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Hidden Hearing Loss–Subjective and Objective Correlation of Cochlear Physiology

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Purpose: The study is aimed at identifying the co-relation of subjective and objective tests' that reveal the site of lesion in Hidden Hearing Loss.

Methods: A total of 40 participants, between the age range 18 to 25 years were included in this study. They were categorized into two groups. Group 1 – Subjects with extended high frequency (EHF) loss but normal thresholds at conventional frequencies. Group 2 with normal EHF and conventional audiogram results. EHF testing was performed at 10 kHz, 12.5 kHz, 14 kHz, and 16 kHz. Click evoked Auditory Brainstem Response was done to elicit Cochlear Microphonics (CM) and Peak I.

Results: Participants with normal EHF thresholds exhibited presence of Peak I and CM, whereas absence of Peak 1 and CM at 70 dB HL and below was seen in the group 1 participants. Results revealed no significant relationship between both groups.

Conclusions: The outcome of this study defines the physiology behind Hidden Hearing Loss as the insult to cochlear structures especially OHC's. This led to a conclusion that there is a strong alliance between EHF loss, absence of CM and Peak I resulting in Auditory dys-synchrony in the far basal regions of the cochlea. This reveals an astonishing impact that alarms young adult population to prevent further incidence at the earliest.

Keywords: Hidden Hearing Loss, Cochlear Microphonics, Extended high frequency, Cochlear physiology

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INTRODUCTION

A slope to the right in the audiogram indicates difficulty with hearing high frequency sounds and is most commonly seen in older population, entitled high frequency hearing loss. Hearing loss that can conjointly occur with normal pure-tone audiometry thresholds in the standard frequency range that is 250 Hz to 8,000 Hz but affected thresholds at further higher frequencies, i.e., beyond 8,000 Hz to 20,000 Hz is called Hidden Hearing Loss. People of all ages can be affected with it and the reasons causing can be varied. In the field of clinical audiology, Hidden Hearing loss is a concept that relatively needs more exploration. It is revealed that the outer hair cells in the basal region of human cochlea are susceptible to damage.

Multiple researches were conducted using different audiological tests to explore Hid-

den Hearing Loss but involved only behavioural tests like Extended High Frequency (EHF) Audiometry, Speech In Noise tests and physiological tests like Distortion Product Oto Acoustic Emissions even though studies about the behavioural hearing thresholds estimation by electrophysiological methods are up to date in the literature.

The auditory brainstem response (ABR) is one of such objective method to evaluate the neurologic functioning of the auditory pathway, auditory brainstem neurologic integrity, and an estimate of hearing thresholds in individuals. The ABR waveform include a series of positives and negatives waves occurring during the first 10 ms following an acoustical stimulation which represents the synchronous neural firing from various locations of the auditory pathway begins from OHC's and distal portions of the auditory nerve as part of peripheral auditory system through different lower and upper brainstem areas until auditory cortex. These peaks are represented with roman numerals I–V. Peak I of ABR generated from the spiral ganglion cells situated at distal portions of the auditory nerve which connects to the cochlear hair cells. Cochlear Microphonics is another electrical potential which can also be elicited using acoustic stimulation, presence of which indicates the integrity of the Outer hair cells functioning. Hence, including these objective tests along with behavioural tests helps to provide more reliable evidences in identifying the physiology behind Hidden Hearing Loss.

AIM

This study is aimed at identifying the co-relation of subjective and objective tests' that reveals the site of lesion in Hidden Hearing Loss.

METHODS

A total of 40 participants, between the age range of 18 to 25 years were included in this study. They were categorized into two groups with 20 participants in each group. Group 1 included 08 males and 12 females subjects with hearing loss (20 dB HL or more) at any one or more of the following extended high frequencies in one or both ears -10 kHz, 12.5 kHz, 14 kHz, and 16 kHz despite having normal hearing thresholds (within 15dB HL) at standard audiometric frequencies. Group 2 included 3 males and 17 females with normal thresholds at EHFs as well as conventional audiometric frequencies. All the subjects included in the study were BASLP students and they were identified during routine biological calibration of audiometers/daily listening checks. None of them were having any co morbid conditions or any complaints related to reduced hearing sensitivity.

The EHF audiometry testing was carried out in a soundproof room using a clinical audiometer (Maico MA 42–Dual channel digital audiometer) and Senheiser HDA 2000 Circum aural earphones. The air-conduction hearing thresholds at 10 KHz, 12.5 KHz, 14 KHz, 16 KHz were detected for right ear and left ear separately using Modified Hughson–Westlake method and plotted on a high frequency audiogram and conventional hearing thresholds were plotted on the standard audiogram.

Followed by this, ABR test was carried out under natural sleep in a sound treated room. The test was intended to elicit Peak I of ABR as well as Cochlear Microphonics at 70 dB HL from the ear which has EHF hearing loss in unilateral EHF hearing loss subjects or the ear with higher degree of EHF hearing loss in bilateral conditions. The first peak obtained in the ABR waveform within 1.5 ms +/-0.2 SD is considered as Peak I of ABR. Ring like appearance of the waveforms seen when rarefaction and condensation polarity waveforms placed together within initial 0.5 ms is considered as presence of Cochlear Microphonics.

