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Original Research Article

Auditory performance and speech intelligibility among children with cochlear implant under a state-sponsored insurance scheme: a cross-sectional study

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ABSTRACT

Background: Cochlear implant is the intervention for improving the auditory performance and speech ability for children between 6-12 years with congenital deafness under the Chief Minister's Comprehensive Health Insurance Scheme, a state-sponsored insurance scheme in Tamil Nadu. Until 2020, 4107 children had been provided with a cochlear implant under the scheme. However, the outcome of this intervention was not studied so far. Hence, as a program evaluation auditory performance and speech intelligibility among patients who received cochlear implant under the scheme is studied.
Methods: A cross-sectional study was conducted among 203 patients who had received a cochlear implant at least 1 year ago. Children were evaluated for auditory performance and speech intelligibility using revised Categories of Auditory Performance (CAP) and Speech Intelligibility Rating (SIR) scores by trained speech therapists in Government Medical College hospitals. The proportion of good scorers in CAP (level ≥7) and SIR (category ≥ 3) was computed. The difference in proportion between different demographics was tested using the Chi-square test and Fischer exact test.
Results: The median CAP and SIR scores of the children were 8 (Interquartile Range – 4) and 3 (IQR – 2) respectively. Almost 2/3rd of the children had good auditory performance and speech intelligibility. Factors that were associated with good auditory performance and speech intelligibility were being a girl child, getting the implant before 3 years of age, and getting it in a private institution.
Conclusions: Gender and age at implant influences auditory performance and speech intelligibility after cochlear implant. Hence, early screening for deafness should be made a routine to enable early detection and management, thereby preventing permanent disability.

Keywords: Cochlear Implant, Outcome, CAP score, SIR score

INTRODUCTION

Congenital deafness is one of the most common birth defects in Tamil Nadu. A hospital-based study conducted in Tamil Nadu in 2013, showed that 6 out of every 1000 newborns have profound hearing loss, which is 3 times higher than the national average.[1] Cochlear implant is the only option available for these children for improving their auditory performance and speech ability. Until 2012, a cochlear implant was not an easily accessible or affordable option for everyone in Tamil Nadu. It was in 2012 when the cochlear implant was included as a package under the Chief Minister's Comprehensive Health Insurance Scheme, a state-sponsored insurance

scheme in Tamil Nadu, it became a viable option for everyone. Ever since it was included under the scheme, 4107 children had been provided with a cochlear implant under the scheme as of 2020. The procedure is being offered in 21 government and 11 private hospitals of Tamil Nadu. Any child below 6 years of age with bilateral profound sensory neural deafness is eligible for getting a cochlear implant under the scheme. Children between 6-12 years can also avail of the services based on the recommendations of a special committee which will be convened for this purpose. However, the outcome of a cochlear implant done under the scheme was not studied so far. Hence, as a program evaluation auditory performance and speech intelligibility among patients who received cochlear implant under the scheme is studied.

METHODS

A cross-sectional study was conducted among patients who had received a cochlear implant at least 1 year ago under the CMCHIS scheme. The sample size was calculated based on the formula Zα2pq/d2, with 5% alpha error and 10% relative precision and p – 73.4 % based on a pilot study and design effect of 1.5, and 20% non-response rate, the calculated sample size was 249. The list of patients who had cochlear implants under CMCHIS at least one year ago was obtained from the CMCHIS office which was the sampling frame. From the sampling frame, 249 patients were randomly selected using Computer generated table. These patients were approached by telephone to participate in the outcome evaluation. Since the beneficiaries were less than 18 years old, the purpose of the study was explained to the adult caretakers. Those who agreed to participate in the study were informed of the venue where they had to come for evaluation and the time and date were also informed. Among 249 patients who were approached, 203 were evaluated for auditory performance and speech intelligibility using revised Categories of Auditory Performance (CAP) and Speech Intelligibility Rating (SIR) scores. The evaluation was done in Government Medical College hospitals. The CAP and SIR score was administered by trained speech therapists. All those children had sensorineural hearing loss and received a unilateral cochlear implant. All of them received auditory-verbal therapy before and after implant.

