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The World of Sound and Speech in Pediatric Cochlear Implant Patients: An Experience from a Tertiary Care Centre in Central India

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ABSTRACT

Objectives – To assess the effect of auditory and speech rehabilitation according to the revised Category of Auditory Performance (CAP) and Speech Intelligibility Rating (SIR) score in patients who underwent Cochlear Implant (CI) surgery at a tertiary care centre in Central India. **Patients and Methods** – This was a retrospective interventional study conducted at the Department of Pediatrics and Otorhinolaryngology of Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, during the period from 2014 to 2018, to assess the hearing and speech of the patients who underwent CI, and was approved by the Institutional Ethical Committee. **Results** – A total of 114 patients underwent surgery using the mastoidectomy-posterior tympanotomy (MPTA) approach at our centre. Of these, 61 (54%) were males and 53 (47%) were females, with a mean average age of 24.66 months. The number of patients with a right ear defect was 107 (93%) whereas with left ear defect there were only 7 (6%). Six patients were lost to follow-up. The majority of children fell into the 4th category followed by the 2nd category of CAP scoring, and in SIR scoring the majority of children fell into the 4th category, followed by the 3rd and 2ndcategories, which is statistically significant. **Conclusion** – CI surgery is the gold standard for prelingual deafness. Early detection and early implantation of a CI is highly recommended for patients to enable them to live a healthier life. The study also indicated that early CI reduces the discrepancies between physical and expressive age. The CAP and SIR questionnaires were relevant and apt for assessment of hearing and speech development after CI.

Key Words: Deaf ▪ Cochlear Implant ▪ Speech.

Introduction

According to the WHO, 466 million people are suffering from hearing loss worldwide, which amounts to 6.2% of the global population (1). Out of this number, 34 million (9%) are children. There are approximately 120,000 children with severe to profound hearing loss that occurred before 7 years of age, and 20,000–30,000 hearing impaired children are born every year (2). The disability "hearing loss" refers to hearing loss greater than 30dB in the better ear in children aged 0–14 years (3). Sensorineural deafness is one of the key factors affecting the health and quality of life of humans. The prevalence and severity of hearing loss vary according to factors including socioeconomic status, exposure to infections, and consanguinity. The prevalence of hearing impairment is greater in regions of low and middle income, and is proportionally related to age and male sex (4). Hearing disabilities in children cause adverse effects related to language acquisition, restricted academic achievement, and missed sound opportunities, leading to damage to social, psychological and professional life (5).

Cochlear Implant (CI) has become a standard and safe procedure for severe to profound sensorineural hearing loss (SNHL), and it enhances speech perception in children with SNHL. CI can improve verbal skills and provides better communication in SNHL children. Many factors have been found to affect the outcome of implantation, such as the duration of deafness, age at onset of deafness, age at implantation, duration of implant use, and length of daily device use (6). Children implanted before 2 years of age are able to develop speech and language at a rate equal to similarly aged children with normal hearing. Speech therapy is thought to be important in improving speech recognition performance. Previous studies have demonstrated the benefits of training in speech recognition skills in CI users, and have shown promising results.

The aim of this study was to assess the effect of auditory and speech rehabilitation in patients who had undergone CI surgery by using a revised Category of Auditory Performance (7) and Speech Intelligibility Rating by O' Donoghue (8) in a tertiary care centre in Central India.

Patients and Methods

This study was approved by the Institutional Ethical Committee to learn about speech development and auditory performance in children after Cochlear Implantation in the pediatric age group. This was a retrospective interventional study conducted at the Department of Pediatrics and Otorhinolaryngology at Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, during the period from 2014 to 2018. The medical records were evaluated of all children aged between 6 months to 5 years who were admitted with a diagnosis of hearing loss in the time period from January 2014 to December 2018, and who underwent cochlear implant surgery. The data collected on the study group comprised: age, sex, time of presentation, site of operation, complications encountered, and the decision maker regarding the operation, with a socio-demographic profile. Written consent was taken from the parents, and clearance from the Institutional Ethical Committee was obtained for the study.

Inclusion Criteria

All patients with severe to profound SNHL aged <5yrs, without perinatal problems (e.g. hyper-bilirubinemia, meningitis, low birth weight/preterm babies and other aetiologies presently associated with SNHL).

Exclusion Criteria

All patients aged >5yrs, with congenital anomalies/disabilities and prior implants (bone-conduction/electro-acoustic and auditory brainstem implant) were excluded.