The instrument used was Intelligent Hearing Systems (HIS) 'Duet' dual channel Auditory evoked potential system. The auditory stimuli was presented via ER–3C insert receivers. Electrode impedance obtained was within 3 KΩ. The details of the protocol used for ABR is given in Table 1. Statistical analysis done using 'Bland Altman comparison test' to check the level of significance between group 1 and group 2.

Table 1. Protocol used for ABR test

Stimulus parameter	Selection	Acquisition parameter	Selection
Transducer	ER-3C	Electrodes	Non in verting-Fz
	Insert		Inverting-Ai/Mi (test ear mastoid process)
	Receivers		Ground (common)-opposite ear mastoid process
Stimulus	Clicks	Filters	100 Hz to 3,000 Hz
		Amplification	×100,000
Duration	0.1 ms	Analysis time	15 msec
Polarity	Rarefaction and condensation	Runs	>/=2 times
Rate	21.1 clicks/sec		
Intensity	70 db HL		

Table 2. BERA test results with Bland Altman comparison shown no significance among two groups

Groups	BERA				Bland Altman test comparison		
	CM		Peak-I				
	Present	Absent	Present	Absent	95 confidence interval	Bias SE (%)	Level of significance
	n (%)	n (%)	n (%)	n (%)			
EHF affected	6 (30)	14 (47)	1 (5)	19 (95)	-353.8 to 391.4	18.82	p=0.76
EHF normal	20 (100)	0 (0)	18 (90)	2 (10)	-353.8 to 391.4	18.82	p=0.76

$p<0.05$ is considered as level of significance.

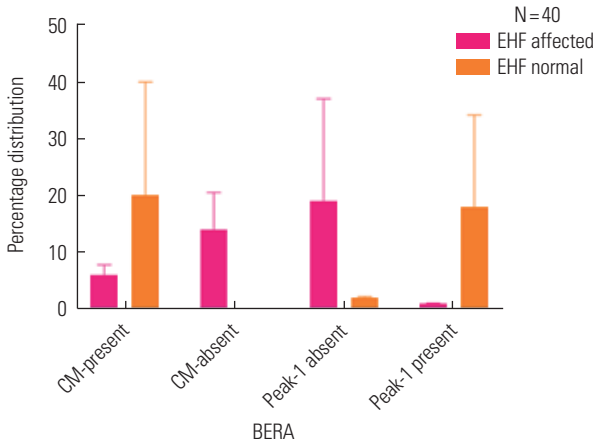

Figure 1. A bar chart illustration of the effects of EHF hearing loss on the presence of Peak I and Cochlear Microphonics for group 1 and group 2.

RESULTS

The results of the present study shows that participants with normal EHF thresholds exhibited presence of Peak I (90%) and Cochlear Microphonics (100%), whereas Peak 1 at 70 dB HL and below was absent for 95% and Cochlear Microphonics was also not seen for 47% at or below 70 dB HL for the group 1 participants for whom hearing loss at EHF's were present. A bar chart illustration of the same is given in Figure 1.

The results of 'Bland Altman comparison test' used to check the level of significance between group 1 and group 2 indicates no statistically significant relation between the two groups. The details of the same is given in Table 2.

DISCUSSION

Hidden Hearing Loss is comparatively a new concept in the filed of auditory disorders where it presents itself with diverse symptoms and signs in different people. Most of the research evidences identifies the common symptom of HHL is difficulties in speech in noise perception despite having normal standard audiogram thresholds. Audiological evaluation results in HHL is identified by recent researches are EHF hearing loss, Reduced or absent DPOAE's, Poor scores in Speech In Noise or Digits In Noise tests etc even though there is poor agreement between several research results. Conclusive idea about the physiological basis of HHL from the available studies indicates a dysfunction at the cochlear hair cells level seen at the far basal regions of the cochlea.

The present study was also aimed at exploring the physiological basis of HHL by performing objective tests such as BERA and subjective test such as EHF audiometry which are sensitive in identifying cochlear dysfunctions. Such studies are comparatively rare in the area of HHL research at present. The results identify the dysfunction at the basal level of the cochlea by absent Peak I of ABR as well as Cochlear Microphonics in correlation with hearing impairment at extended high frequencies despite a normal conventional audiogram. This study also rules out the effects of aging by including only young adults aged between 18 to 25 years with no co morbid conditions like conductive or mixed pathologies, structural deformities, ototoxicity, noise exposure etc.

CONCLUSION

The outcome of this study defines the physiology behind Hidden Hearing Loss as the insult to cochlear structures especially Outer Hair Cells. This led to a conclusion that there is a strong alliance between EHF loss, absence of Cochlear Microphonics and Peak I resulting in Auditory dys-synchrony in the far basal regions of the cochlea. This reveals an astonishing impact that alarms young adult population to prevent further incidence at the earliest as this dysfunction at the far basal region may spread towards the adjacent physiological areas also in long run due to aging, noise exposure etc. The results also alarms to begin early rehabilitation methods to follow at the earliest.

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