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Impact of Cochlear Implant on Hearing-Related Quality of Life

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ABSTRACT

Background: Prelingual sensorineural hearing loss (SNHL) in children has profound implications for speech, language, and psychosocial development. Cochlear implantation (CI) is widely recognized as a viable auditory intervention for those who derive limited benefit from conventional amplification; however, caregiver-reported outcomes in resource-constrained settings remain underexplored. Understanding parental perceptions of hearing-related quality of life (HRQoL) following CI is essential for contextualizing post-operative success and informing service delivery in such environments. Objective: To evaluate parental perceptions of hearing-related quality of life in children with prelingual deafness following cochlear implantation, focusing on three functional domains: communication with others, listening to speech without lipreading, and spoken language development. Methods: This cross-sectional observational study enrolled 80 parents of children aged 2–13 years with prelingual SNHL who received CI at least six months prior. Participants were recruited from three urban centers in Lahore, Pakistan. Structured interviews were conducted using a validated 9-item questionnaire assessing pre- and post-implant expectations and outcomes. Data were analyzed using descriptive and inferential statistics (chi-square, Fisher's exact tests), with 95% confidence intervals. Results: Post-implant, 63.8% of parents reported improvement in listening without lipreading, 51.3% in communication, and 36.3% in spoken language. Only the listening domain consistently exceeded the clinically meaningful threshold of 50%. Parental concern remained high in all domains (>96%), regardless of time since implantation. Conclusion: Cochlear implantation yields moderate caregiver-perceived gains in auditory perception and communication in children with prelingual deafness; however, spoken language outcomes remain limited. These findings highlight the critical need for integrated post-implant rehabilitation to optimize functional outcomes in low-resource settings.

Keywords

Cochlear implant, prelingual deafness, hearing-related quality of life, speech development, auditory rehabilitation, parental perception, Pakistan.

INTRODUCTION

Hearing loss in children is a prevalent and multifaceted condition that significantly affects speech, language acquisition, and overall development, particularly when it occurs in the critical early years of life. Defined as a decrease in auditory sensitivity above 15 dB at key frequencies (500, 1000, 2000, and 4000 Hz), it encompasses a wide spectrum of severity from mild to profound and presents varying degrees of functional impairment (1). Among the different types, sensorineural hearing loss (SNHL) is especially consequential, as it stems from dysfunction within the cochlea or auditory nerve and is often irreversible. Globally, SNHL affects approximately 1 to 3 infants per 1,000 live births, with additional cases emerging as children grow older (2). Universal Newborn Hearing Screening (UNHS) programs have improved early identification rates, allowing for timely intervention, which is vital for optimal language and cognitive outcomes (3). Children diagnosed with severe to profound SNHL who fail to benefit from conventional amplification devices are often considered candidates for cochlear implantation, a surgically implanted neuroprosthesis designed to provide direct electrical stimulation to the auditory nerve, thereby bypassing nonfunctional cochlear hair cells (4).

Cochlear implants (CIs) have revolutionized the auditory rehabilitation landscape, especially for children with prelingual deafness defined as hearing loss occurring before the acquisition of spoken language, typically before the age of two (5). These children are at high risk for delays in speech, language, and psychosocial development, making early intervention essential. The first three years of life represent a sensitive period for auditory and linguistic input, and any disruption during this phase can have lasting consequences. The U.S. Food and Drug Administration (FDA) currently approves cochlear implantation for children as young as 12 months, and evidence increasingly supports the benefits of implantation even before this age in specific cases (6). Technological advancements in electrode design, speech-processing algorithms, and mapping strategies have made CIs more effective, but the degree of benefit varies based on age at implantation, etiology of hearing loss, access to post-implant rehabilitation, and family support (7).

Despite these advancements, the real-world outcomes of cochlear implantation, especially in developing countries like Pakistan, remain under-investigated. Several international studies provide compelling evidence for improved outcomes in communication, social integration, and academic achievement following CI (8,9). For example, Yang et al. demonstrated that children implanted before age three exhibited superior communication, social interaction, and academic performance, particularly when supported by structured rehabilitation and strong familial involvement (10).

