Comparison of Binaural Interaction Component (BIC) in Symmetrical and Asymmetrical Hearing Loss: Pilot Study

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Abstract

Background and Objective: *Binaural interaction component has been seen to be effective in assessing the binaural interaction process in normal hearing individuals. However, there is a lack of literature regarding the effects of SNHL on the Binaural Interaction Component of ABR. Hence, it is necessary to study binaural interaction occurs at the brainstem when there is an associated hearing impairment.*

Methods: *Three groups of participants in the age range of 30 to 55 years were taken for study i.e. one control group and two experimental groups (symmetrical and asymmetrical hearing loss). The binaural interaction component was determined by subtracting the binaurally evoked auditory potentials from the sum of the monaural auditory evoked potentials: BIC= [{left monaural + right monaural)-binaural}. The latency and amplitude of Vth peak was estimated for click evoked ABR for monaural and binaural recordings.*

Results: *One way ANOVA revealed a significant difference for binaural interaction component in terms of latency between different groups. One-way ANOVA also showed no significant difference seen between the three different groups in terms of amplitude.*

Conclusion: *The binaural interaction component of auditory brainstem response can be used to evaluate the binaural interaction in symmetrical and asymmetrical hearing loss. This will be helpful to circumvent the effect of peripheral hearing loss in binaural processing of the auditory system. Additionally the test does not require any behavioral co-operation from the client, hence can be administered easily.*

Keywords: *BIC, symmetrical, asymmetrical, hearing loss, ABR, Binaural interaction*

Introduction

Sensorineural hearing loss (SNHL) is probably the most common form of hearing loss and this type of hearing loss not only lead to elevation of threshold for detection of sound but, also the affects the way in which sound is perceived. The perception of speech in individual with SNHL is also dependent on the configuration of hearing loss. Sensorineural hearing loss can be symmetrical or asymmetrical. Asymmetrical sensory neural hearing loss is defined as binaural difference in bone conduction thresholds of greater than 10dB at two consecutive frequencies or greater than15dB at one frequency (0.25 to 8.0KHZ) and a difference of greater than 15 dB in the maximum speech discrimination score is also significant. Symmetrical sensorineural hearing loss refers to the same or similar degree of hearing loss in both ears. So the people with asymmetrical hearing loss expected to have problem in binaural hearing.

Cochlear hearing loss leads to both frequency and temporal problems, resulting in poor frequency and temporal resolution abilities, i.e. reduction in the ability to resolve the frequency components of complex sounds and reduced ability to process the temporal fine structure of sounds. One of the major consequences of such a type of reduction in resolution is the reduction in the ability to process binaural signals. Binaural processing is the degree to which interactions take place between the two ears. If no interaction occurs between the two ears, then it is expected that the binaural system has been compromised. Binaural cues provide the basis for judgments on sound direction. Binaural hearing has distinct advantages in terms of sound localization and hearing in noise over monoaural hearing and also for binaural loudness summation and binaural release from masking.

The occurrence of binaural interaction in humans has been demonstrated using both psychoacoustic and electrophysiological methods. Van et al., (2009)[1] studied sound localization, sound lateralization and binaural masking differences in young children (4 to 9 years) with normal hearing. The results of this study show that the modified procedures are suitable for testing children from the age of 4 to 5 yr. Furthermore, it seems that binaural hearing capacities of the 5-yr-olds are similar to those of adults. Several observations led to the hypothesis that the observed age differences between 4-yr-olds and older subjects on localization and Behavioural MLD or between those 4- to 9-yr old and adults on lateralization were attributable to both a development in binaural hearing and to non-auditory factors, such as task comprehension, attention, and testing conditions. It is possible that the developmental process is more obvious and prolonged in other aspects of binaural hearing, which require more dynamic or more central processing.

Jerger et al., (1984)[2] studied the effects of both symmetric and asymmetric peripheral hearing loss on the masking level difference (MLD) at 500 Hz in 651 subjects with conductive or sensorineural hearing loss and 270 normal controls. The data supported the hypothesis that the modification in MLD due to peripheral hearing loss results from deterioration in threshold in the antiphasic condition. These results provide correction factors for the normal MLD range as functions of boundary frequency of sensorineural loss above 500 Hz and degree of both symmetric and asymmetric sensitivity loss at 500 Hz in both subjects with conductive hearing loss and those with sensorineural hearing loss.

