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Factors Affecting the Development of Speech in Children After Cochlear Implant

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ABSTRACT

***Objective*:** To determine the odds of different factors for developing poor speech intelligibility in pre-lingually deaf children who have undergone cochlear implantation.
***Study Design*:** Case-control study.
***Place and Duration of Study*:** Department of ENT, Combined Military Hospital, Rawalpindi Pakistan, Jan 2020 to Aug 2022.
***Methodology*:** This study was based on a sample of 60 patients: 30 cases with cochlear implants placed before two years of age, with a total time of using a cochlear implant of ≥1 year, and 30 controls. Both groups consisted of both genders aged between 3 and 12 years. All patients underwent assessment using the Speech Intelligibility Rating system and were documented for various factors influencing speech development.
***Results*:** The mean age of the sample at the time of the study was 6.37±3.17 years. A total of 34(56.7%) participants were male. Factors associated with poorer speech outcomes were male gender (OR0.44[CI 95% 0.15–1.30]), no peers in the household (OR 0.53 [CI 95% 0.15–1.84]), higher maternal literacy (OR 0.42[CI 95% 0.13–1.30]). Factors associated with improved speech development included primarily oral form of communication (OR 2.14[CI 95%0.41–11.17]), less than one-year age at implantation (OR 1.29 [CI 95% 0.24–6.96]), a total duration of speech therapy less than two years (OR 1.70[CI 95% 0.32–8.74]) and the presence of unilateral implants, (OR 6.33[CI 95% 1.00–40.07]).
***Conclusion*:** Earlier cochlear implantation with frequent verbal skill exercise appears essential to developing good speech intelligibility in pre-lingually deaf children.

Keywords: Children, Cochlear Implantation, Pre-Lingual Deafness, Speech intelligibility.

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INTRODUCTION

South Asia has one of the highest prevalences of disabling loss of auditory perception globally, with countries like Pakistan having a frequency of bilateral hearing loss of approximately 1.6 per 1000 population.[1] There are an estimated fifth of a million cases of prelingual (before the age of two years) deafness in the country.[1] Causes of this form of deafness are myriad.[2,3]

Prelingual loss of hearing is associated with poor language development and social, emotional, cognitive and behavioural issues.[4] Early diagnosis and timely, appropriate and effective management can mitigate these complications.[5] Cochlear implants bypass damaged/defective areas of the ear and provide direct stimulation to the vestibulocochlear nerve. While this does not produce an auditory stimulus that exactly replicates what a fully functioning auditory system perceives, it allows the user to hear basic forms of speech and other sounds.[6] These implants are known to be extremely helpful in the development of language skills as well as other forms of communication, especially if the implant is used at an earlier age,[7] however, this improvement is not the rule: a large number of studies have demonstrated dramatic improvements of cochlear implants in pre-lingually deaf children with linguistic development similar to that of non-deaf children,[8] but many studies have failed to demonstrate this benefit, citing various factors for why this is so, such as low socioeconomic status.[9,10]

The present study aimed to determine what impact different factors such as socioeconomic status, parental employment, rehabilitation therapy, the presence of siblings/peers in the household and the use of electronic media, among others, have on the development of speech in patients who are pre-lingually deaf, and have received cochlear implantation. We operated under the rationale that identifying significant positive and negative influencing factors for speech development would help the clinician potentiate or mitigate the effects of

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these factors, respectively, and help their patients attain better functional outcomes.

METHODOLOGY

The case-control study was conducted at the Department of ENT, Combined Military Hospital, Rawalpindi Pakistan, from January 2020 to August 2022, after IERB approval (No.290). The WHO sample size calculator was used to calculate the sample size, keeping population standard deviation (σ) of 13.5, a population variance of (σ2) 182.25, a test value of the population mean (μo) of 37.7, and an anticipated population mean (μa) of 80.9.[11] We used consecutive, non-probability sampling to select our patients.

Inclusion Criteria: The study included patients aged 3 to 12 years, of both genders, with a total time of using a cochlear implant of ≥1 year if the patient was a case.

Exclusion Criteria: Patients who had a concurrent history of visual defects, autism spectrum disorders, motor speech disorders, cognitive dysfunction syndromes or organic brain lesions were excluded.

Sixty patients, 30 cases and 30 controls, whose parents/guardians gave informed consent. Cases were defined as patients who had bilateral hearing loss before the age of two years and had received at least one cochlear implant, while controls were defined as patients who had never had hearing loss and had reported to the Department of ENT for complaints that were not hearing-related. Demographic data such as age, gender, parental consanguinity, family size and maternal education (defined as attaining an education of secondary level or greater) were recorded at the time of inclusion of each participant in the study. This was followed by administering the Speech Intelligibility Test using the validated passage for speech intelligibility called "My Grandfather".[12] Participants were scored according to the Speech Intelligibility Rating (SIR), as displayed in Table-I.[13,14] All assessments were performed by a consultant ENT specialist with a minimum of five years post-fellowship experience, who was blind to the objectives of the study. The assessor was instructed to choose the lower rating if the participant's speech fell between two ratings. A score of 4 or greater was interpreted as being indicative of good speech intelligibility.