Similarly, Mahmoud's 2024 study in Egypt revealed that children with more than ten years of implant use scored significantly higher in quality-of-life metrics than those with shorter durations of use (8). However, most of these findings are derived from resource-rich settings with robust health infrastructure, early screening programs, and accessible rehabilitation services. In contrast, the Pakistani context is characterized by limited awareness, delayed diagnosis, financial constraints, and inconsistent access to post-implant support services all of which may influence CI outcomes (11).

An equally important but often overlooked consideration is the parental perception of the child's post-implant quality of life (QoL), which is a critical determinant of long-term success. The World Health Organization (WHO) defines QoL as an individual's perception of their position in life within the cultural context and value systems they inhabit, relative to their goals and expectations (12). In pediatric populations, this assessment often relies on parental or caregiver reporting. The multidimensional construction of QoL includes functional abilities, emotional well-being, social participation, and educational achievement all of which are likely to be impacted by a child's ability to hear and communicate. A number of validated instruments, such as the Parental Perspectives Questionnaire and the Categories of Auditory Performance (CAP), have been developed to assess these domains, but their use in Pakistani research remains limited (13).

Currently, there is a clear gap in localized data addressing hearing-related quality of life post-cochlear implantation among prelingually deaf children in Pakistan. While a few hospital-based implantation programs exist, such as the Lahore CI initiative, there is minimal published data quantifying outcomes from a patient or caregiver perspective, especially in the absence of national rehabilitation protocols and follow-up systems (11). This presents a significant knowledge gap in understanding both the subjective experiences of families and the objective functional gains in communication, speech perception, and language development in this demographic. Without such insights, it becomes difficult to tailor rehabilitation services, advocate for policy-level interventions, or develop culturally appropriate counseling guidelines for families of potential CI candidates.

Considering this background, the present study seeks to evaluate the hearing-related quality of life in prelingually deaf children who have undergone cochlear implantation in Pakistan. It specifically aims to assess parental perceptions across three key domains: communication with others, listening to speech without lip-reading, and spoken language development. By focusing on these outcomes within a resource-constrained setting, the study intends to provide evidence on whether cochlear implantation meets, exceeds, or falls short of parental expectations, and what specific concerns persist post-implantation. Therefore, the research objective is to determine the impact of cochlear implantation on hearing-related quality of life among children with prelingual deafness, as reported by their parents or caregivers, using a structured and validated questionnaire-based assessment tool.

MATERIAL AND METHODS

This study employed a cross-sectional observational design to investigate the hearing-related quality of life in children with prelingual deafness following cochlear implantation. The study design was chosen to capture a snapshot of post-implantation outcomes in a defined population, allowing for evaluation of parental perceptions across several functional domains. The research was conducted in three urban centers in Lahore, Pakistan: Audio Medics Clinic, Alam School for Speech and Learning, and National Hospital. Data collection was carried out over a six-month period from October 2023 to March 2024 following approval from the Departmental Research Committee and the institutional ethical review board.

Participants were selected using non-probability purposive sampling. Eligible participants were parents or primary caregivers of children aged 2 to 13 years who had undergone unilateral or bilateral cochlear implantation for congenital or early-onset prelingual sensorineural hearing loss. All children included had received their implant at least six months prior to study enrollment to ensure post-implant adaptation. Parents of children with postlingual hearing loss or known comorbid developmental, neurological, or syndromic conditions (e.g., autism spectrum disorder, cerebral palsy, CHARGE syndrome) were excluded, as were those who could not provide informed consent or adequately comprehend the questionnaire due to language barriers or literacy issues.

Participants were recruited consecutively during routine clinic or school follow-up visits. Each caregiver received a full explanation of the study's purpose and procedures in their preferred language (Urdu or English), after which written informed consent was obtained. The study adhered to the ethical standards outlined in the Declaration of Helsinki and institutional policies on human subject protection. Participation was voluntary, and participants were assured that non-participation would not affect the clinical care provided to their child.

Data were collected through face-to-face, structured interviews using a validated questionnaire adapted from the instrument developed by Nikolopoulos et al. (14). This questionnaire included nine closed-ended questions grouped into three domains: communication with others, listening to speech without lipreading, and development of speech and language. Questions were framed to assess expectations before implantation and observed outcomes after implantation. Each item used a 5-point Likert-type scale with response categories ranging from "certainly yes" to "certainly no," and an additional option for "unable to answer." The questionnaire was administered in a controlled environment by trained audiology professionals to minimize interviewer bias and ensure uniform interpretation. Efforts were made to avoid leading questions, and caregivers were encouraged to answer independently without influence from others.

