Original Article

Effect of drill-induced noise on hearing in non-operated ear

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Abstract

Background: The aim of this study was to evaluate the effect of drill-generated noise on hearing loss in non-operated ear and if any, was temporary or persistent.

Materials and Methods: In this prospective clinical study, 23 patients who had undergone mastoidectomy and normal contralateral hearing were enrolled. Patients were evaluated preoperatively and postoperatively (1 and 7 days) following surgery using low and high-frequency pure tone audiometry (PTA) and low and high-frequency transient evoked and distortion product otoacoustic emission (DPOAE) testing.

Results: Comparing preoperative and 1-day after surgery, PTA averages were significantly different at low frequencies, but no statistical significant differences were observed at 0.25 KHz and high-frequencies. Comparing 1-day after surgery and 7 days after surgery showed that, PTA averages at 0.5, 2 and 2 KHz were significantly different with no significant differences at the other average of thresholds in low and high frequencies; PTA average at 1 KHz was significantly different with, no significant differences at the other averages of thresholds in low and high frequencies. DPOAEs showed a significant difference preoperative and 1-day after surgery, 1-day and 7 days after, but DPOAEs were not significantly different. Transiently evoked otoacoustic emissions (TEOAEs) had a significant difference preoperative and 1-day after surgery, 1-day and 7 days after but when comparing preoperative and 7 days after surgery, TEOAEs were not significantly different.

Conclusions: Drill-induced noise during ear surgery (mastoidectomy) can cause reversible changes in PTA, DPOAEs and TEOAEs in the non-operated ear.

Key Words: Distortion product otoacoustic emissions, drill-induced noise, hearing loss, mastoidectomy, pure tone audiometry, transiently evoked otoacoustic emissions

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INTRODUCTION

Exposure to a short time, high-intensity noise can cause either temporary or permanent hearing loss (HL). Bone drilling is an essential part of otological surgery and the drill-generated noise during chronic ear surgery, as well as surgical trauma, has been shown as a cause of sensorineural HL in the operated ear.[1] The possible contribution of drill-generated noise during tympanomastoid surgery to postoperative sensorineural HL is excess of 100 dB.[2] Although, the amount of energy transmitted to the cochlea depend on the noise levelss produced and the duration of exposure.[3,4] The frequency of a

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permanent sensorineural HL after tympanomastoid surgery is 1.2–4.5% in the operated ear.[5,6] The effect of drill-induced trauma on the cochlea in ear surgery has been investigated previously using pure tone audiometry (PTA),[7] high frequency audiometry,[8] otoacoustic emissions (OAEs),[9,10] and electrocochleography.[11]

The contralateral ear is subjected to the drill noise, but the effect of drill-generated noise on the non-operated ear has been discussed even less. Although there is only a 5–10 dB decrease in noise intensity on the contralateral side.[6,12] A drill-induced noise is transmitted to the non-operated ear in two ways: Through the skull and around the ear.[4] Distortion product OAEs (DPOAE) are elicited by the nonlinear characteristics of the cochlear response and have been used among the different methods of detecting a possible alteration to the contralateral ear for assessment of sensory HL. DPOAE is the best existing objective test that can be used in the operating and operating room immediately after surgery for quick evaluations of the outer hair cell (OHC) function.[7,11,13,14]

In our experience, some patients showed transient sensory hears loss in the normal contralateral ear in operating room. Hence, this study designed to determine whether HL if any, was temporary or persistent.

