International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

A Comparative Study of Gap Detection Threshold in Cochlear Implant Users & Normal Hearing Children

Mukesh Sharma[1], Anil Kumar Yadav[2]

[1, 2] Himalayan Institute of Medical Sciences, Swami Ram Nagar, Jollygrant, Doiwala, Dehradun, Uttarakhand, India- 248140

Abstract: ***Gap detection test is used as one measure of the temporal resolving power of the auditory system, i.e., the ability to follow rapid changes over time. The typical threshold for detection of a gap in a wideband noise burst is 2-3 ms (Green, 1985). A Cochlear Implant (CI) is a device that can be surgically implanted into a person's cochlea to stimulate it to cause hearing. It is essential neural stimulator, which directly stimulate auditory nerve & interpreted as sound at the level of auditory cortex. Due to limited discrimination of frequency CI recipients has more difficulty in understanding speech sounds. A total of 10 normal hearing children & 20 children with cochlear implant in the age range of 7-20 years were included in the study. Gap Detection Thresholds were measured for 500Hz, 1K Hz, 2K Hz and 4K Hz frequencies in normal hearing individual and other four groups i.e. CI recipients with 2, 5, 10 and 15 months of post-op duration. It was observed that there was significant difference between normal hearing and cochlear implant group individuals. Cochlear implant group's gap detection thresholds were poor in comparison to normal hearing group individuals. Poor GDT is seen in CI because they rely on either temporal or spectral cues.***

Keywords: Cochlear Implant (CI), Gap Detection Threshold (GDT)

1. Introduction

Auditory temporal processing is defined as the perception of sound or the alteration of sound within a restricted or time defined domain. A person must be able to process auditory information at a rapid pace in order to develop appropriate listening and language skills. The shortest time in which a person can discriminate between two auditory signals is known as temporal discrimination or resolution. The threshold for temporal discrimination is known as temporal auditory acuity or minimum integration time. Gap detection test is a test to measure the temporal resolving power of the auditory system, which is the ability to follow rapid changes over time. The gap detection for normal hearing in a wideband noise burst is 2-3 ms (Green, 1985). Temporal resolution is limited by the decay of sensation produced by the first part of the stimulus, which would fill in the gap (Plomp, 1964). In humans, minimal detectable gap durations are approximately 2–3 ms (Forrest et al., 1989).

A Cochlear Implant (CI) is a device that can be surgically implanted into a person's cochlea to stimulate it to cause hearing. It is essential neural stimulator, which directly stimulate auditory nerve & interpreted as sound at the level of auditory cortex. Due to limited discrimination of frequency CI recipients has more difficulty in understanding speech sounds. Poor frequency discrimination in CI children make difficult to identify formant frequency, which make difficult to identify speech sounds (Watson et al., 1994). Gap detection may be particularly poor in cochlear impaired listeners when the bandwidth of the noise marker is narrow (Moore et al., 1992), and therefore characterized by prominent, random fluctuation. Gap detection for narrowband noise markers may be difficult (even in normal-hearing listeners) because of the ambiguity in distinguishing the gap from the ongoing random dips in the noise.

The purpose of the present study is to measure Gap detection threshold (GDT) at 500Hz, 1 KHz, 2 KHz and 4 KHz for normal's and Cochlear Implantees.

2. Method

A total number of 10 normal hearing children & 20 children with cochlear implant in the age range of 7-20 years were included in the study. These subjects were divided into five groups such as:

Group	*Type of subjects*	*Number of subjects*
1	Normal hearing	10
2	CI with post CI duration of 2 months	5
3	5 months	5
4	10 months	5
5	15 months	5

3. Subject Selection Criteria

For the normal hearing group, the audiometric thresholds were ≤ 25dBHL in the frequency range of 500, 1k, 2k, and 4 kHz. On Immittance screening, they had 'A' type tympanogram & reflexes present. For cochlear implant group, the post implant durations were ≥ 2 months, ≥5 months, ≥10 months, ≥15 months. Their aided thresholds were 25-35dB HL under free field. The subjects were implanted with Nucleus Cochlear Implant with 22 electrodes. All children in all groups were selected on basis of no recent history of middle ear infection, no behavioral & psychological malfunctions, no delay in motor milestones, no cognitive impairments. No illness on the day of testing. No history of Oto-logic/neurologic disorder.

