

EFFECT OF DRILL INDUCED NOISE DURING MASTOID SURGERY ON HEARING STATUS OF CONTRALATERAL EAR

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ABSTRACT

BACKGROUND

Hearing morbidity of a healthy ear resulting from drill induced noise while operating the diseased may add on to the actual morbidity arising due to an unhealthy ear. We wanted to study the effect of drill induced noise during mastoid surgery on hearing status of contralateral non-operated ear.

METHODS

This was a prospective interventional study. 64 patients were enrolled in the study. Audiological tests on patients were done postoperatively after 6 hours, 48 hours, 72 hours, 96 hours and 6 months.

RESULTS

Most subjects (40.62 %) were in the age group of 10-20 years while only 7.81% subjects were \geq 40 years of age. Demographic statistics revealed that majority of the cases were Hindus (92.12%) followed by Muslims (7.81%). PTA revealed that hearing thresholds were not affected at lower frequencies of 250-1000 Hz unlike observations at 4 KHz, 6 KHz and 8 KHz which reflected a certain change though did not differ significantly between time points. Mean hearing threshold changes, considering all frequencies, were 4.4 dB after 6 h, 4.48 dB after 48 h, and 9.1 dB, after 72 h of the surgery which was statistically significant at 6 KHz and 8 KHz. In the present study, the hearing improvement after surgery was considered successful as the air-bone gap closure of \geq 10 dB was noted in 52 cases (81.25%) with the average air-bone gap closure being 15.2 dB on PTA done at 3 months post operatively.

CONCLUSIONS

A wise choice of operative technique and improving range and quality of drilling equipment can be helpful in reducing the morbidity load effectively. Tympanomastoid surgery and drilling during ear surgery has the potential to cause significant acoustic trauma and transient sensory hearing loss in the contralateral ear. Though drill-generated noise cannot be reduced to any great extent, still in order to lower the acoustic trauma in an ear surgery to the contralateral ear, parameter of burr and drill must be known preoperatively.

KEY WORDS

Noise, Mastoid, Hearing

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BACKGROUND

Mastoid bone is the bony prominence that can be felt just behind the ear. It contains a number of air spaces and connects with the air space in the middle ear. For this reason, ear diseases in the middle ear can extend into the mastoid bone. Mastoid disease is potentially life threatening therefore historically the management was focused on creating a safe and if possible dry ear. Today, our aims are higher with a greater emphasis on function. To achieve this, we have three tools that potentiate our success.

Better knowledge of the anatomy, greater clarity and choice of operative technique and improving range and quality of equipment. The Noise-induced damage and related sensorineural hearing loss during ear surgery are a well-discussed issue, having the probability between 1.2 and 4.5%.¹ Despite the fact that noise generated by drilling could easily be transmitted to the contralateral cochlea via bone, postoperative hearing status of the is contralateral ear received less interest. Prolonged noise insult to the contralateral ear can certainly have potential risk for temporary hearing loss.

Since the outer hair cells (OHCs) are the initial target of acoustic trauma,² the damage to OHCs will cause a reduction in otoacoustic emissions (OAEs), and it will be logical to assess the non-operated, normal- functioning cochlea by OAE detection methods to monitor changes caused by mastoid surgery on the contralateral side. The outer hair cells determine overall sensitivity and frequency selectivity of the auditory system.^{3,4,5} The expected hearing loss may be missed if pure tone audiometry is utilized.^{6,7}

Drill-induced contralateral temporary hearing loss by changes in amplitudes of distortion product OAEs (DPOAEs),

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longitudinal recovery of this temporary hearing loss has not been studied before. This study was designed to evaluate hearing in the contralateral normal ear before and after the mastoid surgery in a longitudinal manner and find out the duration of this temporary hearing loss. The damage to hearing may be temporary or permanent (As a result of irreversible changes in the cochlea).⁸ Sixty-four patients requiring mastoid surgery in their diseased ears, having contralateral normal ear were thus evaluated in this study. Pure tone audiometry and otoacoustic emissions (OAEs) were utilized for baseline evaluation.

Aims and Objectives

1. To assess the effect of drill induced noise during mastoid surgery on hearing status of contralateral non-operated ear.
2. To evaluate whether the deafening effect, if any, is temporary or permanent.

