

Academic Outcomes and Coping Mechanisms of Children using Cochlear Implants in Mainstream Schools in Kerala, India

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ABSTRACT

Purpose: *The aim of the present study was to understand the academic outcomes of children using cochlear implants in mainstream schools in Kerala, India and to explore the compensatory strategies used by them to overcome the difficulties faced in classrooms.*

Method: *Thirty-one children using cochlear implants who were attending first and second grades in mainstream schools, and their parents and teachers participated in the study. Teachers were asked to rate a questionnaire, "Teachers' Perceptions of Academic Outcomes", which consisted of five sections – oral comprehension, oral expression, reading, writing and mathematics. The performance of the children using cochlear implants was compared with the performance of typically hearing children in the class. The grades obtained in the previous examination were also used for the comparison. Information was collected regarding difficulties faced by the children inside the classroom and their strategies to overcome the challenges.*

Results: *The class teachers rated the performance of 71 % of these children as 'above average'. Though the academic outcomes were found to be good on the questionnaire and classroom tests, most of the children with cochlear implants faced various difficulties and had used different compensatory strategies to give their optimum performance in the classroom.*

Conclusion: *The study emphasizes the importance of having mid- and long-term follow-ups with children using cochlear implants, even after mainstreaming. It*

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is necessary to orient and train teachers about the needs of these children and to implement support strategies in mainstream schools.

Key words: *children with cochlear implants, academic outcomes, teachers' perspectives, integrated school setting*

INTRODUCTION

A solid foundation in speech and language skills is an important pre-determiner for achieving good academic outcomes (Geers, 2003). Children with severe to profound hearing loss lag behind their typically hearing peers in the acquisition of auditory skills, oral language and speech skills because of their inability to hear speech sounds in their daily life (Zanjani et al, 2013). Hearing impairment may also lead to an inability to interpret speech sounds, and subsequent impairment in spoken language acquisition and literacy development. This affects the literacy acquisition and academic development of children with hearing loss and remains a challenge.

Since the 1980s, cochlear implantation has been an effective management option for individuals with severe to profound hearing loss. Children with cochlear implants (CIs) show significant improvement in speech perception, speech production, language, literacy development (Sarant et al, 2015) and cognitive abilities (Mosnier et al, 2014). Many studies report on the efficacy of CIs in terms of speech perception and production, language, and social development (Tobey et al, 2003; Farinetti et al, 2015; Lund, 2016).

Language Comprehension

Many studies have documented gains in language comprehension of children using CIs. A review of 12 articles comparing children with pre-lingual deafness who use hearing aids and children with CIs concluded that children using CIs achieved better results in speech perception and linguistic development than children using hearing aids (Bittencourt et al, 2012). Studies that compared language abilities of children using CIs with typically hearing children evidence that children with CIs performed within one standard deviation of the typically hearing children on measures of language comprehension (Spencer et al, 2003).

Expressive Language and Literacy

Spoken language competence is now possible for many children who receive

CIs along with appropriate habilitation (Geers et al, 2009). The rate of language development in children after implantation was found to be similar to that of children with typical hearing (Svirsky et al, 2000; Tomblin et al, 2005). Speech intelligibility was also found to be better in children using CIs as they produced significantly fewer phonetic and phonological errors when compared with children using hearing aids (Baudonck et al, 2010). However, some studies also report that children with CIs lag behind their typically hearing peers in several aspects such as expressive sentence formulation, lexical semantics and meta-phonological processing (Spencer et al, 2003; Schorr et al, 2008) and syntax (Geers et al, 2009).

Geers & Hayes (2011) have documented language-based factors necessary for successful literacy development which includes phonological processing skills, vocabulary knowledge, syntax and discourse skills. Children using CIs have been found to have significantly poorer phonemic awareness, which compromised their reading skills (Dashtelei et al, 2015).

Writing

Vocabulary knowledge, syntax, and phonological skills are important prerequisites for developing good writing skills, and children with hearing loss lack these skills (Marschark et al, 1994). Use of CIs has been shown to improve the writing skills of children with deafness. Children using CIs obtained above average scores for writing when compared with typically hearing children (Sarant et al, 2015), but used fewer words, had immature writing patterns (Spencer et al, 2003) and poorer spelling and expository writing skills (Geers et al, 2011).