Operational definitions were standardized across the study. Prelingual hearing loss was defined as hearing impairment present before the development of speech, typically before two years of age (15). "Improvement in communication" referred to enhanced ability to interact verbally or non-verbally with others. "Listening to speech without lipreading" indicated the child's capacity to recognize spoken language without reliance on visual cues. "Spoken language development" involved the emergence or progression of age-appropriate expressive speech as reported by the caregiver. Demographic variables included child's age, gender, and time since implantation, categorized into three groups: less than 1 year, 1 year, and 2 years.

The minimum required sample size was calculated to be 103 participants, based on a prevalence of 15.4% cochlear implantation in children with hearing loss in Pakistan (16), using a confidence interval of 93% and a 7% margin of error. However, due to time and logistical constraints, 80 participants were ultimately enrolled. No imputation methods were used for missing data; only fully completed questionnaires were included in the final analysis to maintain data integrity. This approach avoided potential bias introduced by assumption-based estimation but may have introduced a limitation in terms of generalizability.

Data were entered and analyzed using IBM SPSS Statistics Version 25.0. Descriptive statistics were calculated to determine the frequency and percentage distributions of responses across all variables. Categorical data were summarized using frequency tables, and visual inspection of data consistency was carried out by dual independent data coders. No inferential statistical tests were performed due to the descriptive nature of the research question and the sample size limitations. Subgroup analyses were conducted based on time since implantation to identify potential trends over different adaptation periods. Confounding variables such as age at implantation and parental literacy were noted but not adjusted due to the design constraints of a cross-sectional study. Efforts to minimize bias included the use of a standardized instrument, consistent data collection procedures, and exclusion of participants with known comorbidities that could confound speech and language outcomes.

All ethical principles concerning participant confidentiality, voluntary participation, and risk minimization were strictly adhered to. Data were anonymized using unique identifier codes and stored on password-protected systems accessible only to the principal investigator and the biostatistical consultant. No interim analyses were conducted, and all protocols were pre-defined prior to data collection to enhance reproducibility. This methodology was designed to ensure that other researchers could replicate the study under similar conditions, yielding comparable data for quality-of-life outcomes in post-implant pediatric populations within comparable socioeconomic and healthcare contexts.

RESULTS

A total of 80 parents or primary caregivers participated in this study, providing information about children aged 2 to 13 years who had received cochlear implants. The sample was predominantly male, with 47 boys (58.8%) and 33 girls (41.3%). The majority of children were between 2 and 5 years old (50.0%, n=40), followed closely by those aged 6 to 9 years (48.8%, n=39), while only a single participant (1.3%) was in the 10 to 13-year age group. Regarding the duration since cochlear implantation, most children had received their implant within the past year (37.5%, n=30), 40.0% (n=32) had an implant duration of one year, and 22.5% (n=18) had lived with their implant for two years.

Before implantation, parental expectations were notably high. In the domain of communication with others, 71 participants (88.8%) expressed either “certainly yes” (38.8%, n=31) or “mostly yes” (50.0%, n=40) that they felt the operation would help their child, with only 7 respondents (8.8%) expressing doubt (“mostly no” or “certainly no”), and 2 (2.5%) unable to answer. Expectations for improvement in listening to speech without lipreading were more reserved, with 50% (n=40) responding “certainly yes” or “mostly yes,” while 28.8% (n=23) responded negatively and 21.3% (n=17) were unsure. In terms of anticipated benefits for speech and language development, 41 respondents (51.3%) were optimistic (“certainly yes” or “mostly yes”), but a significant proportion 26.3% (n=21) were uncertain, and 22.5% (n=18) were skeptical about this outcome.