Auditory and Speech Ability Assessment Methods

The classifications performed in this questionnaire were based on the CAP and SIR scoring system by The Shepherd Centre, based on the Nottingham CI Program and O' Donoghue. The Category of Auditory Performance (CAP) classifies the auditory perception ability of deaf patients on a scale of 0 to 7 as follows: 0 = No awareness of environmental sounds; 1 = Awareness of environmental sounds; 2 = Response to speech sounds; 3 = Identification of environmental sounds; 4 = Discrimination of some speech sounds without lip reading; 5 = Understanding of common phrases without lip reading; 6 = Understanding of conversation without lip reading; 7 = Use of telephone with known listener.

Similarly, the SIR classifies the speech intelligibility of deaf patients on a scale of 1 to 5 as follows: 1 = Connected speech is unintelligible. Pre-recognizable words in spoken language, primary mode of communication may be manual; 2 = Connected speech is unintelligible. Intelligible speech is developing in single words when context and lip reading cues are available; 3 = Connected speech is intelligible to a listener who concentrates and lip reads; 4 = Connected speech is intelligible to a listener who has a little experience of a deaf person's speech; 5 = Connected speech is intelligible to all listeners. The child is understood easily in everyday contexts.

These two scales were used for the 2-year follow-up evaluations by trained audiology professionals

of the hearing ability and speech intelligibility of patients at pre-implantation and post-implantation for a period of up to 2 years. The evaluators asked all the questions in the scale. The parents described in detail the auditory and verbal behaviours in the daily life of the children, and the evaluators rated the score according to the descriptions.

Measuring Level of Performance

The outcome of cochlear implantation was measured using the revised CAP score described by The Shepherd Centre, based on the Nottingham CI Program. On the basis of the CAP score, the extent of auditory perception was assessed, in terms of the use of auditory mechanisms to pursue day to day tasks. The ability to discriminate and understand speech with or without lip reading was also assessed, the results were categorized accordingly and a score was given, taking into account the number of months taken to achieve it.

Similarly, the Speech Intelligibility Rating (SIR) of O' Donoghue was used to measure the outcome of cochlear implantation with respect to speech, measuring the intelligibility of speech and its quality, which might be recognizable to the listener. The analysis also included the extent to which speech was understood and discriminated by the listener. The results were assessed and categorized accordingly, and a score was given, taking into account the number of months taken to achieve them. The study also laid emphasis on a comparison of the outcomes with respect to the protocols followed in the institution and the protocols given in the guidelines laid down by the Cochlear Implant Group of India (CIGI). The effectiveness of the protocols was assessed and the practical difficulties in implementing them discussed, highlighting the special issues which need attention and consideration in the present Indian situation. Initially the patients were assessed by an ENT consultant and audiologist by means of comprehensive audiological evaluation, including Brainstem Evoked Response Audiometry (BERA) / Auditory Steady State Response (ASSR) / Otoacaustic Emission (OAE) / Tympanometry / Pure Tone Average (PTA) / Speech Audiometry / middle ear analysis / aided audiogram, and hearing aid trial. If the patient was found to be an ideal candidate for cochlear implantation, imaging studies (CT / MRI scan) were obtained to detect any congenital deformities of the cochlea and the eighth nerve, and to assess the course of the seventh nerve. The guardians of each candidate were counselled for cochlear implantation, explaining the surgical procedure, the types of implants, the working procedure switch, and mapping. The patient's speech, language and auditory skills were assessed. The candidates and parents were made to meet and interact with other cochlear implant recipients to have a perspective on the procedure and its outcome. After counselling and interaction with the guardians of implant recipients, a questionnaire was given to the candidates and their parents to assess their expectations after cochlear implantation. Prior to implantation, a basic work up, including hematology, chest X-ray, ECG and TORCH screen (if required) was conducted. The general physical condition was evaluated by the anesthetist. A specialist's opinion was sought in patients with syndromic etiology of deafness. In the children, pre-implant vaccination was carried out (pneumococcal, meningococcal and Haemophilus influenza type - b vaccine). Cochlear implantation was done and the response of electrodes was confirmed using Neural Response Telemetry (NRT). The switch on and speech processor tuning was conducted two weeks after surgery. Mapping was performed at periodic intervals until a stable map was achieved. The rehabilitation program was commenced taking into account the baseline skills of the patient; periodical assessments of outcome were conducted in terms of environmental sound, open set and closed set speech, speech discrimination and telephonic conversation. The recommended period for rehabilitation at our institute is 2 years.