The auditory performance was assessed by the revised categories of auditory performance (CAP) score described by the shepherd center based on the Nottingham cochlear implant program. The CAP is a twelve-point nonlinear and hierarchical rating scale. Its scores range from the lowest level (0) of being unaware of environmental sounds to the highest level (12) of having the ability to converse on the telephone with an unfamiliar person.[2] (Table 1). In this study, categories 7 and above were defined as good auditory performance.

Speech intelligibility was assessed using speech intelligibility rating (SIR) described by O'Donoghue et al in 1999 was used (Table 2). The SIR was used to measure the speech intelligibility of the implanted children by quantifying their everyday spontaneous speech. It is a time-effective global outcome measure of speech intelligibility in real-life situations. SIR consists of five performance categories ranging from "recognizable words in the spoken language" to "connected speech is intelligible to all listeners". In this study, categories 3, 4, and 5 were all defined as intelligible, following a previous study.[3]

The data were entered in Microsoft Excel and analysed using Statistical package for social sciences (SPSS) version 21. The CAP and SIR scores as a continuous variable were tested using the Mann Whitney U test and Kruskal Wallis Test. The proportion of good scorers in CAP (level ≥7) and SIR (category ≥ 3) was computed. The difference in proportion between different demographics was tested using the Chi-square test and Fischer exact test.

RESULTS

The demographic profile of the study participants are shown in Table 3. Almost 1/3rd of the beneficiaries had the procedure done before 3 years of age. More than 3/4th of the surgeries had been done in private hospitals. The median CAP and SIR scores of the children were 8 (Interquartile Range – 4) and 3 (IQR – 2) respectively.

Table 1: Revised categorical auditory performance.

Level 0	**Unaware of environmental sounds**
Level 1	Detects some environmental sounds
Level 2	Responds to some speech sounds
Level 3	Can identify some environmental sounds
Level 4	Understands some spoken words with additional performatives e.g. 'where is the duck that says quack quack', 'give me the car brmm'
Level 5	Understands common phrases e.g. pick it up; it's bath time.
Level 6	Understands some spoken words without performatives e.g. give me the duck'/ 'go get the car'
Level 7	Responds appropriately to simple questions e.g. what is it?
Level 8	Understands conversations with familiar speakers
Level 9	Understands conversations with unfamiliar speakers
Level 10	Follows recorded stories
Level 11	Uses the telephone with familiar speakers
Level 12	Uses the telephone with unfamiliar speakers

Table 2: The Speech intelligibility rating scale (SIR).

Category 1	**Pre-recognizable words in spoken language.**
Category 2	Connected speech is unintelligible but is developing for single words.
Category 3	Connected speech is intelligible to a listener who concentrates, and lip-reads within a known context.
Category 4	Connected speech is intelligible to a listener who has little experience of a deaf person's speech. The listener does not need to concentrate unduly.
Category 5	Connected speech is intelligible to all listeners. The child is easily understood in everyday contexts

Source: Allen MC, Nikolopoulos TP, O'Donoghue GM. Speech intelligibility in children after cochlear implantation. Am J Otol. 1998;19(6):742-6.

Table 3: Demographic profile of the participant.

Demographic characteristic		Frequency	Percentage
Gender	Male	118	57.84%
	Female	86	42.16%
Mean Age at Surgery (SD)		3.69 years (1.66)	
Age at surgery	<3 years	63	30.88%
	≥ 3years	141	69.12%
Type of institution	Government	48	23.53%
	Private	156	76.47%
Duration since surgery	≤ 2 years	39	19.12%
	2-3years	49	24.02%
	≥3years	116	56.86%

Table 4: Mean score of CAP and SIR among cochlear implant recipients.

Variable		CAP # Score			SIR$ score		
		Mean	**SD**	**P-value**	**Mean**	**SD**	**P value**
Gender##	Female	7.62	2.51	0.048*	3.27	1.21	0.007*
	Male	6.97	2.62		2.84	1.17	
Age at cochlear implant##	<3 years	8.06	2.415	0.005*	3.27	1.153	0.023*
	≥3 years	6.88	2.587		2.89	1.147	
Institution Type##	Government	6.56	2.457	0.040*	2.58	1.069	0.004*
	Private	7.46	2.599		3.13	1.159	
Duration Since Surgery¥	≤ 2 years	6.67	2.377	0.085	2.74	1.117	0.085
	2-3years	6.88	2.514		2.90	1.141	
	≥3years	7.59	2.651		3.14	1.171	

* - statistically significant at p<0.05. # - Categorical Auditory Performance Score. ## - Mann Whitney U test. $ - Speech Intelligibility Score. ¥ - Kruskal Wallis test

Table 5: Auditory performance and Speech intelligibility in comparison with the demographic profile.