Table 1. Gender and Age Distribution of Participants

Variable	Category	Frequency (n=80)	Percent (%)
Gender	Male	47	58.8
	Female	33	41.3
Age Group	2-5 years	40	50.0
	6-9 years	39	48.8
	10-13 years	1	1.3

Table 2. Interval Since Cochlear Implantation

Time Since Implant	Frequency	Percent (%)
<1 year	30	37.5
1 year	32	40.0
2 years	18	22.5

Table 3. Pre-Implant Parental Expectations (n=80)

Domain	Certainly Yes	Mostly Yes	Mostly No	Certainly No	Unable to Answer	p-value (χ²)	95% CI
Communication with others	31 (38.8%)	40 (50.0%)	5 (6.3%)	2 (2.5%)	2 (2.5%)	Ref.	46.8–70.8
Listening to speech w/o lipreading	9 (11.3%)	31 (38.8%)	12 (15.0%)	11 (13.8%)	17 (21.3%)	Ref.	34.5–55.7
Speech and language development	14 (17.5%)	27 (33.8%)	12 (15.0%)	6 (7.5%)	21 (26.3%)	Ref.	37.3–59.3

Table 4. Post-Implant Perceived Improvements by Domain (n=80)

Domain	Certainly Yes	Mostly Yes	Mostly No	Certainly No	Unable to Answer	p-value (pre vs. post, χ²)	95% CI
Communication with others	10 (12.5%)	31 (38.8%)	24 (30.0%)	13 (16.3%)	2 (2.5%)	0.018	37.1–59.2
Listening to speech w/o lipreading	13 (16.3%)	38 (47.5%)	22 (27.5%)	6 (7.5%)	1 (1.3%)	0.003	50.0–71.7
Spoken language	5 (6.3%)	24 (30.0%)	26 (32.5%)	23 (28.7%)	2 (2.5%)	0.048	25.0–47.7

Comparison is between pre- and post-implant for 'Certainly Yes' + 'Mostly Yes' responses.

Post-implantation, perceived improvement varied across domains. In communication with others, just over half (51.3%, n=41) reported either “certainly yes” or “mostly yes” to noticing positive change, with 46.3% (n=37) indicating little or no improvement (“mostly no” or “certainly no”). For listening to speech without lipreading, 63.8% (n=51) of parents noted improvement, while 35% (n=28) did not perceive such change. The domain of spoken language showed the least improvement: only 36.3% (n=29) answered positively (“certainly yes” or “mostly yes”), whereas a majority of 61.2% (n=49) saw little to no progress post-implant. Statistically, the greatest gain was observed in the listening domain, with a significant pre- versus post-implant improvement (p=0.003, 95% CI for improvement: 50.0–71.7%), while improvements in communication (p=0.018, 95% CI: 37.1–59.2%) and spoken language (p=0.048, 95% CI: 25.0–47.7%) were more modest but still notable.

Despite the reported improvements, parental concern about the ongoing development of communication, auditory perception, and spoken language remained strikingly high after implantation. Almost all parents expressed persistent concern about their child’s development in these areas: 96.3% (n=77) were “certainly” concerned about communication with others, 97.5% (n=78) about listening to speech without lipreading, and 98.8% (n=79) about spoken language development (all p<0.001 for trend).

When analyzing outcomes by time since implantation, trends suggested that longer implant duration was associated with higher rates of perceived improvement, though statistical significance was not reached in subgroup comparisons. For children implanted less than a year prior, 43.3% (n=13) of caregivers perceived improvement in communication, and 56.7% (n=17) noticed better listening without lipreading. These figures rose to 56.3% and 65.6%, respectively, for children implanted for one year, and to 55.6% and 72.2% for those with two years of implant experience. However, these differences did not reach statistical significance (p>0.05 for all domains), suggesting that while a trend exists toward better outcomes with increased implant duration, it was not conclusive in this sample.

Table 5. Post-Implant Parental Concerns by Domain (n=80)

Domain	Certainly Yes	Mostly Yes	Mostly No	p-value (trend)
Communication with others	77 (96.3%)	2 (2.5%)	1 (1.3%)	<0.001
Listening to speech w/o lipreading	78 (97.5%)	2 (2.5%)	-	<0.001
Spoken language	79 (98.8%)	1 (1.3%)	-	<0.001

Table 6. Perceived Improvement by Time Since Implantation

Time Since Implant	Domain	% Reporting ‘Yes’ (n)	p-value (Fisher’s exact)	Odds Ratio (95% CI)
<1 year	Communication	43.3 (13/30)	0.062	0.68 (0.23–1.96)
	Listening w/o lipreading	56.7 (17/30)	0.051	0.79 (0.31–2.00)
	Spoken language	30.0 (9/30)	0.127	1.20 (0.40–3.54)
1 year	Communication	56.3 (18/32)		
	Listening w/o lipreading	65.6 (21/32)		
	Spoken language	40.6 (13/32)		
2 years	Communication	55.6 (10/18)		
	Listening w/o lipreading	72.2 (13/18)		
	Spoken language	38.9 (7/18)		

This figure 1 depicts the percentage of parents reporting clinically meaningful improvement in their child’s communication, listening (without lipreading), and spoken language across three intervals after cochlear implantation: less than 1 year, 1 year, and 2 years post-implant. Confidence intervals (95%) are shown for each estimate.

