

Cigarette smoking effect on human cochlea responses

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Abstract

Background: Smoking is one of the most important risk factor in increasing of non-communicable disorders, especially chronic diseases such as cancer, stroke, heart and respiratory diseases. Cigarette smoking could damage the cochlea and causing hearing loss. The otoacoustic emission (OAE) is a source of information for determining cochlear responses to sound stimuli and how to change the response of the auditory system in some diseases. OAE test was sensitive to outer hair cells (OHCs) activity.

Materials and Methods: In this study, tried to evaluate a hearing threshold of the smoker group versus non-smoker ones through pure tone audiometry, transient evoked otoacoustic emission (TEOAE) and distortion product otoacoustic emission (DPOAE) tests.

Results: The results indicated that significant decrement of 8000 Hz threshold, reduced DPOAE/TEOAE amplitude in the smoker group than non-smoker one ($P < 0.05$). DPOAE amplitudes decline reflects the cochlear damage caused by smoking.

Conclusion: OAEs test was clinically non-invasive, accurate, and objective evaluation of the performance of cochlear OHCs.

Key Words: Cigarette, cochlea, otoacoustic emission, smoking

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INTRODUCTION

Smoking is a noticeable public health problem. A number of studies have shown its many damaging effects. Smoking is one of the most important risk factor in increasing of non-communicable disorders, especially chronic diseases such as cancer, stroke, heart, and respiratory diseases.^[1-3] In according to

the studies, smoking is considered to be a threat for the progress of hearing loss, with widely diverse outcomes. Cigarette smoking could increase the blood viscosity and decrease oxygen causing disruption and damage to hair cells of the cochlea.^[4-6] Researches show smoking, whatever directly or indirectly secondhand exposure have been associated with hearing loss.^[7-9] Pure tone audiometry (PTA) was conducted via audiometer to measure auditory system function. The result is recorded as an audiogram which has to main character (intensity and frequency in terms of dB and Hz, respectively) in the range of human hearing (from 250 to 8000 Hz).^[10] The otoacoustic emission (OAE) is a source of information for determining cochlear responses to sound stimuli and how to change the response of the auditory system during any cochlear malfunction.^[11] OAE as the main

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component of auditory tests differentiates the auditory sensory disorder from neurological ones and also used to monitoring cochlear status health changes.^[12] OAEs indicate middle ear function and normal cochlear biologic action. Such these studies provide better understanding into outer hair cell (OHC) cochlear mechanism.^[13] In this study, tried to investigate the effect of smoking on hearing via PTA and OAEs tests.

MATERIALS AND METHODS

The study sample consists of 32 patients and divided in two groups of men with aged ranges between 20 and 50 years which one group with a history of cigarette smoking and the other one normal non-smoking persons as a control group of the same age and gender. Both groups were given in to history taking either with inclusion criteria such as no history of ototoxic drug intake, diabetes, hypertension, hyperlipidemia, hypothyroid, ear infection/surgeries, and no occupational noise exposure. Exclusion criteria include any outer and middle ear disease, unilateral or conductive hearing loss. The written informed consent form was taken from all patients. Demographic data were collected. Some factors like duration of smoking, smoking intensity (number of cigarettes smoked per day) which categorized in three level: mild (<10 cigarette smoked per day), moderate (10-20 cigarette smoked per day) and severe (>20 cigarette smoked per day) and use of other tobacco products and drugs are being questioned and recorded. Then PTA with AC 40 clinical audiometer, HDA 200 audiometric headphone and tympanometry via, AD235 tympanometer and finally OAEs tests were performed by Eclipse EP25 device for whom are eligible. Any case would be excluded from this study if any evidence of middle ear disease was found during tests. Abnormal results for distortion product otoacoustic emission/transient evoked otoacoustic emission (DPOAE/TEOAE) test were considered less than 6 dB at 1000 2000, 4000 and 6000 Hz. The statistical data obtained from the two groups are analyzed via *t*-test and ANOVA test.

RESULTS

Mean threshold values observed in high frequency audiometry for smokers and non-smokers are

presented in Figure 1. In this study, hearing threshold deterioration at frequencies between 2000 and 10000 Hz was significant particularly at 8000 Hz in smoker group compared with non-smoker one ($P < 0.001$).