Mathematics

Mathematics is known to be influenced by language skills. General verbal ability affects how children understand and reason with numbers, and phonological decoding is directly related to arithmetic performance as storing and retrieving numbers from memory is essential for solving mathematical problems (Vukovic & Lesaux, 2012). Studies reporting the mathematical abilities of children using CIs are scarce and the existing evidence is varied. Findings include a less than 10% performance gap between children using CIs and typically hearing children (Thoutenhoofd, 2006; Motasaddi-Zarandy et al, 2009) and, on the contrary, poorer mathematical skills than typically hearing children (Sarant et al, 2015) and low scores in both mathematics and geometric reasoning tasks (Edwards et al, 2013).

Most of the existing research studies on academic outcomes of children with CIs use standardised tools in the areas of oral language, reading, writing, and mathematics. Such standardised tools cannot be used in India because of differences in curriculum and language of instruction across different schools. Standardised tests can also be insensitive to small changes in performance (DuPaul et al, 1991). Teacher rating of students is more suited for use in India and may provide a more representative sample of academic achievement. A wider range of information can be obtained using a Teacher Perception Rating Scale, as teachers are able to directly observe student performance in a more comprehensive way based on academic content.

Cochlear Implant Programme in Kerala

The Kerala State Government has a fully funded cochlear implant project aimed at providing cochlear implantation for children between 1 - 3 years of age who meet specified income guidelines. The project started in 2012 and more than 900 children have received implants through the programme. The programme covers the cost of the CI, implantation surgery and auditory habilitation for 2 years. Approximately 70% of the children, who received implants between 2012 and 2014, attend mainstream schools which are government-funded state-run institutions.

Schooling System in Kerala

Kerala State has the highest literacy rate in India and education is given prime importance. There are private sector schools as well as public sector schools which differ in terms of the language of instruction (English vs. Malayalam), curriculum, and assessment methods. The private sector schools use an assessment scheme, where the children are assigned marks based on their performance in exams which are conducted periodically. On the other hand, the public sector schools use a grading system based on the child's performance in the exams (the marks scored in exams are converted into grades from A to E, which are specified based on the range of marks).

There is no evidence-based research on academic outcomes of children with CIs in the Indian context. It is imperative to study the academic outcomes of children using CIs in a developing country like India, as findings from developed countries cannot be generalised due to cultural and educational differences. The present study provides insight into academic areas of difficulty within the local context, and help to formulate appropriate remedial strategies and school support systems to assist children with CIs.

Objectives

The primary objective of this study was to answer the following questions:

- Do children using CIs perform on par with their peers in an integrated school environment, as perceived by their teachers?
- Is there agreement between their functional academic performance (teacher ratings) and their grades, which is the predominant scholastic assessment method in India?
- What are the challenges faced and the strategies used by children with CIs to cope with their listening and communication difficulties in the classroom?

METHOD

Participants

This study adopted a convenience sampling method. The list of all the children who had cochlear implantation done was obtained from various early intervention centres in five districts of Kerala. All those who met the inclusion criteria (children with no other disabilities and those who were given implants before five years of age) were included in the study.

A total of 31 children using cochlear implants and their teachers and parents participated in the study. All the children (15 boys and 16 girls) were integrated into mainstream classrooms and were students in first and second grades across five districts in Kerala State. The language of instruction at school was Malayalam (for 15 children) and English (for 16 children). Audiological profiles of the children are provided in Table 1.

Table 1: Audiological Profile of the CI Users

	M (months)	SD (months)
Chronological age	90.16	8.2
Age of diagnosis	15.2	2.1
Age at hearing aid fitting	20.6	1.4
Age at implantation	44.8	9.3
Duration of implant use	45.3	7.5
Duration of intervention	38.06	11.1

Information about family income and parental education, which are contributing factors to student success, was collected through parental interviews. The average number of years of maternal education was 12.1 years, (range - 7 to 17 years), and the average monthly income was Rs.8383.8 (range -Rs.300 -100000).