METHODS

The following study was carried out at E.N.T department of Lala Lajpat Rai and associated hospitals, GSVM Medical College, Kanpur extended over a period of 1 year and 9 months. 64 patients were enrolled in the study. Audiological tests on patients were done postoperatively after 6 hours, 48 hours, 72 hours, 96 hours and 6 months. Patients requiring mastoid surgery in their unilateral diseased ears and having otoscopically and audiological normal contralateral ear, were enrolled. Informed consent and Institutional ethical clearance were duly taken. 64 patients were enrolled in the study. Detailed clinical history, elaborate general and systemic examination were duly done. Routine blood tests were performed. Audiological tests on patients were done postoperatively after 6 hours, 48 hours, 72 hours, 96 hours and 6 months.

Study Design

It was a prospective interventional study.

Inclusion Criteria

- Patients > 6 years of age.
- Unilateral unsafe chronic suppurative otitis media (CSOM) with normal hearing of contralateral ear.
- Unilateral mastoid abscess with CSOM with normal contralateral ear.
- Unilateral cholesteatoma with CSOM with normal contralateral ear.

Statistical Analysis

Data was evaluated using SPSS version 23. Descriptive statistics was used for data analysis using indexes like mean and standard deviation. Survival analysis was done using Kaplan Meier test to examine recovery rates. Paired t-test was applied to compare pre and post-op data. Statistical significance was taken with p value ≤ 0.05

RESULTS

Most subjects (40.62 %) were in the age group of 10-20 years while only 7.81% subjects were ≥ 40 years of age. Demographic statistics revealed that majority of the cases

were Hindus (92.12%) followed by Muslims (7.81%). PTA revealed that hearing thresholds were not affected at lower frequencies of 250-1000 Hz unlike observations at 4 KHz, 6 KHz and 8 KHz which reflected a certain change though did not differed significantly between time points. Mean hearing threshold changes, considering all frequencies, were 4.4 dB after 6 h, 4.48 dB after 48 h, and 9.1 dB, after 72 h of the surgery which was statistically significant at 6 KHz and 8 KHz.

Frequency (Hz)	Pre-Op (dB)	Post-Op 6 hrs. (dB)	Post-Op 48 hrs. (dB)	Post-Op 72 hrs. (dB)	Post-Op 96 hrs. (dB)	Post-Op 6 Months (dB)	± SD	p
250	5.65 ±0.34	5.66± 0.56	5.45± 0.44	5± 0.38	7± 0.43	7± 0.56	0.84	> 0.05
500	6.35 ±0.48	6.35± 0.45	6.35± 0.49	4.5± 0.41	6± 0.24	6± 0.33	0.71	> 0.05
1000	6.35 ±0.44	6.35± 0.46	6.35± 0.38	4.7± 0.48	7± 0.42	7± 0.45	0.84	> 0.05
2000	6.41 ±0.34	6.41± 0.57	6.66± 0.49	4.8± 0.40	6± 0.38	6± 0.42	0.66	> 0.05
3000	7.32± 0.55	7.32± 0.51	7.11± 0.54	7± 0.40	7.3± 0.44	7.38± 0.43	0.15	> 0.05
4000	8.9± 0.54	9.7± 0.34	9.8± 0.39	9.7± 0.45	8.8± 0.44	8.89± 0.51	0.46	> 0.05
6000	8.8± 0.43	10.21± 0.42	9.7± 0.50	7.9± 0.36	8± 0.34	8± 0.38	0.98	> 0.05
8000	9.9± 0.32	12.6 ±0.39	11.8± 0.41	9± 0.51	8± 0.33	8± 0.46	1.90	> 0.05
± SD	1.5	2.4	2.2	2.1	1.0	1.0		

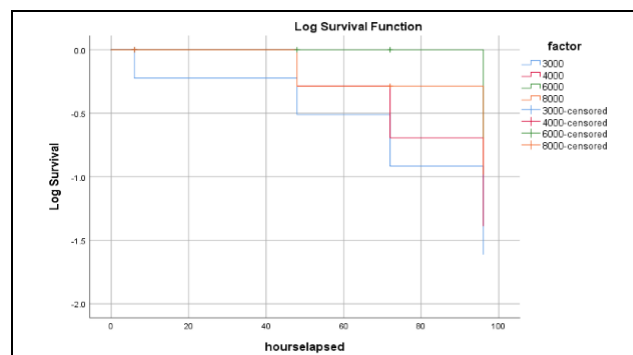
Table 1. Mean ± SD Hearing Threshold (dB) at Different Frequencies via PTA

Test applied- Repeated measure ANOVA.