ABR is a powerful diagnostic tool that provides both valuable neurological and audiological information. Hood (1998)[3] discussed the main clinical applications of ABR which consist of the identification of neurological abnormalities in the VIIIth nerve and auditory pathways of the brainstem, and the estimation of hearing sensitivity. The ABR is a transient potential that is a far-field scalp recording produced by brief acoustic signals such as clicks or tone bursts.[3,4,5] The ABR is a measure of neural synchrony of the time-locked, onset-sensitive, single-unit activity in the auditory nerve and the brainstem.[6] Stimuli with a very rapid onset are used to elicit synchronous discharge of a large number of neurons occurring during the first 10 msec after the presentation of the stimulus.[7]

The auditory brainstem responses have been used for studying binaural interaction component electrophysiologically. The binaural interaction component (BIC) is derived by subtracting the ABR obtained with binaural stimulation from the waveform obtained by adding the responses from the left and right monaural stimulation. This concept is expressed as: binaural difference waveform = (R + L) – BI; where, R + L is the sum of the right and left evoked potentials obtained with monaural stimulation, and BI is the response acquired from binaural stimulation. The BIC is most apparent in the binaural difference waveform obtained in humans at 4.5 to 7.0 ms after the stimulus onset for click stimulus, which is consistent with peaks IV to VI.[8]

Binaural interaction is reflected in electrophysiological activity of neurons activated by binaural stimulation central to the cochlear nucleus.[9] Binaural interaction is known to occur at three levels of the brainstem: the superior olivary complex, the nuclei of lateral leminscus, and the inferior colliculus.[10] Binaural interaction components (BIC) manifest binaural interaction[11,12] and are valid and proven responses which reflect ongoing binaural processing.[9,12]

Researchers have shown that summation of monaural ABRs do not predict the ABRs obtained with binaural stimulation.[8,13,14,15] Binaural interaction in auditory evoked is observed when the sum of the monaural potentials responses is not equal to the binaural response.[16,17]

Behavioural test of binaural interaction is less reliable when there is an associated peripheral hearing loss. Hence it becomes necessary to find an alternative means to assess the binaural interaction process in the hearing impaired. Binaural interaction component has been seen to be effective in assessing the binaural interaction process in normal hearing individuals. However, there are no studies reported in literature regarding the effects of SNHL on the Binaural Interaction Component of ABR. Hence it is necessary to study binaural interaction occurs at the brainstem when there is an associated hearing impairment. Hence it becomes necessary to compare the BIC for ABRs in individuals with normal hearing with individuals with symmetrical as well as asymmetrical SNHL. Also, it is interest to know if there is a significant difference in the encoding of this binaural process at the brainstem in individuals with asymmetrical hearing loss. Hence it becomes necessary to compare the BIC for ABRs in symmetrical and asymmetrical SNHL. The present study aimed at comparing the binaural interaction at the level of auditory brainstem in individuals with normal hearing with individuals with symmetrical and asymmetrical SNHL.

Material and Method

Participants: The study was carried out with aim of studying the effect of sensorineural hearing loss in binaural interaction component electrophysiologically using click evoked ABR in normal hearing individuals and individuals with symmetrical sensorineural hearing loss in the age range of 30 to 55 years. Three groups of participants were taken for study i.e. one control group and two experimental groups (symmetrical and asymmetrical hearing loss). For control group, 10 participants in the age range of 30 to 55 years (mean age of 38.6 years) was considered for the study. The participants under control group should must have normal hearing sensitivity with no history or presence of any other neurological problems. For first experimental groups, 10 participants in the age range of 30 to 55 years (mean age of 39.2 years) with sensorineural hearing loss in both ears and the difference in threshold should not be more than 10 dB between the ears were selected for the study. Clients with sensorineural hearing loss up to moderate degree was considered for the study (PTA should be greater than 15dB and less than 65dB). Experimental subjects should have must have speech identification score of greater than 55% in the test ear and ABR with repetition rate of 11.1 and 90.1/sec was done to rule out retro-cochlear hearing loss. The subjects with no history or presence of any other neurological problems was selected for study.

For second experimental group (symmetrical hearing loss), 10 participants in the age range of 30 to 55 years (mean age 40.3 years) was considered for the study. Participants will be selected on the criteria that they should have Sensorineural hearing loss in both ears and the difference in threshold should be more than 20 dB between the ears for at least 2 frequencies. Clients with sensorineural hearing loss up to moderate degree was considered for the study (PTA should be greater than 15dB and less than 65dB). Speech identification score of greater than 55% in the test ear. ABR with repetition rate 11.1 and 90.1/sec was done to rule out retro-cochlear pathology. No history or presence of neurological problems.

Testing environment: Electrophysiological tests were carried out in a sound treated room where the noise level was as per the guidelines in ANSI S3.1 (1999). The testing rooms were well illuminated and air conditioned for the comfort of the experimenter as well as participant.

