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Effects of Hearing Aid versus Cochlear Implant on Hearing and Speech Recognition in Children

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DECLARATIONS

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ABSTRACT

Background: Hearing loss in children can significantly delay speech and language development, affecting communication skills, educational performance, and overall quality of life. While both devices aim to provide access to sound, their effectiveness on speech recognition outcomes may vary depending on the degree of hearing loss and aided hearing thresholds. **Objective:** To compare the effects of hearing aid versus cochlear implant on hearing and speech recognition in children. **Methodology:** A comparative cross-sectional study was conducted at Superior University, and data were collected from the Audiology and Speech Clinic of the Society for Audiological and Developmental Ailments. The duration of the study was 10 months after approval of the synopsis from the Departmental Research Committee. A total of 26 participants, comprising both genders and aged between 6 and 18 years, were included. Hearing aid users with moderate to severe degree sensorineural hearing loss and cochlear implant users with severe to profound degree sensorineural hearing loss were included in the study. Data was collected through a structured questionnaire/proforma, aided audiometry and speech audiometry, measuring word recognition score by using a phonetically balanced word list in Urdu. The normality of the data was assessed using the Kolmogorov-Smirnov test. According to the data distribution, independent sample t-tests and repeated measures ANOVA were used to analyse the parametric differences between and within each group, respectively. Correlation between different variables was found using Pearson's correlation. **Results:** Children with cochlear implants demonstrated a higher average word recognition score than those using hearing aids, although this difference was not statistically significant ($p>0.05$). Aided hearing thresholds were positively associated with word recognition score performance; children with mild or normal aided thresholds had better speech recognition compared to those with moderate thresholds. **Conclusion:** There is no significant differences in speech recognition outcomes between hearing aid and cochlear implant users. However, a positive trend was observed, suggesting that better aided hearing thresholds are associated with improved word recognition performance. These findings emphasise the importance of achieving optimal aided thresholds in pediatric audiological management, regardless of the amplification device used.

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INTRODUCTION

Hearing loss is a prevalent condition that, if left untreated or if people's communication needs are not met, can have a detrimental impact on many facets of their lives. [1, 2]The quality of life and the ability to communicate verbally can be negatively impacted by auditory deprivation, which can hinder a child's spoken language development and increase the risk of dementia and cognitive decline in later life.[3] Untreated deafness in early childhood is linked to poor reading outcomes and fewer job prospects later in life. Anxiety, depression, loneliness, and isolation are some of the emotional consequences of hearing loss. In many nations, adults with hearing loss have a significantly higher unemployment rate than their hearing counterparts, and children with hearing loss seldom ever attend school.[4]

The World Health Organisation estimates that 34 million children worldwide suffer from hearing loss, making it a major public health concern. If not recognised and treated at an early age, it has a significant impact on academic performance, social integration, cognitive abilities, speech, and language development.[5] In Pakistan, access to early hearing screening remains limited, affecting timely intervention. [6, 7]Neuroplasticity during early childhood allows the auditory cortex to reorganise in response to stimulation. Delays in auditory input may lead to irreversible deficits in speech and language.[8]

The two main technologies utilised to lessen the negative impacts of hearing impairment in children are cochlear implants and hearing aids, among other auditory interventions. Cochlear implants provide children with severe to profound sensorineural hearing loss an alternative method of hearing by directly stimulating the auditory nerve, bypassing destroyed cochlear hair cells, whereas hearing aids enhance sounds to aid residual hearing. Despite the success of these technologies, the comparative effectiveness of hearing aids versus cochlear implants on hearing thresholds and speech recognition outcomes in children remains an area of active debate and research.[9, 10] Hearing aids have been the traditional intervention for children with mild to severe sensorineural hearing loss. They provide amplified sound to the cochlea, enhancing the perception of speech sounds across different frequencies. Studies have shown that appropriately fitted hearing aids significantly improve auditory thresholds and speech recognition scores in children with residual hearing.[11, 12] Despite technological advancements like adaptive directional microphones and frequency-lowering technologies, hearing aid users still experience limitations in soft speech detection and speech recognition in complex auditory environments. [13]Therefore, while hearing aids remain highly effective for moderate degrees of hearing loss, their utility diminishes as hearing loss severity increases. Cochlear implants have revolutionised the management of children with severe to profound sensorineural hearing loss. Unlike hearing aids, cochlear implants bypass the damaged cochlear structures and directly stimulate the auditory nerve, thereby restoring a sense of hearing. The purpose of the study was to compare the effects of a hearing aid versus a cochlear implant on hearing and speech recognition in children.

METHODOLOGY

It is a comparative cross-sectional study in which the sample size was calculated from statistical software G* Power, and the result with a 10% attrition rate is 26, consisting of 13 patients in each group, using non-probability convenience sampling.[14] The study was conducted at the Superior University Department of Rehabilitation Sciences, and data were collected from the Audiology and Speech Clinic of the Society for Audiological and Developmental Ailments (SADA).

