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Original Research Article

Does drilling affect the hearing of contralateral normal ear after mastoid surgery?

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ABSTRACT

Background: Chronic otitis media (COM) is a recurrent infection of the middle ear and/or mastoid air cells affecting 2-3% of global population. Mastoidectomy is the mainstay of the treatment of COM. Bone drilling during mastoidectomy procedure exposes both the ears to acoustic trauma leading to sensorineural hearing loss. The present study was conducted to assess the possible deleterious effect of drilling on hearing of contralateral normal ear by monitoring pre-operative and post-operative pure tone audibility (PTA) and otoacoustic emissions (OAE). Aims and objectives were to evaluate the effect of drill- generated noise on hearing in non-operated ear during mastoidectomy in terms of hearing loss, its nature and duration and recovery of hearing loss.
Methods: An observational study was carried out in ENT department at SMS medical college and hospital, Jaipur. Total 40 patients were studied. Pre-operative and post-operative PTA and OAE were studied and compared. Mean drilling time during mastoid surgery was also studied.
Results: Out of 40 subjects, maximum patients were 11-20 years of age group (37.5%) with female preponderance (57.5%). All had undergone mastiodectomy. Only 6 (15%) subjects had transient sensorineural hearing loss of contralateral normal ear as determined by comparing pre-operative and post-operative PTA and OAE. The mean recovery time was 2-3 days. The study had shown significant effect of drill generated noise on hearing of contralateral healthy ear following mastoidectomy.
Conclusions: Drill-generated noise can't be lowered to a great extent therefore drilling time should be minimized during mastoid surgeries.

Keywords: Mastoidectomy, Drill-generated noise, Contralateral ear, PTA, OAE

INTRODUCTION

Chronic otitis media (COM) is a recurrent infection of the middle ear and/or mastoid air cells in the presence of a tympanic membrane perforation. (COM) is a common disease, defined as a chronic inflammation in the mucosa of the middle ear and/or mastoid, which affects 2% to 3% of the global population.[1-2]

Mastoidectomy is the mainstay of the treatment which may be cortical/intact canal wall/canal wall down mastoidectomy. Mastoidectomy is a surgical procedure of the temporal bone that opens post auricular air cells by removing the thin bony partitions between them. The common philosophy in mastoid surgery is to create a safe and dry ear. The main indications for performing a mastoidectomy include acute mastoiditis, chronic mastoiditis with its sequelae, and cholesteatoma.[3]

Mastoidectomy is typically performed under general anesthesia in an operating room. Surgeons will need an operating microscope, a high-speed drill with appropriately-sized cutting and diamond-type burrs, otologic instruments, and other minor surgical instruments.[4] In mastoidectomy bone drilling forms an important component which exposes both cochlea to acoustic trauma which can lead to sensorineural hearing loss.[5] In contrast, the contribution that instrument-generated noise makes to cochlea damage during ear surgery has received relatively little attention. Similarly, the drill used during mastoid surgery has an effect on hearing of non-operated healthy ear which we underestimate.[6] Noise generated from the drill has the potential to cause inner ear changes in the contralateral ear. Vibrations induced by drilling of temporal bone can cause mild temporary hearing loss in contralateral healthy ear.[7]

Possible pathways of drill-induced noise transmission to the non-operated ear are through the skull and around the ear. This effect can be investigated and documented using PTA, high frequency audiometry, OAEs and electrocochleography (ECoG).[8]

In this study we studied this possible deleterious effect of drilling on hearing of contralateral normal ear by monitoring pre-operative and post-operative pure tone audiogram, and OAE and determined the duration of the effect and time taken for its recovery as well.

Aim and objectives

Aim

Aim of the study was to evaluate the effect of drill - generated noise on hearing in non-operated ear during mastoidectomy.

Objectives

Objectives were to assess whether the hearing loss is transient or permanent in contralateral ear after mastoid surgery, to find out the duration of temporary hearing loss and degree and types of hearing loss [conductive or sensorineural].

METHODS

The study was carried out in department of otorhinolaryngology, SMS medical college, Jaipur to assess the effect of drill-generated noise on hearing in non-operated ear during mastoidectomy. All participants submitted informed consent before enrolment.

Study type

Study type was of hospital based observational comparative study

Place

Study conducted at otorhinolaryngology department, SMS hospital.

Duration

Study conducted from May 2020 onwards for one year or till the sample size was achieved and two months for data compilation and analysis. The study was approved by the ethics committee of our institution.

Inclusion criteria

Patients with unilateral chronic suppurative otitis media requiring mastoidectomy in their diseased ear and patient having otoscopically and audiologically normal contralateral ear were included in the study

Exclusion criteria

Patient with bilateral COM, patients who had previously undergone mastoid surgery or any surgery in the ear, patients with history of use of ototoxic drugs, past medical history of diabetes mellitus, hypothyroidism, hyperlipidemia, ear trauma and acoustic trauma., patient with pathology in external or inner ear and lack of desire to participate in the study were excluded from the study.