Procedure

Development of the 'Teachers' Perception of Academic Outcomes' (TPAO) questionnaire was done to study the academic outcomes of children using cochlear implants. Item generation was done after a rigorous literature review and based on suggestions provided by several audiologists and speech language pathologists working in the area of rehabilitation. Studies focusing on various domains, namely language skills, literacy, reading, writing and academic skills of children using hearing aids and cochlear implants, were reviewed for item generation (Marschark et al, 2007; Sarant et al, 2015; Harris et al, 2017). The items were divided into five domains - oral comprehension, oral expression, mathematics, reading, and writing. Under each item, the possible difficulties and strategies that could be used by the teachers and students were also listed. The generated items were given to a linguist for item wording.

The selected items were reviewed for face and content validity by 5 Audiologists and Speech Language Pathologists (ASLP) with a Master's degree and more than 5 years of clinical experience. All the ASLPs were briefed about the aim and procedure of the study. They rated each item on a 5-point Likert Scale, based on the relevance of the item, appropriateness of language used, grammar, comprehensiveness, and appropriateness of the scaling used in the questionnaire. Only those items rated as relevant by 70% of the professionals were considered for the final questionnaire. Item reduction, sequencing, and modifications were done while keeping in mind suggestions from the experts. The final questionnaire consisted of 29 items that used a 5-point rating Scale (1 – Poor; 2 - Below average; 3- Average; 4- Above average; 5- Excellent) with a total possible score of 145.

Data Collection

The purpose of the study was explained to the participants and informed consent was obtained from the teachers and parents of children. Basic demographic details and audiological profile of the children were obtained through a parent interview by the first author.

TPAO was administered on the teachers by the first author using a face-to-face structured interview format. Teachers were asked to rate the performance of children with CIs on each item compared to hearing children in the same class. The teachers had taught their respective students as class-in-charge for more than six months. This ensured that they could give reliable information regarding their wards. The difficulties faced and the strategies used by children and/or the teachers to cope with the challenges were probed during the interview. Teachers were further asked to list out other difficulties or strategies used by the children or teachers, apart from the ones listed in the questionnaire. Additionally, marks obtained by the child for the previous class exams were also collected. To bring uniformity in the scoring system, the grades were converted back to the respective marks. The grades were assigned based on a range of scores; hence the median score of this range was considered as the student's marks.

The domain-specific scores and total score from TPAO were converted into a percent score for the ease of comparison with academic marks. The converted TPAO percent scores were categorised as poor (0 – 20%); below average (21-40%); average (41 – 60%); above average (61 -80%) and excellent (81 – 100%).

RESULTS

The results are presented in three domains: academic performance, agreement between TPAO scores and academic marks, and challenges and strategies used by children and their teachers.

Academic Performance

The means and standard deviations of the scores obtained by the children in each of the domains of TPAO are shown in Table 2. The results reveal that the mean performance score in each domain and the overall performance score is above average.

Table 2: Mean and Standard Deviation of the Domain-specific Scores

Domain	Mean (%)	SD
Oral comprehension	71.6	15.15
Oral expression	67.6	13.53
Reading	60.1	17.24
Writing	69.89	16.78

Mathematics	71.33	17.38
Overall	68.77	14.80

The percentage distribution of scores across the components of TPAO is shown in Table 3. The Table shows that most of the children are in the 'above average' category and only a small percentage of children fall in the 'below average' category.

Table 3: Distribution of TPAO Scores across the Subcategories of TPAO

Percent Score on TPAO	Criteria	Percentage of Children					
		Compre- hension	Expression	Reading	Writing	Mathe- matics	Overall
0-20	Poor	-	-	-	-	-	-
21-40	Below average	-	3.2	9.6	3.2	3.2	-
41-60	Average	22.5	16.1	35.4	22.5	22.6	29
61-80	Above average	41.9	54.8	32.2	38.7	38.7	45.2
81-100	Excellent	35.4	25.8	22.5	35.4	35.5	25.8

Agreement between TPAO Scores and Academic Marks

The mean and standard deviations of TPAO scores and academic marks are shown in Table 4. The Spearman's rank correlation coefficient of 0.94 indicates a strong correlation between the academic marks/grades and TPAO scores.