The duration of the study was 10 months after approval of the synopsis from the Departmental Research Committee. Children with 6 to 18 years of age, bilateral hearing aid users with moderate to severe degree sensorineural hearing loss, or unilateral cochlear implant users with severe to profound degree sensorineural hearing loss and no amplification to the other ear, consistent use of hearing aid or cochlear implant for more than one year, known or presumed early onset of hearing loss before three years of age, Urdu as primary language of education, enrolled in rehabilitation program (school or pre-school for hearing impaired children) focused on oral communication were recruited.[15] Children below six years or above 18 years, with less than one year of consistent use of hearing aids or cochlear implants, and cognitive, neurological, or developmental disorders. Written informed consent was obtained from the parents or

guardians before inclusion in the study. After getting the signed consent, the patient's personal, audiological, and medical details were obtained through the questionnaire/record-keeping form. Aided Free Field Audiometry was performed to evaluate the hearing ability of a patient using hearing aids or a cochlear implant in a two-room setup through a calibrated audiometer.

Patient was instructed to respond by dropping a toy in a bucket whenever he/she listened to the sound through the loudspeaker. Speech audiometry was performed on live voice to evaluate the word recognition score by using the phonetically balanced monosyllabic word list in Urdu through a calibrated audiometer. The patient was instructed to repeat the word whenever they heard it through the loudspeaker. Randomisation was not applicable because participants were already using their respective auditory devices (either hearing aids or cochlear implants). Blinding was not feasible in this study due to the visible nature of the hearing devices, which made it evident to both participants and assessors whether a child was using a hearing aid or cochlear implant.[16] Data was analysed using SPSS version 26. The normality of the data was assessed using the Kolmogorov-Smirnov test. As per the distribution of the data, independent sample t-test and repeated measure ANOVA were used to analyse the parametric differences between and within each group, respectively. Correlation between different variables was found using Pearson's correlation. The p-value ≤0.05 was considered statistically significant.

RESULTS

The ages range from a minimum of six years to a maximum of 16 years, indicating 10 years in the age group studied. The mean age of participants is approximately 9.46±2.64 years, suggesting a moderate spread of ages around the mean. Accounting for 12(46.2%) of the total children, middle childhood represents the next significant group with 11(42.3%). A smaller percentage, 3(11.5%), is in the adolescent age group. This distribution indicates that the study primarily focuses on children in their middle to late childhood stages, with a smaller representation of adolescents. The gender distribution in the sample of 26 individuals shows that 9(34.6%) were male and 17(65.4%) were female.

This indicates a greater proportion of females compared to males in the study. The mean word recognition score (WRS) was higher in those with mild aided hearing thresholds (M=76.25%, SD=12.5) compared to those with moderate aided thresholds (M=71.56%, SD=8.78). The WRS scores ranged from 60% to 90% in the mild group and from 55% to 88% in the moderate group. ANOVA test revealed the difference was not significant (p=0.44). The data on descriptive statistics of the cochlear implanted group shows that among children using cochlear implants, the mean WRS was higher in those with Normal aided hearing thresholds (M=77.83%, SD=10.49), scores ranged from 63% to 90% while one child with Mild aided thresholds (M=60.0%). Anova test revealed that the test was not significant with p=0.13, as shown in Table 1.

A cross-tabulation between aided hearing thresholds (250 Hz to 4 kHz) and WRS levels of difficulty shows that among children with mild aided hearing thresholds, the majority had either mild difficulty, whereas those with moderate aided thresholds had either mild or moderate difficulty in word recognition. Notably, no child

Table 1: Aided hearing thresholds and speech recognition scores in both groups

Groups	Aided Hearing Thresholds	Speech Recognition Scores					
		n	Mean	Std. Deviation	Minimum	Maximum	p-value
Hearing Aid Group	Mild	4	76.25	12.5	60	90	0.44
	Moderate	9	71.56	8.77	55	88	
	Total	13	73.00	9.77	55	90	
Cochlear Implanted Group	Normal	12	77.83	10.49	63	90	0.13
	Mild	1	60.00	9.67	60	60	
	Total	13	76.46	11.2	60	90	

Table 2: Crosstabulation between aided audiometry and word recognition score (level of difficulty) in both groups

Groups	Aided Hearing Thresholds	Word Recognition Score (level of difficulty)				Total	p-value
		Normal WRS	Mild difficulty	Moderate difficulty	Severe difficulty		
Hearing Aid Group	Mild	1	2	1	0	4	0.39
	Moderate	0	4	4	1	9	
	Total	1	6	5	1	13	
Cochlear Implanted Group	Normal	3	4	5	-	12	0.53
	Mild	0	0	1	-	1	
	Total	3	4	6	-	13	