Instrumentation: Calibrated double channel clinical audiometer (Orbitor-922) was used for pure tone audiometry. Calibrated GSI-Tympstar Immittance meter was used for tympanometry and reflexometry. Intelligent Hearing System with smart EP was used to record click evoked ABR.

Procedure

Pure tone thresholds were obtained using modified version of Hughson and Westlake procedure across octave frequencies from 250 Hz to 8000 Hz for air conduction and frequencies from 500, 1000, 2000 and 4000Hz for bone conduction. Middle ear analyzer (GSI-Tympstar) was used to carry out tympanometry using a probe tone frequency of 226 Hz and to obtain ipsilateral and contralateral acoustic reflexes thresholds at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. For electrophysiological testing electrodes was placed on the sites with conduction paste and secured with skin tape. It was made sure that each electrode impedance should be within < 5 kohms and inter electrode impedance should be within < 2kohms. Impedance for each electrode was also checked during testing to make sure that patient did not cause any variation in the impedance. Participants was instructed to sit comfortably on a reclining chair and relax during the testing. It was also requested to close their eyes during testing to avoid any artifacts. Click evoked ABR was recorded twice for the reproducibility. Test protocols of click evoked ABR is given in Table 1.

Table 1: Test protocol for recording click evoked ABR

Transducer	**ER 3A Insert ear phones**
Filter band	100 to 3000HZ
No of sweeps	3000
Stimulus, duration	Clicks, 0.1 ms
Intensity	85dBspl
Polarity	Rarefaction
Repetition Rate	7.1/sec
Time window	12ms
Electrode Placement	
Inverting electrode (-)	Nape of the neck
Non Inverting electrode (+)	Vertex
Ground electrode	Forehead

Response Analysis

Click evoked ABR was recorded monaurally and binaurally for both the groups. Response obtained by giving the stimulus monaurally (right and left ear) separately and then binaurally. The binaural interaction component was determined by subtracting the binaurally evoked auditory [potentials from the sum of the monaural auditory evoked potentials: BIC= [{left monaural + right monaural)-binaural}. The latency and amplitude of V^{th} peak was estimated for click evoked ABR for monaural and binaural recordings. The amplitude was estimated by taking the peak which has got maximum energy within 10ms for click evoked ABR and the peak which comes under 5-6 ms was estimated for obtaining the latency of the Vth peak. Finally the amplitude and latency of BIC was also estimated. The parameters calculated were latency and amplitude of wave V of click evoked ABR summed monaurally, latency and amplitude of wave V of click evoked ABR recorded binaurally and latency and amplitude binaural interaction component for click stimuli.

Results

The present study aimed to find out the presence of binaural interaction component using click evoked stimuli in normal hearing individuals and individuals with symmetrical sensorineural hearing loss. To study the presence of binaural interaction component in normal hearing individuals and individuals with symmetrical as well as asymmetrical sensorineural hearing loss the latency and amplitude of binaural interaction component was analyzed for the click stimuli for both groups.

Statistical analysis had been done using SPSS (version 16.0) for both groups in this present study. Descriptive analysis was carried out to find out the mean and standard deviation of latency of wave V of click evoked ABR for summed monaural, binaural and binaural interaction component for both groups. Similarly, amplitude of wave V of click evoked ABR for summed monaural, binaural and binaural interaction component for both groups. One way ANOVA was done to compare the significant difference between two groups, for latency and amplitude of wave V of click evoked ABR for summed monaural, binaural and binaural interaction component for both groups.

Latency of Wave V: ABR for click stimulus was recorded for right ear and left ear separately first, then the two responses were added together to get a summed monaural responses. Binaural ABR was recorded using simultaneous presentation of click stimulus to both ears. BIC for click was derived by subtracting binaural responses from monaural responses. The representative waveform of summed monaural, binaural and binaural interaction component for the normal hearing group has been given in the Fig. 1.