Calibrated diagnostic two channel audiometer (Elkon EDA 3N3 Multi) used for subject selection as well as to measure Gap detection threshold. Stimulus was delivered through head phone and free field to measure hearing threshold and gap detection threshold for normal and cochlear implant

individuals respectively. Stimulus for auditory thresholds for frequencies 500 Hz, 1K Hz, 2K Hz, and 4K Hz will be directly delivered through audiometer. Stimulus for gap detection threshold will be presented through a diagnostic audiometer, with an input from a personal computer, (Compaq Presario CQ 60) and delivered through a loudspeaker at 45° azimuth from the test ear.

4. Development of Test Material

Broad band noise will be generated using Adobe Audition software version 1.0, which will be then filtered using band pass filter to generate noise track of 500Hz, 1 kHz, 2 kHz and 4 kHz. These noise track were generated by using 438Hz, 563Hz, 938Hz, 1063Hz, 1813Hz, 2063Hz and 3563Hz, 4063Hz high pass and low pass bands respectively. These frequencies were selected according to lower and upper frequencies of the electrodes in the nucleus cochlear implants. Three Interval Forced Choice (3-IFC) methods were used in developing the test material. In 3-IFC each set of stimulus consists three stimuli, each stimulus recorded for two seconds duration. One second gap was introduced between the stimuli. Three seconds gap was introduced between each set of the stimulus. Each set of stimulus contain the three stimuli, between two sets of stimulus three seconds gap was introduced. This will allow the recipient/subject to prompt that there will be next set of stimulus as well as to respond to the heard set of stimuli. Within set between stimuli one second gap was introduced. In this way four noise tracks were generated for 500Hz, 1 KHz, 2 KHz and 4 KHz. For each tracks a normalized 1 KHz pure tone was recorded for three seconds duration for the calibration purpose. The subject was instructed to listen to the set of three noise stimuli, one of the three stimuli contain a gap of varying duration. The children were demonstrated audio-visually to understand the test procedure. Descriptive statistics was done to see the mean scores and SDs for each group of children.

5. Results

Gap Detection Thresholds were measured for 500Hz, 1K Hz, 2K Hz and 4K Hz frequencies in normal hearing individual and other four groups i.e. CI recipients with 2, 5, 10 and 15 months of post-op duration. Mean and Standard deviation were calculated to evaluate the gap detection thresholds and compared CI groups with normal group at frequencies 500 Hz, 1 KHz, 2 KHz & 4 KHz. The Mean for Group I (Normal Hearing) were 3.8ms, 3.4ms, 3.8ms, and 4.8ms, for Group II (post op duration 2 months) 19.6ms, 20.8ms, 22.8ms & 23.2ms, for CI Group III (post op duration 5 months) were 12.8ms, 14.8ms, 14.4ms & 15.2ms, for CI Group IV (post op duration 10 months) were 10.8ms, 12.4ms, 12.8ms & 13.2ms and for CI Group V (post op duration 15 months) were 11.2ms, 12.4ms, 12.8ms & 12.8ms for 500 Hz, 1 KHz, 2 KHz & 4 KHz respectively. Standard deviation varied from 0.8 to 1.67ms in all frequencies in all groups.

Table 2: shows the Mean and Standard deviation of scores obtained from Gap detection threshold test, for both the normal hearing and cochlear implant group individuals with respect to post op duration.

