P300 in Children with Early and Late Cochlear Implantation

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Abstract: ***Introduction**: P300 shows the cortical electrophysiological activity which involved in attention, memory, discrimination, integration and decision making skills. T Therefore P300 is used for assessing the cortical function of the individual with hearing impairment. **Aim and Need of the study**: This present research is focused on objective assessment of P300 in early and late cochlear implantees. So the present study aimed on investigating the P300 in individuals with early and late cochlear implantation. **Method**: 30 participants were included in this study. All the 30 participants had undergone unilateral cochlear implantation. The selected participants were divided into two groups. The group I includes children who had undergone CI below the chronological age of 3.5 years and group II includes children who had undergone CI after the chronological age of 3.5 years. All the selected participants were recorded with P300 (endogenous potential) through loud speaker. This elicited a positive response in the latency region of 250msec to 400 msec. **Results and discussion**: The data on latency and amplitude were tabulated and analyzed using SPSS for Windows (Version 16.0). The data in terms of latency and amplitude of P300 in early and late cochlear implantees were analyzed using descriptive statistics (mean, Standard Deviation and range values of latency and amplitude).The group I and group II were compared using the inferential statistics i.e. the Independent sample t test was used, to find out the significant difference between the groups. The results revealed that latency of early and late implantees were statistically significant. **Conclusion**: To conclude the present study that hearing impairment during first few years of life can create a negative consequences for developing brain and if not stimulated on optimal period that can lead to reduce or poor performance, hence the younger the chronological age of implantation can lead to a better prognosis.*

Keywords: Implantees, Early and Late, P300, Cochlear Implants

1. Introduction

Hearing is an important sense that provides information about the background sounds and has an important role in speech and language development (Finitzo & Crumley, 1999). Hearing loss is mainly caused by congenital and acquired conditions. Hearing loss will affect the communication skill which results in learning difficulties and poor academic achievements. So intervention should mainly focus on preventing the communication problems, improve the child's hearing ability and also facilitate family support. Thus various intervention options are available for them such as hearing aids, Assistive Listening Devices, Middle ear implants and cochlear implants.

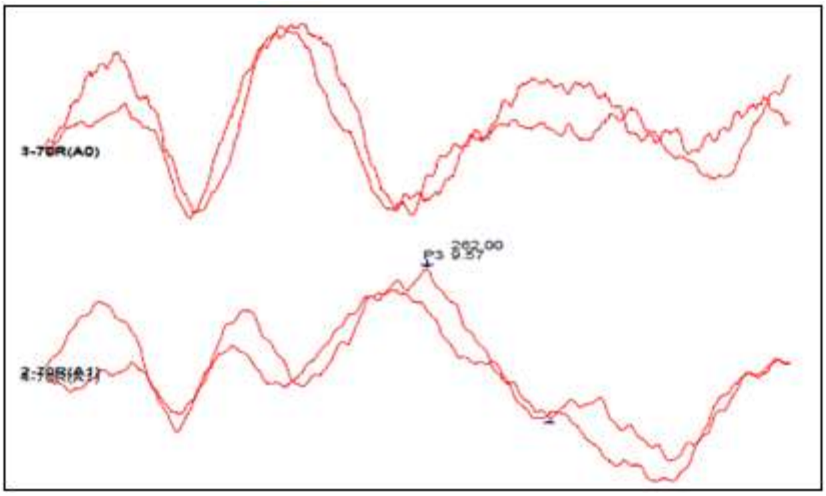
Research in the field of CI is mainly based on how signal processing occurs with the cochlear implantees for speech and non - speech stimulus. Various assessment techniques are used to determine how closely cochlear implantees process the sound compared to normal auditory system. The most common technique is measurement of Auditory Evoked Potentials (AEP). The Auditory Evoked Potentials which occurs after 50msec is considered as Late Latency Response (LLR) (Davis, 1964). LLR mainly reflects the activity of the thalamus and auditory cortex. It records the responses from structures which are involved in attention, integration and discriminative functions of brain.

LLR is also called as Event Related Potentials (ERP). It includes two broad classes of potentials namely exogenous auditory potential and endogenous auditory potential. Exogenous responses, mainly involves the transient response to the stimulus. But in case of endogenous, responses are elicited by the cognitive process of an individual. It requires stimulus manipulation or performance of a task by the patient. There are many endogenous potentials such as P300, Mismatch Negativity, and P600.