Decreasing of DPOAE amplitude at 1000, 2000, 4000, and 6000 Hz in smokers group rather than non-smokers was statistically significant ($P < 0.001$) as seen in Table 1. In spite of TEOAE amplitude declining at all frequencies in smoker than non-smoker, results are not statistically significant ($P > 0.05$) as shown in Table 2. Results indicated significant differences between smoking intensity (mild and severe level) and hearing threshold at 2000, 4000 and 8000 Hz in, but no statistically significant difference between smoking intensity and DPOAE/TEOAE test results was found.

DISCUSSION

OAEs test is a fast technique to evaluate OHCs motility. Cigarette smoking interfere the OHCs tasks leading to cochlear dysfunction and then hearing threshold levels were possibly affected throughout the frequency range 250-16000 Hz especially at higher frequencies. Fabry *et al.* study indicated that the second hand smoke exposure shown hearing loss in all frequencies.^[14] In Ohgami *et al.* study, the effect of smoking on extra high frequency hearing thresholds of smoker group was significantly worse than non-smokers specifically at 12 kHz.^[15] A study by Gopal *et al.* found that ABR and DPOAE could be appropriate tests for evaluating youth smokers who had normal hearing with high sensitivity^[16] and in this study DPOAE was conducted because of OAE and OHC correlation. Subsequently, metabolic

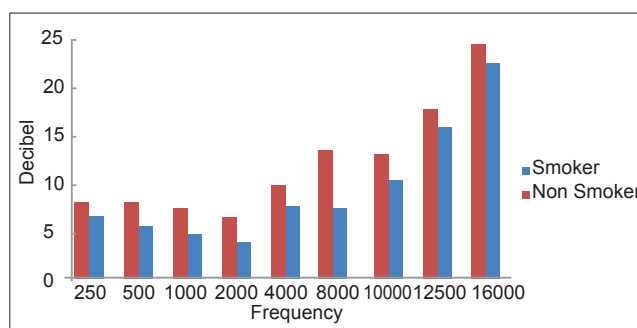


Figure 1: Audiometry results in smoker and non-smoker groups

Table 1: DPOAE test results in smoker and non-smoker group (dB)

DPOAE Frequency	Smoker				Non-smoker				P value
	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	
1000	7.04	3.86	2	16.60	10.33	4	3.80	16.65	0.001
2000	6.58	3.57	1.85	20.20	10.46	3.87	2.30	18.05	0.0001
4000	0.15	5.96	-14.70	10.10	3.57	5.68	-5.10	14.50	0.022
6000	-10.27	7.24	-25.30	2.15	-5.28	6.86	-20.35	4.40	0.006

DPOAE: Distortion product otoacoustic emission, SD: Standard deviation

Table 2: TEOAE test results in smoker and non-smoker group (dB)

Frequency	Smoker		Non-smoker		P value
	Mean	SD	Mean	SD	
0.5-1.5	7.67	4.50	9.23	3.15	0.114
1.5-2.5	8.62	3.97	10.03	3.71	0.149
2.5-3.5	8.17	2.45	7.18	2.71	0.133
3.5-4.5	6.62	3.36	7.04	1.98	0.545
4.5-5.5	1.79	3.74	2.29	2.25	0.521

TEOAE: Transient evoked otoacoustic emission, SD: Standard deviation

disruption of cochlea impacts DPOAE and then poorer thresholds point out the cochlear dysfunction. Nomura *et al.* study, the effects of smoking on DPOAE was a significant decrement in the DPOAE amplitude in smokers than non-smokers^[17] that was consistent with the results of this study.

CONCLUSION

This study shows that smoking has destructive effects on hearing, as the smoker group had not as good as auditory thresholds in high frequencies (above 8000 Hz), poorer response levels to OAEs when compared to non-smokers. In according to the results of human studies, OAEs test was clinically non-invasive, accurate, and objective evaluation of the performance of cochlear OHCs. This can be important for the design of experiments applied and can easily be observed amplitude changes in response to a specific stimulus. Cochlear nonlinearity and frequency selectivity could be changed because of noise exposure, infection and drugs. DPOAE amplitudes reduction reflects the cochlear damage caused by smoking. Another finding of this study is the ability to record more sensitive at high frequency via DPOAE rather than TEOAE test. Finally it is recommended to follow-up the study group after 5 years to recheck the effect of extended duration on their hearing thresholds.

