Early detection of noise induced hearing loss by using ultra high frequency audiometry

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Citation

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Abstract

Exposure to noise is known to cause irreversible hearing loss, typically affecting higher-frequency hearing first and progressing to lower frequencies. Standardized methodology has not been developed for early detection of noise induced hearing loss. Serial conventional (0.25-8 kHz) and high frequency (10-20 kHz) hearing threshold was measured prospectively in 20 cases with history of exposure to noise and 50 normal healthy subjects. Hearing loss was detected in the high-frequency range in 62% of patients with history of noise exposure. Results confirm the critical need for auditory threshold monitoring encompassing high frequencies in patients exposed to noise.

INTRODUCTION

With the advancement in the technologies the treatment and rehabilitation of the hearing handicapped have reached highly sophisticated levels but man should not be overly impressed with his achievements. One of the important causes of deafness (noise) is a result of our mechanized and advanced society.

Normal human hearing sensitivity ranges from approximately 15 to 20,000 Hz with lower frequencies located towards the apical end of cochlea and higher frequencies towards the basal end of cochlea. Hearing loss as a result of exposure to noise has been shown to typically begin in the high frequencies corresponding with the basal end of cochlea. The frequencies critical for understandings of speech are 500 Hz to 3,000 Hz. In most of the cases monitoring of hearing loss due to exposure to noise are limited to audiometric testing of frequencies from 0.25 to 8 KHz. By the time hearing loss is detected with these conventional methods, damage has already involved the speech frequencies and it can affect the verbal communication ability of a person. In the ultra high frequency pure tone audiometry, the frequency range tested is from 8 to 20 KHz. Therefore, by using the ultra high frequency audiometry, we can identify initial hearing loss in these frequencies. This will also provide the earliest possible warning to take preventive and corrective measures before the loss encroaches upon speech frequencies, which are critical for verbal communication.

The actual risk of hearing loss due to exposure to noise is equivocal due to different monitoring protocols reported in the literature. As a result, the true incidence of hearing loss is unknown. Standardized guidelines for monitoring hearing loss due to noise exposure do not exist. In view of the above, it was appropriate to carry out a study to investigate the efficacy of strategies for the early detection of hearing loss due to noise exposure.

MATERIAL AND METHODS

The present study was conducted in the department of Otorhinolaryngology, Himalayan institute of medical sciences, Jolly Grant, Swami Ram Nagar, Dehradun.

A total of 70 patients of different age groups and sex attending E.N.T. department were randomly selected. The cases studied were divided into two groups

Group A– 20 cases with history of noise exposure

Group B – 50 normal subjects with no history of hearing loss, ototoxic drug exposure or noise exposure

Relevant history and ear examination of these cases were recorded in the preformed Proforma for the study including the informed consent. Otoscopy was performed to visually confirm normal ear canal and tympanic membrane.

In the group-A, complete history of noise exposure and its duration were recorded. The cases were then subjected to pure tone audiometry with thresholds from 0.25 to 20 KHz.

In the group-B, normal subjects were selected with no history of previous ototoxic drug induction or exposure to noise. The pure tone audiometry was performed in these subjects from 0.25 to 20 KHz. Normal subjects were divided in three sub age groups. Hearing thresholds were plotted on the graph paper to obtain the age specific reference curve of hearing thresholds. The thresholds obtained from group A were compared to the age specific thresholds curve of group B, and hearing loss were calculated in group A at higher frequencies.

PURE TONE AUDIOMETRY

Pure tone audiometry was conducted in double walled sound – attenuated room. By using an Interacoustics AC40 audiometer, TDH – 39 (for low frequencies) and Koss-Pro (for high frequencies) headphones, hearing was assessed in the range of pure tone thresholds from 0.25 to 20KHz. Responses were based on subject activation of hand held response buttons. Steps of 5 dB were used in obtaining all threshold results. The resulting levels were expressed in dB HL. Also bone conduction threshold were measured from 0.25 to 4 KHz in order to assess the conductive component of each hearing loss.

RESULTS

The study was conducted during the period of Dec 2004 to Sep 2006. It comprised of 70 patients presenting to the department of ENT, Himalayan Institute of Medical Sciences, Swami Ram Nagar, Dehradun. They were subjected to detailed history and thorough ENT examination as per preformed proforma. Audiometry (0.25-20KHz) was performed to detect early hearing loss. The age of the patients ranged from 13-65 years with a mean age of 39 years. The maximum number of patients 36(51.4%) were found in the age group of 10-30 years (Table no. 1).