Statistical Package for Social Sciences (SPSS) version 23.0 was used for the data analysis. Quantitative variables were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Data analysis was conducted in two phases. The first phase involved comparing cases and controls, while the second involved comparisons within the case group. Odds ratios were calculated for the effect of different patient characteristics on developing good speech intelligibility.

Table-I: Speech Intelligibility Rating (SIR)

Category	Description
5	Connected speech is intelligible to the listener; the child is understood easily in every day contexts.
4	Connected speech is intelligible to the listener who has little experience of a deaf person's speech; the listener does not need to concentrate unduly.
3	Connected speech is intelligible to the listener who concentrates and lip-reads within a known context.
2	Connected speech is unintelligible; intelligible speech is developing in single words when context and lip-reading cues are available.
1	Pre-recognizable words in spoken language (the child's primary mode of everyday communication may be manual).

RESULTS

We studied sixty participants, with a mean age of 6.37±3.17 years. Males were in a slight majority (34,56.7%). The mean age at which cochlear implants were placed was 15.63±4.26 months. The mean duration for which cases received speech therapy was 32.43±24.56 months. The mean number of languages spoken at home was 1.93±0.71. The mean number of siblings/peers in the home environment was 2.18±1.82 for the entire sample. Most cases had bilateral cochlear implants, i.e., 23(76.6%). A total of 13(21.7%) mothers were illiterate, 19(31.7%) had received primary education only, 17(28.3%) were educated to the secondary level, while 7(11.7%) and 4(6.7%) mothers had a bachelor's and a master's degree, respectively. Consanguinity was seen in 41(68.3%) of the parents of the sample. The mean SIR of the sample was 3.75±1.30. Speech intelligibility was good in 35(58.3%) cases (Table-II). Table-III shows the odds ratios of various factors for developing good speech, with ratios calculated between cases and controls. Males were associated with comparatively lower odds of having good speech intelligibility. Surprisingly, speaking only one language was also associated with a slightly higher odds of poor intelligibility, while not having peers at home was associated with poorer speech development. Higher degrees of maternal education were associated with a poorer speech outcome. Participants who used oral forms of communication without aids had better speech development. We also performed a statistical analysis of variables specific to cases, the results of which are displayed in Table-IV. Cochlear implantation before the age of one year was associated with a good speech outcome. Patients who had received unilateral implants and those with shorter durations of speech therapy appeared to perform better.

Table-II: Descriptive Statistics of the Patients (n=60)

Variables	Cases (n=30)	Controls (n=30)
Gender		
Males	19(63.3%)	15(50.0%)
Females	11(57.8%)	15(50.0%)
Age (years)	6.10±2.04	6.63±2.01
Age at Implantation (months)	15.63±4.26	-
Duration of Speech Therapy (months)	32.43±24.56	-
Number of Languages Spoken in Household	2.00(IQR: 1.00)	2.00(IQR: 0.00)
Number of Siblings/Peers in Household	2.00(IQR: 0.00)	2.00(IQR: 0.00)
Number of Cochlear Implants		
Unilateral	7(23.3%)	-
Bilateral	23 (76.6%)	-
Degree of Maternal Education		
Illiterate	8(26.7%)	5(16.6%)
Primary	11(36.7%)	8(26.7%)
Secondary	6(20.0%)	11(36.7%)
Bachelor's	4(13.3%)	3(10.0%)
Master's	1(3.3%)	3(10.0%)
Consanguineous Parents	22(73.3%)	19(63.3%)
Primary Mode of Communication		
Oral	11(36.7%)	-
Combination of Oral and Visual	19(63.3%)	-
Speech Intelligibility Score	3.00(IQR:2.00)	5.00 (IQR: 1.00)
Good Speech Intelligibility	19(63.3%)	19(63.3%)

Table-III: Calculated Odds Ratios for Cases and Controls (n=60)

Variables	Odds Ratio (CI 95%)
Male Gender	0.44(0.15–1.30)
Languages Spoken in Household (=1)	0.63 (0.19–1.99)
Number of Siblings / Peers in Household (<1)	0.53(0.15–1.84)
Maternal Literacy	0.42(0.13–1.30)
Consanguineous Parents	0.75(0.24 – 2.28)
Primary Mode of Communication (Oral)	2.14(0.41 – 11.17)

Table-IV: Calculated Odds Ratios for Intra-Case Variables (n=60)

Variables	Odds Ratio (CI 95%)
Age at Implantation (≤1 year)	1.29 (0.24–6.96)
Duration of Speech Therapy (≤2 years)	1.70 (0.32–8.74)
Unilateral Implants	6.33 (1.00–40.07)

DISCUSSION

Our study demonstrated that males had higher odds of having lower speech intelligibility than females, OR:0.44(CI 95% 0.15–1.30), although this difference between genders was not too marked. While this result was in agreement with studies such as Geers *et al*. who noted that females with cochlear implants consistently score higher in speech intelligibility testing versus boys,[15] however, it should be noted females tend to have better development of language skills compared to males of a similar age, even with normal hearing,[16] therefore, these findings should be interpreted cautiously.