MATERIALS AND METHODS

This clinical trial study was performed on the patients who underwent mastoid surgery, and tympanoplasty to determine the effect of surgery on sensory-neural HL in non-operated ear. The basis of this study included 23 patients who had undergone mastoidectomy between 2012 and 2014 at Kashani Training and Research Hospital. Inclusion criteria were defined as patients referred for mastoidectomy or tympanoplasty and non-operated ear was intact. Noninclusion criteria were defined as the use of ototoxic drugs, past medical histories such as diabetes mellitus, hypothyroidism, hyperlipidemia, severs and recurrent otitis, ear trauma and surgery acoustic trauma. Exclusion criteria were lack of desire to participate in the study, change in treatment method, and medical problem in extern or inner ear. At the first, age, education level, job and smoking were recorded. Furthermore, otoscopy was performed in all patients. We performed preoperative and postoperative evaluations of the normal contralateral ear using: Transient evoked OAEs (TEOAEs), DPOAEs (with a Vivosonic Integrity V500 System; Vivosonic Inc. ON, Canada). And pure tone high frequency audiometry (with a Grason Stadler clinical audiometer; Grason Stadler Inc. MN, USA), the tests were obtained prior to surgery and immediately (1-day) and 7 days after the surgery. The tests were rechecked 1-month later if a significant change in threshold or amplitude were seen. DPOAE 0.5–1.5, 1.5–2.5, 2.5–3.5, 3.5–4.5 and 4.5–5.5 KHz were measured at frequencies and TEOAEs were measured at frequencies 1, 2, 4 and 6 kHz, and threshold of <6 dB at any frequency is considered to be abnormal. Bone and air conduction audiometric thresholds (PTAs) were calculated and compared pre and postoperatively with hearing level at 0.25, 0.5, 1, 2, 4 and 8 kHz. Bone conduction threshold of more than 20 dB at any frequency is considered abnormal. All the data were recorded by the same examiner. Statistical analysis was performed using repeated measures analysis (ANOVA), *t*-test. The study was approved by the Ethics Committee of Medical University of Isfahan, which is certified by the Office of Human Research Protections as an Institutional Review Board. All participants signed an informed consent form.

RESULTS

The sample population consisted of 23 patients; age was 35.52 ± 9.4 years (range: 17–49 years). Of the patients, 52.2% were male, and 47.8% were female.

Pure tone audiometry

Pure tone audiometry for convenience of analysis, we divided pure tone averages into: Bone and air conduction at low frequencies (calculated as the average of thresholds at 0.5, 1.0 and 2.0 KHz) and bone and air conduction at high frequencies (calculated as the average of thresholds at 4.0 and 8.0 KHz). We compared pre and postoperative (1 and 7 days after surgery) bone and air conduction averages at low and high frequencies. We showed by repeated measures analysis test, there were significant differences between bone and air conduction averages at most low frequencies but, no significant differences were observed at 0.25 KHz and high-frequencies [Table 1].

When comparing preoperative and 1-day after surgery, bone and air conduction averages were significantly different at low frequencies but, no statistical significant differences were observed at 0.25 KHz and high frequencies.

In second evaluation, when comparing 1-day after surgery and 7 days after surgery, bone and air conduction average at 0.5, 2 and 2 KHz were significantly different but, no statistical significant differences were observed at the other average of thresholds in low and high-frequencies.

In third evaluation, when comparing preoperative and 7 days after surgery, bone and air conduction average at 1 KHz was significantly different but, no statistical significant differences were observed at the other average of thresholds in low and high frequencies [Table 2].

Otoacoustic emissions

For the purpose of analysis, we divided the DPOAE amplitudes into two groups: Low frequency DPOAEs (1.0 and 2.0 kHz) and high frequency DPOAEs (4.0 and 6.0 kHz).

The data showing of DPOAEs, preoperatively and on serial postoperative testing are shown in Table 3. Repeated measures analysis, conducted to examine changes in low and high frequency DPOAEs. As the values for low and high frequency, DPOAEs were significantly different preoperatively and postoperative (1 and 7 days) [Table 3].

As the values for low and high frequency, DPOAEs were significant difference preoperative and 1-day after surgery, 1-day and 7 days after surgery. When comparing preoperative and 7 days after surgery, DPOAEs were no statistical significantly different [Table 4].

The data showing of TEOAEs, preoperatively and on serial postoperative testing are shown in Table 5. Repeated measures analysis, conducted to examine changes at different frequency TEOAEs. In first evaluation, as the values for different frequency TEOAEs were significant difference preoperatively and postoperative (1 and 7 days) [Table 5].

