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Original Research Article

Factors affecting outcome of cochlear implant: an observational study

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ABSTRACT

Background: Aim and objectives of the study was to evaluate various factors affecting outcome in cochlear implant surgery.
Methods: A hospital based retrospective observational study in which 51 patients who underwent cochlear implant surgery from July 2017 to January 2019 were evaluated at Dr. Babasaheb Ambedkar Memorial Hospital, Byculla, Mumbai using 3 parameters i.e. Revised CAP score (CAP), meaningful auditory integration scale (MAIS), speech intelligibility rating (SIR) at various intervals postoperatively and outcome was evaluated.
Results: It was found that the postoperative mean scores in all age groups were comparable but not significant at 3, 6 and 9 months interval while the difference was statistically significant at 12 and 24 months interval post implantation with less than 2 years age group performing better than other age groups patients with less than 2 years duration of auditory deprivation, the mean scores were found to be statistically significant at 12 and 24 months implantation Relationship to common causes such as prenatal infections, low birth weight, prolonged labour, hyperbilirubinemia, meningitis and consanguineous marriage were considered but not significant. No significant difference was observed in parent's education level, urban-rural population to the outcome of cochlear implantation.
Conclusions: Two most important factors that affect the outcome cochlear implantation are the age at implantation and the duration of auditory deprivation. Other factors are important but not significant and do not affect the outcome significantly.

Key words: Cochlear implant, Congenital sensorineural hearing loss, Age at implantation, CAP score, SIR score, MAIS score

INTRODUCTION

Hearing is the means through which an individual can exchange information. It allows the acquisition and development of speech and language, and consequently favours school learning. Hearing is composed of a peripheral and a central part, and the integrity of these systems is necessary as learning is connected to these factors.[1]

In the act of hearing and deciphering what is being said, the relation between the integrity of the peripheral auditory system and the central auditory system may be observed. Therefore, in order to have effectiveness in communication, the auditory processing skills are extremely important.[2]

Cochlear Implants have transformed the management of severe to profound hearing loss in both children and adults. Its greatest impact is in transforming the education of children born with a profound hearing loss who are implanted early, and majority of these children attend mainstream education, using spoken language to communicate.

There are many factors which alone or in combination will decide the outcome of cochlear implantation. However, the outcome in cochlear implantation is yet not entirely predictable. Categorizing these determinants increases the ability of clinicians to offer educated preoperative prognosis and might potentially allow for manipulation of variables to achieve the best possible outcome.

Despite extensive research examining both adult and paediatric post implantation outcomes, the considerable variability in postoperative performance remains incompletely understood.

Predictions of post implantation benefit should be individualized and based on comprehensive preoperative assessment, with attention to the complex interplay of various factors including age at implantation in years, duration of auditory deprivation, Relationship with common causes of SNHL, abnormalities of inner ear, Education level of parents, speech rehabilitation and rural v/s urban population.

Taking the above factors into consideration, the present study has been taken to analyse the outcome of various factors in cochlear implant surgery.

METHODS

Study site

Dr. Babasaheb Ambedkar Memorial Hospital, Byculla, Mumbai.

Study population

Target population for this study included those patients who underwent cochlear implant surgery from January 2010 to June 2017 and satisfied the inclusion criteria and showed their willingness to be a part of this study with written informed consent.

Study design

Hospital based retrospective observational study.

Sample size

Patients who underwent cochlear implant surgery from January 2010 to June 2017 and satisfied the inclusion criteria which were a total of 51 patients.

Study duration

Study duration was from July 2017 to January 2019.

Inclusion criteria

Pre lingual deaf patients who underwent cochlear implant surgery. Willing to give written informed consent.

Exclusion criteria

Those who do not fulfil the inclusion criteria. Pre-lingual deafness in children more than 10 yrs. Patients suffering from syndromic hearing loss. Post traumatic profound hearing loss. Patient who were lost to follow up. Patients unwilling to give written informed consent

Methodology

The study was conducted after getting approval from our institutional ethics committee and after obtaining a written informed consent from the legal guardians of the children who underwent cochlear implantation in our hospital. The data was collected from patient registers, fully completed clinical records and information regarding the present performance levels of the implantees was obtained from ENT surgeons and Audiologists and from the parents of the children.

Hearing was assessed by CAP score, MAIS score and SIR score as a parent reported scale in an interview format. The interview was carried out by independent observer i.e. the audiologist who was not involved in the selection of the patient for the surgery.