Speaking only one language in the household was associated with slightly raised odds of poor speech intelligibility in our sample, OR:0.63(CI 95% 0.19–1.99). Conversely, Yorgancılar *et al*. noted that there was no difference between deaf patients raised in monolingual and bilingual environments,[17] while Sosa *et al*. noted that patients who were raised in bilingual environments had slightly decreased speech intelligibility.[18] We attribute this variability across literature primarily due to the differences in the languages tested in each study, with each language having its complexities. In general, pre-lingually deaf, cochlear-implanted children are encouraged to focus on one language.[17,18]

The current study showed that not having peers or siblings in the household was associated with a higher odds ratio for poor speech development, OR:0.53(CI 95% 0.15–1.84). While this aspect has not been directly studied in the literature, studies such as Schafer et al. have shown that patients receiving regular schooling among normal peers have good speech intelligibility.[19] Whether interaction with social peers in regular schools produces improved intelligibility or good intelligibility allows pre-lingually deaf children to attend regular schools is a subject that needs further study. However, it is clear that the more a patient hears and practices oral speech, the higher the chances of a good speech outcome.

Maternal literacy, specifically mothers who were educated with higher degrees, was associated with poor speech outcomes in pre-lingually deaf children with cochlear implants, OR: 0.42(CI 95% 0.13–1.30). This is at odds with results from previous studies, such as Panda *et al*. who noted that poor parental literacy was associated with poor speech outcomes in such children, likely due to a lack of good insight and poor compliance with speech therapy.[20] The most likely explanation for this discrepancy is the degree of education itself: more educated mothers were more likely to have a higher frequency of being employed in our sample, thus having less time to interact with their children. However, this aspect requires further study. Moreover, Parental consanguinity was associated with poorer speech outcomes, OR: 0.75(CI 95% 0.24–2.28); however, the odds were insignificant. This nominal effect is likely due to the higher prevalence of consanguineous marriages in the subcontinents, resulting in a three-fold increase in congenital deafness and less likely due to a direct effect of consanguinity of speech development.[21]

The current study showed that increased duration of speech therapy, i.e., longer than two years, was associated with poor speech outcomes, OR: 1.70(CI 95% 0.32–8.74). The reason this difference arose between our study and theirs is unclear; however, we postulate that this may be due to the quality of speech therapy provided to the patient. In Pakistan, the standards for speech therapy vary between institutions. Additionally, we did not look at patient compliance with speech therapy while they remained under treatment, nor could we assess its quality; these factors may account for the difference in results.

Lastly, Patients with unilateral cochlear implants had better speech outcomes in our study, OR: 6.33(CI 95% 1.00–40.07). This difference is because our study had only 7(23.3%) patients with unilateral implants, and the small sample may have led to confounding. Additionally, it was undocumented whether patients received implants during a single sitting or whether they received them in a staggered fashion. Further, a randomized study comparing unilateral and bilateral implants is warranted before ascribing causality.

LIMITATIONS OF STUDY

Our research did not consider whether patients who received bilateral implants did so simultaneously or whether the implantation process was staggered. Whether standardized speech therapy practice was implemented in each case is still being determined, which may have produced some confounding. Moreover, it was unclear whether family members also communicated primarily through verbal methods or if they used visual communication forms such as sign language, which may also affect speech development. Lastly, the schooling a case received was not recorded as there was a lack of standardization of education for pre-lingually deaf children across the sample, which may also play a role in speech intelligibility.

CONCLUSION

Prelingual deafness is a debilitating condition that grossly affects the patient's life in every domain. While cochlear implants represent a significant ray of hope, they are imperfect, and implantation only does not guarantee full functional outcomes. A holistic approach involving the home, school, speech therapist, and patients is required to optimize speech outcomes. In this regard, mitigation or potentiation of the factors described above, as required to improve speech intelligibility, will serve as useful adjuncts to which the treating clinician should remain sensitized.

Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

IS & AH: Conception, study design, drafting the manuscript, approval of the final version to be published.

SI & SBN: Data acquisition, critical review, approval of the final version to be published.

NK & SK: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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