Sample size

Sample size was calculated 40 cases of mastoidectomy (in which drilling is used) as per previous studies shows minimum mean detectable difference of mean 2, SD 2.491 hearing loss post-operative day for 80% power and 0.05 Alpha error.

Methodology

All eligible patients coming during study period at study location were approached by investigator himself and were explained about nature and purpose of study.

After obtaining their written informed consent, detailed history was taken and thorough general and local examination was done.

Furthermore, the patients were subjected to basic preoperative haematological investigations, PTA, OAE, plain X-ray both mastoids (Law's view) and coronal and axial views of plain high resolution computerised tomography temporal bones (in cases of unsafe chronic suppurative otitis media).

After obtaining anaesthetic clearance for surgery, the patients were taken up for mastoidectomy surgery. During the part of the surgery involving drilling of the mastoid bone, noise levels were recorded at multiple points in the surgery using a digital sound level meter. The types of burrs were used during surgery included

round stainless-steel cutting and diamond burrs, of various dimensions, i.e., small (head diameters, HD, ranging between 1 and 3 mm), medium (HD range: 4-6 mm) and large (HD range: 7-10 mm) with speeds of 60,000 revolutions per minute (rpm) and 35,000 rpm, according to the different phases of the surgery. We noted total intraoperative drilling times, and the individual drilling times for each type of drill were recorded.

Postoperatively, beginning from day 1 to day 7 (the day of surgery being considered as day 0), PTA and OAE of the contralateral ear was done for all patients. The patients then followed up at 1, and 3 months postoperatively, at which times PTA and OAE were repeated. All the findings were recorded and statistically analyzed.

Outcome variables

Mean drilling time, mean recovery time, type and degree of hearing loss.

Statistical analysis

The data was collected and complied on Microsoft Excel 2020 and data was analyzed using SPSS 20.0 version. Data were analyzed and statistically evaluated using statistical package for social sciences (SPSS)-PC-20 software (version 20, SPSS, Inc, Chicago, IL, USA). Data were presented as mean and standard deviation (SD) for normally distributed continuous variables and as frequencies for categorical variables. Comparisons were made for means of three variables using ANOVA statistical test for continuous variables and by x^2 analysis for categorical variables.

All statistical analyses were performed taking level of significance at $p<0.05$.

RESULTS

The total of 40 patients presenting in the General Otorhinolaryngology wards, with unilateral chronic suppurative otitis media requiring mastoidectomy in their diseased ear, were enrolled for the study.

Maximum patients 37.5% were aged 11-20 years of age followed by 30% of 21-30 years; with mean age reported to be 25.58 ± 9.14 years (Table 1).

Out of 40 study subjects, 23 were females and rest 17 were males, showing a female predilection (Figure 1).

Out of 40 study subjects, 24 (60%) subjects were with left normal hearing ear i.e., the contralateral side which was studied, and the rest 16 (40%) were with right normal hearing ear.

The mean drilling time was observed to be 66.50±39.50 min.

Out of 40 study subjects, 12 (30%) patients had undergone right intact canal wall mastoidectomy with type-3 tympanoplasty and 11 (27.5%) had right canal wall down mastoidectomy with type-3 tympanoplasty. Minimum 1 (2.5%) had right cortical mastoidectomy.

Table 2 showed the mean PTA (dB) of contralateral normal ear at different time periods. Maximum value of mean PTA was observed to be 13.73±4.08 dB at day1 of post-operative period, followed by 13.55±3.69 dB at day 2. It was observed that from day 4 to 3rd month value of PTA remained consistent (13.16±0.463 db). ANOVA statistical analysis revealed a significant difference ($p<0.05$) statistically in PTA values at different time periods. It was due to the transient hearing loss present in 6 patients out of 40.

Table 3 showed changes observed in OAE in contralateral normal ear. At pre-operative time, OAE showed 100% normal. Maximum 15% change was observed at day 1 and day 2, followed by 12.5% change at day 3. After day 4 till 3rd month, no change was observed. Chi square statistical analysis revealed a significant difference ($p<0.05$) statistically in OAE changes at different time periods.

Out of 40 patients, 34 (85%) showed no hearing loss, whereas 6 (15%) showed sensorineural hearing loss. (Figure 2).

Out of 40 patients, 34 (85%) showed no hearing loss and rest 6 (15%) showed hearing loss for 2 days on pure tone audiometery while on testing otoacoustic emissions 5 patients showed hearing loss for 3 days and 1 patient showed hearing loss for only one day. The rest 34 had no hearing loss on otoacoustic emissions.

According to recovery time, 34 (85%) showed no hearing loss, whereas 5 (12.5%) showed recovery time in 3 days and 1 (2.5%) in 2 days (Figure 3).