In second evaluation, as the value for low and high-frequency TEOAEs were significant difference preoperative and 1-day after surgery, 1-day and 7 days after surgery. In third evaluation, when comparing

Table 1: Average PTAs at different frequencies preoperative and postoperative (1 and 7 days)

Frequencies (KHz)	Mean±SD			*P*
	Preoperative	Postoperative (1-day)	Postoperative (7 days)	Preoperative and postoperative (1 and 7 days)
Low frequencies				
0.25	11.08±5.2	11.7±6.5	11.7±5.6	0.39
0.5	8.6±4.8	10.4±6	8.9±6	0.09
1	5.2±4.4	7.7±4.3	8.3±6.1	0.00
2	6.9±5.5	9.1±55.1	7.4±6	0.06
High frequencies				
4	11.1±8.1	12.4±7.8	9.8±7.9	0.13
8	18.7±11.7	20.2±10.3	18.3±11.5	0.28

PTAs: Pure tone averages, SD: Standard deviation

Table 2: Average PTAs at different frequencies before, 1 and 7 days after surgery

Frequencies (KHz)	Mean±SD			*P*		
	Preoperative	Postoperative (1-day)	Postoperative (7 days)	Preoperative and postoperative (1-day)	Postoperative (1-day) and postoperative (7 days)	Preoperative and postoperative (7 days)
Low frequencies						
0.25	11.08±5.2	11.7±6.5	11.7±5.6	0.69	0.62	0.61
0.5	8.6±4.8	10.4±6	8.9±6	0.03	0.04	0.8
1	5.2±4.4	7.7±4.3	8.3±6.1	0.001	0.55	0.001
2	6.9±5.5	9.1±55.1	7.4±6	0.03	0.04	0.68
High frequencies						
4	11.1±8.1	12.4±7.8	9.8±7.9	0.28	0.04	0.08
8	18.7±11.7	20.2±10.3	18.3±11.5	0.2	0.57	0.11

PTAs: Pure tone averages, SD: Standard deviation

Table 3: Average DPOAEs at different frequencies preoperative and postoperative (1 and 7 days)

Frequencies (KHz)	Mean±SD			*P*
	Preoperative	Postoperative (1-day)	Postoperative (7 days)	Preoperative and postoperative (1 and 7 days)
Low frequencies				
1	12.7±7.4	9.8±6.7	12.4±7.0	0.02
2	15.2±6.1	12.2±6.3	15.0±6.0	0.00
High frequencies				
4	13.2±7.8	10.6±8.1	13.1±7.6	0.00
6	6.8±7.1	2.5±8.1	6.7±6.9	0.00

DPOAEs: Distortion product otoacoustic emissions, SD: Standard deviation preoperative and 7 days after surgery, TEOAEs were no statistical significant difference [Tables 4 and 6].

DISCUSSION

The main aim of this study was to determine the effect of drill noise on contralateral ear and OHCs in patients referred for tympanomastoid surgery. The literature on the influence of drilling during mastoid surgery on the non-operated ear is controversial. Tos *et al*. and Hallmo and Mair failed to find significant postoperative hearing changes in the ears contralateral to mastoidectomy ears.[13,14]

In contrast, the study of Palva and Sorri on the non-operated ears in patients who had undergone simple or radical mastoidectomy demonstrated that HL occurred more frequently and more severely in patients with drilling times of 6 3 h.[15]

Our findings showed that there were significant differences between bone and air conduction averages at most low frequencies but, no significant differences were seen at high frequencies. In more evaluations, there were significant different at some frequencies, but all PTA changes healed after 7 days. Hence, PTA changes were transient in our patients. Our results were similar to Paksoy *et al*. They reported that bone conduction can impaired with drill noise most at frequencies but, they showed PTA changes can be permanent.[16] Kylén and Arlinger had described that the noise trauma can account some patient in high-tone frequency after tympanoplasty.[17] As the values, different frequencies of DPOAEs and TEOAEs were significantly different preoperatively and postoperative (1 and 7 days). As the values, for different frequencies of DPOAEs and TEOAEs there were significant difference in preoperative and 1-day after surgery, 1-day and 7 days after surgery. When comparing preoperative and 7 days after surgery, DPOAEs and TEOAEs were no statistical significantly different so, it showed TEOAEs healed progressive, and their changes were transient. Karatas *et al*. showed a negative effect of drill-generated noise on the contralateral normal ear in patients who underwent mastoid surgery. They found deterioration of DPOAE amplitudes immediately after the surgery, with progressive improvement that eventually led to preoperative normal values within

Table 4: Average DPOAE at different frequencies before, 1 and 7 days after surgery

