinolaryngology

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ABSTRACT

Background: Though there has been evidence suggestive of sensorineural hearing loss in contralateral normal ear after mastoid drilling with OHCs bearing maximum insult; their incidence, duration, maximum sound produced and recovery time, in several studies have been widely varied as measured by DPOAE, which allows testing of wide range of frequencies. **Aims and Objectives:** To study hearing loss occurring due to mastoid drilling, by assessing the changes occurring in functioning of outer hair cell (OHC) of contralateral normal ear by DPOAE and to assess corelation between duration of drilling and hearing loss recorded. **Methodology:** In this prospective study, 50 patients diagnosed with unilateral CSOM requiring mastoidectomy were included and DPOAE done, one day prior to surgery; total duration of drilling recorded intraoperatively, postoperatively DPOAE recorded on POD 1, 3, 7, 30 & 90. **Results:** DPOAE values of contralateral ear were reduced on all frequencies postoperatively but was significantly reduced on POD 1 for high frequencies and then returned to pre-operative levels by POD 30 and remained normal on POD 90. Duration of drilling had significant correlation with hearing loss recorded on DPOAE during 1st postoperative week, but showed no significance thereafter. **Conclusion:** Temporary hearing loss in contralateral ear after mastoidectomy can be expected as observed by DPOAE, which would be regained slowly within 1 month of surgery, reaching preoperative levels by 30th day of surgery. Hence, burrs used during mastoidectomy can cause temporary threshold shift in the contralateral normal ear as well.

KEYWORDS

Outer Hair Cells, Mastoidectomy, Temporary Threshold Shift, Drilling Induced Hearing Loss, DPOAE

INTRODUCTION

In advanced surgical methods powered instruments are indispensable part of surgical ornamentum, but major concern is their effect on quality of life or loss of sensations.[1] When a patient is exposed to loud noises during surgery, it can cause surgical trauma.[2] Drilling burrs can cause noise-induced hearing loss especially when used on or adjacent to ossicular chain, on stapes footplate and during work on mastoid bone.[2] Therefore drill-generated noise, getting transmitted via the skull, has been incriminated as a cause of sensory-neural hearing loss[2] in both operated as well as non-operated normal ear.[3,6]

Noise levels reaching cochlea when calculated on intact skulls of cadavers, showed ipsilateral cochlea was exposed to over 100 dB and contralateral cochlea to levels of 5 to 10 dB lower.[3,1] For example, when drilling in mastoid cavity, noise levels ranged from 85 to 117 dB and during cochleostomy it ranged from 114 to 128 dB SPL.[1,3,5] Cutting burrs produced 9dB more noise that diamond burrs.[7]

During vibration of organ of Corti the basilar membrane moves up and down and because the hair cells reside on top of the basilar membrane, the area of maximal vibration is near the third row of OHCs[4] making then the initial target of acoustic trauma as well, so it is logical to assess the non-operated, normal ear by distortion product OAE[8] as it is best investigation to evaluate cochlear function.[9]

Sensorineural hearing loss has many causes, including noise exposure, ototoxicity, and age-related hearing loss. The common site of pathology in inner ear is the OHC. The attachments of OHC stereocilia to the tectorial membrane can be broken, even with mild noise exposure, reducing the ability of OHC electromotility, leading to a temporary hearing loss. With further damage, actin core of the OHC stereocilia can fracture and with enough trauma, hair cell death occurs and a permanent hearing loss result because cochlear hair cells in mammals do not regenerate. After OHCs begin to degenerate, additional structures within the cochlea die as well, including IHCs, supporting cells, and auditory nerve cells.[4]

In recent times drilling is being widely employed in ENT surgeries such as labyrinthectomy, endolymphatic sac surgery, facial nerve decompression, cerebello-pontine angle lesions, cochlear implantation and lateral skull base tumour surgeries; which can damage OHC and this has practical implications for both patients as well as ENT surgeons, hence the need for this study.