Out of 40 patients, 85% showed no hearing loss, whereas 15% showed transient hearing loss.

All patients showed good prognosis.

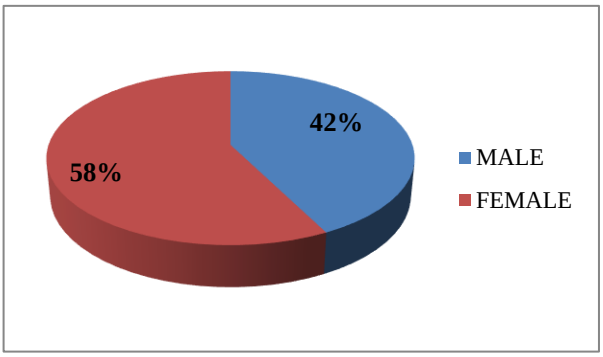

Figure 1: Distribution of subjects according to gender.

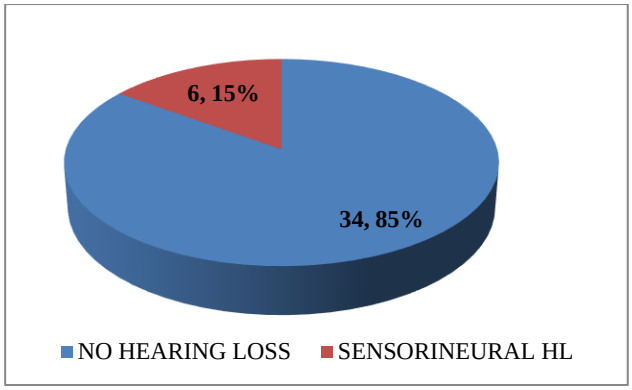

Figure 2: Distribution of subjects according to nature of hearing loss.

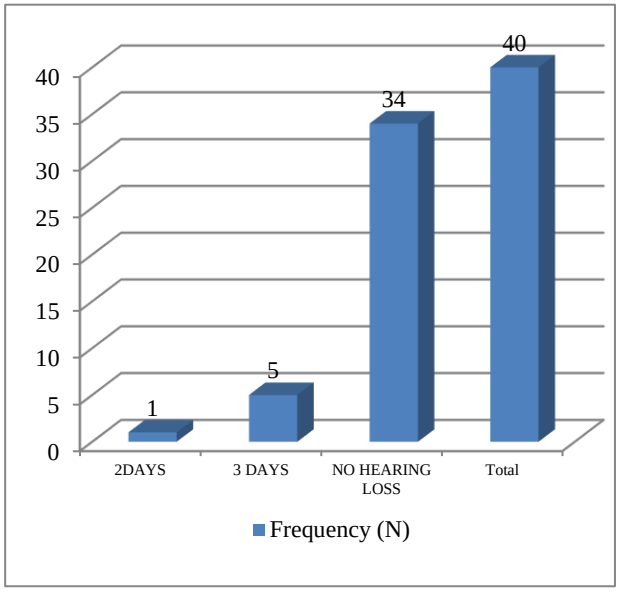

Figure 3: Distribution of subjects according to recovery time.

Table 1: Mean PTA (dB) of contralateral normal ear at different time periods.

Time interval	Mean	SE	SD
Pre-operative	13.1742	0.46884	2.96523
Post operative at day 1	13.7308	0.64523	4.08082
Day 2	13.5535	0.58400	3.69357
Day 3	13.1925	0.46640	2.94978
Day 4	13.1570	0.46394	2.93424
Day 5	13.1570	0.46394	2.93424
Day 6	13.1570	0.46394	2.93424
Day 7	13.1570	0.46394	2.93424
Month 1	13.1570	0.46394	2.93424
Month 3	13.1570	0d.46394	2.93424
Anova statistical analysis	F-statistics	11.231	
	Df	39	
	P value	0.017*	

Table 2: Distribution of subjects according to changes observed in OAE in contralateral normal ear.

Time interval	Frequency (N)	Percentage (%)
Pre-operative (normal)	40	100
Post operative at day 1	6	15
Day 2	6	15
Day 3	5	12.5
Day 4	0	0
Day 5	0	0
Day 6	0	0
Day 7	0	0
Month 1	0	0
Month 3	0	0
Total	40	100
Chi square statistical analysis	X^2	12.001
	P value	0.032*

DISCUSSION

The exposure of the ear to noise is a known, identified factor leading to hearing loss. In various types of surgeries of the ear and ear-related conductive bones, a wide variety of devices are used that are potential sources of high-frequency noise outputs, which accounts for cochlear acoustic trauma.[9] Drills and surgical tools (such as suctions) can especially cause noise-induced hearing loss when used on or adjacent to the ossicular chain and stapes footplate and during work on the mastoid bone, thus drill-generated noise has been ascertained as the main cause of hearing loss in the operated ear and even in the contralateral healthy ear.[10]

Thus the present study was conducted to assess the possible deleterious effect of drilling on hearing of contralateral normal ear by monitoring pre-operative and post-operative pure tone audiogram, and OAE. The study also determined the duration of the effect and time taken for its recovery as well.

