IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 24, Issue 4, Ser. II (Jul. –Aug. 2022), PP 01-06
www.iosrjournals.org

Comparative Study Of Threshold And Comfort Level Voltages For Electrodes In Mapping For Blue Hearing System User : A Case Study

Parul Saxena
Department of Computer Science,
S.S.J. University Campus Almora, UK, India-263601

Abstract : *The present work includes the case study of threshold and comfort level voltages for the electrodes of cochlear implant for one Blue Hearing System(BHS) user. The patient after surgical implantation has been observed at regular intervals at the time of mapping. The present study shows that the comfort level voltages are always set at higher level in comparison to the threshold level voltages. Later in this study it has been observed that the variation between voltage levels of comfort level or threshold level for all electrodes during two consecutive mapping reduces significantly and becomes almost fixed after few regular mappings.*
Keywords: Blue Hearing System, Cochlear Implant, Mapping, Threshold Level, Comfort Level.

Date of Submission: 21-07-2022 Date of Acceptance: 05-08-2022

I. INTRODUTION

BHS which is the combination of cochlear implant device followed by regular sessions of speech therapy and real world learning, is very important system for deaf and mute patients [1]. Any patient who is deaf and mute by birth is first of all diagnosed for the cause of hearing lose. If in a patient the hearing is lost due to the absence of transmission of vibrations from cochlea to brain then he or she is suggested for BHS. First of all the patient is checked for internal anatomy of ear, if there exists cochlea and all other organs involved in hearing are normal then inner part of cochlear implant device is surgically imposed inside the ear. After approximately one month of the implantation the outer part of cochlear implant device is added to the patient. After surgical implantation the next required phenomenon is mapping to adjust internal parameters of cochlear implant device.

CI provides the bypass mechanism of the normal hearing. It directly stimulates the inner ear sensory cells of the auditory nerve by supplying electrical signals to an electrode array, implanted inside the cochlea. These electrical signals are derived from the external sound picked up by a microphone. Captured sound signals are first manipulated by an external speech processor and then transmitted via transcutaneous link in the form of electromagnetic waves to the inner ear. Inside the inner ear they are finally converted into electrical pulses. With high success rates and increasing demand of implants worldwide, a substantial growth and progress is seen in Cochlear Implant research in the last few decades [2][3].

The mechanism of electrical stimulation is at the heart core of cochlear implant. Each electrode in the electrode array corresponds to a different frequency level, which forms a combination to cover the complete audible frequency range to be heard by human. Each electrode is fired at different voltage level. This voltage level is adjusted in mapping procedure after implantation. In mapping the threshold and comfort levels of voltages are studied so that the user hears properly in enough loud volume and does not feel discomfort. Simultaneously to provide noiseless and appropriate sound to the user, is another measure goal of cochlear implant [3].

II. NEED OF MAPPING

After surgical implantation in BHS, the inner part of cochlear implant is programmed in an appropriate manner. In mapping process a map is created to represent the voltage levels for all electrodes. Threshold level is the minimal amount of electrical stimulation required for the auditory system to perceive sound and comfort level is the upper limit of electrical stimulation judged to be the most comfortable. For appropriate perception the patients visit regularly at scheduled interval for mapping. In the case when the visit of the patient is not possible or patient is having multiple level disorder as blindness or some mental weakness etc then some objective measures are taken into considerations, this phenomenon is known as Neural Response Telemetry(NRT)[4]. The mapping is the process of customizing the voltage levels for all the electrodes. These set of voltage levels varies from patient to patient. BHS has restricted electrical range and all the sounds of different parameters are to be mapped in this range. The current optimized values for the current session are stored in the speech processor [5][6]. In 2011 Elizabeth Rosenzweig wrote an article regarding mapping of cochlear implant[5] and compared the Neural Response Telemetry with behavioral mapping for cochlear implant. Greenwood told about Greenwood function to calculate channel frequency bands for cochlea [7][8] and studied the mapping of pediatrics Implantee. Olga Stakhovs kaya et al [9] studied the implications of cochlear implant in terms of the frequency map for spiral ganglion of human. It also sometimes depends on human ear anatomy because if cochlea is not developed then implantation is not possible in the deaf and mute patient [6][10].