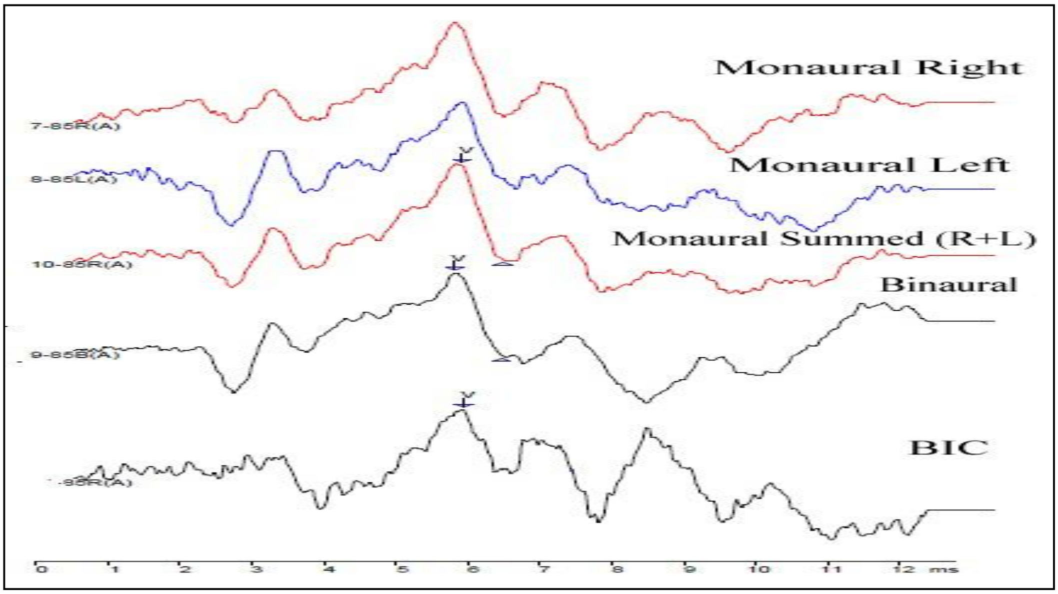

Fig. 1: Sample waveform of summed monaural binaural and binaural interaction component using click stimuli recorded in one subject of normal hearing group

Descriptive statistics were done to find out the mean and standard deviation of latency for summed monaural, binaural and binaural interaction component for normal hearing group using click stimulus. The details of the mean and standard deviation are given in Table 2.

Table 2: Mean and standard deviation of latency of wave V for normal hearing group

Latency	N	Mean (µv)	Std. Deviation
Summed Monaural (R+L)	10	5.51	0.12
Binaural	10	5.47	0.18
BIC	10	5.73	0.39

In the normal hearing group, all the subjects had a clear summed monaural, binaural and BIC responses. The grand average BIC is shown in the Fig. 1. The summed monaural **(R+L)** had a mean latency of 5.51 ms. The binaural had a mean latency of 5.47 ms and the BIC had a mean latency of 5.73 ms as displayed in the Table 2.

For the symmetrical sensorineural hearing loss group, BIC for click was derived by subtracting binaural responses from summed monaural responses. The representative waveform of summed monaural, binaural and binaural interaction component for the symmetrical sensorineural group has been given in the Fig. 2.

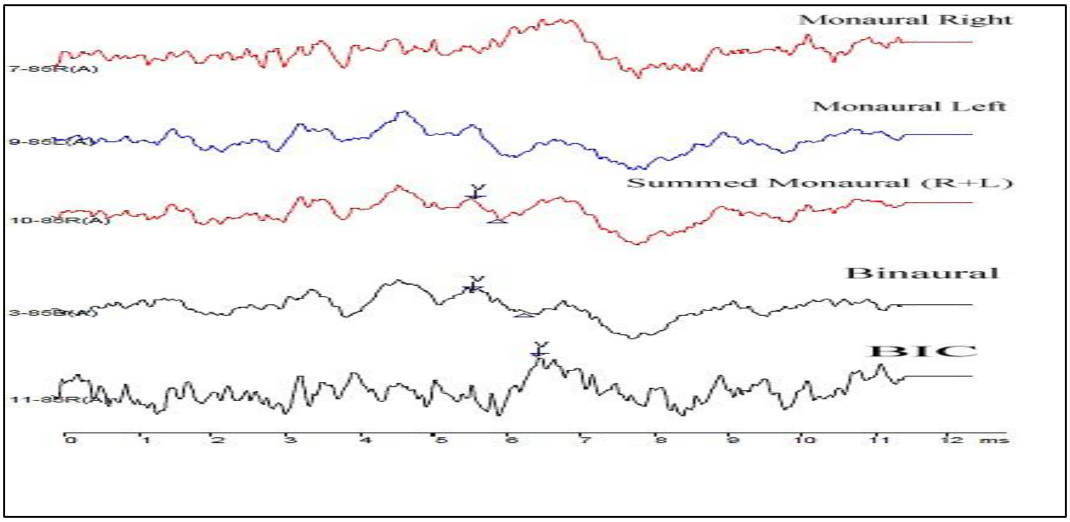

Fig. 2: Sample waveform of summed monaural binaural and binaural interaction component using click stimuli recorded for one subject of symmetrical hearing group

Descriptive statistics was done to find out the mean and standard deviation of latency for summed monaural, binaural and binaural interaction component for symmetrical sensorineural hearing loss group using click stimulus. The details of the mean and standard deviation are given in Table 3.