Table 4: Mean and Standard Deviation of TPAO Scores and Academic Marks

	Mean (%)	SD	Correlation Coefficient
TPAO scores	68.77	14.80	.94*
Academic marks	71.07	17.99	

*Correlation is significant at the 0.01 level

On assessment of internal consistency, Cronbach's alpha of 0.97 was achieved,

suggesting that the TPAO is a valid tool for assessing the functional academic performance of children using CIs.

Challenges and Strategies

The difficulties faced and the strategies used by children with cochlear implants in mainstream schools were compiled through the TPAO interview. The results are summarised in figures 1, 2 and 3.

Figure 1: Compensatory strategies used by teachers and children to facilitate oral comprehension

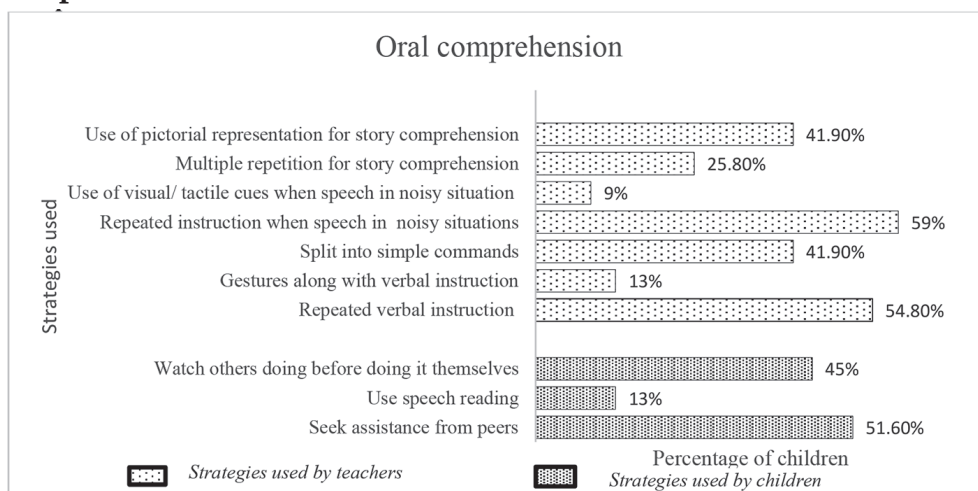


Figure 2: Compensatory strategies used by teachers and children to facilitate oral expression

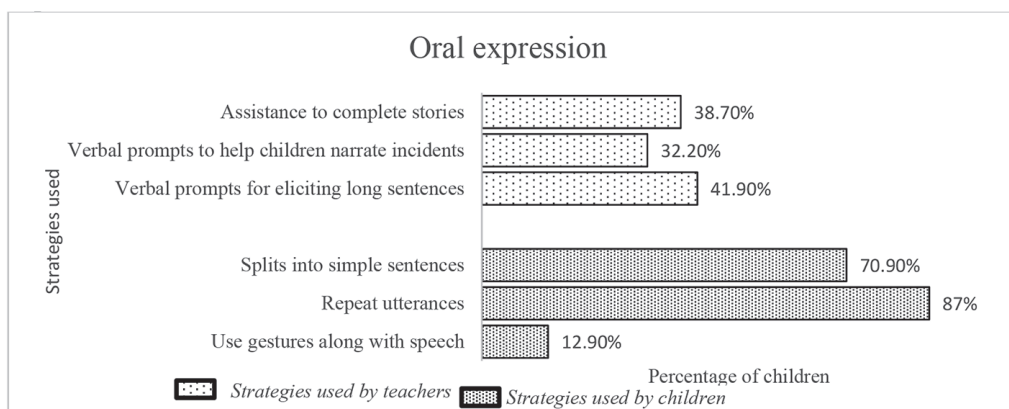
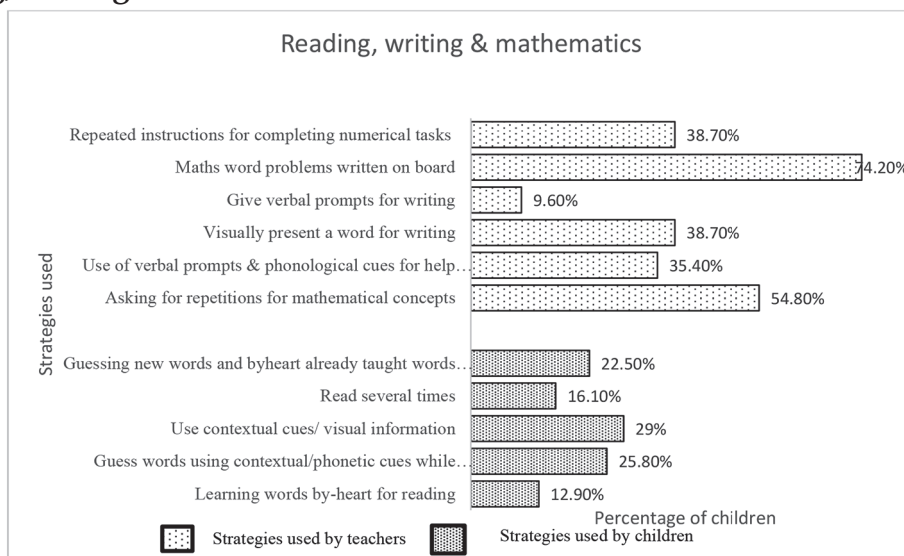


