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Original Article

Ear, Nose and Throat Section

Alterations in Cochlear Function after Exposure to Short Term Broad Band Noise Assessed by Otoacoustic Emissions

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ABSTRACT

Background: Sudden or chronic exposure to sound alters the functioning of cochlea. This results in temporary or permanent alteration of functioning of cochlear cells. Alteration of functioning of outer hair cells (OHC) of cochlea following exposure to noise can be assessed by measurement of transient otoacoustic emissions (TEOAE). Such a measurement is of great clinical importance in early detection of the damage to the OHC.

Aim: In this study we aim to study effect of noise on outer hair cell function by studying the changes in TEOAE's amplitude following exposure to short term broad band noise in healthy volunteers.

Materials and Methods: Twenty volunteers' ten males and ten females participated in the study. They underwent pure tone and impedance audiometry to rule out ear pathology. Then pre-exposure TEOAE's were recorded. After that they were exposed to broad band noise for two minutes. After gap of five minutes again TEOAE's were recorded. Pre and post exposure amplitude of TEOAE's was analysed statistically.

Results: There was statistically significant difference between pre exposure and post-exposure amplitude of TEOAE's. Pre and post exposure values for A & B amplitudes showed p-value of 0.0001 whereas values for A-B amplitude showed p-value of 0.0001.

Conclusion: Measurement of TEOAE's can detect early changes in the functioning of outer hair cells which cannot be picked by routine pure tone audiometry. Thus they can be used in assessing early changes in cochlear function following exposure to noise in individuals exposed to sudden noise or working in noisy environments. Thus preventive methods to reduce the noise induced hearing loss in such individuals can be implemented.

Keywords: Broad band noise, Transient evoked otoacoustic emissions, Temporary threshold shift

INTRODUCTION

Kemp (1970) discovered Oto Acoustic Emissions (OAE), adding a new tool in audiological investigations [1]. OAE are produced by an active non linear process involving outer hair cells of cochlea and can be recorded after proper amplification. They can be picked up by a small microphone placed in the external auditory canal [2,3]. OAE are present in 98% of population with normal hearing. Thus, it is used as non invasive simple tool to assess the function of OHC of cochlea. OAE's are absent when behavioral auditory thresholds are above 30 Db HL, that is even in mild degree of hearing loss [2-4]. Because of this OAE's have been used for screening hearing loss especially in neonates and infants. TEOAE are recorded in response to short stimuli, such as clicks at 500Hz to 6 KHz. They are present in virtually all normal ears not in patients with hearing loss greater than 30 Db HL [2,3,5,6].

Distortion Product OAE's are evoked by using pair of primary tones f1 and f2 (f1>f2). The evoked responses for these stimuli occur at predictable frequencies depending on f1, f2 and are known as distortion products. The most important DPOAE is fdp=2f1-f2 (the cubic distortion tone) most commonly used for screening hearing loss. DPOAE response is shown to be more sensitive than auditory brain stem responses in .revealing the changes in auditory dysfunction after exposure to ototoxic drugs [7].

Hearing loss due to exposure to noise is the preventable form of sensory neural hearing loss. Noise exposure can occur in two forms short duration impulse form or continuous exposure. Noise exposure either in short duration impulse form or continuous exposure leads to alterations in the cochlear functions especially when the sound threshold levels are more than 75-85dB. This short duration change in cochlea is reversible if further exposure is prevented and is known as temporary threshold shift (TTS) [8]. However, in continuous exposure permanent changes in cochlear function develops and become irreversible and is known as permanent threshold shift (PTS).

These changes in cochlear function due to noise exposure is routinely evaluated by pure tone audiometry. However, considerable damage to OHC could have occurred before it becomes evident on audiometric evaluation [9].

Since TEOAE'S and DPOAE'S can detect subclinical damage to the cochlea following noise exposure, they can be used as objective tool to detect changes in individuals who are prone to develop noise induced hearing loss (NIHL).

MATERIALS AND METHODS

Total of 20 normal hearing adults ten males and ten females in the age group of 19 to 25y were selected for the study. Informed written consent was obtained from all the participants. All the subjects underwent otoscopic evaluation, pure tone audiometry and impedance audiometry to rule out ear pathology. Individuals whose pure tone thresholds were less than 15 dB HL at octave frequencies 250Hz, 500Hz, 1KHz, 2KHz, 4KHz, 8KHz and with bilateral 'A' type tympanogram were selected.

INSTRUMENTATION

A calibrated dual channel amplaid audiometer was used for pure tone threshold estimation. A calibrated "MICO MI24" diagnostic impedance audiometer was used to rule out middle ear pathology. TEOAE was measured by using VI.0-RC3(software version-1.043) screener .

TEST ENVIRONMENT

All the measurements were carried out in an acoustically treated single room situation. The ambient noise level was within the permissible level according to ANSI (1991).

