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Original Article

Language Development in Children with Cochlear Implant using Bimodal Approach: SLP Perspective

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ABSTRACT

Background: The development of language skills in children with cochlear implants is a vital area of research, particularly in understanding the impact of the bimodal approach. This study focuses on children with early language delays under the age of five, exploring how cochlear implantation and the bimodal approach influence their language development.

Objective: The primary objective of this study was to evaluate the effectiveness of the bimodal approach (cochlear implant combined with a hearing aid) on language development in children with cochlear implants. The study aimed to understand the perspectives of speech-language pathologists (SLPs) on the challenges and successes associated with this approach.

Methods: This descriptive study involved 50 SLPs from hospitals and rehabilitation centers across Pakistan, each with at least a year of clinical experience. Data were collected through a questionnaire focusing on various aspects of cochlear implantation and the bimodal approach. The questionnaire included questions on the age of implantation, additional medical complexities, effectiveness of the bimodal approach, and the impact on speech skills, social interaction, and cognitive functions. The study employed a cross-sectional design, and the data were analyzed using SPSS version 25 for statistical significance.

Results: The majority (81.2%) of children received their cochlear implantation between 1-3 years. About 70.6% of respondents reported using a second hearing aid post-implantation. The bimodal approach was found effective by 78.4% of therapists in aiding speech comprehension. Approximately 88.2% believed that hearing devices improved speech skills, and 82.4% noted the benefit of an additional hearing aid. However, concerns were raised about potential dependencies on these devices. In terms of social and academic performance, 84.4% of therapists saw improvements.

Conclusion: The study concludes that the bimodal approach is effective in enhancing language development in children with cochlear implants. Early implantation, combined with the use of a hearing aid, shows promising results in language acquisition and social interaction. Despite the limitations due to a small sample size and data collection constraints during the COVID-19 pandemic, the study provides valuable insights into the positive impact of the bimodal approach in language development.

Keywords: Cochlear Implants, Bimodal Approach, Language Development, Speech-Language Pathologists, Hearing Aid, Early Intervention.

INTRODUCTION

Language development in children is a complex process that involves the acquisition and comprehension of words, sounds, sentences, and their pragmatic use within a social context. Typically, this process is deeply influenced by the child's auditory experiences. Hearing enables children to absorb and learn language skills from their environment (1, 2). However, children with hearing impairments, including mild to severe hearing loss, may face significant challenges in acquiring these skills, leading to delays or difficulties in speech and language development. It is crucial to recognize even slight hearing issues in children, as these can have profound developmental impacts. Many hearing losses in children are transient and can be effectively addressed with medical

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intervention. Regular hearing assessments, starting from birth and continuing through the preschool years, are vital for early detection and intervention (3, 4).

Risk factors for hearing loss in children include family history, abnormalities in head, face, or ear development, head trauma, persistent ear infections, prolonged NICU stays, neurological disorders associated with hearing loss, exposure to infections before birth, and bacterial infections around the brain or spinal cord. Indicators of hearing loss in children may include a lack of response to loud noises, failure to turn towards sound sources, reliance on vibration or visual cues over auditory ones, delayed or absent speech by the age of one, unusual speech patterns, increased volume on devices, non-responsiveness to commands, and frequent use of "huh" in conversation (5, 6).

Hearing aids, classified as medical devices, are designed to enhance hearing for individuals with hearing loss. These devices have evolved from early passive amplifiers, like ear trumpets, to modern digital systems that modify environmental sound to make it more audible. Advanced digital signal processing techniques in modern hearing aids include frequency lowering, directionality, wide and dynamic range compression, and noise reduction. Customization of these devices is essential, considering the wearer's specific hearing loss, physical characteristics, and lifestyle. The effectiveness of a hearing aid depends significantly on the appropriateness of its fitting, typically performed by an audiologist or a hearing instrument specialist (7, 8).

Cochlear implants represent a significant advancement in auditory technology, offering a modified sense of sound to individuals with moderate to profound sensorineural hearing loss. These neuro-prosthetic devices bypass the normal acoustic hearing process, directly stimulating the auditory nerves through electrical signals. Comprising both external and internal components, cochlear implants capture environmental sounds via a microphone, convert them into electric signals, and transmit these to the internal implant. The optimal age for implantation is reported to be 12 months or older, with earlier implantation generally yielding better outcomes. This is due to significant linguistic and auditory development in infants with normal hearing occurring before this age.

