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Evaluation of outer hair cells function of non-operated ear after mastoid drilling using distortion-product otoacoustic emissions

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Abstract

Aim: To analyze the effect of acoustic and mechanical trauma of drilling on the outer hair cell function of the non operated ear using distortion-product otoacoustic emissions (DPOAE's) after mastoidectomy and its relation with the duration of drilling, age, and gender of the patient along with duration and permanency of the effects. **Study Design:** Observational study. **Materials and Methods:** Screening DPOAE's were recorded preoperatively, immediate postoperative period, one hour postoperatively, 1st and 7th postoperative days in the normal ear in 94 patients who underwent tympanomastoidectomy for unilateral chronic suppurative otitis media (CSOM). DPOAE's were measured using Neuro-audio-screener (Neurosoft Inc.) at 1.5 KHz, 2.1 KHz, 3.3 KHz, and 4.2 KHz. If DPOAE's were absent preoperatively, the patients were not evaluated further and patients who had absent DPOAE's post-operatively were successively followed till DPOAE's were regained. **Results:** Of the 94 patients included, in 62 patients DPOAE's were present preoperatively. Out of these 62, in 30 patients DPOAE's were absent immediate postoperatively. On repeat testing, DPOAE's were absent in 20 patients after 1 hour and in 8 patients after 1 day. On re-evaluation of these 8 patients after 1 week all of them had regained the DPOAE's. In terms of duration of drilling, 66.6% patients in immediate post operative period, 90% patients in 1-hour post operative and 100 % patients on post operative day 1, having absent DPOAE's had drilling time more than 60 minutes. Patients more than 30 years of age are affected more, but there is no preponderance for any gender. **Conclusion:** Nonoperated ear does have the effect of acoustic and mechanical trauma by vibration transmitted from another side during drilling of the operative ear mastoid bone. This effect is temporary and depends on the duration of drilling also.

Keywords: Distortion-product otoacoustic emissions (DPOAE's), Tympanomastoidectomy, Outer hair cells (OHCs).

INTRODUCTION

Chronic suppurative otitis media (CSOM) is one of the common diseases affecting the ear in India. It is defined as chronic inflammation of the mucoperiosteal lining of the middle ear cleft, causing persistent ear discharge and progressive deafness, and the patient is prone to developing intracranial and extracranial complications [1,2]. Mastoidectomy is performed as part of surgical treatment of chronic suppurative otitis media. In mastoidectomy drilling forms an important component and the sound by the drill can be up to 107 Db [3] which is above the safe limit levels. Kylén and Arlinger were able to determine that the operated ear was exposed to noise levels of about 100 Db and more, thus indicating an almost similar level of exposure in the non-operated ear [4].

Drilling can cause acoustic trauma to the contralateral cochlea by affecting outer hair cells (OHCs) which cause reduced otoacoustic emissions (OAEs). Otoacoustic emissions are low-level sounds that are recordable in the external auditory meatus and reflect the active mechanism of the OHCs in the cochlea.These are absent if there is damage to the OHCs [5] so the effect in the contralateral ear is better judged by using distortion-product otoacoustic emissions (DPOAE's) which asses the OHCs function. Since DPOAE's do not rely on behavioral response and are quick to obtain, they are strongly proposed to monitor cochlear damage. DPOAE's are stable and unaffected by the

the action of middle ear reflexes or anesthesia [6,7]. Various studies have described the effect on outer hair cells and changes in the contralateral normal ear due to acoustic trauma by drilling [4, 8,9].

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The aim of this study is to analyze the effect of noise-induced trauma and vibratory trauma to the nonoperative contralateral ear following mastoidectomy in the diseased ear by monitoring pre-operative and serial post-operative DPOAE's and determining the duration of the effects and time taken for their recovery as well.

MATERIALS AND METHODS

We conducted a clinical observational prospective study for a period of 24 months (November 2016- November 2018) in a tertiary care hospital of Mysuru, Karnataka. The study was approved by the institutional ethical committee. Written informed consent was obtained from all patients included in the study. Inclusion criteria was patients presenting to the department of otorhinolaryngology with chronic or recurrent ear discharge for more than 12 weeks, diagnosed to have unilateral chronic suppurative otitis media on clinical examination and willing for mastoidectomy (either cortical mastoidectomy or modified radical mastoidectomy), with normal otoscopic findings, pure-tone audiometry, and DPOAE values in the contralateral ear. Patients with bilateral middle ear disease, previously operated cases of the mastoid surgeries, patients with sensorineural hearing loss, patients with cochlear damage and patients using ototoxic drugs were excluded from the study.