Measuring the level of performance

The outcome of CI was measured using revised Category of Auditory Performance (CAP) score described by O Donohogue et al; the speech intelligibility rating (SIR) scale by O' Donohogue, et al and the MAIS (meaningful auditory integration scale) designed by Robins et al in 1991.[3-5]

Outcome variables

Revised CAP Score (CAP); Meaningful Auditory Integration Scale (MAIS); Speech Intelligibility Rating (SIR).

Method of statistical analysis

The following method of statistical analysis has been used in this study. Data was entered in Microsoft Excel and analysed using SPSS (Statistical Package for Social Science, Ver. 22.0).

The results were averaged (mean±standard deviation) for continuous data and number and percentage for dichotomous data. Continuous variables were represented by mean±standard deviation and categorical variables were represented by frequency and percentage. Inference was detected by T test, Posthoc tukey test, ANOVA test, $p<0.05$ was considered statistically significant.

RESULTS

In our study, we evaluated 51 patients with the ratio of male to female of 1.4:1.

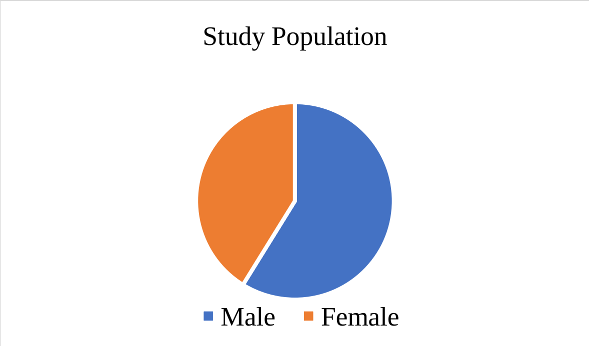

Figure 1: Gender distribution.

Around 10% of study population was implanted at age less than 2 years, 58% at 2-5 years and around 25% at age more than 5 years. Around 17% of study population had duration of auditory deprivation of less than 2 years, 66% for 2-5 years and around 15% had auditory deprivation for more than 5 years.

The mean CAP, SIR, MAIS score increased postoperatively in all the three age groups at 3, 6, 9, 12 and 24 months interval postoperatively. In first group (less than 2 years), the mean CAP, SIR and MAIS scores rapidly improved after implantation as compared to the other two groups (2-5 years and more than 5 years) and the difference was statistically significant at 12 and 24 months.

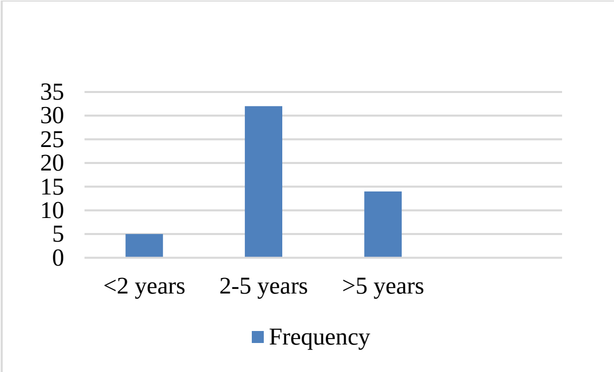

Figure 2: Incidence of age at implantation in study population.

The mean CAP, SIR, MAIS score increased postoperatively in all groups in relation to duration of auditory deprivation at 3, 6, 9, 12 and 24 months interval postoperatively. In first group (less than 2 years), the mean CAP, SIR and MAIS scores rapidly improved after implantation as compared to the other two groups (2-5 years and more than 5 years) and the difference was statistically significant at 12 and 24 months.

Table 1: Age at implantation in relation to Mean CAP, SIR, MAIS score at various intervals.

Age at implantation (years)	Frequency	Mean CAP score			Mean SIR score			Mean MAIS score		
		Pre-op	Post-op		Pre-op	Post-op		Pre -op	Post-op	
			12 months	24 months		12 months	24 months		12 months	24 months
Less than 2	5	0.6	5	7.4	0	2.2	3.8	0	21.4	33.4
2-5	32	0.19	4.75	6.41	0.09	2.59	3.28	1.19	23.56	31.53
More than 5	14	0.07	4.21	5.21	0.14	2.07	2.71	1.21	17.79	23.93
P value		0.345	0.058	<0.001	0.662	0.047	<0.001	-	0.002	0.009

Table 2: Duration of auditory deprivation in various age groups and mean CAP, SIR, MAIS scores.