Figure 3: Compensatory strategies used by teachers and children to facilitate reading, writing and mathematics



Oral Comprehension

The mean score obtained for oral comprehension was 71.6 (SD = 15.15). Although 77.3% of children scored 'above average' or 'excellent', they faced various difficulties in the classroom situation. Only 29% of children were able to understand and organise tasks in response to complex instructions given in class, without any repetitions. Hence, 35.4 % of these children had difficulties following class content and lessons, and often missed concepts as they were not able to follow at the same pace as their peers. In order to overcome these problems and facilitate learning, both teachers and students used various compensatory strategies.

Strategies used by Teachers and Children

For 54.8% of the children, teachers repeated the verbal instructions and for 13% gestures or visual cues were also provided along with simple verbal instructions. Multi-step commands had to be split for 41.9% of children, 59% of children required repetitions and 9% required additional visual/tactile cues in noisy situations. Stories are the most important part of the academic curriculum for first and second grade children; however, 41.9% of children required pictorial representations to understand the whole story while 25.8% of children required multiple repetitions for story comprehension.

Children with CIs also used strategies to cope with their difficulty in following verbal instructions and lessons in the classroom. While 13% of children used speech reading to understand simple instructions, 51.6 % sought assistance from their peers to follow multi-step commands, and 45 % watched what others were doing before doing it themselves.

Oral Expression

The mean score obtained for oral expression was 67.6 (SD = 13.53). Children using CIs faced many difficulties in the classroom situation when conveying their ideas and expressing answers or stories verbally via complex sentence structures. Reduced intelligibility of speech was the major issue raised by most of the teachers. Only a few (13%) of the children had nearly acquired the articulatory skills that their peers had. Along with speech errors, several linguistic aspects were also noted, such as difficulty in constructing complex sentences and narrative skills. While 64.6% of children made syntactic errors in sentences, only 9.6% of children were able to retell a whole story or narrate an incident in correct sequential order.

Strategies used by Teachers and Children

Use of verbal prompts by teachers helped 41.9% of children to construct long sentences, 32.2% of children could narrate incidents with assistance and 38.7% could narrate entire stories. Gestures, along with speech, were used by 12.9% of children and repetition of utterances was necessary for 87% of children to make themselves understood to the listener. About 70.9% of the children had to shorten their sentences to make their ideas clear.

Reading

Teachers reported that 67.7% of children took a longer time to read than their peers and 9.6% of children skipped letters or words when trying to increase the speed of reading. Children using CIs faced severe difficulties in decoding. While 74.1% of children correctly identified all sounds, only 19.3% were able to correctly blend these sounds to form words. Around 29% of children made various errors like omission and substitution of sounds while reading. Since decoding was affected among most of the children, they were not able to read and understand new words. Reading fluency was also affected. Only 29.1% of children could read words with ease, whereas 70.9% took a lot of time moving from one sound to the other, which often reduced fluency.