REFERENCES

1. Haenle MM, Brockmann SO, Kron M, Bertling U, Mason RA, Steinbach G, *et al.* Overweight, physical activity, tobacco and alcohol consumption in a cross-sectional random sample of German adults. *BMC Public Health* 2006;6:233.
2. Hughes K, Choo M, Kuperan P, Ong CN, Aw TC. Cardiovascular risk factors in relation to cigarette smoking: A population-based survey among Asians in Singapore. *Atherosclerosis* 1998;137:253-8.
3. Imamura H, Tanaka K, Hirae C, Futagami T, Yoshimura Y, Uchida K, *et al.* Relationship of cigarette smoking to blood pressure and serum lipids and lipoproteins in men. *Clin Exp Pharmacol Physiol* 1996;23:397-402.
4. Müller BW, Specka M, Steinchen N, Zerbin D, Lodemann E, Finkbeiner T, *et al.* Auditory target processing in methadone substituted opiate addicts: The effect of nicotine in controls. *BMC Psychiatry* 2007;7:63.
5. Fransen E, Topsakal V, Hendrickx JJ, Van Laer L, Huyghe JR, Van Eyken E, *et al.* Occupational noise, smoking, and a high body mass index are risk factors for age-related hearing impairment and moderate alcohol consumption is protective: A European population-based multicenter study. *J Assoc Res Otolaryngol* 2008;9:264-76.
6. Ferrite S, Santana V. Joint effects of smoking, noise exposure and age on hearing loss. *Occup Med (Lond)* 2005;55:48-53.
7. Jacobsen LK, Slotkin TA, Mencl WE, Frost SJ, Pugh KR. Gender-specific effects of prenatal and adolescent exposure to tobacco smoke on auditory and visual attention. *Neuropsychopharmacology* 2007;32:2453-64.
8. Key AP, Ferguson M, Molfese DL, Peach K, Lehman C, Molfese VJ. Smoking during pregnancy affects speech-processing ability in newborn infants. *Environ Health Perspect* 2007;115:623-9.
9. Liang K, Poytress BS, Chen Y, Leslie FM, Weinberger NM, Metherate R. Neonatal nicotine exposure impairs nicotinic enhancement of central auditory processing and auditory learning in adult rats. *Eur J Neurosci* 2006;24:857-66.
10. Cruickshanks KJ, Klein R, Klein BE, Wiley TL, Nondahl DM, Tweed TS. Cigarette smoking and hearing loss: The epidemiology of hearing loss study. *JAMA* 1998;279:1715-9.
11. Agrawal Y, Platz EA, Niparko JK. Risk factors for hearing loss in US adults: Data from the National health and nutrition examination survey, 1999 to 2002. *Otol Neurotol* 2009;30:139-45.
12. Babanov SA. The epidemiological characteristics of tobacco smoking. *Vestn Ross Akad Med Nauk* 2006;10:27-9.
13. Lalwani AK, Liu YH, Weitzman M. Secondhand smoke and sensorineural hearing loss in adolescents. *Arch Otolaryngol Head Neck Surg* 2011;137:655-62.
14. Fabry DA, Davila EP, Arheart KL, Serdar B, Dietz NA, Bandiera FC, *et al.* Secondhand smoke exposure and the risk of hearing loss. *Tob Control* 2011;20:82-5.
15. Ohgami N, Kondo T, Kato M. Effects of light smoking on extra-high-frequency auditory thresholds in young adults. *Toxicol Ind Health* 2011;27:143-7.
16. Gopal KV, Herrington R, Pearce J. Analysis of auditory measures in normal hearing young male adult cigarette smokers using multiple variable selection methods with predictive validation assessments. *Int J Otolaryngol* 2009;2009:745151.
17. Nomura K, Nakao M, Morimoto T. Effect of smoking on hearing loss: Quality assessment and meta-analysis. *Prev Med* 2005;40:138-44.

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