To reveal the duration of the negative effect of drill-generated noise on the normal ear, we used serial PTA and OAE measurements performed longitudinally in subjects who had undergone mastoidectomy surgery.

We observed that maximum value of mean PTA was observed to be 13.73±4.08 db at day 1 of post-operative period, followed by 13.55±3.69 db at day 2 It was observed that from day 4 to 3rd month value of PTA remained consistent (13.16±0.463 dB). ANOVA statistical analysis revealed a significant difference ($p<0.05$) statistically in PTA values at different time periods. It is due to 6 patients in which hearing loss present. At pre-operative time, OAE showed 100% normal. Maximum 15% change was observed at day 1 and day 2, followed by 12.5% change at day 3. After day

4 till 3rd month, no change was observed. Chi square statistical analysis revealed a significant difference ($p<0.05$) statistically in OAE changes at different time periods.

Similar to our study, Karatas et al the amplitudes of the OAEs of contralateral normal ears were found affected immediately after surgery and progressive improvement was detected with full recovery at 72-96 h.[11] None of the patients had permanent deterioration in OAE amplitudes. The burs used during mastoid surgery can cause temporary hearing threshold changes in the contralateral ears. This adverse effect recovers spontaneously within 72-96 h postoperative.

In present study, out of 40 patients, 85% showed no hearing loss, whereas 15% showed sensorineural hearing loss. Duration of hearing loss according to PTA, out of 40 patients, 85% showed no hearing loss, whereas 15% showed hearing loss for 2 days. According to OAE, out of 40 patients, 85% showed no hearing loss, whereas 12.5% showed hearing loss for 3 days and 2.5% showed hearing loss for 2days.

On the contrary, in Man and Winerman's survey, no changes in hearing were found in the contralateral ear, and it was thus suggested that there may be no damage exclusively due to drill noise during mastoid surgery.[12]

Also, Urquhart et al showed that sensorineural hearing loss soon after mastoid surgery was not due to the noise generated by the drill and concluded that in the event of any hearing loss during this period, other causes should be sought.[10] It seems that besides noise generated by drilling, other underlying factors may affect the normal hearing threshold, but according to recent reports, demographic characteristics, type of surgery, and even the parameters of drills may not have any effect.

In our study, out of 40 patients, 85% showed no hearing loss, whereas 15% showed sensorineural hearing loss which is transient and return to normal in few days. In PTA, out of 40 patients, 15% showed reversal of hearing loss in 2 days and in OAE 12.5% showed reversal of hearing loss in 3 days and 2.5% in 2days. All patients showed good prognosis.

Similar to our study, Migirov et al observed transient hearing changes in the contralateral normal ear in 9 out of 13 patients during the postoperative period following mastoidectomy.[13] In contrast to our study, Urquhart et al and Hornung et al did not observe any significant hearing change during the postoperative period in the contralateral ear following mastoidectomy.[10,14]

Tympanomastoid surgery and drilling during ear surgery can cause significant acoustic trauma and transient sensory hearing loss to the contralateral ear. Drill generated noise cannot be lowered to a great extent. Otological surgeons must minimise drilling time during surgical management of COM. Routine mastoidectomy in patients with dry ear should be discouraged unless necessary. Drill induced noise as a cause of hearing loss should be considered during mastoid surgery.

However, each study has its own limitations. The major limitations were limited sample size and sample size limited only to Indian population which might prejudice any comment on its efficacy and reliability. The present study did not assess the effect of different noise frequencies. Role of different kinds and sizes of burrs and drill used in mastoid surgery was also not evaluated.

CONCLUSION

In conclusion, we studied 40 patients in which 6 patients had sensorineural hearing loss which is transient in nature and return to normal in few days. in majority of the cases, the cause of the hearing loss can be attributed to trauma because of noise and vibration produced by the drills. There was significant correlation between the influence of drill generated noise on hearing of contralateral healthy ear following mastoid surgery ($p<0.05$). Otological surgeons must minimise drilling time during surgical management of COM. Routine mastoidectomy in patients with dry ear should be discouraged unless necessary. Drill induced noise as a cause of hearing loss should be considered during mastoid surgery.

Recommendations

The similar study can be replicated with larger sample with different demographic characteristics. Further study should be conducted comparing the effect of different types of ear surgeries on hearing loss in contralateral healthy ear. Further studies should be conducted evaluating effect of different frequencies of noise. Role of different kinds and sizes of burrs and drills should be taken into consideration in future studies.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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