Review Article

Development of language in children after cochlear implantation: A narrative review

Santosh Kumar Swain, MS(ORL), DNB(ORL), MNAMS

From, Department of Otorhinolaryngology and Head and Neck Surgery, All India Institute of Medical Sciences, Sijua, Patrapada, Bhubaneswar-751019, Odisha, India.

ABSTRACT

Background: For newborns and young children with congenital bilateral severe to profound sensorineural hearing loss who benefit little from properly fitting hearing aids, pediatric cochlear implantation (CI) is the recommended course of treatment. Pediatric CI significantly improves speech and language development. The development of speech and language is often faster than pre-CI rates. **Materials and Methods:** A narrative review of published literature was conducted by using databases like Google Scholar, Scopus, PubMed, and Medline. Key references were identified through searching the database and manual screening of reference lists from seminal papers. There were 45 out of the 70 publications (24 case reports, 20 case series, and 26 original studies) received from different databases included in this PRISMA Flow diagram for study selection. **Results:** The outcomes of CI in pediatric patients are highly variable. The consistent speech therapy, involvement of family, and early intervention are vital for maximizing language skills. For young children with severe-to-profound sensorineural hearing loss (SNHL), CI is a surgical substitute for conventional amplification (hearing aids) that can promote spoken language development. Post-implant spoken language outcomes are still very diverse, ranging from strong speech recognition and age-appropriate language to little improvement in sound detection with limited speech perception and language delays, despite notable advancements in cochlear implant device technology and surgical safety. By considering post-implant language development predictions into intrinsic and extrinsic elements and emphasizing clinically useful tactics to maximize therapies, this narrative review incorporates data from the literature. **Conclusion:** Early CI in children followed by early auditory verbal therapy (AVT) is helpful for optimum speech and language development. Regular follow-up and active participation by parents are required to optimize the outcomes. The duration of AVT after pediatric cochlear implantation has an impact on the hearing and language development of a child.

Key words: Cochlear implantation, Language development, Hearing loss.

In pediatric age, deafness adversely affects language acquisition as well as educational and social-emotional development. Children with bilateral congenital severe to profound sensorineural hearing loss usually have limited access to sounds that are required for age-appropriate development of receptive and expressive language. Cochlear implants (CI) are helpful to provide profoundly deafened children with hearing sensitivity within the speech range [1]. A CI is the most successful of all prostheses of the nervous system [2]. CI is indicated in patients with severe to profound hearing loss caused by loss of cochlear hair cells, and there is no significant improvement after use of a conventional hearing aid for 3 to 6 months [3].

The speech sounds required for the age-appropriate development of language are typically inaccessible to children with bilateral congenital severe to profound sensorineural hearing loss [4]. CI is very helpful for the acquisition of spoken language [4]. It is now becoming standard care for pre-lingually deaf children who derive limited benefits from the use of hearing aids [5]. Children who have received CI before two and even one year of age, get better results [5]. Most of the children receive Auditory Verbal Therapy (AVT) for two years at par with their normal hearing peers.

Following pediatric CI, the development of speech and language is still very diverse, reflecting the combined impact of the child's intrinsic limitations and modifiable extrinsic factors. Developmental profile, imaging, and genetic testing can identify the intrinsic causes, such as inner ear deformity

Access this article online

Received – 17th April 2026
Initial Review – 25th April 2026
Accepted – 30th April 2026

DOI: 10.32677/ijch.v13i5.8227

Quick Response Code

Correspondence to: Dr. Santosh Kumar Swain Professor, Department of Otorhinolaryngology and Head and Neck Surgery, All India Institute of Medical Sciences, Sijua, Patrapada, Bhubaneswar-751019, Odisha

Email: santoshvoltaire@yahoo.co.in

and neurodevelopmental comorbidities. Clinical optimization should focus on the extrinsic variables since they are typically actionable [6]. Prompt CI among children with severe to profound hearing loss, followed by early AVT, is helpful for optimum speech and language development.

METHODS OF LITERATURE SEARCH

Research articles on pediatric CI and language development were sought after. This started by looking through online databases, including Google Scholar, Scopus, PubMed, and Medline, which covered the research that has been published up to this point. This scoping review assessed subtotal petrosectomy and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The manuscript includes the specific search terms and Boolean operators used, e.g., " pediatric cochlear implantation and language development ". Once the data had been extracted from all articles, numerical and thematic analyses were conducted. All search results were reviewed based on inclusion and exclusion criteria. The data included all age groups and both genders with pediatric cochlear implantation and language development. Articles were initially screened by their titles to determine eligibility, followed by a thorough review of each abstract to ensure they met the inclusion criteria. The studies included in this review are restricted to the English language and cover publications from 1998 to 2025.