Table 3: Correlation between the two groups

Groups	Symmetric Measures					
			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Hearing Aid Group	Interval by Interval	Pearson Correlation	0.41	0.21	1.50	.16[c]
	Ordinal by Ordinal	Spearman Correlation	0.38	0.23	1.39	.19[c]
Cochlear Implanted Group	Interval by Interval	Pearson Correlation	0.27	0.13	0.95	.35[c]
	Ordinal by Ordinal	Spearman Correlation	0.29	0.14	1.00	.33[c]

with moderate thresholds achieved a normal WRS was achieved in the hearing aid group. This cross-tabulation also shows that among children with normal aided hearing. thresholds, 5 individuals had moderate difficulty, 4 individuals had mild difficulty, and 3 individuals had Normal WRS, whereas those with mild aided thresholds had only 1 individual had moderate difficulty. However, the difference was not significant with p=0.53 in the cochlear implanted group (Table 2).

Symmetric measures (Pearson's R=0.41, Spearman's rho=0.38) indicated a moderate positive relationship, suggesting that better aided hearing may be related to better WRS levels in the hearing aid group. However, in the cochlear implanted group, the symmetric measures (Pearson's R=0.27, Spearman's rho=0.29) indicated a moderate positive relationship, suggesting that better aided hearing may be related to better WRS levels.

DISCUSSION

This study aimed to evaluate the effect of hearing aids versus cochlear implants on aided hearing thresholds and speech recognition (word recognition scores) in children with sensorineural hearing loss. The findings provided insight into the auditory and speech outcomes in children using either amplification device, with a specific focus on their performance on aided audiometry and speech perception tasks.

Overall, children with cochlear implants exhibited slightly better mean word recognition scores compared to those using hearing aids. However, the differences observed in this study were not statistically significant (p>0.05), suggesting that while there may be a clinical trend, this difference could be due to chance or influenced by sample variability. This aligns with existing literature, which shows that while cochlear implants are

often associated with improved speech perception, especially in cases of profound hearing loss, hearing aids can still provide substantial benefits when aided thresholds are within a functional range.[17] The descriptive analysis showed that children with better aided hearing thresholds (normal or mild) tended to have higher word recognition scores than those with moderate thresholds. This finding supports the notion that audibility plays a critical role in speech recognition outcomes, consistent with the theoretical underpinnings of auditory access and neural plasticity during early language development. However, the statistical tests (ANOVA and chi-square) failed to show significant group differences. This lack of statistical significance may be attributed to the small sample size and uneven distribution of participants across groups 10.

Chi-square and symmetric correlation measures showed a moderate positive relationship between aided hearing thresholds and speech recognition difficulty levels. While not statistically significant, the trends indicate that better aided thresholds may contribute to improved speech outcomes, echoing findings from previous studies that emphasise the importance of early intervention and optimal amplification. Interestingly, the study also highlighted that none of the children with moderate aided thresholds achieved a "normal" word recognition score, and children with mild aided thresholds performed relatively better. This means that children with more favourable aided thresholds (closer to normal hearing levels) are more likely to develop age-appropriate speech and language skills, and the pattern of this study resembles previous reports.[18] As the findings have no significant difference between different aided hearing levels and their speech outcomes in the cochlear implant group, it might be due to other variables such as age at implantation, duration of device use, neural integrity, and consistency of speech therapy that influence the cochlear implant performance.

According to the other studies, because of the variation in auditory pathways and central processing, the cochlear implant outcomes vary more than hearing aid users. It is important to note that due to the methodological constraints, many of the expected statistical associations may not have reached significance. Convenience sampling, which may have introduced selection bias, and the small sample size, which limits generalizability and power, may have played a role in the results being non-significant. The findings of this study are still significant and contribute valuable information and knowledge to the growing body of literature and research, despite the limitations. Depending upon the severity of hearing loss and individual factors, both hearing aids and cochlear implants can provide meaningful hearing and speech benefits.

Fitzpatrick et al. also found this in their study, and they reported that when early, timely, and appropriate intervention is given to children with hearing aids and moderate-to-severe degree hearing loss, they can also achieve language outcomes comparable to those with cochlear implants.[19] Ching et al. found that bilateral amplification has more benefits, and both methods, i.e., bilateral implantation and bimodal (HA+CI) fitting, provide binaural benefits that can support speech development depending on aided thresholds and auditory input.[20] This discovery supports the fact that comprehensive aided audiometry, speech recognition testing, and developmental factors should be taken into account while selecting an amplification for the patient with hearing loss, and the concept of generalisation should not be applied to anyone with hearing loss.

CONCLUSION

In conclusion, the findings of the study are non-significant as there is no statistical difference between hearing aid and cochlear implant users in terms of word recognition scores. However, children with cochlear implants demonstrated slightly higher average word recognition scores compared to those using hearing aids. Regardless of the device used, children with normal or near-normal aided thresholds have better speech recognition scores. The data trend is aligned with current clinical knowledge and supports the understanding that aided hearing thresholds play a crucial role in speech perception outcomes.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.

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