Ethical Statement

The study was approved by the Institutional Ethics Committee of Chirayu Medical College and Hospital via letter no EC/1/2018.

Statistical Analysis

Statistical analysis was performed using the SPSS program, Windows version 22.0.SPSS. The P value <0.05 indicated statistical significance. The Chi-square test and Pearson correlation coefficient were used to examine the association of categories.

Results

A total of 114 patients underwent surgery at the Chirayu Medical College during the study period. All 114 patients underwent surgery by the mastoidectomy-posterior tympanotomy (MPTA) approach. Most of the patients with cochlear disease were from lower class families who were not highly educated. They were mostly living in large families with limited space and minimum earnings. 90% of the total patients had siblings without any deafness. One family had had a previous deaf child whose male baby underwent surgery. The number of patients implanted on the right side was 107 (93%) and only 7 (6%) on the left side. Table 1 gives the parameters and characteristics of the study population, which had a mean age of 24.66 months. We lost 6 patients to follow up and they were excluded from the study.

In the present study, most of the children were aged between 25 and 36 months although their physical age was higher than their expressive age. The majority of the children were in the 4thcategory, followed by the 2nd category in CAP scoring, and in SIR scoring the majority of children were in the 4th category, followed by the 3rd and 2nd (Table 2).

Table 1. Distribution of Children According to Gender, Site of Implantation, and Age Group

Distribution	N (%)
Gender	
Female	53 (46.5)
Male	61 (53.5)
Site	
Left ear	7 (6.1)
Right ear	107 (93.9)
Age groups	
Up to 12	26(22.80)
13 – 24	24(21.06)
25 – 36	46(40.35)
37 – 42	18(15.79)
Total	114 (100.0)

When comparing categories <3 for CAP and SIR it was noticed that more children were in the CAP category as compared to SIR in the same age group. For categories ≤3, the CAP and SIR scores were found to be statistically significant regarding age group, with a P value of 0.003

In category >4 more children were in the SIR category 4 as compared to the CAP category 4 for the same age group. For category ≥4, the difference between CAP and SIR was not statistically significant, with a P value of 0.67 (Tables 3 and 4).

Table 2. CAP* and SIR† Category Distributions According to Age Group

Age group‡	N	Categories													Total
		Auditory performance								Speech intelligibility rating					
		0	1	2	3	4	5	6	7	1	2	3	4	5	
Up to 12	26	1	4	20	1	0	0	0	0	4	22	0	0	0	26
13 - 24	21	0	1	2	1	7	05	05	0	0	2	10	9	0	21
25 - 36	46	0	0	1	1	39	5	0	0	0	1	22	22	01	46
37 – 42	15	0	0	1	0	03	9	1	1	0	0	4	11	0	15
Total															
N	108	01	05	24	3	49	19	06	01	04	25	36	42	01	108
Percentage	100	(0.9)	(4.6)	(22.2)	(2.9)	(45.4	(17.6)	(5.6)	(0.9)	(3.7)	(23.1)	(33.3)	(38.9)	(0.9)	100

*Category of Auditory Performance; †Speech intelligibility rating; ‡Months.

Table 3. Association of Age Groups with CAP* and SIR† Category ≤3

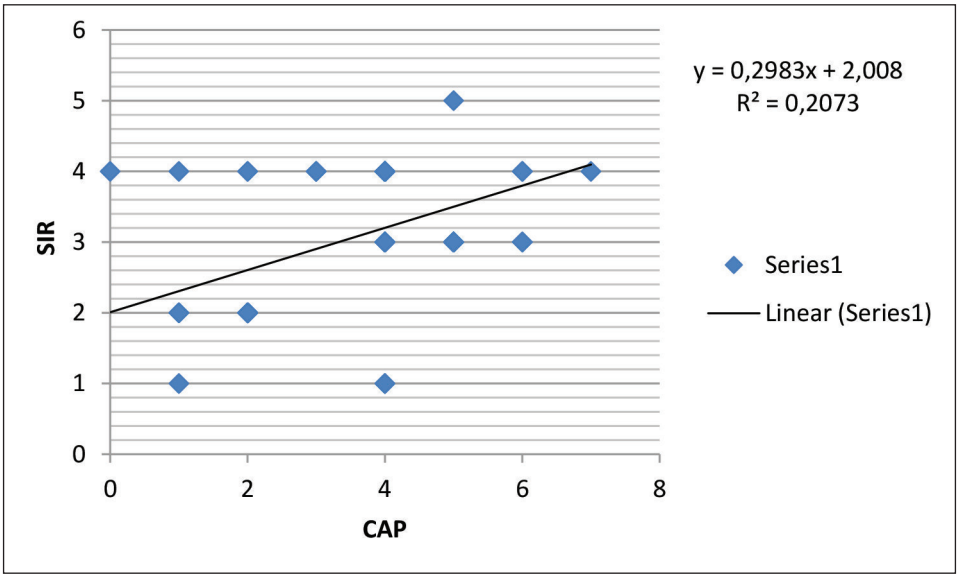
Expressive age group‡	CAP*	SIR†	Chi square test
	≤3	≤3	
Up to 24	30	38	Chi-square statistic is 11.1176; P=0.003853
25 – 36	2	23	
37 – 49	1	4	
Total	33	65	