Preoperatively the patients underwent thorough history taking and clinical examination, the findings of which were recorded. Furthermore, the patients were subjected to basic preoperative hematological investigations. Hearing assessment of all the 94 patients was done by Pure Tone Audiometry (PTA) and screening DPOAE's. Screening DPOAE measurements were recorded in the contralateral normal ear during the preoperative, immediate postoperative periods, 1 hour post-operative and on the 1st and 7th postoperative days.

Screening DPOAE's were measured by Neuro-Audio-Screener (Neurosoft Inc.) which gives the result as either PASS or REFER. Initially, a baseline waveform was obtained and the tones were presented at frequencies of 1.5 kHz, 2.1 kHz, 3.3 kHz, and 4.2 kHz, and responses were picked up. The difference between the baseline waveform and the response waveform was taken as SNR. A SNR of ≥ 6 dB indicates the presence of a DPOAE's at that particular frequency and a PASS outcome was reported when DPOAE's were present for more than 50% of test frequencies, otherwise the outcome was reported as REFER. PASS indicates that the DPOAE's were present and REFER indicates that the DPOAE's were absent.

If the DPOAE were absent in preoperative assessment those patients were not evaluated further and those patients who had absent DPOAE's post operatively were successively followed till DPOAE's were regained.

RESULTS

Out of 94 cases studied aged between 17-48 years, 60 (63.8%) were males and 34 (36.17%) were females.Out of the 94 patients included in the study, in 62 (66%) patients DPOAE's were present in preoperative evaluation while in 32 (34%) patients DPOAE's were absent.

In the immediate postoperative period, out of these 62 patients who underwent mastoidectomy, in 32 (51.6%) patients DPOAE's were present and in 30 (49%) patients DPOAE's were absent.

When the test was repeated after 1 hour in these 30 patients, we found that in 20 (66.6%) patients DPOAE's were still absent while the rest 10 patients had regained DPOAE's.

On post-operative day 1, ie. after 24 hours, 12 (60%) patients out of these 20 regained their outer hair cell function while in 8 (40%) still DPOAE 's were absent.

On re-evaluation of DPOAE's of these 8 patients after 1 week we found all of them had normal outer hair cell function. i.e. DPOAE's were present.

Out of the 62 patients who had DPOAE's in the preoperative period, 54.9% (34) were operated as cortical mastoidectomy and 45.1% (28) were operated as modified radical mastoidectomy.

In cortical mastoidectomy, in 52.9 % (18/34) Patients, DPOAE's were absent in the immediate postoperative period and after 1 hour postoperative there were only 8 patients in this category. On postoperative day 1, only in 2 patients out of these 8 patients DPOAE's were absent, and all these patients had normal outer hair cell function by 1 week.

Of the patients who underwent modified radical mastoidectomy, in 42.8% (12) DPOAE's were absent immediately after the procedure, which remained the same for all these 12 patients even after 1-hour postoperatively. On postoperative day 1, in 50 %(6) of these 12 patients DPOAE's were present, and by 1 week, in all patients DPOAE's were present.

In terms of duration of drilling, we divided our surgeries into two groups, one group had those patients who had drilling time of less than 60 Minutes and the other group had drilling time of more than 60 Minutes

In the immediate postoperative period, 66.6% (20/30) of the patients not having DPOAE's had drilling time of more than 60 minutes and 33.3% (10/20) had drilling time less than 60 minutes.

After 1 hour, in 90% (18/20) of the patients not having DPOAE's, drilling was more than 60 minutes.And on post-operative day 1, we had 8 patients who had absent DPOAE's absent and all were from the group where drilling was done for more than 60 minutes.

As per age, we had two groups of patients; group 1 (less than 30 years) and group 2 (more than 30 years). In the immediate postoperative period, out of 30 patients not having DPOAE's, 14 were from group 1 and 16 were from group 2. After 1 hour postoperatively we had equal patients in both the groups who did not have DPOAE's. After postoperative day 1, out of 8 patients who did not have DPOAE's 6 were from group 2 i.e. age more than 30 years.

On analyzing gender we found that out of 30 patients who did not have DPOAE's in the immediate postoperative period, 18 were females, and on analyzing these patients after 1 hour we had 12 females out of 20 patients who did not have DPOAE's. On postoperative day 1, DPOAE's were absent in 6 male and 2 females.