P300 is an endogenous evoked response that depends mainly on subject attention to certain stimuli. It shows the cortical electrophysiological activity which involved in attention, memory, discrimination, integration and decision making skills (Polich & Herbst, 2000). P300 reflects the conscious process involved in differentiation of two stimuli (Martin, Tremblay & Korczak, 2008). The P300 is mainly generated from hippocampus, other structures within the limbic system, and the thalamus, auditory cortex, frontal lobe. Therefore P300 is used for assessing the cortical function of the individual with hearing impairment.

P300 is widely used for the assessing central auditory functions in people with hearing loss (Reis et al., 2015). Many studies used P300 in evaluating individuals with cochlear implant with respect to the time of use of the device, performance and stimulus parameters. Different studies reported that implanted patients with good performance have P300 potential similar to control group of similar age range.

Figure 1 Normal P300 waveform



(A) (B)

Figure 1: Indicates P300 waveform of a hearing subject, waveform A represents frequent stimuli and B represents infrequent stimuli.

P300 wave occurs when a subject detects the target stimuli from a standard stimulus. Thus it will elicits a positive response in the latency 300ms. It also called as P3 wave because it is the third major peak in LLR. P300 latency is related to the speed with which a subject able to classify signals, updates memory and attention. Patients with progressive deficits in cognitive function shows increase in P300 latency.

Cochlear implant benefit can be identified using auditory cortical evoked potentials were reported by Beynon, Snik and Broek, 2002. Endogenous P300 was obtained with tone and speech stimuli in five children using cochlear implant with poor speech recognition (Group I) and compared them with five children using CI with good speech perception (Group II). The responses were compared with children with normal hearing. N1 and P2 latencies of Group I and Group II were prolonged. And also, noticed that Group I, P300 is present with tone contrast, but absent or delayed with speech stimuli. P300 obtained in group II is similar to that of normal children. It is suggested that P300 recordings are very sensitive in identifying the poor and good performer.

There are also enormous reports on P300, on individuals with cochlear implant with respect to the duration of the usage of the CI. Hence P300 can be used as one of the prognostic indications of the device. This present research is focused on objective assessment of P300 in early and late cochlear implantees. So the present study aimed on investigating the P300 in individuals with early and late cochlear implantation.

2. Method

30 participants were included in this study. All the 30 participants had undergone unilateral cochlear implantation. The selected participants were divided into two groups. The group I includes children who had undergone CI below the chronological age of 3.5 years and group II includes children who had undergone CI after the chronological age of 3.5 years. Mean implant age of early cochlear implantees was 2.9 years and late cochlear implantees was 1.9 years. All the participants should have patent cochlea, complete electrode insertion and they should have attended minimum one year of Auditory Habilitation. I. e. the minimum one year of implant age is considered. Participants who have abnormal cochlea and cochlear nerve anomalies, partial electrode insertion or any other associated disorders were excluded from this study.

3. Procedure

All the participants had undergone aided audiometry using warble tone from 250 Hz to 8 KHz and ensured that aided thresholds are within speech spectrum. The participants also underwent speech audiometry test in order to identify the Speech Detection Threshold (SDT).

Endogenous P300 potential were recorded in a sound treated room. Intelligence Hearing system was used for the procedure. Participants were seated in a comfortable position. The loud speaker was placed at an angle of 0^0 azimuth at the distance of 1 meter. The parents of all the participants were informed about the test procedure prior to the test. Also informed regarding the placement of electrodes and also informed the test is harmless and he/she can stop the test at any point if the procedure is uncomfortable.

Cotton applicator and Nuprep was used to clean the electrode sites to get impedance properly. Ten 20 conduction gel was used to place the electrodes in appropriate sites. Active electrode placed on the vertex (Cz), reference electrode on contralateral mastoid (M1/M2) and ground placed on forehead (Fpz). The electrode was secured to their sites using micropore surgical tape. Electrode impedance was maintained within 3kohm and the Electro Encephalography (EEG) activity monitored throughout the recording.