Strategies used by Teachers and Children

Verbal prompts and phonological cues were necessary for 35% of children to decode and read words. Rather than phonetically decoding words, 12.9% of children memorised words and 25.8% of children guessed the words using contextual or phonetic cues. Contextual cues or pictorial representations were used by 29% of children for comprehending what was read, and multiple readings were required by 16.1 % of children.

Writing

The mean score obtained for writing was 69.8 (SD = 16.78). Children using CIs faced several difficulties although they obtained good scores. While 74.1% of children were able to copy words/sentences without mistakes, 80.6% of children could identify and use upper and lower case letters; however, 25.8% of children had difficulty in following rules for using upper and lower cases. One of the children exhibited the same errors in spoken and written language. Most of the children used proper spacing (74.1%) and good alignment (54.8%) while writing. Although 51.6% of children were able to write at the same pace as their peers, only a few (19.3%) were able to write words without spelling errors. Errors like letter omission (45.1%) and substitution of letters with similar sounding letters (38.7%) were observed by the teachers, while 6.4% of children did not attempt to write new words. About 29% of children were able to construct sentences and use subject-verb order in the right way while writing sentences, but teachers reported that 12.9% of children made incorrect use of tenses while writing and 3.2% included unnecessary morphemes when constructing sentences by themselves.

Strategies used by Teachers and Children

For 38.7% of children to write at the same pace as that of their peers, visual representation of the words was necessary rather than spelling them out. When verbal prompts were given by the teachers, 9.6% of children could write new words.

Children made wild guesses when writing new words (22.5%), while some of them memorised words and wrote words they had already been taught for written tasks. This helped them to score high in first and second grades, despite poor phonological segmentation.

Mathematics

The mean score obtained for mathematics was 71.3 (SD = 17.38). Children with CIs had several difficulties in mathematics and both teachers and children used certain strategies to cope with them. According to the teachers, 41.9% of children were able to complete numerical tasks with the same accuracy and speed as that of their peers. Pre-mathematical skills were reported to be good in these children as 90.3% of them were able to identify basic size differences and 87% knew all basic shapes.

Children using CIs had difficulties in certain aspects of mathematical tasks. Grasping numerical comparison was difficult for 32.2% of children, 35.4% had difficulty with simple addition and subtraction, whereas 25.8% were able to do verbally instructed mathematical problems. They found word problems difficult, as 51.6% of them had difficulty in converting word problems to numerical figures. The difficulty was predominantly due to lack of comprehension of the written instructions. About 29% often had confusion with numerical terminologies which were synonymously used, such as “add,” “plus,” and “combine.”

Strategies used by Teachers and Children

Numerical operations had to be written on the black/whiteboard for 74.2% of children and repeated instructions were required for 38.7% of children to complete their task.

Multiple repetitions were the only strategy used by children (54.8%) in order to generalise the mathematical concepts.

DISCUSSION

In the present study, teachers perceived that 71% of the children were performing above average in all academic domains. Teachers' assessments of the children with CIs correlated well with their academic grading in exams. This indicated that teachers were aware of their students' strengths and weaknesses and were contributing to help them cope in the classroom, even though they had no formal training to manage children with hearing impairments in a regular classroom. Furthermore, the good performance by the children can be attributed to their younger age at implantation, duration of auditory verbal therapy and incessant support from the parents and teachers.

Although performance on academic tasks was perceived to be good, children as well as teachers had to use several coping mechanisms and strategies to overcome the challenges in a real-world classroom setting. The need to use coping mechanisms can be due to both extrinsic and intrinsic factors. Extrinsic factors include environmental factors that limit the child's participation in classroom activities, such as classroom acoustics, seating, and class size. Intrinsic factors include limitations imposed on the child due to the hearing impairment, such as deficient speech perception and language skills, decoding deficits and poor phonological processing skills (Transler & Gombert, 2001; James et al, 2005; Blamey et al, 2006; James et al, 2008, 2009).