Sidman M. and Tailby W. (1982) elaborated that the main part of rehabilitation is the speech therapy training provided to the cochlear implantee so that he or she can produce the best throughput to launch symbolic functions for auditory stimuli [11]. To detect the outcomes of speech therapy sessions, it is necessary to evaluate symbolic function of auditory stimuli perceived through the implant. They presented many stimuli examples and produced corresponding results for the improvement of hearing in CI based children.

III. MAPPING MECHANISM

Basically in the inner part of CI there are number of electrodes in the shape of a spiral, which are fitted around the cochlea during the surgical implantation. These electrodes are stimulated by electric current to evoke auditory nerve system. The amount of the electric current necessary to trigger an auditory sensation is different for each individual and for each stimulation channel [5]. After 3 to 4 weeks after implantation, the inner device of cochlear implant is switched on by a remote and at that time first mapping is conducted. The mapping process involves the resetting of voltage for the electrical stimulation limits of the electrodes in the inner instrument to grasp different sounds in a proper way. The BHS is having limited electrical range and all the real world sounds of different frequencies and amplitudes are to be mapped in this range. The standard stimulation levels are Threshold and Comfort[6][8]. The range of mapping parameters varies from patient to patient as it also depends on the dimensions of implantation

IV. RESULTS AND DISCUSSIONS

There are two different approaches - Mapping and Neural Response Telemetry to set the internal voltage levels of electrodes, here we have considered the first one. In table 1, the comfort and threshold voltage levels have been shown for one patient at five different intervals which can be visualized in figure 1, figure 2, figure 3, figure 4 and figure 5 respectively. From table 1, it can be observed very clearly that the comfort listening levels have been set at higher levels in comparison to the threshold levels. When the inner instrument is switched on for the very first time then the first map is generated for the patient. Hence the initial data has been taken when the first map is set for the patient. The voltage levels are set at very higher levels initially. Then the mapping was repeated after six months and the map was caught at relatively lower voltage levels. Again the mapping procedure was repeated after one year, two years and three years again the maps were set at lower levels relatively.

Table 1: Mapping Parameters of one patient at various time intervals

Electrode Number	Initially		After Six Months		After One Year		After Two Years		After Three Years	
	T Level	C Level	T Level	C Level	T Level	C Level	T Level	C Level	T Level	C Level
1.	170	240	145	190	135	180	132	178	131	177
2.	160	230	143	191	135	182	132	181	132	180
3.	170	240	140	192	135	180	132	180	132	180
4.	175	242	144	192	138	180	134	180	133	180
5.	180	245	148	192	138	176	134	175	134	176
6.	180	244	135	189	133	176	134	175	134	175
7.	178	242	136	189	133	174	133	174	133	174
8.	178	242	135	188	135	172	133	172	133	172
9.	178	242	135	182	135	172	135	172	135	172
10.	170	241	138	181	134	172	132	172	132	172
11.	170	241	142	181	133	170	132	172	132	172
12.	170	241	140	182	133	170	130	171	130	171
13.	170	238	141	182	132	170	130	170	130	170
14.	172	242	140	183	131	170	130	170	130	170
15.	168	242	142	183	133	172	132	172	132	172
16.	170	235	141	183	134	170	133	170	133	170

17.	164	239	142	185	138	172	137	172	136	172
18.	160	238	142	185	133	173	132	172	132	171
19.	170	240	143	184	140	175	140	173	139	173
20.	170	240	140	184	135	170	134	171	134	171
21.	163	240	141	183	132	164	132	165	132	165
22.	160	236	141	182	130	160	130	160	130	159