All the selected participants were recorded with P300 (endogenous potential) through loud speaker. Stimulus consists of standard and target stimuli presented at 70 dBHL. The instruction given to the participants that the series of sounds (/ba/ and /da/) will be heard through loud speaker. They were asked to either raise your hands or place the blocks whenever hearing the /da/ sound. Appropriate reinforcement provided for each correct responses.

This elicited a positive response in the latency region of 250msec to 400 msec. Analysis was done based on the morphology, latency and amplitude of the P300 peaks. The amplitude of the wave forms were measured as peak to trough amplitude, measured in µV the latency of each P300 is measured from the onset of the stimulus to the peak, measured in ms.

Participants were instructed to avoid excessive eye blinks or movements. As the difficulty of listening increases, amplitude reduced and latency increases. Environmental noise, stimulation strategies, implant age, type and model of cochlear implant may also effect the latency and amplitude of P300 potential. The protocol for measuring P300 is given in the table 1 below

Table 1: The Protocol Used For Recording P300

Parameters	Settings
Stimulus parameters	
Transducer	Loudspeakers
Stimulus type	Speech /ba/ as standard stimuli /da/ as target stimuli
Duration of stimulus	/ba/: 20 msec /da/: 20 msec
Intensity	70dBHL
Repetition rate	1.1/s
Stimulus probability	Standard stimuli: 80% Target stimuli: 20%
Polarity	Rarefaction
Acquisition parameters	
No. Of sweeps	200
Amplification	50, 000 (lesser for larger response)
Filter setting	1 - 30Hz
Electrode type	Disc electrode
Electrode montage Non - inverting Inverting Ground	 C_z (vertex) Contralateral mastoid Fpz (lower forehead)

4. Results and Discussion

An attempt was made to compare the latency and amplitude of two different groups. The data on latency and amplitude were tabulated and analyzed using SPSS for Windows (Version 16.0). The data in terms of latency and amplitude of P300 in early and late cochlear implantees were analyzed using descriptive statistics (mean, Standard Deviation and range values of latency and amplitude).

The group I and group II were compared using the inferential statistics i. e. the Independent sample t test was used, to find out the significant difference between the groups. The results revealed that latency of early and late implantees were statistically significant with a p value 0.004 ($p < 0.05$). It can be appreciated from table 2. It indicates that P300 latency of early cochlear implantees is better when compared to late cochlear implantees. However no significance difference were observed for amplitude and p value found to be 0.598 ($p > 0.05$).

Table 2: Comparison of Early and Late Cochlear Implantees

	Group	N	Mean & Standard Deviation	Range	p value
P300 latency in (ms)	Early (< 3.5 yrs)	15	299.80 (18.667)	52	0.004**
	Late (>=3.5 yrs)	15	321.33 (18.757)	70	0.004**
P300 Amplitude in (mV)	Early (< 3.5 yrs)	15	5.95 (2.405)	7.59	0.598
	Late (>=3.5 yrs)	15	5.50 (2.191)	7.56	0.598

