Fine structure DPOAE's in identifying Noise Induced Hearing Loss due to traffic noise exposure in South India's Metropolitan

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***Abstract* - Noise-induced hearing loss (N.I.H.L) has become the most common occupational injury. It is largely preventable, when the noise exposure is terminated, that contains the hearing loss. The aim of the present study was to understand the usefulness of fine structure DPOAEs to indicate ears having initial damage if observable in normal-hearing adults exposed to traffic noise. The parameters that were evaluated DPOAE amplitude and ear laterality effect (right ear versus left ear); and the DPOAE amplitude for the octave frequency effects (2-4 KHz & 4-8 KHz) in control group as well as experimental group with 30 participants in each group. The results indicate that the subjects in experimental group were having better DPOAE amplitudes in the 2-4 kHz region than in the 4-8 kHz region, no such difference in amplitude was noted in the control group.**

Thus, we need to use improved objective measures in order to identify early the damaging effects of traffic noise even before it is shown by the conventional pure-tone audiogram. It may be concluded that cochlear dysfunction in traffic noise-induced hearing loss may extend beyond the frequency region suggested by the audiogram, and that Fine structure DPOAEs is a sensitive test to detect this damage. However, it is alarming that individual who for the occupational need are getting exposed to such traffic noise for 8-12 hours/day are at high risk for hearing loss and related problems.

***Index Terms* - DPOAEs, Early Identification of Noise induced hearing loss, traffic noise in metropolitans and fine structure DPOAE's.**

1.INTRODUCTION

Noise Induced Hearing Loss is still detected and monitored with pure-tone audiometry performed in a sound attenuated room using a calibrated audiometer in many clinical settings. The main disadvantage of pure-tone behavioral audiometry is its insensitivity to subtle noise induced cochlear changes. Furthermore, the audiogram reflects the entire auditory pathways, even though the only site affected in Noise Induced Hearing Loss (NIHL) is the cochlea. It is well known that the audiogram is also very subjective in that it requires full cooperation of the individual and is influenced by many learning effects.

Noise induced emission loss (N.I.E.L.) without hearing loss provides the first and sometimes the silent sign of cochlear damage induced by noise (Attias et al, 1996 & Anjali et al , 1999). Noise exposure may cause detrimental effect on the cochlear functions which may not be always shown with the corresponding changes in the audiogram (Joseph Attias, Gil Horovitz, Nariman El-Hatib, & Benny Nageris, 2001). The traffic noise pollution in metropolitian city during the peak working hours can have adverse effect on individuals hearing sensitivity, if the individual is in that noisy condition due to their occupational need, they are exposed to such noise for 8-10 hours/day.

Literature reports that with the advent of Distortion Product Oto-acoustic Emission (DPOAEs) it has been found to be a useful tool in identifying hearing loss and also is an effective tool in screening the hearing loss. The Oto-acoustic Emission (OAE) has been reported in literature to be useful in monitoring hearing sensitivity by various researchers (Musiek, Smurzynski, and Bornstein,1994). It has been used as a valuable part of a test battery approach for determining an auditory site of lesion due to exposure to chemical agents, drugs or effects of treatment or medicines, music induced noise etc. The Spontaneous OAEs (S.O.A.E) as well as Evoked OAEs exhibit periodic variations in the amplitude and phase with frequency, which are called 'fine structures' as reported by various researchers like Jedrzejczak, W.W, Blinowska, K. J., Konopka, W. and Grzanka, A. (2005); Reuter, K and Hammershøi, D. (2006);

Furthermore, fine structures might be useful as an indicator of healthy cochlea whether or not it leads to any gain in hearing, influences our perception significantly, or is a minor side effect. Cochlear fine structure is a property of a healthy ear. Fine structure is very sensitive to Cochlear insult e.g. DPOAE fine structure reappears at a very late stage of recovery after a sudden hearing loss. (Mauermann et. al., 1999). Similar effects can be observed for DPOAES fine structure in ears with noise-induced temporary threshold shift (Furst et. al., 1992; Engdahl & Kemp, 1996). Overall, damage affecting the cochlear amplifier will cause a reduction in fine structure. The high sensitivity of fine structure to cochlear damage may offer the opportunity for early diagnosis of incipient cochlear damage.

Hence, this study was taken up with an aim to investigate if the presence of fine structure would indicate a very healthy ear or perhaps, initial damage already observable in normal-hearing adults exposed to traffic noise in a south India's metropolitan city. The study was carried out with two aims. Primarily, it aimed at describing the 2f1-f2 DPOAE fine structure in the two frequencies range of 2-4 KHz & 4-8 KHz in participants with and without exposure to traffic noise. Secondly, it aimed at identifying the amplitude difference in fine structure in the participants with and without noise exposure.