Duration of auditory deprivation (years)	Frequency	Mean CAP score			Mean SIR score			Mean MAIS score		
		Pre-op	Post-op		Pre-op	Post-op		Pre-op	Post-op	
			12 months	24 months		12 months	24 months		12 months	24 months
Less than 2	9	0.44	4.67	6.67	0.11	2.33	3.44	0.78	21.56	32.22
2-5	34	0.18	4.74	6.26	0.09	2.56	3.21	1.35	22.79	30.24
More than 5	8	0	4.13	5.25	0.13	1.88	2.75	0.25	17.63	24.13
P value		-	0.15	0.004	0.945	0.038	0.044	0.08	0.048	0.005

Relationship to common causes was compared taking into considerations prenatal factors, perinatal factors, post-natal factors and hereditary factors. Causes such as prenatal infections, low birth weight, prolonged labour, hyperbilirubinemia, meningitis, consanguineous marriage was considered. And, we found that around 11% patients had history of prenatal infections, 10% had low birth weight, 6% had prolonged labour, 17% had hyperbilirubinemia, one patient had meningitis, and 17% had family history of consanguineous marriage.

38 out of 51 patients had normal cochleovestibular anatomy and thirteen had abnormal anatomy which includes four patients with features suggestive of

TORCH infections (including one labyrinthitis ossificans sequelae, two Dysplasia/Hypoplasia, one fused vestibulocochlear neve, one absent modiolus, two mondini's deformity).

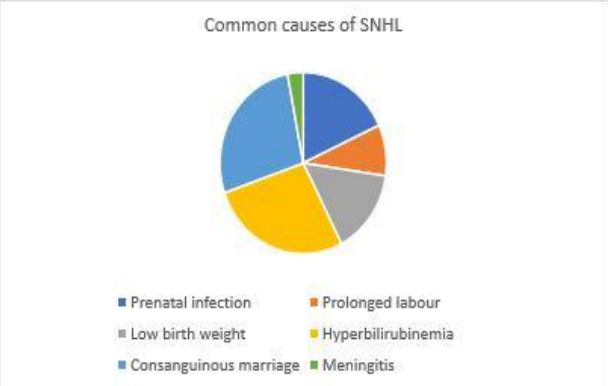

Figure 3: Distribution among various causes of SNHL in study population.

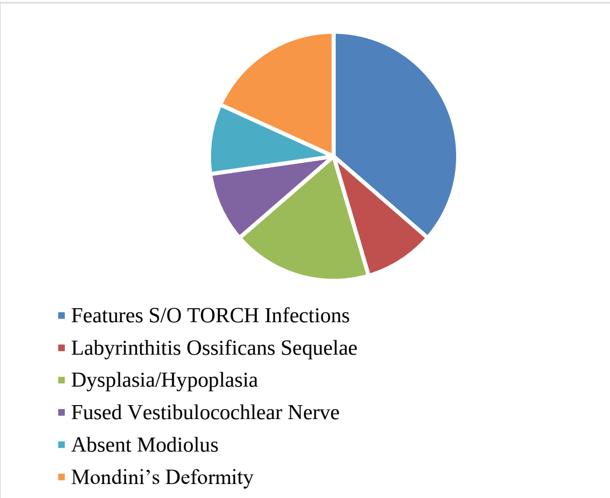

Figure 4: Incidence of various abnormalities of inner ear observed.

In our study, it was observed that 47% implantees had either parent educated up to 12th standard and 53% implantees had either parent educated up to graduation and above.

Out of fifty-one, only two patients in our study did not follow AVT regularly. Results showed better performance among impantees taking regular AVT than the other group, but the difference was not statistically significant. All patients underwent regular AVT except two patients who had discontinued speech therapy in between or did not follow up regularly as advised by speech therapist.

Almost 65 % of the study population belonged to urban region and 35% belonged to rural population.

DISCUSSION

This study includes 51 patients who underwent cochlear implant at ENT department of Dr. Baba Saheb Ambedkar Central Railway Hospital, Byculla, Mumbai and were evaluated at various intervals.

The mean CAP, SIR, MAIS score increased postoperatively in all the three age groups at 3, 6, 9, 12- and 24-months interval postoperatively.

In first group (less than 2 years), the mean CAP, SIR and MAIS scores rapidly improved after implantation as compared to the other two groups (2-5 years and more than 5 years) and the difference was statistically significant at 12 and 24 months. A study by Basir Hashemi on 98 children between 2-7 years age group revealed a highly significant association with age at the time of implantation. Using both retrospective longitudinal and cross-sectional study designs, Govaerts, et al in 2002 evaluated data from six age groups implanted up to 6 years of age and concluded CAP scores were rapidly normalized in children implanted before the age of 2 years.[6,7] Myung whan suh studied 86 prelingual deaf children who underwent cochlear implantation before age of 6 years and found that group of 3-4 years appeared to have poor improvement scores after 1-3 years, however, RM ANOVA for CAP revealed a significant effect of time ($p<0.001$) and a non-significant effect for group.[8] That is, CAP Score continued to improve with time, but the improvement of the CAP score was not significantly different among groups. The younger age groups showed a more rapid improvement.