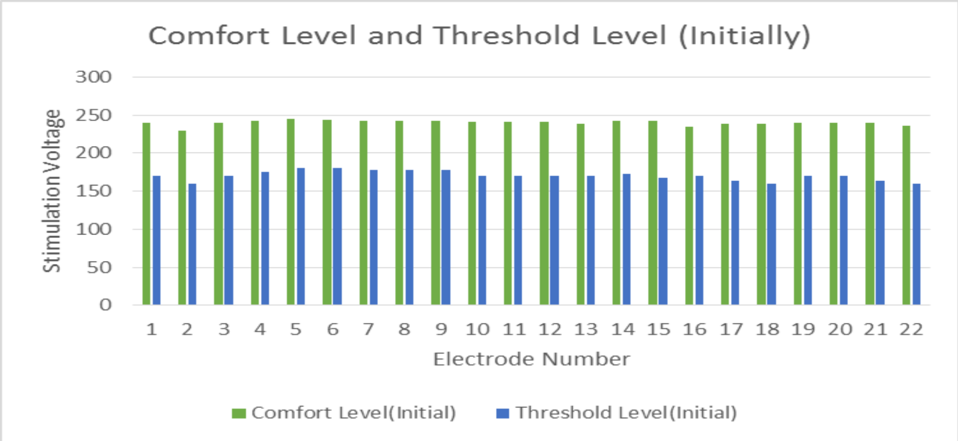

Figure 1: Voltage–Frequency Map of the Patient Initially

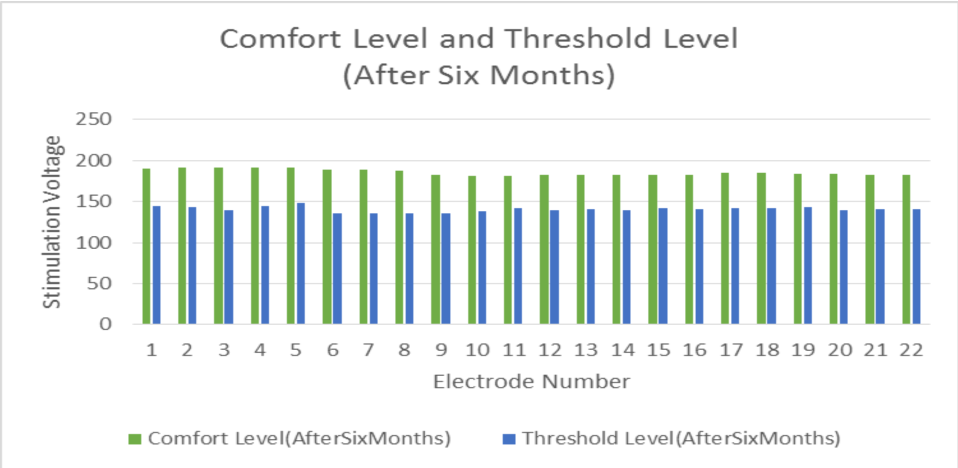

Figure 2: Voltage–Frequency Map of the Patient after Six Months

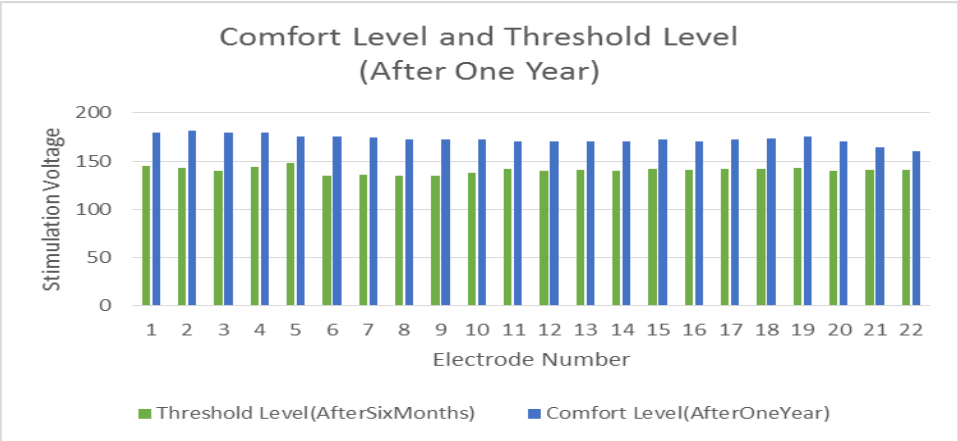

Figure 3: Voltage–Frequency Map of the Patient after One Year

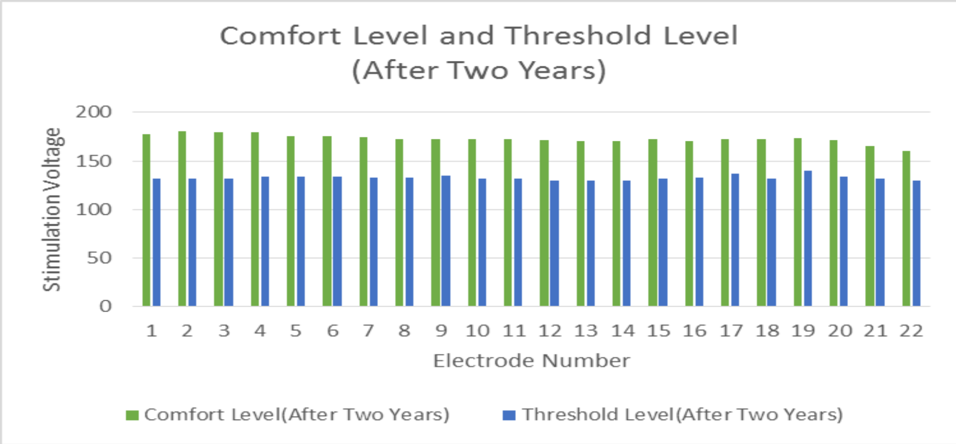

Figure 4: Voltage–Frequency Map of the Patient after Two Years

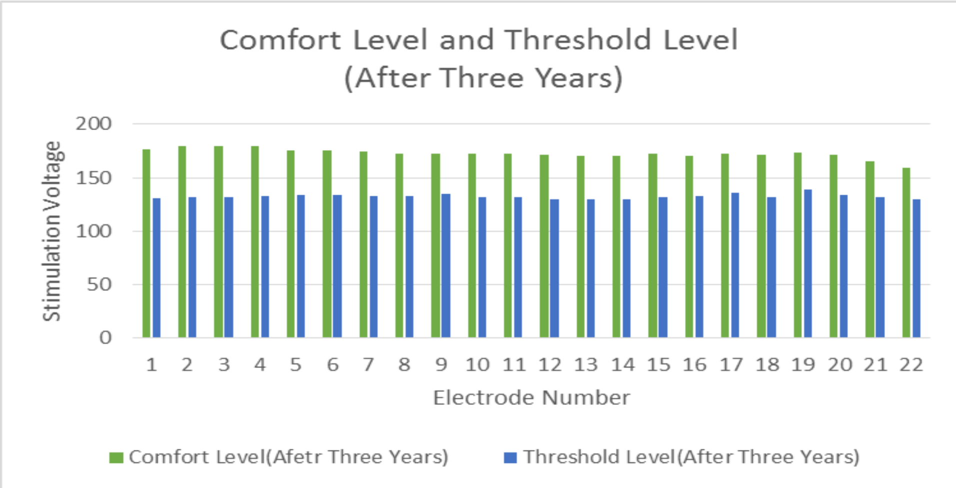

Figure 5 : Voltage –Frequency Map of the Patient after Three Years

Table 2 represents the differences between the successive voltage levels The most important thing to be observed from Table 2 is that the variation between the maps of two consecutive mapping is reducing after every mapping. Conclusively we can say that if the patient becomes habitual to perceive some sound then the frequent mapping is not required or in other words we can say that the map tends towards fixed trends after some time.

Figure 6 shows the differences of voltage levels between threshold levels at initial Vs Six Months Later, Six Months Later Vs One Year Later, One Year Later Vs Two Years Later and Two Years Later Vs. Three Years Later. From the figure 6, it is also clear that the differences between voltages are coming down after every mapping, hence we can say that frequent mappings fix the threshold level voltage for all electrodes, which reduces the need of frequent mapping.