Figure 1

Table 1: Age distribution in different groups

Groups	10-30 Years	31-50 Years	51-70 Years
A	6	10	4
B	30	11	9
Total	36(51.4%)	21(30%)	13(18.6%)

In group A, males were 20 (100%). In group B, males were 27 (54%) and females 23 (46%)

Figure 2

Table 2: Sex distribution in different groups

Groups	N	Male	Percentage	Female	Percentage
A	20	20	100%	0	0%
B	50	27	54%	23	46%

As shown in table no. 3, fifty normal subjects were divided into three groups according to their age, and auditory thresholds were obtained at different frequencies. The average normal thresholds for different age groups are shown in the figure no. 1.

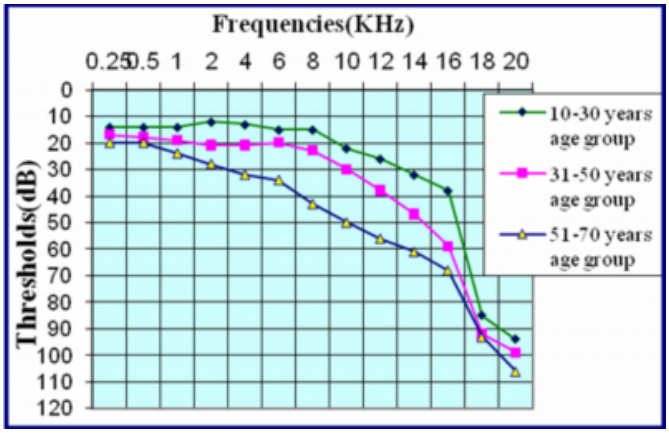
Figure 3

Table 3: Average normal thresholds (dB) in different age groups in group B

	Frequencies (KHz)												
Age groups	0.25 kz	0.5K	1K	2K	4K	6K	8K	10K	12K	14K	16K	18K	20K
10-30 years	14	14	14	12	13	15	15	22	26	32	38	85	99
31-50 years	17	18	19	21	21	20	23	30	38	47	59	92	99
51-70 years	20	20	24	28	32	34	43	50	56	61	68	93	106

Figure 4

Figure 1 : Average normal thresholds in different age groups in group B



HEARING LOSS AT DIFFERENT FREQUENCIES IN GROUP A

Hearing loss was more frequent in high frequencies (16K, 18K, 20K) in age group 10- 30 years. In age group 31-50 years it was more at frequencies 18K and 20K. In age group 51-70 years hearing loss was more at frequencies 8K, 10K and 12K (Table no. 4)(Figure no. 2).

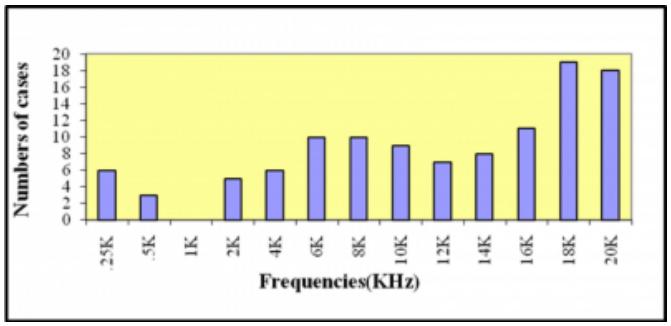
Figure 5

Table 4: Hearing loss number of times at different frequencies in Group A

	Frequencies (KHz)												
Age groups	0.25 K	0.5 K	1K	2K	4K	6K	8K	10K	12K	14K	16K	18K	20K
10-30Years	0	0	0	1	2	4	3	2	3	5	9	10	8
31-50 years	1	0	0	3	3	4	4	4	1	2	1	7	10
51-70 years	5	3	0	1	1	2	3	3	3	1	1	2	0

Figure 6

Figure 2: Hearing loss number of times at different frequencies in group A



Hearing loss was in 74% of subjects in higher frequencies and 26% at lower frequencies in age group of 10-30 years. In age group of 30-50 years, higher frequencies were affected more (63%) in comparison to lower frequencies (27%). This ratio was 40% to 60% in age group 50-70 years (Table no 5). On an average higher frequencies were affected in 63% cases and lower frequencies were affected in 27% cases (Figure no. 3).

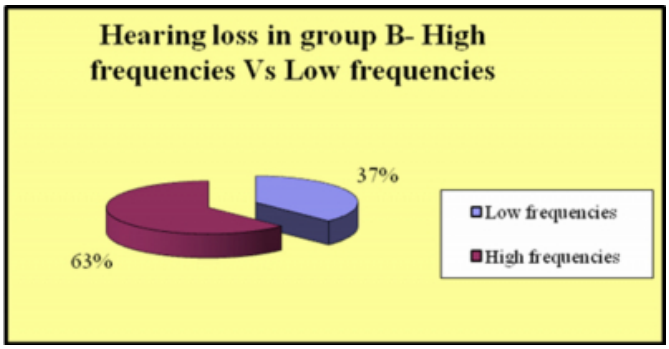
Figure 7

Table 5: Hearing loss in group A- Low frequencies Vs high frequencies

Age groups	Low frequenc (0.25-8KHz)	High frequencies (10-20KHz)
10-30Years	13 (26%)	37 (74%)
31-50 Years	15 (37%)	25 (63%)
51-70 years	15 (60%)	10 (40%)
Average	37.4%	62.6%