Hence the present study is aimed to evaluate hearing loss occurring due to mastoid drilling, by assessing the changes occurring in functioning of outer hair cell (OHC) of contralateral normal ear by Distortion product otoacoustic emissions and to study relationship between duration of drilling and the resultant hearing loss.

Methodology

This study was conducted in department of Otorhinolaryngology, Basaweshwara Teaching and General Hospital attached to Mahadevappa Rampure Medical College, Kalaburagi; after taking their consent, from 1st of August 2022 to 31st of January 2024 (18 months).

Study Design: Prospective study
Study Sample: 50 cases

Inclusion Criteria

1. Patients with unilateral Chronic Otitis Media undergoing mastoidectomy with normal functioning contralateral ear.
2. Patients of all ages and sexes.

Exclusion Criteria

1. Patient of Chronic Otitis Media with any type of hearing loss in contralateral ear.
2. Patients with any congenital malformations of ear.
3. Patients with history of any surgical procedure done on either of the ears.

Once enrolled, patients were evaluated clinically and routine investigations done. They were subjected to DPOAE, one day prior to surgery (pre-operative); intraoperatively, the aggregate of duration of drilling was recorded; and postoperatively, DPOAE was recorded on POD 1, POD 3 and POD 7 post mastoidectomy. Then patients were followed up on POD 30 (1 month) and POD 90 (3 month), at which times DPOAE was repeated and data recorded.

Statistical Analysis

All the data was recorded by same audiologist. The Statistical data was analysed using IBM SPSS software 28.0.1.0 version. The descriptive data was analysed with mean, standard deviation, and percentage calculations. For qualitative data analysis Chi Square test was done for test of significance and a p- value of <0.05 was considered as significant.

RESULTS

This study enrolled 50 patients of unilateral COM who fulfilled inclusion and exclusion criteria. In our study population 46% (23) were aged between 31 to 45 years, 24% (12) were 16 to 30 years, 16% (8) were 0 to 15 years and 14% (7) were between 46 to 60 years. The age of the youngest and oldest patient was 7 years and 58 years, respectively; with an average of 31.46 ± 13.48 years (Fig. 1).

Out of 50 patients, 18 (36%) patients were females and 32 (64%) patients were males (Fig. 2); 20 (40%) underwent Cortical Mastoidectomy and 30 (60%) patients underwent Modified Radical Mastoidectomy (Fig. 3). The average duration of drilling was 78.5 minutes, minimum and maximum duration was 50 mins and 140 mins respectively, where 41% patients required less than 1 hour of drilling time, 41% patients required drilling time between 1 to 2 hours and 18% patients required drilling time between 2 to 3 hours.

In our study we observed that the average DPOAE values were reduced drastically on POD 1, POD 3 and POD 7 of mastoidectomy, especially at 6 kHz on POD 1, and later it normalised to attain pre operative DPOAE values on POD 30 and POD 90 of follow up on all frequencies (Table 1).

In our study there was a significant correlation between duration of drilling and DPOAE values on POD 1, POD 3 and POD 7, while there is no significant corelation with duration of drilling on POD 30 and POD 90 (Table 2).