Table 2: Difference between Levels in terms of Voltage

Electrode Number	Difference Between Levels at Initial Vs. Six Months		Difference Between Levels at Six Months Vs. One Year		Difference Between Levels at One Year Vs. Two Years		Difference Between Levels at Two Years Vs. Three Years	
	T Level	C Level	T Level	C Level	T Level	C Level	T Level	C Level
1.	25	50	10	10	3	2	1	1
2.	17	39	8	9	3	1	0	1
3.	30	48	5	12	3	0	0	0
4.	31	50	6	12	4	0	1	0
5.	32	53	10	16	4	1	0	1
6.	45	55	2	13	1	1	0	0
7.	42	53	3	15	0	0	0	0

8.	43	54	0	16	2	0	0	0
9.	43	60	0	10	0	0	0	0
10.	32	60	4	9	2	0	0	0
11.	28	60	9	11	1	2	0	0
12.	30	59	7	12	3	1	0	0
13.	29	56	9	12	2	0	0	0
14.	32	59	9	13	1	0	0	0
15.	26	59	9	11	1	0	0	0
16.	29	52	7	13	1	0	0	0
17.	22	54	4	13	1	0	1	0
18.	18	53	9	12	1	1	0	1
19.	27	56	3	9	0	2	1	0
20.	30	56	5	14	1	1	0	0
21.	22	57	9	19	0	1	0	0
22.	19	54	11	22	0	0	0	1

The figure7 shows the differences of voltage levels between comfort levels at initial Vs Six Months Later, Six Months Later Vs One Year Later, One Year Later Vs Two Years Later and Two Years Later Vs. Three Years Later. From the figure7, it is also clear that the differences between voltages are coming down hence we can say that the consecutive mappings fix the comfort level voltage for all electrodes, hence the need of frequent mapping is reduced after some time.