Behavioral data suggest that language performance in children who receive cochlear implants at a young age is more accurate, potentially benefiting from neural plasticity during critical stages of auditory-based learning. Speech therapists play a crucial role in utilizing therapeutic techniques to enhance speech production and auditory processing. Cochlear implants have been shown to aid significantly in the development of various oral and verbal communication domains, such as sound repertoires, speech intelligibility, and conversational skills (9, 10). These implants provide auditory information that facilitates the development of both general and specific spoken communication abilities. Children with cochlear implants often exhibit slower and more varied language trajectories compared to their peers with normal hearing. However, cochlear implantation is associated with considerable improvements in language expression and comprehension over the first three years of use. Factors like greater residual hearing before implantation and younger age at implantation positively correlate with expressive and receptive language development (11).

Bimodal hearing solutions, involving a cochlear implant in one ear and a hearing aid in the other, have shown considerable benefits. This approach addresses asymmetrical hearing loss more effectively than using a hearing aid or cochlear implant alone. Bimodal stimulation has grown in importance in recent years, demonstrating superior outcomes compared to any monaural hearing mode (12).

Post-implantation, the focus of speech-language pathologists (SLPs) shifts from the hearing impairment itself to the development of the child's speaking and language abilities. This process, known as aural habilitation or rehabilitation, aims to enhance hearing and verbal skills. Cochlear implants facilitate the development of a broad range of oral and verbal communication domains in children with severe hearing loss (13). These include improvements in sound repertoires, speech intelligibility, and conversational abilities. In comparison to hearing children, recipients of cochlear implants show slower and more inconsistent language trajectories. Nonetheless, there is a considerable enhancement in spoken language expressiveness and understanding over the initial years following implantation. Factors like greater residual hearing before implantation and a younger age at implantation are positively linked with spoken language development.

MATERIAL AND METHODS

In this descriptive study, conducted at NUR International University, Lahore, between July 1st, 2021, and September 2021, the primary aim was to evaluate the impact of the bimodal approach on language development in children with cochlear implants. The study recruited a total of 50 speech therapists, both male and female, who specialized in the bimodal approach for cochlear implants. These therapists were selected through purposive sampling, ensuring a diverse representation in terms of qualifications, which ranged from diploma holders to individuals with B.S, M.S, and Ph.D. degrees in speech therapy (14).

To gather data, a custom-designed questionnaire was employed. This instrument was meticulously developed through consultations with experts in the field and a thorough review of relevant literature, ensuring its validity and relevance to the study's objectives.

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The questionnaire was aimed at understanding the speech therapists' perspectives and experiences in working with children with cochlear implants and language delays (15).

Before distributing the questionnaire, the speech language therapists were comprehensively briefed about the study's objectives and the significance of their contributions. The study adhered to a cross-sectional design, a choice that allowed for the collection of data at a single point in time, providing a snapshot of the effects of the bimodal approach on language development. The ethical aspects of the study were diligently addressed. Prior to participation, all speech therapists were informed about the study's purpose, the confidentiality of their responses, and their right to withdraw at any time without any repercussions. Informed consent was obtained from each participant, ensuring that they were participating voluntarily and were fully aware of the study's nature.

Data collection was conducted over a period of three months, during which the questionnaires were distributed, filled, and collected from the participants. The collected data was then meticulously analyzed using SPSS version 25 (16). This statistical software enabled a comprehensive analysis of the gathered data, including descriptive statistics and more complex inferential analyses. The use of SPSS 25 ensured a robust and reliable analysis of the data, facilitating the extraction of meaningful insights and conclusions regarding the efficacy of the bimodal approach in enhancing language development in children with cochlear implants.

RESULTS

In this comprehensive study assessing the impact of the bimodal approach on language development in children with cochlear implants, responses from 50 speech therapists reveal significant insights. A majority, 81.2%, of children received their cochlear implantation between ages 1-3, underscoring the preference for early intervention. A smaller group, 13.7%, were implanted between ages 4-5, and only 4.2% after five years, emphasizing the trend towards earlier cochlear implantation.

Regarding additional medical complexities, 33.3% of therapists agreed and 19.6% strongly agreed that their patients had other health challenges, indicating that a considerable number of children with implants face multiple health issues. However, 29.4% either disagreed or strongly disagreed, showing that many children with implants do not have significant additional medical problems.