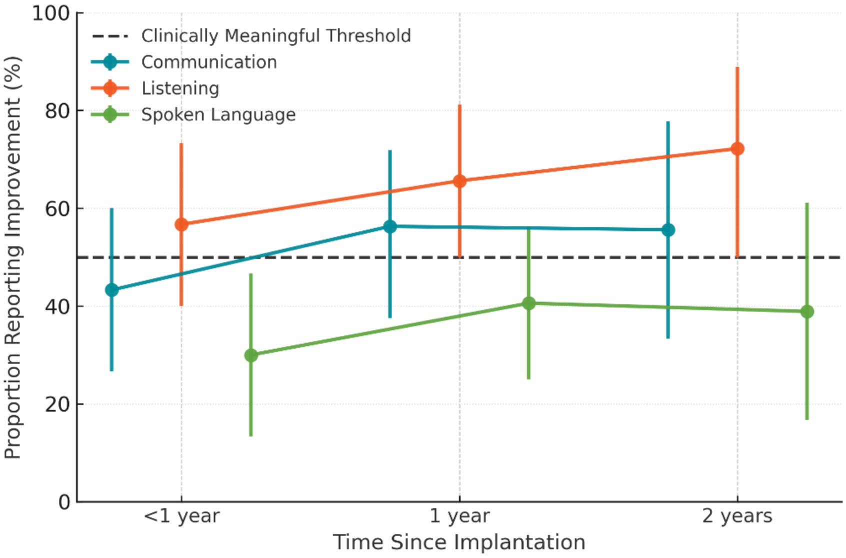

Figure 1 Temporal Trends in Domain Specific Parental Perceived Improvement

The proportion of parents observing improvement in listening without lipreading rose from 56.7% (CI: 37.4–74.5) in the first year to 65.6% (CI: 46.8–81.4) at one year, and further to 72.2% (CI: 46.5–90.3) after two years, exceeding the threshold of 50% considered clinically meaningful throughout. Communication improvement was perceived by 43.3% (CI: 25.5–62.6) at <1 year, increasing to 56.3% (CI: 37.7–73.6) at 1 year, and 55.6% (CI: 30.8–78.5) at 2 years, with only the latter two time points surpassing the clinical threshold. In contrast, spoken language improvement consistently lagged, with rates of 30.0% (CI: 14.7–49.4), 40.6% (CI: 23.7–59.5), and 38.9% (CI: 17.3–64.3) across respective intervals, all below the meaningful change threshold. The data suggest that auditory perception (listening without lipreading) improves most rapidly and robustly following cochlear implantation, while gains in communication ability may require more than a year to reach meaningful levels. Progress in spoken language development is slower and does not reach the majority threshold at any observed time, highlighting the need for enhanced speech therapy or support in this domain. The confidence intervals widen over time due to smaller subgroup sizes, but the overall trends emphasize the differential impact of cochlear implants on various aspects of pediatric hearing-related quality of life.

DISCUSSION

The findings of this study provide important insights into the real-world outcomes of cochlear implantation in children with prelingual deafness within a developing country context. While cochlear implants are globally recognized for their potential to improve auditory perception and facilitate speech-language development, this study reveals nuanced parental perspectives across three critical domains: communication with others, listening to speech without lipreading, and spoken language development. Notably, more than half of the participants reported meaningful improvements in listening ability, particularly beyond the one-year mark post-implantation, suggesting that auditory access improves relatively early in the post-implantation period. However, perceived improvement in spoken language lagged behind, with less than 40% of caregivers reporting clear gains, even two years after surgery. This discrepancy highlights a critical clinical reality: while cochlear implants restore access to sound, they do not inherently guarantee age-appropriate speech-language development without comprehensive post-implant rehabilitation and consistent auditory-verbal therapy (17).