The analysis has been performed in the laboratory when patient actively participated in the mapping procedure but if the patient is not ready to participate in the mapping process then objective measures are applied for designing the map for the patient. In these objective measures the frequencies of various electrodes are taken into consideration.

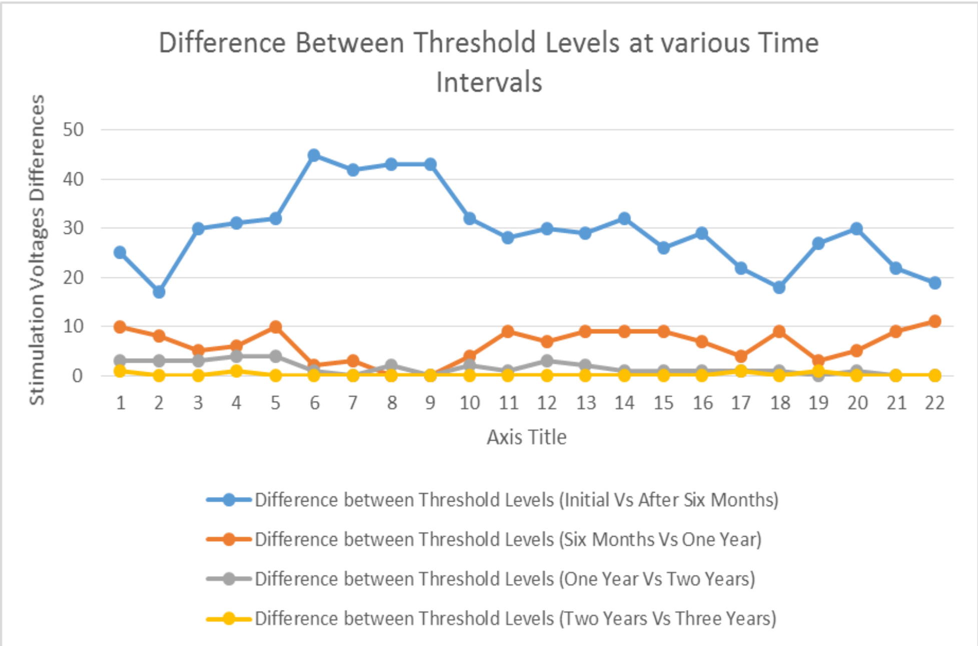

Figure 6: Differences of Voltages between successive Threshold Levels

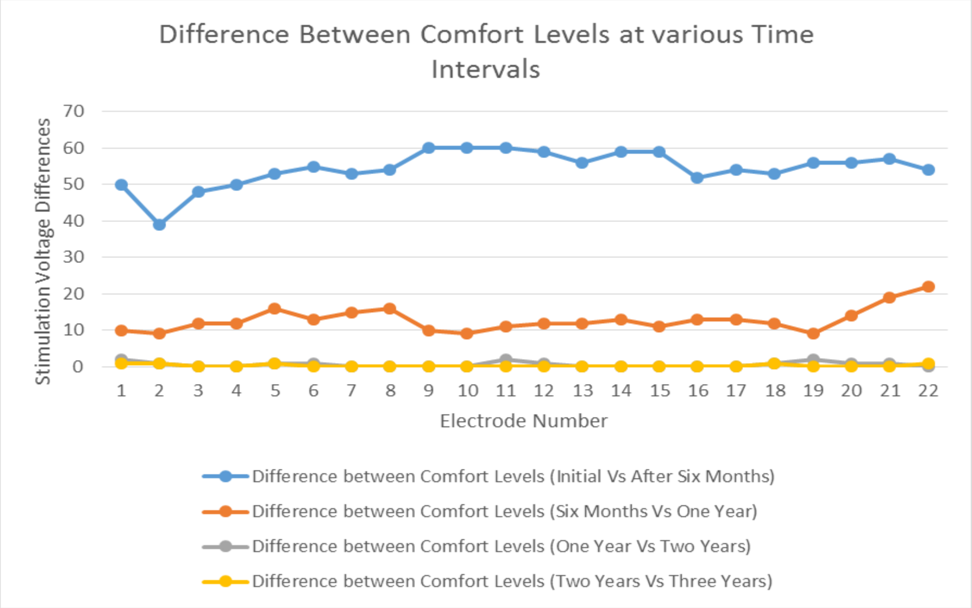

Figure 7: Differences of Voltages between successive Comfort Levels

V. CONCLUSION

The present study produces very significant results for Blue Hearing System that the comfort level voltages are caught always at higher levels than the threshold levels. After initial mapping the voltage levels are reduced in next successive mappings and become almost fixed after some frequent mappings. Hence it may be concluded that the mapping frequency may be reduced by time as the patient becomes habitual for perceiving the sounds at particular voltage levels. Because as soon as the time passes the speech therapy sessions are also increased and the patient becomes more smart to give response at the same level of sound.

REFERENCES

[1]. **Saxena P.,Mehta A**, Refinement of Input Speech by Suppressing the Unwanted Amplitudes for Blue Hearing System, Proceedings of International conference, IEEE, 2016.

[2]. **Zeng Fan-Gang, Rebscher Stephen, Harrison William V., Sun Xiaoan, Feng Haihong,** Cochlear Implants :System Design, Integration and Evaluation, NIH Public Access Author Manuscript IEEE Rev Biomed Eng. 2008 January 1; 1: 115–142. doi:10.1109/RBME.2008.2008250.

[3]. **Talha J. Ahmad, Hussnain Ali, Muhammad Asim Ajaz, Shoab A. Khan**, Efficient Algorithm development of CIS Speech Processing Strategy for Cochlear Implants, 31st Annual International Conference of the IEEE EMBS Minneapolis, Minnesota, USA, September 2-6, 2009.