Table 3: Mean and standard deviation of latency of wave V for symmetrical sensorineural group

Latency	N	Mean (μv)	Std. Deviation
Summed Monaural (R+L)	10	5.66	0.22
Binaural	10	5.63	0.23
BIC	10	5.91	0.21

All the subjects in symmetrical sensorineural hearing loss group had a clear summed monaural, binaural and BIC responses. The sample waveform of BIC in experimental group is shown in the Fig. 2. The summed monaural **(R+L)** had a mean latency of 5.66 ms and the binaural had a mean latency of 5.63 ms. The BIC had a mean latency of 5.91 ms as displayed in the Table 3.

For asymmetrical sensorineural hearing loss group, ABR for click stimulus was recorded for right ear and left ear separately first, then the two responses were added together to get a summed monaural responses. Binaural ABR was recorded using simultaneous presentation of click stimulus to both ears. BIC for click was derived by subtracting binaural responses from monaural responses.

The representative waveform of summed monaural, binaural and binaural interaction component for the asymmetrical sensorineural hearing loss group has been given in the Fig. 3.

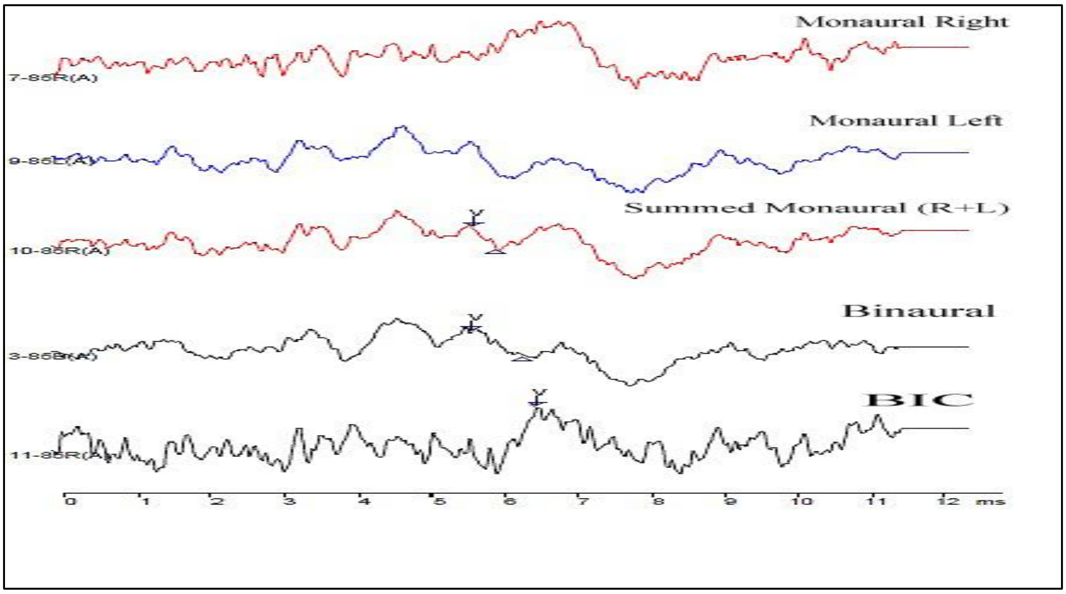

Fig. 3: Averaged waveform of summed monaural binaural and binaural interaction component using click stimuli recorded in asymmetrical sensorineural hearing group hearing group

Descriptive statistics were done to find out the mean and standard deviation of latency for summed monaural, binaural and binaural interaction component for symmetrical hearing loss group using click stimulus. The details of the mean and standard deviation are given in Table 4.

Table 4: Mean and standard deviation for asymmetrical sensorineural group

Latency	N	Mean(µv)	Std. Deviation
Summed Monaural (R+L)	10	5.79	0.30
Binaural	10	5.63	0.33
BIC	10	6.03	0.26

In asymmetrical sensorineural hearing loss group, all subjects had a BIC. The summed monaural **(R+L)** had a mean latency of 5.79 ms. The binaural had a mean latency of 5.63 ms The BIC had a mean latency of 6.03 ms as displayed in the table 4.3. By comparing the BIC waveform across figures 1 to 3, it can be observed that the latency of BIC for normal hearing group morphology was similar to the symmetrical sensorineural hearing loss group i.e. the latency of BIC for normal hearing group was 5.73 ms, 5.93 ms for symmetrical sensorineural hearing loss group. But the latency of asymmetrical sensorineural hearing loss group was delayed by around 0.40 ms when compared to the normal hearing group.