2. METHOD

Present study is a retrospective data analysis of the larger study. The original study was done on individuals with normal hearing sensitivity on Pure tone audiometry and having no history of any otological problems. These individuals had exposure to traffic noise of the Metropolitan city of South India. Present study was aimed to test if there exists any effect on fine structure DPOAEs in those individuals who had noise exposure of less than three years and who had normal pure tone audiometric findings. The main study was carried out with ethical clearance from the ethical committee where the research was carried out. All the participants in the study gave their consent.

2.1 Participants

The participants for the present study were selected between the age group of 18-40 years. These participants were divided into two groups based on their noise exposure, as control group and experimental group. All the participants were categorized based on the pre-selection criteria. The participants in the control group were 30 normal hearing subjects. None of these subjects reported any history of ear disease, no prolonged noise exposure (not more than 2 hours in traffic noise or any other noise) , medical intervention for any ear pathology etc. Further, they had Pure tone thresholds less than 15dBHL in the frequency range of 250Hz to 8000Hz, and speech recognition scores of 100% in quiet. All the participants had normal otoscopic examination findings, immittance audiometry findings showed "A" type tympanogram and acoustic reflex threshold within the normal range for 1 KHz. Type "A" tympanogram is defined as the peak pressure within +/- 50 dapa and acoustic compliance between 0.3ml and 1.6ml. Normal acoustic reflex threshold can be defined as 0.3ml amplitude of acoustic compliance, which should be present at a level of </= 90dBSL for frequencies 500Hz, 1000Hz, 2000Hz and 4000Hz.

The participants in the experimental group were 30 individuals who were working in the Metropolitan city. They were selected randomly using purposive sampling method. Their detailed case history did not reveal any significant otological hearing conditions. However, these participants had exposure to traffic noise in the metropolitan city of south India for 8-12 hours/ day (due to occupational need) at around 70-80dBA for a duration of less than three years. These participants in the experimental group had normal PTA findings. All the participants had normal otoscopic examination findings, immittance audiometry findings showed "A" type tympanogram and acoustic reflex threshold within the normal range for 1 KHz.

2.2 Test Environment

All the testing were done in a sound treated audiometric room as per the American National Standard Institute (1999). Room was well lit and ventilated and free from any distraction.

2.3 Instrumentation

For the purpose of classifying the participants into two groups a Calibrated GSI-16 audiometer, GSI-tymp star impedance meter and GSI-60 DPOAE instrument were used in this study. The GSI-60 application software operates within the Microsoft windows environment, which had the facility for complete automatic testing of the DPOAEs based on the preset protocol. It provided a display format to allow changes in parameters and to notify the test status and test results. The DPOAE was done using the F1/F2 (frequency ratio of the two primaries) set at 1.2 value (Abdala,1996). The two intensities were L1(intensity of the first primaries) selected as 65dBSPL and L2 (intensity of the second primaries) selected as 55dBSPL. The testing was done at a high frequency range in two octave frequencies 2-4 KHz and 4-8 KHz with total number of points per octave set at 20. Further, the configuration type was Oz template. These templates were selected as recommended in the literature for they give better signal to ratio across wide frequency range.

2.4 Test Procedure

All the 60 subjects of both the groups underwent a detailed case history followed by otoscopy, pure-tone audiometry, tympanometry and reflexometry prior to the DPOAE fine structure testing. Each participant was seated comfortably on a chair in the sound treated room. The participant was instructed to avoid excessive body movements and also instructed to avoid yawning, coughing, jaw clenching, head tilting etc, while the testing was carried out. The probe assembly of the DPOAE equipment was placed carefully on the shoulder of the patient. The correct size of the ear tip was selected and securely inserted into the ear canal in order to obtain an airtight seal. The probe fit was ensured to be a good fit by checking for the presence of DPOAE at the low frequencies. If the DPOAEs obtained at low frequencies had a fair amplitude of difference from the noise floor and met the Oz template condition, then the probe fit was considered to be a good fit. After the good fit was ensured then the test for DPOAEs was then obtained for each ear separately. The entire testing was repeated twice to ensure that there was no test-to-test variability.

STATISTICAL ANALYSIS

The data obtained from the two groups of participants, control as well as the clinical group were subjected to appropriate statistical analysis. As the data followed normal distribution on the Shapiro-Wilks test of normality the parametric analysis was carried out. As there were only two groups of participants the parametric students t-test was administered.

III. RESULTS AND DISCUSSION

Present study was carried out with the aim of identifying the usefulness of fine structure DPOAEs in identifying hearing loss in individuals exposed to less than three years of traffic noise for 8-12 hours/day in a Metropolitan city of South India. In order to obtain the efficacy of fine structure DPOAE following parameters were evaluated- firstly DPOAE amplitude and ear laterality effect (right ear versus left ear) at the 2-4 KHz and 4-8 KHz octave frequency were compared; also, the DPOAE amplitude for the octave frequency effects for the 2-4 KHz and 4-8 KHz were compared.

DPOAEs amplitudes and ear laterality effects in control group and experimental group: The fine structure DPOAEs were measured for control group participants in both the ears. The right and left ears were compared separately both for 2-4 kHz and 4-8 kHz octave frequencies. Statistical analysis using the student's 't' test was carried out at 0.05 level of significance to statically verify significant differences in DPOAE amplitudes between right and left ears at each of these octave frequencies.