Frequency (Hz)	After 6 hrs.	After 48 hrs.	After 72 hrs.	After 96 hrs. & 6 Months	p
3000	12	3	0	0	Log Rank (0.458) Breslow (0.343) Tarone-Ware (0.386)
4000	10	3	0	0	
6000	15	2	1	0	
8000	13	3	2	0	

Table 2. Survival Comparison of Hearing Loss (dB) in Subjects with Respect to Frequency in PTA

Test applied- Chi-Square test

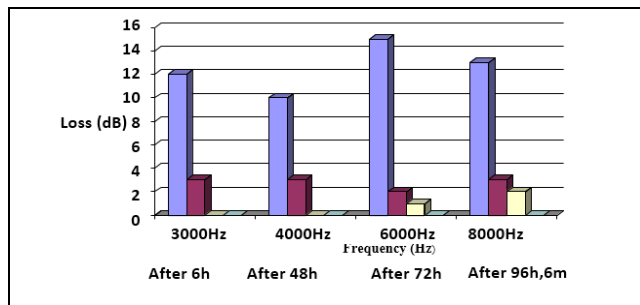


Graph 1. Survival Comparison of Hearing Loss (dB) in Subjects with Respect to Frequency in PTA

Air Bone Gap Closure (dB)	Frequency	% Sample	Average Air Bone Gap Closure (dB)
≥10	52	81.25	15.2
<10	12	18.75	
Total	64	100	

Table 3. Hearing Improvement in Subjects

Of the 12 cases with less improvement, 5 cases were those who had graft failure.



Graph 2. Comparison of Hearing Loss in Subjects with Respect to Frequency in PTA

Time of Estimation	Pre-Post Threshold difference (Loss)		p-Value*
	Mean (dB)	±SD	
After 6 h at 2 KHz	-0.69	2.87	0.12
After 6 h at 3 KHz	-2.56	5.9	0.05
After 6 h at 4 KHz	-3.12	4.98	0.01
After 6 h at 6 KHz	-7.89	8.1	0.06
After 6 h at 8 KHz	-9.82	8.6	0.002
After 48 h at 3 KHz	-10.12	4.6	0.5
After 48 h at 4 KHz	-1.76	4.7	0.00
After 48 h at 6 KHz	-1.23	5.1	0.00
After 48 h at 8 KHz	-5.45	6.7	0.01
After 72 h at 3 KHz	-4.23	5	0.45
After 72 h at 4 KHz	-1.22	6	0.8
After 72 h at 6 KHz	-3.24	6	0.3
After 72 h at 8 KHz	4.12	8	0.06

Table 4. Mean Hearing Threshold Difference Pre and Postoperative in PTA

p-Value* > 0.05 [Insignificant], ≤ 0.05 [Significant], Test applied; Paired t-test.

Estimation Time	Paired difference (Loss)		p Value
	Mean (dB)	± SD	
After 6 h at 2 Hz	-1.06	4.1	0.01
After 6 h at 4 Hz	-9.87	8.1	0.00
After 6 h at 6 Hz	-12.91	9.6	0.40
After 6 h at 8 Hz	-16.83	8.8	0.02
After 48 h at 2 Hz	-11.12	7.9	0.01
After 48 h at 4 Hz	-3.11	5.9	0.04
After 48 h at 6 Hz	-7.01	9.1	0.00
After 48 h at 8 Hz	7.12	8.9	0.05
After 72 h at 4 Hz	-1	3.7	0.06
After 72 h at 6 Hz	-3.6	6.9	0.02
After 72 h at 8 Hz	-3.82	6.4	0.01

Table 5. Pre & Post-Op Hearing Level difference (SPL) in DPOAE

p- Value* > 0.05 [Insignificant], ≤ 0.05 [Significant], Test applied: Paired t-test.

DISCUSSION

In the present study the minimum age for the study subjects was 7 years and the maximum age was 48 years, mean 27.2 years ± SD = 10.23. Most subjects (40.62 %) were in the age group of 10-20 years while only 7.81% subjects were ≥ 40 years of age. Baradaranfar MH et al. (2015)⁹ reported the mean age as 35.57 years ± 11.61 (median 32.5 years, range 16 to 62 years).

Demographic statistics revealed that majority of the cases were Hindus (92.12%) followed by Muslims (7.81%). Socioeconomically most cases belonged to social class IV (32.81%) followed by class V (29.68%), class III (20.31%), class II (14.06%) and class I (3.12%).