To compare whether there is any significant difference exists among latency of summed monaural, binaural, binaural interaction component for the three different group, one-way ANOVA and Duncan's post hoc analysis had been done. There was not much variation in standard deviation seen for all the three different groups for latency compared to the amplitude of summed monaural, binaural and BIC of the three different groups. One way ANOVA results indicated no significant difference for wave V latency of summed monaural recording for three different group [$F(2, 27)= 0.12$, $P> 0.05$]. It also revealed no significant difference for wave V latency of binaural recording across three group [$F (2, 27) = 0.30$, $P> 0.05$]. However, One way ANOVA revealed a significant difference for binaural interaction component for different groups [$F (2, 27) = 0.01$, $P< 0.05$]. To further understand the group difference the Duncan's post hoc analysis was done. The results of Duncan's post hoc analysis are given in the Table 5.

Table 5: Results of Duncan's post hoc analysis

	Symmetrical	Asymmetrical
Normal	> 0.05	< 0.05
Symmetrical		> 0.05

It can be seen from the table 5 that there was no significant difference seen between latency of binaural interaction component for normal and symmetrical sensorineural hearing loss group. But there was significant difference seen for latency of binaural interaction component for normal hearing group and asymmetrical sensorineural group. The asymmetrical sensorineural hearing loss had a longer latency compared to the normal hearing group.

Amplitude of wave V: Amplitude of summed monaural, binaural and binaural interaction component were calculated by measuring the peak to trough amplitude of wave V in each condition. Descriptive statistics was done to find out the mean and standard deviation of amplitude for the summed monaural, binaural and binaural interaction component for the click stimuli. The details of the mean and standard deviation of three different groups are given below in the table 6 to 8.

In the normal hearing group, mean amplitude for summed monaural was 0.57μv. Binaural had a mean amplitude of 0.97 μv. Binaural interaction component had a mean amplitude of 0.14 μv. The average mean and standard deviation for amplitude of summed monaural, binaural and binaural interaction for normal hearing group is shown in the Table 6.

Table 6: **Mean and standard deviation for amplitude of normal hearing group**

Amplitude	**N**	**Mean(**µv)	**Std. Deviation**
Summed Monaural(R+L)	10	0.57	0.22
Binaural	10	0.97	0.39
BIC	10	0.14	0.13

In symmetrical sensorineural group, mean amplitude for summed monaural was 0.54μv. Binaural had a mean amplitude of 0.89 μv. Binaural interaction component had a mean amplitude of 0.11 μv. the average mean for amplitude of summed monaural, binaural and binaural interaction for symmetrical sensorineural group is shown in the in the Table 7.

Table 7: Mean and standard deviation for amplitude of symmetrical sensorineural group

Amplitude	N	**Mean(**µv)	**Std. Deviation**
Summed Monaural(R+L)	10	0.54	0.37
Binaural	10	0.89	0.78
BIC	10	0.11	0.06

In asymmetrical sensorineural group, mean amplitude for summed monaural was 0.34 μv. Binaural had mean amplitude of 0.58 μv. Binaural interaction component had mean amplitude of 0.13 μv. The average mean for amplitude of summed monaural, binaural and binaural interaction was displayed in the Table 8.

Table 8: Mean and standard deviation for amplitude of asymmetrical sensorineural group

Amplitude	**N**	**Mean(µv)**	**Std. Deviation**
Summed Monaural(R+L)	10	0.34	0.14
Binaural	10	0.58	0.26
BIC	10	0.13	0.02

As it can be seen from Table 6 to 8 that mean amplitude of wave V for the summed monaural, binaural and amplitude of BIC were almost similar across the three different groups.

It can also be noted that the standard deviation for the amplitude of summed monaural, binaural and BIC is very high across the three different groups.

To compare whether there is any significant difference exists among amplitude of summed monaural, binaural, binaural interaction component for the three group, one-way ANOVA and Duncan's post hoc analysis had been done. There was no significant difference seen between the three different groups. The amplitude of summed monaural, binaural and binaural interaction component was similar between these groups [$f\ (2, 27) = 0.12 > 0.05$] for summed monaural responses, [$f\ (2, 27) = 0.23 > 0.05$] for binaural responses and [f (2, 27) = 0.23 > 0.05] for BIC respectively. This reveals that the amplitude of summed monaural, binaural and BIC was similar for normal hearing group, symmetrical sensorineural hearing group as well as for asymmetrical sensorineural hearing group.

Table 9: **Results of Duncan's post hoc analysis**

	Symmetrical	Asymmetrical
Normal	>0.05	>0.05
Symmetrical		>0.05

Thus, it is clear from table 9 that the amplitude of BIC was not significantly different across the three different group.