Amplitude of TEOAE			
Pre	Post	Pre	post
A&B	A&B	A-B	A-B
18.06	14.6	10.6	8.06
13.06	10.06	7.06	6.06
13.01	11.09	10.09	3.92
11.26	10.53	11.11	5.63
13.03	12.06	8.05	6.06
12.06	11.06	6.06	5.46
21.46	19.36	16.36	14.26
14.05	12.65	6.04	5.06
16.36	12.34	14.46	13.46
13.01	10.06	6.06	4.05

[Table/Fig-1]: Pre and post exposure TEOAE amplitudes in male participants.

Amplitude of TEOAE			
Pre	Post	Pre	Post
A&B	A&B	A-B	A-B
16.05	13.06	12.05	10.45
16.94	14.93	6.05	5.85
14.22	13.03	6.22	3.02
12.57	10.48	7.85	4.06
18.23	14.36	12.64	10.24
16.04	15.05	13.12	12.06
20.53	18.46	15.46	13.36
14.90	13.90	9.06	8.98
14.69	13.07	6.03	5.03
14.06	12.65	6.04	5.03

[Table/Fig-2]: Pre and post exposure TEOAE amplitudes in female participants

TEST PROCEDURE

TEOAE's are measured using non linear clicks at 80 dB peak sound pressure level (SPL) to estimate amplitude response with appropriate probe tip. TEOAE'S amplitude was measured before exposure to noise with a good probe fit prior to recording. A total of 200 clicks stimulus was presented. Signal to noise ratio (SNR) of 3dB or above was considered as response. Responses were indicated as pass or fail for frequencies 1KHz, 2KHz, 3KHz, 4KHz, 5KHz. After obtaining the base line TEOAE responses all the participants were exposed to 90dBSPL (white noise) for 2min by using TDH39 head phones. After 2min gap again TEOAE amplitude was measured. 2 min gap was given as Hirsh & Ward (15) reports that TTS is more stable 2 min after exposure of noise,

The stimuli are presented in groups of four. Out of four responses the first three responses in each group are in one phase and considered as "A " waveform. The fourth is produced in the opposite phase and at an amplitude that is three times greater than each of the preceding transients which is considered as' B" waveform. A & B is the sound pressure level of the average of the A and B wave forms.

A-B is the average difference between A and B wave forms and is the level of energy represented by the cross-hatched area of the response fast fourier transforms (FFT) window. It is computed by taking the difference between the A and B wave forms on a point by point basis minus 3dBS.

RESULTS

Age of the patients varied from 19 y to 25 y with mean age of 20.75 y. Results obtained from OAE evaluation were analysed statistically by calculating mean and standard deviation, paired t-test was used to find out whether any significant changes in values of OAE responses for pre and post sound exposure existed. OAE results before exposure had Amplitude of 15.17+/- 2.8. Other values are shown in [Table/Fig-1,2,3].

S. No	Amplitude of TEOAE	Mean	Std. Deviation	t value	P value
1	PreA &B	15.1795	+/-2.77074	8.936.	0.0001
	PostA&B	13.1400	+/-2.53128		
2	PreA-B	9.5205	+/-3.50995	5.581.	0.0001
	PostA-B	7.5050	+/-3.58632		

[Table/Fig-3]: Table showing pre and post exposure mean values of TEOAE amplitude measurements.

These values were statistically analysed. Comparison between pre test A & B and post test A & B showed that t-value was 8.0 and p-value was 0.0001 which was highly significant. Similarly for pre test A-B and post test A-B t-value was 5.5 and p-value was 0.0001 which was highly significant. Both indicate there was a temporary threshold shift in the thresholds.

DISCUSSION

Results in this study show that there is a difference between pre and post exposure TEOAE amplitude. The difference seen in pre and post exposure values was found to be statistically significant (p value 0.0001). This difference in TEOAE's amplitude is due to the effect of noise on OHC which leads to temporary threshold shift. This shift is seen because of the effect of the noise on several structural elements in hair cells, including cell membrane and intracellular biochemical pathways [10]. Several studies have shown that noise exposure results in permanent loss of hair cell stereocilia and destruction of hair cells which are replaced by scar tissue [10-12]. Since OHC are responsible for generating of TEOAE'S, any effect of sound on (OHC) is reflected by the changes in the amplitude of the TEOAE'S. Thus minimal changes in the OHC function which cannot be assessed by PTA can be precisely picked up by measuring TEOAES. This helps in assessing the effect of sound exposure on OHC. Although OAE's are routinely used for neonatal hearing screening, they can also be used for precise and early assessment of noise induced hearing loss. This is of great clinical importance in situations where early diagnosis of change in hearing threshold is to be diagnosed following sound exposure. This measurement of TEOAES can be used as a cost effective investigation in screening large number of subjects like army recruits and factory workers working in noisy surroundings. This helps in identifying individuals prone to develop noise induced hearing loss. Thus individuals susceptible for noise induced hearing loss can be detected early and necessary preventive measurements can be taken.

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