*Category of Auditory Performance; †Speech intelligibility rating; ‡Months.

Table 4. Association of Age Groups with CAP* and SIR† Category ≥4

Expressive age group‡	CAP*	SIR†	Chi square test
	≥4	≥4	
Up to 24	17	09	Chi-square statistic is 0.7833; P=0.675953
25 – 36	44	23	
37 – 49	14	11	
Total	75	43	

*Category of Auditory Performance; †Speech intelligibility rating; ‡Months.



SIR=Speech intelligibility rating; CAP=Category of Auditory Performance.

Fig. 1. *Correlation between CAP and SIR categories.*

The correlation between CAP and SIR was found to be statistically significant with a Pearson correlation coefficient value of 0.455and a P value of 0.001. This shows that the correlation was positive for CAP and SIR (Fig. 1).

Discussion

This study of CI is the first ever report conducted at our institute. The study used CAP and SIR to evaluate outcomes, before and after CI. The CAP and SIR assessments in all age groups established

that implantation scores did not differ significantly before and after the CI as the scores were on the lower side (<2). However, significant differences started to appear 12 months after CI. Different age groups showed different levels of auditory performance. The combined use of CAP and SIR gave an accurate and reliable measure of post-operative auditory and speech performance in paediatric cochlear implant recipients. Preferably, the ideal age for implant, recommended for paralinguistic and deaf patients, is 1 to 6 years in many countries across the globe for CI surgery (9, 10). The younger the age of implantation, the better the results and outcomes, since early implantation helps patients achieve better hearing and speech (11, 12). Studies show that children who receive implants before the age of 3 show better language performance, as this is the age at which the brain readily adapts and masters language. In children who were given implants before the age of 18 months, spoken language appeared to come out at a natural pace. It has been observed in many children who were given implants that the stimulated source of hearing offered through CI can offer a better opportunity for the child's improvement and progress in language learning than correcting their language.

It was also observed that early CI and especially rehabilitation training within the first six months post CI are crucial for the development of auditory ability in young hearing-impaired children. It was also seen that during 6–24 months of follow up after CI, auditory ability improved significantly. However, it was noticed that improvement was slower in the initial 6 months and after 24 months post CI surgery.

The present study shows a male predominance 61 (54%) in the children who underwent CI surgery (13). In our study we observed that the primary cause of sensory neural deafness remained unknown and unclear, despite the extensive workup done in comparison to other studies which mentioned a particular diagnosis (14, 15). The literature shows from major to minor complications of cochlear implant surgery, although most are transient while a few need intensive care (16). Complications seen immediately after CI surgery are: facial paralysis, meningitis, local infection, tinnitus, vertigo and electrode misplacement, but in the present study the authors encountered minor complications in 3 patients with headache and dizziness (minor complications).

From the published research it is very easy to determine the variables that lead to optimum speech perception and language outcomes for children who undergo CI surgery, such as their age when they received the implant, the use of current speech processor technology, communication modes that accentuate the oral approach, the absence of developmental delay, shorter duration of profound hearing loss, and pre-implant residual heaving. Wiley et al. reported improvement in communication skills after cochlear implantation (17). Post CI, all children showed significant improvement in auditory skills and speech perception in the present study.

Conclusion

The results of this study show that the CAP and SIR questionnaires were relevant and apt for assessment of hearing and speech development after CI. To conclude, the study showed that the hearing and speech development of patients who had CI under the age of 3 years improved continuously over the passage of time for up to 5 years after CI. The development of hearing ability in the early stages surpassed the development of speech ability.

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Conflict of Interest: The authors declare that they have no conflict of interest.

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