[4]. **Jennifer Mertes, AuD, Jill Chinnici,** Cochlear Implants - Considerations in Programming for the Pediatric Population, February 13, 2006, https://www.audiologyonline.com/articles/ cochlear-implants-considerations-in-programming-1011/

[5]. **V. R. Pradeep**, A comparative Study on the Differences between NRT and Behavioral Mapping in Cochlear Implant- A Single Case Study, Global Journal of Otolaryngology, Vol.9 Issue No.4 , pp.01-04,2017.

[6]. **Saxena P., Mehta A.,** Study of Audible Frequency Levels in Mapping Phase of Blue Hearing System using MATLAB GUI, International Journal of Computer Sciences and Engineering, Vol.-6, Issue-6, 637-641,June 2018

[7]. **H. Ali ,J.H.Noble, R.N. Gifford, R.F. Labadie ,B. M. Dawant, J. H.L .Hansen, E. Tobey,** Image-Guided Customization of Frequency-Place Mapping in Cochlear Implants, Proceedings of IEEE conference ICASSP, pp. 5843-5847, 2015.

[8]. **Gulden Kokturk** , Wavelet Based Speech Strategy in Cochlear Implant, Cochlear Implant Research Updates, 2012 . http://www.intechopen.com/books/cochlear-implant-research-updates/wavelet-based-speech-strategy-incochlear-implant/.

[9]. **Olga Stakhovs kaya, Divya Sridhar, Ben H. Bonham, and Patricia A. Leake**, Frequency Map for the Human Cochlear Spiral Ganglion: Implications for Cochlear Implants, Journal of the Association for Research in Otolaryngology ; 8(2): 220–233, Jun 2007

[10]. **R. Mittal, S.S. Panwar , S. Nair, V.R. Sinha , A. V. Ramesh , A. Nilkanthan and P. Raj** , Mapping of Paediatric Cochlear Implant Recipients using EABR as a Tool, Journal of Otology & Rhinology,Vol. 4, Issue No. 2, pp. 01-04, 2015.

[11]. **Sidman, M., Tailby, W.**, Conditional discrimination vs. matching to sample: An expansion of the testing paradigm, Journal of the Experimental Analysis of Behavior, 37, 5 -22, 1982

Parul Saxena. “Comparative Study Of Threshold And Comfort Level Voltages For Electrodes In Mapping For Blue Hearing System User : A Case Study.” *IOSR Journal of Computer Engineering (IOSR-JCE)*, 24(3), 2022, pp. 01-06.