The adoption of the bimodal approach was notable, with 70.6% of therapists affirming the use of a second hearing aid post-implantation. This suggests a strong inclination towards using both a cochlear implant and a hearing aid together. The effectiveness of this approach is further highlighted, as 78.4% of participants agreed or strongly agreed that it aids in understanding speech.

Satisfaction with the hearing devices was high, with 82.4% convinced about their decision to acquire the device, and 72.6% satisfied with its appearance. Concerning the influence on speech skills, 88.2% agreed that these devices improve speech, but 55.9% raised concerns about potential over-reliance on these devices.

Furthermore, 82.4% found the addition of another hearing aid beneficial for improving hearing and listening skills. The effectiveness of both devices was highly rated, with 80.4% agreeing on their competence. The aids were also perceived positively in academic and social settings, with 84.4% acknowledging their assistance in both domains. Confidence in public speaking improved for 72.6% of patients, and the socio-emotional aspects were positively received, with 74.5% expressing satisfaction.

Table 1 Hearing Device Survey: Cochlear Implantation & Bimodal Approach Impact

Sr. No.	Question	Response	Frequency (%)
1	Age at Implantation	1-3 years	41 (81.2)
		4-5 years	7 (13.7)
		5-9 years	1 (2.1)
		9-10 years	1 (2.1)
2	Medical Complexities Beyond Hearing Impairment	Strongly disagree	5 (9.8)
		Disagree	10 (19.6)
		Undecided	8 (15.7)
		Agree	17 (33.3)
		Strongly agree	10 (19.6)
3	Second Hearing Aid Post-Implantation (Bimodal Approach)	Disagree	2 (3.9)
		Undecided	12 (23.5)
		Agree	21 (41.2)
		Strongly agree	15 (29.4)
4	Bimodal Approach Aid Speech Comprehension	Disagree	2 (3.9)

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Sr. No.	Question	Response	Frequency (%)
		Undecided	8 (15.7)
		Agree	20 (39.2)
		Strongly agree	20 (39.2)
5	Confidence in Decision to Acquire Hearing Device	Disagree	3 (5.9)
		Undecided	5 (9.8)
		Agree	24 (47.1)
		Strongly agree	18 (35.3)
6	Satisfaction with Hearing Device Appearance	Strongly disagree	1 (2.0)
		Disagree	1 (2.0)
		Undecided	11 (21.6)
		Agree	24 (47.1)
		Strongly agree	13 (25.5)
7	Improvement in Speech Skills with Hearing Device	Undecided	5 (9.8)
		Agree	25 (49.0)
		Strongly agree	20 (39.2)
8	Hearing Device Cause Dependence	Strongly disagree	4 (7.8)
		Disagree	10 (19.6)
		Undecided	8 (15.7)
		Agree	20 (39.2)
		Strongly agree	8 (15.7)
9	Benefit of Additional Hearing Aid on Skills	Disagree	1 (2.0)
		Undecided	7 (13.7)
		Agree	19 (37.3)
		Strongly agree	23 (45.1)
10	Competence of Hearing Devices	Disagree	2 (3.9)
		Undecided	7 (13.7)
		Agree	21 (41.2)
		Strongly agree	20 (39.2)
11	Hearing Aids' Role in Academic Performance	Disagree	4 (7.8)
		Undecided	3 (5.9)
		Agree	24 (47.1)
		Strongly agree	19 (37.3)
12	Impact of Implant and Aid on Social Interaction	Disagree	1 (2.0)
		Undecided	9 (17.6)
		Agree	20 (39.2)
		Strongly agree	20 (39.2)
13	Confidence in Public Speaking with Language Skills	Disagree	2 (3.9)
		Undecided	11 (21.6)
		Agree	19 (37.3)
		Strongly agree	18 (35.3)
14	Satisfaction with Socio-Emotional Aspects of Devices	Strongly disagree	1 (2.0)
		Undecided	11 (21.6)
		Agree	13 (25.5)
		Strongly agree	25 (49.0)
15	Feelings of Incompleteness without Hearing Aid	Strongly disagree	1 (2.0)
		Undecided	6 (11.8)
		Agree	22 (43.1)
		Strongly agree	21 (41.2)