An optimal listening environment is critical for young learners and the challenge of speech recognition in noise aggravates with hearing impairment. Many classrooms in India have an average size of 35 or more students, and the mean occupied noise levels in these classrooms have been reported to be 62.1dBA and 65.6dBC, with mean unamplified teacher speech to noise ratio of 10.6dB and estimated reverberation time > 2.6 seconds (double the duration of accepted standards) (Sundaravadhanan et al, 2017). Additionally, most of the classrooms do not use any noise reduction strategies like carpeting or curtains. Despite these extrinsic challenges, it is noteworthy that children and teachers in this study used self-developed strategies to compensate for the lack of any explicit training.

Oral Comprehension and Expression

Oral comprehension and expression is regarded as the most important predictor for academic success (Desjardin et al, 2009; Geers et al, 2009; Von Muenster & Baker, 2014). The use of CIs considerably improves speech perception and production which eventually makes oral language development easier for children with severe to profound deafness (Svirsky et al, 2000; Geers et al, 2009; Bittencourt et al, 2012). Despite good oral comprehension, most of the children and their teachers in this study had to use several compensatory strategies to overcome the intrinsic and extrinsic challenges. The speech intelligibility and the syntactic quality of linguistic output were perceived to be limited in these children. One major factor contributing to these finding in oral comprehension and expression could be the age at implantation. The mean age at implantation for the children in this study was 44 (± 9.3) months. Moreover, it is also speculated that these children use predominantly visual rather than auditory modality for language processing, and hence miss out on essential segmental cues for speech

and language production. These findings are corroborated by studies which have shown that inflectional morphology and sentence comprehension are poorer in late implanted children compared to early implanted children (Lopez-Higes et al, 2015). It may be beneficial to work on generalisation of auditory and language-based tasks in a noisy environment during the early intervention programme, in order to increase success in noisy school classrooms.

Reading, Writing and Mathematics

The different types of difficulties perceived by the teachers for reading and writing can be directly attributed to the limitations in phonological processing abilities, morphosyntax, vocabulary knowledge and integration of auditory and visual inputs (Vermeulen et al, 2007; Weiss et al, 2013; Dashtelei et al, 2015). Mathematics is often explained using complex verbal descriptions (Nunes & Moreno, 2002) and analogical reasoning is a significant prerequisite for achieving good mathematical skills. Language measures have been found to be significant predictors of verbal analogical reasoning (Edwards et al, 2010). Thus it is assumed that the limitations in mathematical skills of children using CIs arose due to the lack of understanding of the complex language used in mathematics and from language deficiencies leading to hampered verbal analogical reasoning.

Implications

Children with CIs may need additional accommodations and support to reach their full potential. The type and frequency of services needed will vary across children and time. It may be beneficial to organise programmes to train and orient teachers regarding the needs of children with CIs and what they can do to optimise learning in the classroom. Professionals involved in the rehabilitation of children with CIs should support mainstream teachers to implement the above strategies in classrooms. They should also be educated about the importance of classroom acoustics, environmental modifications and the use of assistive listening devices like FM systems for better speech perception in noisy classroom settings.

In addition to teacher training, students with hearing impairments should be provided with preferential seating close to the teacher and away from sources of noise in the room. Low-tech options for minimising classroom noise should be considered in order to improve the signal-to-noise ratio in the room. Where possible, FM systems should be utilised to overcome the challenges of noise and

distance so that children are better able to hear the teacher.

Regular follow-ups should be planned to assess higher language abilities and academic development as children grow older. Children who face little or no challenge in the lower grades may have problems as their curriculum becomes more challenging. Academic performance can also vary according to individual factors. Therefore, it is essential for the professionals involved in aural rehabilitation to monitor each child on a regular basis. Active communication is required between audiologists, teachers and parents of children with CIs to know their challenges and take corrective measures.

CONCLUSION

The basis for all the difficulties faced in the academic development of children using CIs is their inability to acquire adequate auditory, speech and language skills. In a developing country like India where cochlear implant programmes are in their infancy, future goals need to be targeted on developing and stabilising the use of auditory verbal intervention strategies and outcome assessments. School-based support systems for children who are mainstreamed should be implemented to enhance the middle and long-term outcomes of children with CIs.

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