Fig. 1: Age distrubution

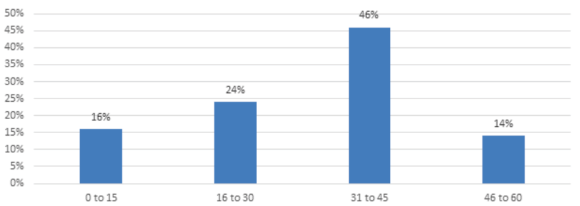

Fig 2: Gender distrubution

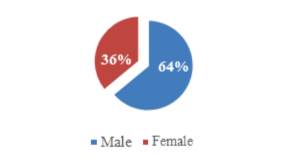

Fig 3: Surgeries

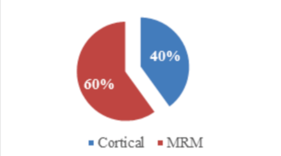

Table 1: Distribution of Outcome of OAE

Frequency (kHz)	Pre-op (mean± SD)	POD 1 (mean± SD)	POD 3 (mean± SD)	POD 7 (mean± SD)	POD 30 (mean± SD)	POD 90 (mean ± SD)
1.00	11.9 ± 2.28	9.2 ± 2.9	9.45 ± 4.37	9.8 ± 3.19	11.6 ± 1.93	12.46 ± 2.28
2.00	12.25 ± 2.29	8.8 ± 3.18	8.83 ± 4.4	8.79 ± 2.73	11.74 ± 2.28	11.98 ± 2.31
4.00	11.6± 1.9	7. 5 ± 2.87	8.1 ± 4.63	9.1 ± 2.84	10.58 ± 3.1	10.73 ± 1.92
6.00	10.53 ± 2.1	6.5± 3.9	7.2 ± 3.91	8.03 ± 2.7	10.19 ± 2.96	10.33 1.6

Table 2: Correlation Between the Drilling Duration with OAE

Parameters	OAE	
	Pearson correlation coefficient	Sig. (2-tailed)
Drilling duration vs POD 1	0.8	<0.001
Drilling duration vs POD 3	0.39	<0.001
Drilling duration vs POD 7	0.65	<0.001
Drilling duration vs POD 30	0.32	0.41
Drilling duration vs POD 90	0.27	0.33

DISCUSSION

Organ of Corti is a complex sense organ consisting 3 rows of outer hair cells (OHCs) and a single row of inner hair cells (IHCs) supported by cellular and acellular structures. Each hair cell has bundles of actin filaments known as stereocilia, that deflect with mechanical disturbances of cochlear fluid by soundwaves reaching stapes footplate. Stereocilia of OHCs are attached to tectorial membrane forming a section of endolymph filled compartment whose movements are directly linked to movement of cochlear fluid by mobile stapes footplate and is known as 'cochlear partition', whereas stereocilia of IHC are not attached to tectorial membrane and lie freely in subtectorial space.[4]

Sensory receptor potentials are produced by bending of OHC stereociliary which are converted into mechanical force by lateral wall of the OHCs which contains a voltage-dependant membrane protein called Prestin, this renders OHCs its unique electromotility. Prestin is expressed on OHCs but not on IHCs.[4]

When sound is transmitted to the inner ear, basilar membrane moves up and down, causing a shearing force that deflects the OHC stereocilia i.e., the 'cochlear partition', but movements of the IHC stereocilia are not as straightforward as it requires OHC electromotility to “pump” fluid back and forth within the subtectorial space causing bending of IHC stereocilia which generates receptor potentials and triggers afferent nerve activity sending signals to auditory centres in brain.[4]

This mechanical force generated by OHC refines the stimulation of the IHCs, thereby enhancing the perception and discrimination of the high-frequency sounds. This forms the basis of the 'cochlear amplifier' that enhances sensitivity and frequency selectivity.[4] And as a side effect of this mechanical force produced by OHC, one can measure it using highly sensitive high-quality miniature microphone placed in external auditory canal (EAC) and is known as otoacoustic emissions (OAE).[4]

There are various types of OAEs recordable like stimulus frequency otoacoustic emissions (SFOAE), transient evoked otoacoustic emissions (TEOAE) and distortion product otoacoustic emissions (DPOAE).[9]

DPOA is generated by biomechanical activity of OHCs of the cochlea, i.e. the cochlear amplifier, which enhance the travelling wave making them taller and sharper, hence it can be elicited only in ears with normally functioning OHCs with fully functional cochlear amplification mechanism.[9] In DPOAE the elicited sound is different from the stimulus sound presented and frequency of interest from the elicited response can be recorded separately[9], unlike other forms of OAE where stimulus and elicited sound are similar and entire response is recorded; this makes DPOAE highly useful in assessing and monitoring changes of cochlea safely and effectively.[9]

This is a prospective study comprising 50 patients, diagnosed as unilateral COM with normal functioning contralateral ear, who underwent mastoidectomy; either cortical or modified radical mastoidectomy. We subjected all the patients to DPOAEs, pre-operatively, a day before surgery and on POD 1, POD 3 and POD 7 post mastoidectomy. Intraoperatively, average duration of drilling was recorded. Then patients were followed up on POD 30 and POD 90. Aim of the study was to evaluate the effect of mastoid drilling on the functioning of OHCs of contralateral normal ear by DPOAE and to assess relationship between duration of drilling and the resultant hearing loss.