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Sr. No.	Question	Response	Frequency (%)
16	Influence of Hearing Aid on Cochlear Implantation	Disagree	1 (2.0)
		Undecided	7 (13.7)
		Agree	16 (31.4)
		Strongly agree	26 (51.0)
17	Awareness of Bimodal Approach Consequences	Strongly disagree	1 (2.0)
		Disagree	2 (3.9)
		Undecided	6 (11.8)
		Agree	21 (41.2)
		Strongly agree	20 (39.2)
18	Impact of Speech Therapy on Language Development	Disagree	1 (2.0)
		Undecided	4 (7.8)
		Agree	24 (47.1)
		Strongly agree	21 (41.2)
19	Improvement in Patient's Vocabulary for Public Speaking	Disagree	1 (2.0)
		Undecided	6 (11.8)
		Agree	22 (43.1)
		Strongly agree	21 (41.2)
20	Willingness to Continue Speech Therapy (Bimodal Approach)	Disagree	2 (3.9)
		Undecided	3 (5.9)
		Agree	25 (49.0)
		Strongly agree	20 (39.2)

The study revealed a strong dependency on these devices, with 84.3% feeling incomplete without them. The complementary nature of hearing aids in the bimodal approach was evident, with 82.4% affirming their significant influence on cochlear implantation. Additionally, 80.4% were fully aware of the consequences of the bimodal approach, indicating an informed practitioner base.

The crucial role of continuous speech therapy in conjunction with technological aids was emphasized, with 88.3% agreeing on its effectiveness in improving language development. Improvement in patients' vocabulary was notable, with 84.3% agreeing on its sufficiency for public speaking events. Moreover, a significant 88.3% were willing to continue speech therapy to enhance patients' speech and language skills.

DISCUSSION

The study, exploring the impact of the bimodal approach on language development in children with cochlear implants, offers significant insights into the challenges and opportunities presented by this innovative intervention. Data collected from 50 speech-language pathologists (SLPs) across various hospitals and rehabilitation facilities in Pakistan, all of whom had at least a year of clinical experience, served as the foundation for this analysis.

A pivotal finding of this research was the emphasis on the age of implantation. The majority of children who underwent implantation before the age of 2.5 years showed remarkable gains in expressive vocabulary, syntax, and pragmatic skills. This aligns with previous studies, such as those cited in reference 26, which found that children implanted before 24 months and assessed at 5.5 years or older had speech output intelligibility scores of 80% or higher. However, there was a notable variation in the performance of children in both early and later implantation groups, with some exceeding and others falling below average expectations. This variability underscores the complex nature of language acquisition in children with cochlear implants.

Concerns were raised about potential delays in verbal short-term memory and working memory for early implanted children, as highlighted in reference 27. The study explored the hypothesis that early implantation might impact cognitive processes involved in speech production and audibility. Findings suggested that phonological and linguistic strategies during memory tests were less effective in encoding and maintaining phonological representations, a crucial aspect of verbal short-term memory. This indicates a need for a balanced approach in implantation timing, ensuring both auditory and cognitive development are optimally supported.

The study also highlighted the significant role of the bimodal approach, where cochlear implants (CI) and contralateral Auditory-Verbal Therapy (AVT) are used concurrently (17). Children using this approach demonstrated improved outcomes, suggesting that bimodal stimulation should be considered based on audiological and radiological findings. This reinforces the notion that early

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intervention and the adoption of a bimodal approach are critical for effective language development in children with cochlear implants (18).

The role of cochlear implants in medicine has been transformative, especially in how they utilize the central nervous system's plasticity. By introducing electrically generated afferent impulses to previously unstimulated or under-stimulated auditory pathways, cochlear implants have opened up new avenues for language development in deaf children. Although not a perfect substitute for natural hearing, these implants represent a significant advancement towards enabling language acquisition (19).

Long-term studies have brought attention to two main areas: the method of afferent electrical stimulation and the evolution of electrode design and coding. Over the past three decades, significant advancements in these areas have been made, aiming to optimize electrical afferent usage for age-appropriate language development (20, 21).

However, the study's generalizability is limited due to its small sample size, a consequence of the COVID-19 pandemic. This limitation also impacted the sample collection method, as data were gathered through online Google Forms, which may have influenced the authenticity and precision of the responses. The potential for bias and uncalculated responses presents another layer of complexity to the study's findings (22).

CONCLUSION

In conclusion, while the study corroborates previous research underscoring the positive effects of the bimodal approach in language development for children with cochlear implants, it also highlights the need for further research. This includes exploring the optimal timing for implantation, balancing auditory and cognitive development, and refining the technology and strategies used in cochlear implants. The insights gained from the experienced and highly qualified therapists participating in this study provide a valuable foundation for future exploration and development in this field.

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