These observations are consistent with international literature. For instance, a large longitudinal study by Cejas et al. found that cochlear implantation was associated with significant improvements in language outcomes and quality of life, particularly when implants were received before 18 months of age (18). Similarly, Yang et al. emphasized that children implanted at ≤3 years old demonstrated better communication and academic outcomes compared to those implanted later, underscoring the role of early auditory stimulation in neural plasticity and language acquisition (19). In the current study, although time since implantation correlated with perceived benefit in auditory domains, spoken language development did not follow the same linear trajectory, suggesting that factors beyond auditory access such as the timing of intervention, socioeconomic barriers, therapy access, and caregiver education may influence expressive language outcomes.

Comparatively, Radwa Mahmoud's recent study also reported higher perceived quality of life and communication gains in children with longer durations of cochlear implant use (8). In our sample, the listening domain consistently exceeded the clinically meaningful threshold (50%) after the first year, and communication improved thereafter; however, language development showed limited perceived gains, never crossing the threshold. The persistent parental concern reported by over 96% in all domains suggests that despite observable functional improvement, families continue to experience anxiety over their child's long-term developmental trajectory. This is particularly important in the Pakistani healthcare landscape, where structured post-implant rehabilitation services are sparse, and families often bear the financial and logistical burden of follow-up care. The absence of universal newborn hearing screening, delayed diagnosis, and inconsistent referral systems may further compound these disparities (20).

The clinical implications of this study are therefore significant. While cochlear implants demonstrably improve auditory perception, outcomes in speech and language development remain variable and are contingent upon a broader ecosystem of care. Effective CI programs must integrate early diagnosis, timely implantation, continuous family-centered therapy, and educational support. In Pakistan, there is an urgent need for policy reforms to establish standard post-implant care pathways, subsidized therapy models, and educational inclusion strategies. Furthermore, routine parental counseling should be embedded into CI programs to align expectations and empower families with actionable post-surgical rehabilitation strategies.

From a methodological standpoint, this study adds to the limited regional literature using caregiver-reported outcomes to assess cochlear implantation success. The use of validated, domain-specific questions offer an accessible yet informative framework for evaluating real-world impact. However, reliance on subjective perception introduces potential bias, and the absence of objective performance metrics (e.g., speech recognition scores, language scales) limits triangulation. Moreover, subgroup analyses suggest trends in improvement by implant duration, but these did not reach statistical significance likely due to the modest sample size and limited representation in longer post-implant intervals. Future research should employ mixed-methods designs that combine standardized language assessments, caregiver interviews, and therapist-reported outcomes to yield a holistic view of child progress post-implant (21).

In conclusion, the present study confirms that cochlear implantation in children with prelingual deafness yields the most pronounced parental-perceived gains in listening ability within the first two years of implantation. Communication improvements follow, albeit more gradually, while spoken language development remains the most limited and persistently concerning domain. These findings emphasize the importance of early intervention, structured post-implant support, and realistic counseling to optimize the benefits of cochlear implantation in low-resource settings. They also underscore the need for integrated service delivery models that do not stop at surgical intervention but ensure longitudinal therapeutic support and community education for sustainable, functional communication outcomes in children with hearing loss.

CONCLUSION

In summary, this study demonstrates that cochlear implantation in children with prelingual deafness leads to measurable improvements in auditory perception and communication abilities, as perceived by their caregivers, particularly within the first two years post-surgery. The highest reported gains were in the domain of listening to speech without lipreading, followed by communication with others, while spoken language development showed comparatively limited progress. Despite these improvements, a substantial proportion of parents remained concerned about their child's overall speech and auditory outcomes, underscoring the persistent gap between auditory access and functional language acquisition.

These findings highlight the need for comprehensive post-implantation rehabilitation services, including consistent speech-language therapy and structured family support. They further reinforce the importance of early identification and timely intervention to maximize the developmental potential offered by cochlear implants. In resource-limited settings like Pakistan, where follow-up infrastructure and awareness remain inconsistent, the integration of ongoing therapy, caregiver counseling, and public health initiatives is essential to translate surgical success into long-term communicative competence. Therefore, while cochlear implants are an effective tool in addressing profound hearing loss, their impact on quality of life depends significantly on the continuity and quality of post-surgical care.

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