It was found that statistically at, 0.05 level of significance there was no significant ear effect in both 2-4 kHz and 4-8 kHz octave frequencies as shown in table 1. Hence the results for left ear and right ear were not taken separately; rather they were combined. Similar findings were reported in the literature by Lonsbury-Martin et al (1997). They studied both right and left ears of 55 subjects and found that the fine structure DPOAE amplitudes did not show any differences between right ear and left ear among their subjects. However, the highest DPOAE amplitudes were obtained in the lower octaves (2-4 kHz) and the lowest DPOAE amplitudes were obtained in the higher octaves (4-8 kHz) in the current study. Such findings are also been reported by He and Schmiedt,1997.

Similarly, in the experimental group also there was no significant difference between the right ear and left ear amplitude in either of the octaves that were tested as shown in the table 1. Hence, the data from these subjects for the right ear and left ear were combined for further statistical comparisons. This shows that in person with or without noise exposure their right ear performance did not differ from their left ear performance. This indicates that the traffic noise in the Metropolitan city of South India do not alter the performance of right and left ear differently.

Table 1: Showing the comparison of the DPOAE amplitude between the control group and the experimental group at the 2-4 kHz and the 4-8 kHz.

Participant Group	Ear or Laterality	Frequency Octave	t-value	Level of significance
Control Group	Right vs Left	2-4 KHz	0.933	P >.05
	Right vs Left	4-8 KHz	0.386	P >.05
Experimental Group	Right vs Left	2-4 KHz	1.063	P >.05
	Right vs Left	4-8 KHz	0.840	P >.05

DPOAEs amplitudes effects with ears combined in control group at 2-4 KHz and 4-8 KHz fine structure DPOAEs were tested by combining both the ears at frequency range 2-4 kHz and 4-8 kHz. Statistical analysis using the student's 't' test was carried out at 0.05 level of significance to statically verify significant differences in DPOAE amplitudes between 2-4 kHz & 4-8 kHz octave frequencies.

It was found that statistically at 0.05 level of significance there was no significant difference between 2-4 kHz and 4-8 kHz octave frequencies. These results indicate that there is no significant difference between the two octave frequencies as shown in table 2. As, there was no significant difference in amplitude in control group at lowest octave frequency(2-4KHz) and highest octave frequencies (4-8 KHz) these octaves were combined for further analysis.

Table 2 Comparison of Lower frequency range 2-4KHz with Higher frequency range 4-8 KHz in control group and clinical group.

Frequency Range	Participant group	t-value
2-4 KHz verses 4-8 KHz	Control Group	0.09
2-4 KHz verses 4-8 KHz	Clinical Group	3.01

DPOAEs amplitudes effects with ears combined in experimental group at 2-4 KHz and 4-8 KHz on fine structure DPOAEs were tested at frequency range 2-4 kHz and 4-8 kHz. Statistical analysis using the student's 't' test was carried out at 0.05 level of significance to examine the significant differences in DPOAE amplitudes between 2-4 kHz & 4-8 kHz. It was found that statistically at 0.05 level of significance there is a significant difference between 2-4 kHz and 4-8 kHz octave frequencies. The results indicate that the subjects in this group were having better DPOAE amplitudes in the 2-4 kHz region than in the 4-8 kHz region as shown in table 2. This indicates that the exposure to traffic noise in the experimental group has affected the higher frequencies octaves first. Such evidence showing the effects of noise in the higher frequency region are reported in literature, that states noise affects at the higher octave (4000 to 6000 Hz) spectras due to noise spectral enhancement at one half octave frequency due to ear canal resonance (Tonndorf, 1976). Due to this reason the changes in the cochlea would start in the higher frequency octave (4-8 KHz) before it appears in the lower frequency octaves (2-4 KHz).

It is evident from the above findings that individuals exposed to traffic noise in the metropolitan city of south India for 8-12 hours for their occupational needs are susceptible to subtle hearing problem. Such hearing problems are not obviously noted by them at early stages nor can these be identified using conventional method of testing using pure tone audiometry. However, it is convenient to carry out fine structure DPOAEs to identify such subtle differences in the hearing physiology by monitoring the emissions. This would curb the incidence of noise induced hearing loss by taking appropriate precautions. However, the study does not limit to say that fine structure DPOAEs are useful in the test battery of assessments, although it is. It is more important to emphasize the need to spread awareness to the general public to protect their ears with safety measures. Especially those individuals with noise exposure in the traffic of Metropolitan city exceeds to 8-12 hours/day.

Clinical Implication of the present study not only adds to corpora of previous findings that fine structure DPOAEs being non-invasive and quick objective tool for finding the sensitive and effective cochlear functioning in individuals with history of noise exposure. This study also alarms the exposure to traffic noise in a Metropolitan city for 8-12 hours can lead to hearing loss and its associated problems.

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