Frequencies (KHz)	Mean±SD			*P*		
	Preoperative	Postoperative (1-day)	Postoperative (7 days)	Preoperative and postoperative (1-day)	Postoperative (1-day) and postoperative (7 days)	Preoperative and postoperative (7 days)
Low frequencies						
1	12.7±7.4	9.8±6.7	12.4±7.0	0.001	<0.001	0.39
2	15.2±6.1	12.2±6.3	15.0±6.0	<0.001	<0.001	0.40
High frequencies						
4	13.2±7.8	10.6±8.1	13.1±7.6	<0.001	<0.001	0.28
6	6.8±7.1	2.5±8.1	6.7±6.9	<0.001	<0.001	0.61

DPOAEs: Distortion product otoacoustic emissions, SD: Standard deviation

Table 5: Average TEOAEs at different frequencies preoperative and postoperative (1 and 7 days)

Frequencies (KHz)	Mean±SD			*P*
	Preoperative	Postoperative (1-day)	Postoperative (7 days)	Preoperative and postoperative (1 and 7 days)
0.5-1.5	7.8±5.9	4.1±5.9	7.4±5.6	0.001
1.5-2.5	10.5±4.6	7.8±4.2	10.2±4.7	0.000
2.5-3.5	6.7±5.7	3.2±6.0	5.8±5.2	0.002
3.5-4.5	5.3±6.3	2.7±6.1	5.1±5.9	0.005
4.5-5.5	0.96±6.5	−1.6±5.5	0.65±5.2	0.002

TEOAEs: Transient evoked otoacoustic emissions, SD: Standard deviation

Table 6: Average TEOAEs at different frequencies before, 1 and 7 days after surgery

Frequencies (KHz)	Mean±SD			*P*		
	Preoperative	Postoperative (1-day)	Postoperative (7 days)	Preoperative and postoperative (1-day)	Postoperative (1-day) and postoperative (7 days)	Preoperative and postoperative (7 days)
0.5-1.5	7.8±5.9	4.1±5.9	7.4±5.6	<0.001	<0.001	0.10
1.5-2.5	10.5±4.6	7.8±4.2	10.2±4.7	<0.001	<0.001	0.13
2.5-3.5	6.7±5.7	3.2±6.0	5.8±5.2	<0.001	0.001	0.04
3.5-4.5	5.3±6.3	2.7±6.1	5.1±5.9	0.001	0.001	0.54
4.5-5.5	0.96±6.5	−1.6±5.5	0.65±5.2	0.019	0.001	0.57

TEOAEs: Transient evoked otoacoustic emissions, SD: Standard deviation

72–96 h.[11] Furthermore, da Cruz *et al*. stressed that the non-operated ear experienced a reversible physiologic disruption in the OHC function following the mastoidectomy by drill noise trauma.[7] Migirov and Wolf evaluated hearing using DPOAE. They showed drill-induced noise during the mastoidectomy can cause reversible changes in DPOAE in the non-operated ear.[18]

Furthermore, Goyal *et al*. showed drilling during mastoid surgery poses a threat to hearing in the contralateral ear due to noise and vibration conducted transcranially. Their findings revealed statistically significant changes in distortion product OAEs at high frequencies, and in TEOAEs at both low and high frequencies. There was a higher statistical association between OAE changes and cutting burrs compared with diamond burrs.[19]

Most studies confirmed drill noise trauma can make sensory-neural HL in different frequencies. The differences of studies are due to their different methods and limitations. The major difference of our study from other studies was evaluation the effect of drilling on the normal contralateral hearing using three adiometry tests in different (low and high) frequencies for sensory-neural HL pre and postoperative. According to long period, evaluation of patients it seems that variables such as side effect of anesthetic drugs and hypotension during surgery did not affect our results, but we proposed better designed studies with control group to overcome confounding factors. Furthermore, we did not study the parameters of burr such as type, size, vibratory force, rotation speed and for the same size of burr, the cutting burr because some studies showed parameters of burr can affect on acoustic.

CONCLUSIONS

Tympanomastoid surgery and drilling during ear surgery has the potential to cause significant acoustic trauma and transient sensory HL to the contralateral ear, and drill-generated noise cannot be reduced to any great extent. In order to lower the acoustic trauma in an ear surgery and contralateral ear parameter of burr and drill must be known preoperatively. Otological surgeons must minimize drilling time during surgical management of ear surgery.

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Conflicts of interest

There are no conflicts of interest.

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