Figure 8

Figure 3: Hearing loss in group A



DISCUSSION

Hearing loss is becoming more and more prevalent in our mechanized and advanced society because of increasing noise pollution. The age of patients in our study ranged from 13-65 years with a mean age of 39 years. The maximum numbers of patients (51.4%) were in the age group of 10-30 years. In our study male predominance was seen. In the group A, the male preponderance can be explained by the fact that in our country, mainly the males work outdoor and in noisy environment, like factories, and the attendance of males in the out patient department of hospitals for treatment of decreased hearing is greater than their female counterparts.

AVERAGE NORMAL THRESHOLDS IN GROUP B

Normal average thresholds were obtained from the data of fifty normal patients. Fifty cases were divided in to three subgroups according to their age. Average normal thresholds were calculated in different age groups. A number of factors were associated with increasing interest in the measurement of high frequency normal thresholds. High frequency thresholds were not predictable from thresholds in the conventional frequency range (Erickson et al and Fausti et al). And despite the acknowledged importance of high frequency hearing, there were no normative reference data, even for adults (Sandra et al). Although the effect of noise exposure tended to be evident first in high frequencies (Flottorp et al), but there was no criteria to detect early hearing loss in the absence of normal high frequency reference data. In our study we obtained the normal high frequency reference curve for the comparison. As reported by Terry L et al, the ultra high frequency signal were higher in older age group, so to eliminate the aging effect from the normal reference data, we obtained three high frequency reference cures (1) for age group 10-30 years (2) for age

group 31-50 years (3) for age group 51-70 years.

HEARING LOSS IN GROUP A

In the present study cases with history of noise exposure were evaluated with a high frequency (0.25-20 KHz) test system. Data were categorized according to their age. Then these data were compared to the normal reference curves obtained in group B. Maximally affected frequencies were 16, 18 and 20 KHz in the age group 10-30 years, 18 and 20 KHz in 31-50 years. But in age group 51-70 years, middle zone and higher frequencies were maximally affected. Serra et al, Deborah A. Erickson et al, S. A. Fausti et al also reported the similar results. Ahmed HO et al reported that the noise exposed subjects had significantly higher hearing thresholds at high frequencies and upper frequency limit deteriorated as a function of age and frequency, and age was the primary predictor and noise exposure the secondary predictor of hearing thresholds in a high frequency range (10-18 KHz), but in the lower frequency range noise exposure was the primary predictor and age was secondary predictor. That fact explained the less hearing loss at the frequencies 18 and 20 KHz in age group 51-70 years. While 18 and 20 KHz were the maximally affected frequencies in the age group 10-30 years, because in this age group these frequencies were not affected by age factor. These results also suggested that high frequency screening was an early indicator for noise induced hearing loss particularly for younger groups.

Figure 9

Table 6: Most affected frequencies in different studies

S.	Studies	Affected Frequencies
1.	D. A. Erickson et al	12-20 KHz
2.	S. A. Fausti et al	13-20 KHz
3.	Grzesik J et al (1983)	10-20 KHz
4.	Ahmed HO et al (2001)	10-18 KHz
5.	Turkkahraman S et al	4-16 KHz
6.	Serra et al (2005)	14 and 16 KHz
7.	Present study	16-20 KHz

HEARING LOSS IN GROUP A: HIGHER FREQUENCIES VS LOWER FREQUENCIES

In the comparison of higher frequencies and lower frequencies, hearing loss was in 74% subjects in higher frequencies and 26% at lower frequencies in age group 10-30 years. Hearing loss was 63% at higher frequencies and 37% at lower frequencies in age group 31-50 years. Age group 51-70 years showed the more involvement of lower frequencies (60%). S A Fausti et al, D A Erickson et al also reported the more involvement of higher frequencies in case of noise induced hearing loss. In the age group 51-70 years hearing thresholds at higher frequencies were not obtainable. In that situation it was difficult to know whether these unobtainable thresholds were due to aging or noise exposure. On an average the study showed the 62.6% involvement of higher frequencies (10-20 KHz) and 37.4% involvement of lower frequencies.

CONCLUSION

Noise induced hearing loss can be detected by using only high frequency audiometry in 62.6% cases. In the younger age group (10-30 years) 74% cases can be detected by high frequency audiometry at the early stage. Thus it was concluded that ultra high frequency was useful in detecting early noise induced hearing loss

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