In a study conducted by Latheef et al involving 50 patients with unilateral chronic suppurative otitis media requiring mastoidectomy operation, they assessed contralateral normal ear using PTA and DPOAE preoperatively and postoperatively, beginning from Day 1 to Day 7 and followed up at 1, 3 and 6 months postoperatively, at which times PTA and DPOAE were repeated and analysed.[10]

In our study majority i.e. 46% were between 31 to 45 years, minimum age was 7 years and maximum age was 58 years, with an average age of 31.46 years. Out of 50 patients, 36% were females and 64% were males; 40% underwent Cortical Mastoidectomy and 60% underwent Modified Radical Mastoidectomy.

In our study we observed a reduction in DPOAE values for all frequencies, i.e. from 1 kHz to 6 kHz on POD 1, 3 and 7, with most significant reduction noted for 6 kHz on POD 1; but OAE values returned to preoperative levels by POD 30 for all frequencies and remined so on POD 90.

In a study by Agarwal N et al, average OAE values recorded pre operatively and on POD 1, 3, 5, 7 and 30, for 1 kHz and 4 kHz showed significant temporary hearing loss from POD 1 to POD 7 which normalizes around POD 30.[11]

In another study done by Latheef et al there was significant increase in the absence of high frequency DPOAE on the 1st and 2nd post-operative days, and gradually returns to normal by 72 hours. They used both PTA and DPOAE to asses hearing loss and found DPOAE to be more sensitive at diagnosing and tracking the progress of affected patients.[10]

We observed similar findings in our study and it is evident that there is a temporary threshold shift present on POD 1, 3 and 7; suggesting that hearing loss could be resulting from noise/vibration induced outer hair cell damage from the drilling of opposite diseased mastoid; it later recovered completely to preoperative hearing threshold on POD 30 and 90, indicating complete recovery of outer hair cells, thus explaining the transient sensory threshold shift seen.

Similarly, another study by Da Cruz M et al, explained that otologic drill is not only source but also a strong vibration generator and a strong oscillation is transmitted into the cochlea. Movement of cochlear partition in presence of burr's vibration can cause more damage to cochlea than noise alone.[12] This could explain the loss of functioning of outer hair cells we have observed in our study as well.

In our study, the average duration of drilling was 78.5 minutes with minimum and maximum duration being 50 mins and 140 mins respectively.

In a study by Agarwal N et al, average drilling duration was 78 mins, minimum and maximum being 30 & 160 mins; they observed significant correlation on POD 1, 3, 5 and non- significant correlation on POD 7 and 30.[11]

Our study also found significant correlation between duration of drilling and hearing loss seen on POD 1, 3 and 7; suggesting that longer duration of drilling will affect functioning of contralateral normal ear resulting in more hearing loss on these days; whereas it had no effect on POD 30 & 90 as hearing here was normal, suggesting that duration had no significance on hearing outcome on these days.

CONCLUSION

Hence, we conclude that, drilling in ear surgeries can cause transient temporary threshold shift by affecting functioning of outer hair cells in contralateral normal ear, but it was only transient in nature and recovered completely by 1 month; and the duration of drilling had no significant correlation on long term hearing loss, as recoded by DPOAE.

SNHL occurring in both operated and contralateral normal ear secondary to drilling is well-documented and with increasing use of drilling in various ENT and skull base surgeries, factors under the control of an ENT surgeon should be evaluated and utmost caution exercised to avoid adding on to the burden of the disease itself and instead improve patients' overall quality of life.

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