To summarize the results, with existence of peripheral loss there is no significant difference in the latency obtained for summed monaural, binaural and interaction component for normal and symmetrical sensorineural hearing loss group as well as for symmetrical and asymmetrical sensorineural hearing loss group. But there was a significant difference obtained for latency of BIC for normal hearing group and asymmetrical hearing group and it was statistically significant compared to the other groups. There is no significant difference in the amplitude obtained for summed monaural, binaural and binaural interaction component across the tree different groups. However, the amplitude of BIC recorded for all the tree groups had a large standard deviation.

Discussion

The present study was aimed to find out the presence of binaural interaction component in symmetrical and asymmetrical sensorineural hearing loss group compared to normal hearing.

Latency of Wave V: In the present study the mean latency of the binaural interaction component for the normal hearing group was found to be in the range between 5.73 to 6.09 ms. The latency obtained for BIC for the normal hearing group was almost similar compared to the previous studies[18,19] reported in the literature. Chiappa et al., (1979)[18] reported a mean latency of 5.75+ 0.25 msec and Gopal and Pierel[19] reported latency as 5.63+0.26 msec. The reason for obtaining similar is because of the similar recording protocols used in the present study. Earlier studies used a presentation level of 80 dBnHL and a repetition rate of 7.7/sec for recording the binaural interaction component. In the present study almost similar recording protocols used were presentation level of 85 dBnHL and repitition rate of 7.1/sec.

For normal and symmetrical sensorineural hearing loss group, there was no significant difference seen for the latency of binaural interaction component. The subjects included in the study range from 22 years to 55 years. The degree of hearing loss of the subjects included in the study varied from minimal to moderate sensorineural hearing loss. Out of 10 subjects, 6 subjects had bilateral minimal sensorineural hearing loss and remaining 2 had bilateral mild sensorineural hearing loss and the other 2 had bilateral moderate sensorineural hearing loss. Click stimuli was used for the study with the presentation level of 85 dbnHL with repetition rate of 7.1/sec.

As reported by various researchers, the wave V latency increases as hearing loss at 4000HZ increases.[20,21] Latency of ABR wave V with sensory neural impairment (for high stimulus intensity level of clicks stimuli) was analyzed as a function of audiometric HTL (hearing threshold level) at 4000 HZ. Latency was stable for hearing loss up to 60 dBHL and then it increased linearly to a maximum of about 0.4ms through 90 dBHL. The most pronounced latency change occurred for patients with hearing loss greater than 70 dBHL. So, hearing threshold level (HTL) at 4000 HZ for minimal loss was around 25 dBHL in both ears, for mild loss was around 35dBHL in both ears and for moderate loss was around 50 dBHL respectively. The latency values for ABRs in present study was in consonance with previous studies considering the high presentation level (85 dBnHL) and hearing threshold level less than 70 dBHL for 4 KHz. It was almost similar to the latency of normal hearing group. So, there was no effect on the latency of binaural interaction component seen. There are no studies in the literature reporting the effect of symmetrical sensorineural hearing loss in BIC. However, it can be assumed that Binaural Interaction depends on the interaural asymmetry, which in case of symmetrical sensorineural hearing loss, the interaural hearing thresholds are similar. Based on the theories of binaural interaction, equal levels of sound in both ears lead to adequate binaural interaction. Hence it can be assumed that, this phenomenon lead to latencies of BIC being similar to normal. Therefore it may be assumed to be, this might be the possible mechanism underlying for the latency of binaural interaction in symmetrical sensorineural hearing loss.

For normal and asymmetrical sensorineural group, there was a significant difference seen in the latency of binaural interaction component, but for summed monaural and binaural there was no significant difference seen. The mean latency of normal hearing group was around 5.73 to 6.09 ms, which is similar to the results reported in earlier studies.[18,19] For asymmetrical sensorineural hearing group, the mean latency of binaural interaction component was around 6.03 to 6.31 ms. The latency was prolonged around 0.30 ms as seen in the Fig. 3.

The subjects included in the asymmetrical group had a prolonged latency for binaural interaction component compared to the normal hearing group. This is because of the asymmetry between the two ears is almost more than 20 dB from 2000 HZ to 4000 HZ where the maximum energy for click stimuli is present. The monaural response of the poorer ear (right ear) is prolonged compare to the left ear. By adding the response of both monaural responses, the summed monaural (R+L) had a more rounded peak compared to the binaural responses. This is because of the delay in the signal reaching at the level of lateral lemniscus, which is anatomically considered as the generation site of binaural interaction component. So, there was latency shift of more than 30 ms seen in the latency of binaural interaction component in asymmetrical sensorineural group compared to the normal hearing group.