Variable		CAP #			SIR $		
		Good scorer	**Test statistic@**	**P value**	**Good scorer**	**Test statistic@**	**P value**
Gender	Female	60 (69.7%)	4.519	0.042*	62 (72.1%)	5.018	0.025*
	Male	65 (55.1%)			67 (56.8%)		
Age at surgery	<3 years	48 (76.2%)	8.546	0.003*	47 (74.6%)	5.067	0.024*
	≥3 years	77 (54.6%)			82 (58.2%)		
Institution type	Government	26 (54.2%)	1.336	0.248	23 (47.9%)	6.336	0.012*
	Private	99 (63.5%)			106 (67.9%)		
Duration since implant	≤ 2 years	20 (51.3%)	3.897	0.048*	19 (48.7%)	6.959	0.008*
	2-3years	27 (55.1%)			28 (57.1%)		
	≥3years	78 (67.2%)			82 (70.7%)		

*- statistically significant at p value < 0.05.# - Categorical Auditory Performance Score. $ - Speech Intelligibility Score. @ - Chi Square test

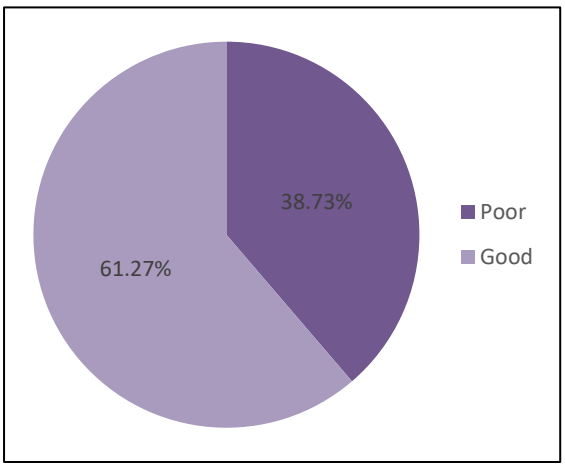

Figure 1: Auditory performance among cochlear implant recipients in Tamil Nadu.

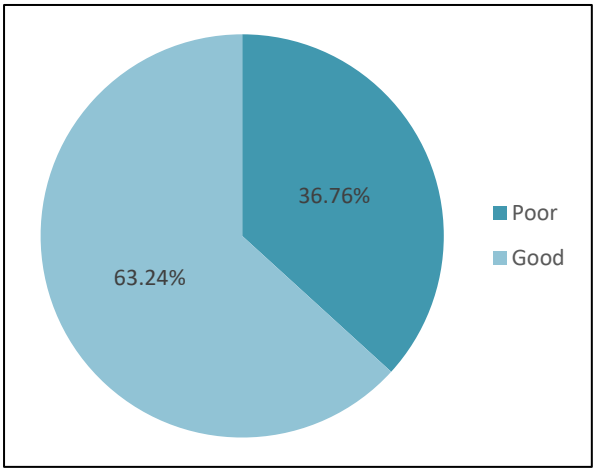

Figure 2: Speech intelligibility among cochlear implant recipients in Tamil Nadu.

From Table 4, it is evident that among children who had received a cochlear implant, the CAP score was significantly better among girl children, children who received implant before 3 years of age and if done in a private institution.

With regards to SIR score, girl children, children who received implants before 3 years of age, getting the procedure in a private hospital had a higher score than their counter groups which was statistically significant. There was an increase in Mean CAP and SIR score with increasing duration of implant use, though statistically not significant.

Figure 1 and 2 shows that among the cochlear implant recipients, 61.27% and 63.24% had good auditory performance and speech intelligibility respectively.

From Table 5, it is evident that a larger proportion of girl children had good auditory performance and speech intelligibility compared to male children. Similarly, a larger proportion of children who had received cochlear implants less than 3 years of their age had good auditory performance and speech intelligibility. There was an increasing proportion of children with good auditory performance and speech intelligibility with increasing duration since implant which was statistically significant. The median age at implant with good CAP and SIR was 3 years (Interquartile range – 3).