DISCUSSION

Noise generated from the drill has the potential to cause inner ear changes in the contralateral ear. The literature on the influence of drilling during mastoid surgery on the opposite ear is controversial, with Tos et al. and Hallmo et al. failing to find significant postoperative hearing changes in the ears contralateral to the mastoidectomy side [10, 11]. Urquhart et al. and Hornung et al. did not observe any significant hearing change during the postoperative period in the contralateral ear following mastoidectomy [12, 13] while Lela Migirov et al., observed transient hearing changes in the contralateral normal ear in 9 out of 13 patients during the postoperative period following mastoidectomy [9]. In the current study, the effect of drill-generated noise on the nonoperated normal ear was studied using DPOAE's which gave an assessment of the OHCs likely to be damaged during noise exposure. DPOAE measurements have the capability to differentiate the mild variations in the cochlea on exposure to noise. In our study, we found recovery in all of our patients.

Table 1: Evaluation of DPOAE's in preoperative and postoperative period

DPOAE's	PRESENT	ABSENT	TOTAL
Preoperative	62(66%)	32 (34%)	94
Immediate Post Operative	32 (51.6%)	30 (48.3%)	62
1 Hour Post Operative	10 (33.3%)	20 (66.6%)	30
Post Operative Day 1	12 (60%)	8 (40%)	20
Post Operative Day 7	8 (100%)	0	8

Table 2: Type of surgery in patients having DPOAE's in preoperative period

Type of Surgery in Patients Having DPOAE s Preoperatively	Number of Patients
Cortical mastoidectomy	34 (54.9 %)
Modified radical mastoidectomy	28 (45.1 %)
Total	62

Table 3: Evaluation of DPOAE's in patients who underwent cortical mastoidectomy

Cortical mastoidectomy	DPOAE's present	DPOAE's absent	Total
Immediate post operative	16 (47 %)	18 (52.9 %)	34
1 hour post operative	10 (55.5%)	8 (45.5%)	18
Post operative day 1	6 (75%)	2,25%	8
Post operative day 7	2 (100 %)	0	2

Table 4: Evaluation of DPOAE's in patients who underwent modified radical mastoidectomy

Modified Radical Mastoidectomy	DPOAE's present	DPOAE's absent	Total
Immediate post operative	16 (57.1%)	12 (42.8%)	28
1 hour post operative	0	12 (100 %)	12
Post operative day 1	6 (50 %)	6 (50 %)	12
Post operative day 7	6 (100 %)	0	6

Table 5: Correlation of DPOAE's and duration of mastoid drilling

DPOAE's Absent in	< 60 minutes drilling time	>60 minutes drilling time	Total
Immediate post operative	10 (33.3%)	20 (66.6%)	30
1 hour post operative	2 (10 %)	18 (90 %)	20
1 day post operative	0	8 (100 %)	8
7 days post operative	0	0	0

Table 6: Correlation of DPOAE's and age group

DPOAE's Absent in	Group 1,< 30 years (n=30)	Group 2 >30 years (n=64)	Total=94
Immediate postoperative	14	16	30
1-hour postoperative	10	10	20
1-day postoperative	2	6	8
7 days post operative	0	0	0

Table 7: Correlation of DPOAE's and gender

DPOAE's Absent in	Male (54)	Female (40)	Total =94
Immediate post operative	12	18	30
1-hour postoperative	8	12	20
1-day postoperative	6	2	8
7 days post operative	0	0	0

While Da Cruz et al. reported reversible drill related DPOAE's changes in the contralateral ear in 2 out of 12 cases [14], in the present study, we were able to observe a recovery in the DPOAE's on the 7th postoperative day. This was similar to the study by Shenoy et al. who noticed complete recovery by the 7th day in previous studies [15].

While Kartas et al. noticed complete recovery in 3 days [1], Migirov et al. observed complete recovery by the end of 4 weeks [9].

Goyal et al. in their study found complete recovery in 10 out of 15 patients where changes or reductions occurred in OAEs postoperatively, and 'incomplete recovery' or persistent deficit in 5 patients at the end of the postoperative follow up period at 72 hours [17].

Palva et al. and Shenoy et al. observed that the nonoperated ears in patients who underwent mastoidectomy were more prone to hearing loss and more severely in patients with increased drilling times [15,16], which is similar to the results in our study.

The majority of patients who had absent DPOAE's in the immediate postoperative period (66.6%), 1-hour postoperative period (90%), and on postoperative day 1 (100%) had drilling time of more than 60 minutes.

CONCLUSION

Our study highlights the fact that the non-operative ear does have the effects of acoustic trauma and mechanical trauma by vibration transmitted from the contralateral side during drilling of the mastoid bone of the diseased side.

Conflict of Interest

All the authors declare they have no conflicts of interest and have not received any funding.

Informed Consent

Informed and written consent was obtained from all the patients in the study.

Ethical Approval

All procedures performed in the study were in accordance with the ethical standards of the institution.

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