There are no studies in the literature which report the effect of binaural interaction component in normal and asymmetrical sensorineural hearing group. Hence it can be assumed that the interaural intensity difference have an adverse effect at the level of brainstem. Asymmetry in the auditory brain stem evoked response (ABR) and its effect on measurements of binaural interaction were studied by Spivak & Seitz., (1988).[22] Monaural and binaural ABRs were recorded from 24 normal hearing subjects at two sensation levels: 70 and 50 dB. Monaural responses were judged to be asymmetrical when the right response minus the left response resulted in a difference trace which was significantly greater than the level of the background noise in the ABR. It was found that sensation level significantly affected the frequency of monaural response asymmetry. It was concluded that the BIC is affected by factors other than those which can be attributed solely to binaural interaction as reported by Spivak & Seitz., (1988).[22]

Correlating with the above study, the amount of time required for the poorer ear in the asymmetrical hearing loss to reach at the level of brainstem is more compared to the better ear. So, interaural time delay between the ears results in the prolonged latency of binaural interaction component. But in normal group there are no interaural time delay between the ears reaching the level of brainstem. Because both ears have threshold within in the normal range. Hence there will be little chance of an adverse interaural time delay.

For symmetrical and asymmetrical sensorineural hearing group, there was no significant difference seen for summed monaural, binaural and BIC. In this present study stimuli used was clicks. Whereas, clicks contain a broad range of frequencies and it is onset response for synchronous firing of neurons. It is important to know that human beings are exposed to speech stimulus in the environment and not the click stimulus. If it is assumed that humans have little exposure to clicks and that clicks have little relevance, regardless of age, the auditory system would not to be expected to change its response to such a stimulus.

Amplitude of wave V: In this present study, there was no significant difference seen for amplitude of BIC obtained between any groups. Amplitude obtained for both group are within the range of 0.11 – 0.24 µv. large standard deviation in amplitude of BIC might be a result of the large standard deviation obtained for the summed monaural and binaural recording. Previous studies have also reported a very large variation of the binaural interaction component recorded with click stimuli.[23] It is known that the electrophysiological recordings often don't replicate well and the peak to peak measures of the components vary widely. This has led to many researchers to believe that amplitude measure of the ABR components is highly variable.[24] While it is true that the measurements often vary from run to run, it is not necessarily true that the variation is solely due to electrophysiological changes. The measured average waveform (i.e. the ABR amplitude) is composed both of synchronous neural component- the true electrical potential and the residual noise. Therefore, it is possible that the variation in the measurement is due to the variation in the EP component. Also there are episodic noise bursts or changes in the level of the background noise from one run to the other. As a result, the residual noise can vary greatly from one run to the next when a fixed number of sweeps are used, thus, affixed number of sweeps will not guarantee the same SNR for repeated runs.[3,24] The measured amplitude is influenced by many factors such as individuals gender, anatomy and physiology.[24]

Therefore relying on the amplitude measure will be misleading the audiologist to know the effect of peripheral hearing loss on binaural interaction component. Thus it is preferable to use a more reliable measure to decreases the errors in the evaluation. Therefore the latency parameter of the BIC can be used to evaluate the binaural interaction component to know the effect of binaural interaction abilities in asymmetrical sensorineural hearing loss. And also, the latency of BIC can be used to circumvent the problem of peripheral hearing loss in individuals with CAPD with associated peripheral hearing loss.

Another reason why there is no significant difference might be the amplitude of the BIC itself. BIC is a derived waveform and the amplitudes are generally of much smaller magnitudes compared to the normally recorded ABRs (0.54μv for summed monaural and 0.97 μv for binaural of ABR wave V and 0.14 for BIC). The amplitudes are very small even in normal hearing individuals. Hence owing to small amplitude and the relatively large variation, there might have been a flooring effect which has been achieved. Hence it is possible that, inspite of having symmetrical and sensorineural hearing loss, the responses are not significantly different from normal responses.

Conclusion

Present study was undertaken with an objective of studying the effect of peripheral hearing loss in binaural interaction component using click evoked stimuli. The binaural interaction component of auditory brainstem response can be used to evaluate the binaural interaction in symmetrical and asymmetrical hearing loss. This will be helpful to circumvent the effect of peripheral hearing loss in binaural processing of the auditory system. Additionally the test does not require any behavioral co-operation from the client, hence can be administered easily. Hence, latency of the BI is a better parameter to evaluate the binaural interaction compared to the amplitude, as amplitude of the BIC shows a very large standard deviation.

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