While assessing MAIS Score for audiological assessment, we found that preoperative mean scores of the second group is more than the first, possibly because of long term sound stimulation by the noise in the surroundings, verbal communication by the family members and via hearing aids while in earlier implanted group exposure to stimulation by sound and sound awareness is comparative of lesser duration. While the post-operative score in earlier implanted group supersedes the second, despite lesser preoperative score; this may be because of the implantation in the critical period and lesser duration of auditory deprivation. Post-operative MAIS score was found to be increasing at various intervals but not significant at 3, 6, 9 months while they were found to be significant at 12 and 24 months postoperatively. The results are in line with other studies which show the improvement in auditory performance. Anderson et al reviewed data of 37 children who received cochlear implants before the age of 2 years and were compared to those implanted at later age.[9] Results showed significant improvement over time.

Similarly, SIR score was used to measure the outcome of cochlear implantation with respect to speech, measuring the intelligibility of speech and the quality, which might be recognizable by the listener. The SIR scores in all groups were increasing at various intervals and results were comparable at 3, 6, 9 months interval but not significant while they were significant at 12 months and 24 months interval. Our study showed that <2 years age group achieved better speech perception scores. Study done by Dunn who performed a retrospective analysis to determine the effect of age at implantation on speech outcomes associated with modifiers of rates of language learning that differ as children with implants age.[10] Similar results were seen in study done by Tobey et al where they examined specific spoken language abilities in 160 children and followed postoperatively at 4, 5 and 6 years after implantation.[11] It showed that younger age of implantation is associated with higher level of performance, while later ages of implantation are associated with higher probabilities of continued language delays.

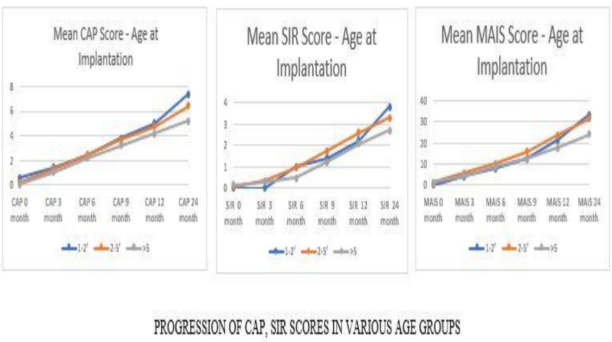

Figure 5: Progression of CAP, SIR, MAIS scores in various age groups.

We observed that duration of auditory deprivation strongly correlates with the outcome. This is commensurate with the past studies in the literature. The shorter the period from the identification of deafness to the time of cochlear implantation, the easier it tends to be to develop spoken language. As observed in a study done by Devendra Gupta, a predictive model for outcome of cochlear implantation in children below the age of 5 years: A multivariate analysis in Indian scenario where they studied 30 children and concluded strong positive correlation between Duration of auditory deprivation and outcome of CI. It appears that the less time the auditory channels remain dormant and unused, the greater the chance for these pathways to be ready and open to accept the new incoming information available through the cochlear implant.[12]

As seen in our study, children with duration of auditory deprivation less than 2 years achieved significantly better scores than 2-5 years group and more than 5 years group.

The CAP, SIR, MAIS scores when compared between all three groups viz. less than 2 years, 2 to 5 years, more than 5 years of auditory deprivation, it revealed that the results were comparable in 3, 6, 9 months interval postoperatively but not significant while the results were significant at 12 and 24 months interval postoperatively.

In the first group, CAP, SIR, MAIS score rapidly improved after implantation as compared to the other two groups and the difference was statistically significant at 12- and 24-months interval.

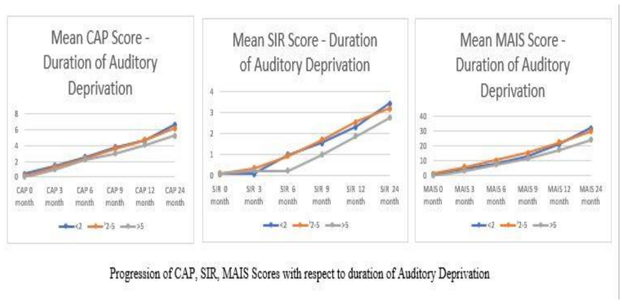

Figure 6: Progression of CAP, SIR, MAIS scores with respect to duration of auditory deprivation.