	Normative		Cochlear Implant Recipients							
	Group I		Group II		Group III		Groups IV		Group V	
Frequency	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
500 Hz	3.8	1.13	19.6	1.67	12.8	1.09	10.8	1.09	11.2	1.09
1K Hz	3.4	0.96	20.8	1.09	14.8	1.09	12.4	0.89	12.4	0.89
2K Hz	3.8	1.47	22.8	1.09	14.4	0.89	12.8	1.09	12.8	1.09
4K Hz	4.8	1.03	23.2	1.09	15.2	1.09	13.2	1.09	12.8	1.09

It was observed that there was significant difference between normal hearing and cochlear implant group individuals. Cochlear implant group's gap detection thresholds were poor in comparison to normal hearing group individuals. Within the cochlear implant recipients there is a difference in gap detection based on post implant duration. It was observed that for all the test frequencies there was significant ($p<0.001$) difference between 2 and 5, 10 and 15 months post op duration in cochlear implant recipient group. Between 5 months to 10 and 15 months and between 10 and 15 months there is no significant difference for all the test frequencies.

6. Conclusion & Discussion

Gap Detection Threshold was measured at 500Hz, 1K Hz, 2K Hz, 4K Hz in five groups i.e., Normal hearing individual and other four groups are cochlear implant recipients with 2, 5, 10 and 15 months of post-op duration with the age range of 7-20 years. Results shows that scores of GDT obtained from CI group subjects were significantly higher than that of normal hearing subjects. The gap detection threshold was poor in cochlear implant groups in comparison to normal hearing group. Same type of result was also observed in Shannon, (1989); Van Wieringen and Wouters, (1999) study. Poor GDT is seen in CI because they rely on either temporal or spectral cues. Normal cochlea has 28 independent channels, whereas CI has only 22 channels, which affect the temporal processing, as it is dependent on the number of neurons engaged in process as well as the channels or filters in the cochlea. So the information delivered by CI to the auditory system is degraded, despite poor gap detection thresholds, speech and language abilities of the cochlear Implantees are comparable to the normal hearing.

References

[1] Allen, P. D., Tracy, M., Virag, & Ison, J. R. (2002): Humans detect gaps in Broadband noise according to effective gap detection without additional cues from abrupt envelope changes. Journal of the Acoustical Society of America, 112 (6), 2967-2974.

[2] Bench, R. J., and Bamford, J., In Busby, P. A., & Clark, G. M., (1999): Gap detection by early-deafened cochlear-implant subjects. Journal of the Acoustical Society of America 105 (3), 1841-1852.
[3] Busby, P. A., & Clark, G. M. (1981): In Abstracts Paediatric Cochlear Implantation. 4th European Symposium on Paediatric Cochlear Implantation, s-Hertogenbosch, Netherlands Department of Otolaryngology, University of Melbourne
[4] Buumen, T. J., & Van Valkenberg, D. A. (1979): Auditory detection of a single gap in noise. Journal of the Acoustical Society of America, 65 (2), 534-536.
[5] Buus, S., & Florentine, M. (1982): Detection of temporal gap as a function of level and frequency. Journal of the Acoustical Society of America, 72: 89.
[6] Fitzgibbons, P. J. & Wightman, F. L. (1982): Gap detection in normal and hearing impaired listeners. Journal of the Acoustical Society of America, 72 (3), 761-765.
[7] Formby, C., Barker, C., Abbey, H., & Raney, J. J.(1993): Detection of silent temporal gaps between narrow band noise markers having second formant like properties of voiceless stop/ vowel combinations. Journal of the Acoustical Society of America, 93, 1023-1027.
[8] Hall, J. W., & Fernandes, M. A., (1983): Temporal integration, frequency resolution and off frequency listening in normal hearing and cochlear impaired listeners, Journal of the Acoustical Society of America, 74 (4), 1172-1177.
[9] Jennifer Brooke Shinn & Frank E. Musiek (2003)**:** Temporal processing: The basics**.** Hearing Journal, Volume 56 - Issue 7 - p 52
[10] Phillips, D. P., (1999): Auditory gap detection, perceptual channels, and temporal resolution in speech perception. Journal of the American Academy of Audiology, 10, 343 - 354.