***Note:* **** p value < 0.01

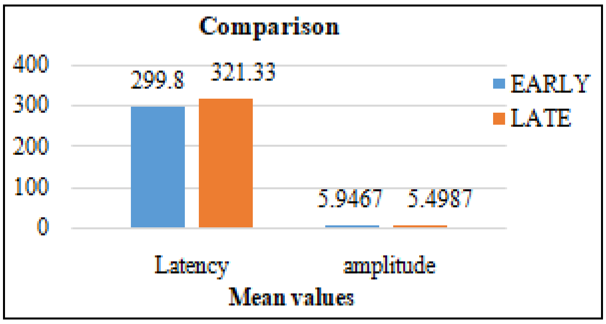


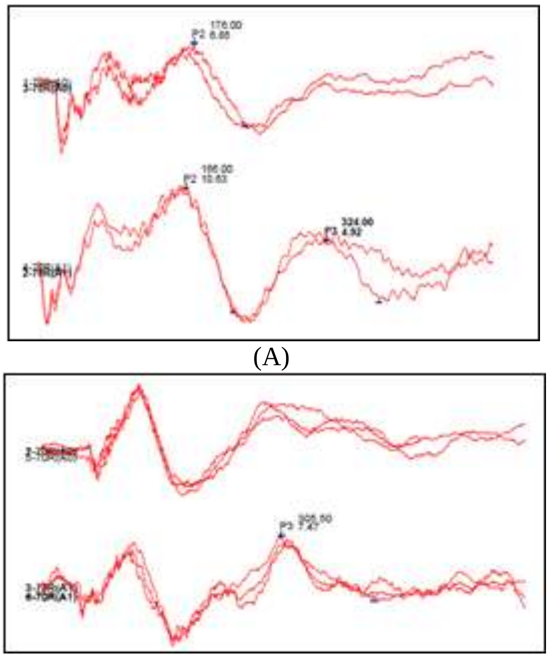
Figure 2: Latency and amplitude comparison

The results from the present study is contradicting with the findings that is reported by Ghiselli. et. al, 2016. They have compared the latency and amplitude between early and late cochlear implantees and it is reported that there was no significant difference were observed, and suggesting that late cochlear implantation did not affect the outcome of P300.

However in the present study finding, it is observed there is a significant difference between the latency for both the groups and the mean latency were earlier for the early implantees than late implantees were observed. Also, the mean implant age of group 1 was 2.9 years and mean implant age of group 2 was 1.9 years. It shows that the mean implant age is higher for early cochlear implantees. Hence this could be one of the reason for obtaining better latency of P300. It is mainly due to maturation of cortical structures and reorganization of neural network.

Similar study reported by Sharma et al, 2009. Cortical development, plasticity and reorganization is crucial for children with cochlear implantation. The findings are consensus with the present findings that age at implant and sensitive period is important for the development of central auditory pathways. If a younger congenitally hearing impaired child implanted within the chronological age of less than 3.5 years, the central auditory pathway shows the maximal plasticity. If sensitive period ends around 7 years of age, it would leads to decoupling of the primary cortical areas from the surrounding higher order cortex and cross modal reorganization of secondary cortical areas noted. Hence the finding from the present study shows the difference in the latency between the groups can be one of the reasons.

Figure 3 Sample waveform of early and late implantees



(A)

(B)

Figure 3: Represents sample waveform representing early Cochlear Implants (A) and late Cochlear Implants (B)

During early years of life, the development of brain mainly depends on external stimulation which helps to form meaningful neural connections and functional network within the brain (Hubel & Wiesel, 1970; Pallas, 2001). If sensory input such as hearing is absent, it will affect the brain development. Significantly it also affects the auditory cortical development, mainly synaptogenesis (formation of new connections) and maturation of cortical layers is delayed and abnormal. The development of lower – subcortical structures occurs normally, but the development of neuronal connections and synaptic firing in the cortex is affected (Klinke et al., 1999; Kral et al., 2000, 2001). So, the cochlear implant provided for the child in order to provide adequate stimulation. This helps in the development of auditory pathway. So, if the implantation occur within the developmental period results in maximal neuronal plasticity i. e. sensitive period results in the most optimal outcomes for the implanted child. To comment about the present study that hearing impairment during first few years of life can create negative consequences for developing brain and if not stimulated on optimal period that can lead to reduced or poor performance. Hence the younger the chronological age of implantation can lead to a better prognosis. So, the children with pre or peri – lingual deafness who received cochlear implants later stage achieves lower speech perception skills than young children at similar duration of implant use (Osberger et al., 1991; Dawson et al., 1992; Fryauf - Bertschy et al., 1992; Nikolopoulos et al., 1999).

In spite of a lower sample size the present study had inferred the significant difference between both the groups on latency aspects, the P300 can be used as one of the objective tool for analyzing the outcome of cochlear implantees. But the study should be extended in terms of subjects with similar implant age for better conclusions. Hence P300 is an objective test tool to emphasis the fact that early the CI, better the outcome. However, P300 can be used to measure attention level, decision making, and cognitive process.

5. Conclusion

Hence to conclude about the present study that hearing impairment during first few years of life can create a negative consequences for developing brain and if not stimulated on optimal period that can lead to reduced or poor performance, hence the younger the chronological age of implantation can lead to a better prognosis. This study can be extended to a larger group of children with cochlear implants and to compare between the implant ages.

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