Repeated measure ANOVA with Greenhouse-Geisser correction determined that mean threshold did not differed significantly between time points. (Table 1)

The mean level of hearing loss based on PTA (Table 4), revealed a significant difference (p ≤ 0.05), after surgery compared to that before surgery at frequencies of 3000-8000 Hz. It also revealed a significant difference (p ≤ 0.05) in

mean hearing level at 48 h & 78 h post operatively at 6 KHz & 8 KHz compared to that before surgery. Mean hearing threshold changes, considering all frequencies, were 4.4 dB after 6 h, 4.48 dB after 48 h, and 9.1 dB, after 72 h of the surgery which was statistically significant at 6 KHz and 8 KHz. There was no significant change in mean hearing threshold at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz (Table 1) based on the PTA. It was similar to a study conducted by Baradaranfar MH et al. (2015).

Furthermore, according to DPOAE analysis (Table 5), the mean difference in the level of hearing found at 6 h after surgery at frequencies of 2000, 4000 and 8000 Hz was statistically significant (p ≤ 0.05). Where on one hand, the mean difference in hearing levels at 48 h after surgery compared to pre-op results were significant at the frequencies of 2000 Hz, 4000 Hz, and 8000 Hz; the difference in hearing levels at 72 h after surgery compared to pre-op results was significant at the frequencies of 6000 Hz, and 8000 Hz.

The survival of hearing loss based on PTA, in non-operated ears at frequencies of 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz was 48.2%, 37.3%, 49.9%, and 48.6%, 6 h after surgery; 12.4%, 8.9%, 11.1%, and 14.1%, 48 h after surgery; and 0%, 0%, 2.8%, and 2.3%, 72 h after surgery. At all frequencies at 96 h and 6 months after surgery, the survival rate of hearing loss was determined to be 0%. (Table 2) (Graph 1)

Baradaranfar MH et al. 2015 in their study also reported similar findings with respect to the survival of hearing loss based on PTA, the survival rate in non-operated ears at frequencies of 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz was 44.4%, 36.4%, 51.7%, and 47.4%, 24 h after surgery; 11.1%, 9.1%, 10.3%, and 13.2%, 48 h after surgery; and 0%, 0%, 3.4%, and 2.6%, 72 h after surgery. At all frequencies at 96 h after surgery, the survival rate of hearing loss was determined to be 0%. In this regard, survival rate in non-operated ear based on DPOEA at frequencies of 2000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz was 96.4%, 94.3%, 94.3%, and 99.3%, 6 h after surgery; 74.9%, 86.7%, 89.2%, and 97.5%, 24 h after surgery; 49.9%, 64.0%, 70.1%, and 82.4%, 48 h after surgery; and 25.0%, 33.1%, 38.8%, and 54.5%, 72 h after surgery, respectively.

In the present study (Table 3) (Graph 3) the hearing improvement after surgery was considered successful as the air-bone gap closure of ≥ 10 dB was noted in 52 cases (81.25%) with the average air-bone gap closure being 15.2 dB on PTA done at 3 months post operatively. In the remaining 12 cases that failed, the graft was not taken up in 5 cases while the other 7 had an improvement < 10 dB.

Regarding patients' personal perception of their hearing status, the similarity in hearing levels before and after surgery at 6 h, 48 h, 72 h after surgery was reported in 18.7%, 36.5%, 47.9, and 97.1% of cases respectively.

Doménech et al. reported a measurable hearing loss in the upper limits of the audible frequencies in 9 patients (37.5%) and it was considered important in 4 of them (16.7%). This hearing loss was recorded above the upper frequency limit of conventional audiometer.¹⁰

Present study recorded that the survival rate of hearing loss was 0% (Graph 1) for all tested frequencies with no significant difference (Table 2) unlike Baradaranfar MH 2015 who found that after the various individual fluctuations, the

DPOAE amplitudes remained decreased in some of the patients at the end of the study.

The mean hearing recovery time for non-operated ears based on DPOAE in our study was 57.38 ± 26.35 h (2000 Hz), 64.13 ± 27.57 h (4000 Hz) 66.51 ± 28.26 h (6000 Hz), and 76.18 ± 21.23 h (8000 Hz). Likewise, Karatas et al. studied the amplitudes of the OAEs of contralateral normal ears which where was found to be affected immediately after surgery, but showed progressive improvement with full recovery in 72-96 h. None of the patients had permanent deterioration in OAE amplitude.¹¹

CONCLUSIONS

Tympanomastoid surgery and drilling during ear surgery has the potential to cause significant acoustic trauma and transient sensory hearing loss in the contralateral ear. Though drill-generated noise cannot be reduced to any great extent, still in order to lower the acoustic trauma in an ear surgery to the contralateral ear, parameter of burr and drill must be known preoperatively. Otological surgeons must minimize drilling time during surgical management of ear surgery especially in older subjects who are more vulnerable to vibration and noise than younger subjects.^{12,13}

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