DISCUSSION

Among children who had received cochlear implants under CMCHIS, almost 2/3rd of them had good auditory performance and speech intelligibility. Factors that were associated with good auditory performance and speech intelligibility were being a girl child, getting the implant before 3 years of age, and getting it in a private institution.

The outcome in terms of auditory performance and speech intelligibility is comparable to that of other studies conducted in India. The median CAP and SIR score at the end of 1 year among recipients of cochlear implant in Assam was 7 and 3 respectively.[4]

In this study, it is found that gender influence both auditory performance and speech intelligibility, with the female gender performing better. From the literature, there is no consensus on the influence of gender on acquiring language and hearing among normal-hearing children.[5,6] The influence of gender in hearing and language development among children with cochlear implants also finds no consensus.[5,7] Studies by Ching et al and Geers et al concluded that female children were showing better results in language than male children.[8,9] The studies of Gérard et al and Ramos et al concluded that there were no statistically significant differences between genders regarding language development.[5,7]

In this study, it is found that age at implant has a significant effect on auditory performance and speech intelligibility. This finding is very similar to other studies which have been done across the world and have stated that children receiving cochlear implants before 3 years of age had better hearing and speech outcome.[9–15] A study done in Italy, demonstrated improved auditory, speech-language, and cognitive performances in children implanted below 12 months of age compared to children implanted later.[16] Similarly in a population-based study conducted in Australia, it was found that getting a cochlear implant before 12 months of age had a better outcome.[17] Delaying implantation from 10 to 24 months of age was associated with a reduction of 8–9 global factor score points. Given that the global factor score has been scaled so that a normal population should have a mean of 100 and a standard deviation of 15 points, a reduction of 8 points represents a more than one-half standard deviation shift in outcomes, which is a substantial decrement.[8] There are evidence from India which also reiterate the same finding. In a study conducted in Assam, age at implant was found to be

significantly associated with auditory performance and speech intelligibility.[4] Other factors which were found to be associated with improved auditory performance and speech intelligibility were duration of auditory deprivation before cochlear implantation.[4] In another hospital-based study conducted in Chennai, it was observed that earlier the child receives implant better the auditory performance and speech intelligibility. In this study auditory performance was assessed using the original version of the CAP scale which has 7 categories. It was observed in this study that 10% of children between 1-5 years achieved category 7 at the end of 12 months post implant whereas only 4% of the children between 6-10 years achieved category 7 in the same duration. This study also pointed the importance of auditory verbal therapy post implant.[18] However, it was also observed in a study conducted by Zhou et al in China which showed that great communication benefits are achieved by early implantation without routine speech therapy. The study reported that there was no significant difference in the CAP score and SIR score between children who received speech therapy in the rehabilitation centers and those of untrained children with early implantation.[19] This finding was further substantiated with the explanation that there exist a sensitive period for central auditory and spoken language development .If the auditory system is deprived of sensory input during this sensitive period, then it is likely that the higher order auditory cortex gets reorganized due to neural scavenging. The auditory cortex is taken by other sensorial systems, especially by visual one, which is called as cortical re-organization. If cochlear implantation is done after reorganization, it becomes less useful for speech and language acquisition. Hence, very early implantation is necessary to allow at least relatively normal organization of auditory pathways in congenitally deaf children. This might be a potential factor explaining why earlier implantation leads to good results in children.[20,21] This signifies the importance of early new born screening for hearing impairment for early action.

The difference in the CAP and SIR was observed between the type of institution in which the implant was done. The score was better if the implant was done in a private institution. This could be because the private institutions were providing cochlear implant services for quite a number of years and had better exposure and experience compared to government hospitals which were relatively new entrants under the schemes. While these are mere assumptions, the reason for such difference needs to be studied in detail and actions taken for improvement. The auditory performance and speech intelligibility increased as time progressed which depicts the cumulative effect of the external auditory stimulus.

This study is the first in India to have done the outcome evaluation among more than 200 patients. While other studies had focused on results from an individual hospital, this is the first population-based study in India. This study however did not look at the other factors like cause of deafness, use of hearing aid before implant, getting auditory verbal therapy on the outcome, which could also have an impact.

CONCLUSION

Gender and age at implant has an effect on auditory performance and speech intelligibility after cochlear implant. Thus, it is essential that early screening for deafness is made a routine which would enable early detection and management, thereby preventing disability.

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