There is a wide variation among the incidence and prevalence of congenital hearing loss and its causes. The etiological diagnosis was obtained by means of an interview carried out with the parents. We took various causes which involved prenatal, perinatal, post-natal factors. Prenatal infections were the most common cause among the prenatal period. Perinatal causes include low birth weight and prematurity and post-natal causes included hyperbilirubinemia and meningitis as most common causes are:

- Around 11% patient had Prenatal Infection and Comparison of the CAP, SIR, MAIS score at periodic intervals between the two groups shows that CAP, SIR, MAIS score is higher in No group and is statistically not significant.
- Around 10% study population had low birth weight and comparison of the CAP, SIR, MAIS score at periodic intervals between the two groups shows no significance statistically among both groups.
- Only 3 patients in study population had prolonged labour and comparison of the CAP, SIR, MAIS score at periodic intervals between the two groups shows that CAP, SIR, MAIS score is higher in No group and is statistically non-significant.
- Around 17% of study population had Hyperbilirubinemia and comparison of the CAP, SIR, MAIS score at periodic intervals between the two groups shows that CAP, SIR, MAIS score is higher in NO group and is statistically non-significant.
- Around 11% of study population had delayed milestones and Comparison of the CAP, SIR, MAIS score at periodic intervals between the two groups shows no significance statistically among both groups.

- No comparison can be made in patients who had history of Meningitis as only one patient had history of Meningitis in study population.
- Around 17% of study population had family history of Consanguineous marriage and comparison of the CAP, SIR, MAIS score at periodic intervals between the two groups showed that the CAP, SIR and MAIS score is higher in No group and is statistically not significant.

The incidence of deafness varies among regions, and the prevalence of genetic congenital deafness is influenced by various factors like prevalence of consanguineous marriage in community. Atas et al in turkey studied 216 CI patients and reported no etiologies in that study.[13] Study by Calhua, et al reported unknown cause is the most common factors.[14] Second most common contributing factor was the genetic cause while calhua reported maternal rubella to be the second most common cause. We observed that unknown is the most common cause (35%). We found no significant correlation among various causes of congenital Hearing loss and outcome of cochlear implant surgery.

Approximately 74% of the study population had normal inner ear anatomy and 26% had cochleovestibular anomaly on radiological imaging. Out of thirteen, four had features suggestive of TORCH Infections, two had Mondini's deformity, and one had absent modiolus, one had labyrinthitis ossificans sequelae, one had dysplasia/hypoplasia. On comparison of the CAP, SIR, MAIS score at various intervals between the two groups, it showed that the CAP, SIR and MAIS score is higher in Normal group with greater t value in each interval and is statistically not significant. Similar results were seen in a study done by Jansen et al in 1969 where they reported abnormalities of inner ear in 20% patients with congenital sensorineural hearing loss.[15] We observed that both groups performed similar in CAP, SIR, AND MAIS score over various intervals. This may be due to better understanding of cochlear anatomy preoperatively by extensively discussing the surgical approaches, Intraoperative NRT and Check X-ray and confirming the position of electrodes.

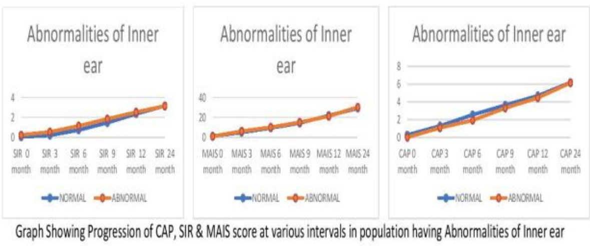

Figure 7: Progression of CAP, SIR, MAIS scores at various intervals in population having abnormalities of inner ear.

There were 47% implantees whose either parent was educated up to 12th standard and 53% implantees whose either parent was educated up to Graduation and above. There is no significant difference in both the groups. After implantation, scores in both groups increased with increasing time of implant use during the follow up period. We did not find any significant correlation between education level of parents and outcome of cochlear implant surgery

We observed that population belonging to rural and urban population does not affect the outcome of Cochlear Implant surgery. Almost 65% of study population belonged to urban region and on comparison, both groups showed no significant difference in the outcome of surgery. Demographic factors do not affect the outcome of surgery.

Out of 51 patients, only two patients in our study did not follow AVT regularly. Incidence of regular speech therapy population is higher due to rigorous preoperative counselling and participation of Speech therapist at various levels preoperatively and postoperatively.

CONCLUSION

From our study, it can be concluded that the two most important factors that affect the outcome of a prelingual deaf child who undergoes Cochlear Implantation are - the Age at implantation and the duration of auditory deprivation. Other factors are important but not significant and do not affect the outcome significantly.

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