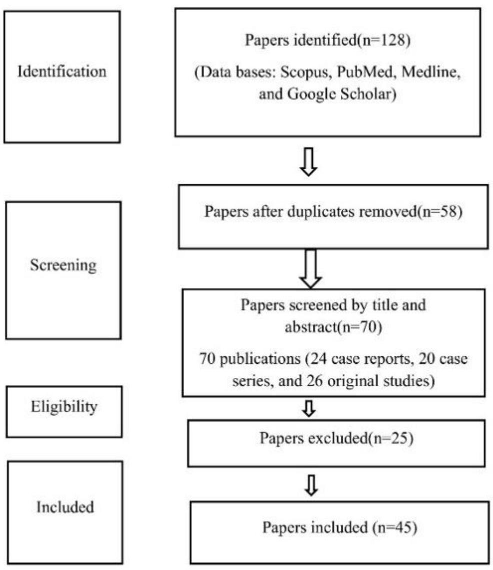

Fig.1: Methods of literature search.

The citations were employed manually to locate further research articles after the search strategy turned up published article abstracts. Articles were excluded as per the criteria, such as non-peer-reviewed articles, non-original research, reviews, case reports, letters, editorials, and insufficient information on pediatric CI and language development. The evaluation assessed whether observational studies, comparative studies, case series, case reports, and randomized controlled trials were appropriate. There were 45 of the 70 publications (24 case reports, 20 case series, and 26 original studies) received from different databases included in this PRISMA Flow diagram for study selection (Figure 1). The synthesis of findings was conducted by use of quantitative and qualitative methods. This review article discusses the prevalence of hearing loss, speech development, cochlear implantation in pediatric age, and assessment of speech and language development.

RESULTS

Prevalence of Hearing impairment

Most people worldwide experience hearing impairment, the most prevalent sensory loss [7]. The effects of hearing impairment include lower speech ability and inability to comprehend speech signals, delayed language acquisition, economic and educational regression, social isolation, and stigmatization. Approximately 360 million people worldwide, or 5.3% of the world's population, have hearing impairments.

CIs: Mechanism and Time of Treatment

For pre-lingually deaf children who benefited little from hearing aids, CI has become the standard of care since its introduction in the 1980s. The eligibility for CI has increased along with the benefits; infants are now fitted with implants earlier in infancy and with less severe impairment than in the past. By introducing electrically generated afferent impulses to the central nervous system (CNS) that had not previously been stimulated or had ceased to be stimulated by sound, the structure and function of the CNS are being deliberately altered as a medical intervention [9]. Although the replacement of synthetic stimulus is not flawless, it is a significant advancement in helping deaf children acquire their language skills.

The CI makes use of the CNS's adaptability to this artificial stimulation, as well as the ability of genetically supplied pathways. Most implanted children before the age of 2 years can develop speech and language at a rate equal to similarly aged children with normal hearing [10]. Intervening in the bilateral severe to profound hearing loss with CI is based on behavioral data suggesting language performance. The language development is more accurate the earlier children can be implanted [11]. The neural plasticity seen throughout crucial stages of auditory-based learning may be exploited by early CI [12]. Early implantation is beneficial for both receptive and expressive language, according to one study [13]. While children with intellectual disabilities exhibit slower language development, those with CIs and regular intellectual development exhibit more consistent language improvements. Furthermore, even while spoken language learning is adequately audible, intellectual disability typically co-occurs with diseases like autism spectrum disorders [14].

CI and speech perception

Several areas of auditory functioning, including detection, discrimination, resolution, and noise avoidance, are negatively impacted by hearing loss. These deficiencies can make it harder to perceive and produce speech, which is made worse by background noise. Reduced speech and hearing skills are strongly linked to depression and functional deterioration, which lowers quality of life [15]. Compared to their counterparts with normal hearing, children with congenital hearing loss have far worse speech and language abilities [16]. Speech and language production are hampered by auditory deprivation brought on by congenital hearing loss [17]. Poorer neuroplasticity is the consequence of less sensory activation [18].

CI can reverse the sensory deprivation by stimulating the auditory nerve [19]. Speech and language impairment may result from delayed diagnosis and treatment of hearing loss. Early detection of hearing loss in babies can be achieved by newborn hearing screening programs. The advancement of infant hearing screening, early detection, and treatment of hearing loss, along with advancements in CI technology, has increased the number of pediatric patients receiving hearing loss management. Children with congenital hearing loss, if diagnosed and treated early, have significantly improved speech and language skills in comparison to children diagnosed and treated late [20]. CI in pre-lingual hearing impairment provides greater access to speech and language via heightened auditory skills and speech perception [21].

Language development following pediatric CI remains quite varied across several domains, despite advances in medical interventions, including CI. While some pediatric patients merely make an improvement in recognizing environmental sounds, many acquire open-set word and sentence identification in speech perception. Performance varies greatly throughout listening in terms of noise, spatial hearing, and listening effort in more complicated situations, such as classroom listening [22]. These vary from robust speech-in-noise understanding and accurate sound localization with minimal fatigue, which can limit daily learning opportunities [23].

Many factors influence speech perception in children with hearing impairment. Early identification of deafness, early intervention, and early hearing technology are important factors in developing language skills [24]. The implementation of universal newborn hearing screening is beneficial for early detection of hearing loss and allows parents who prefer spoken communication to make early decisions concerning CI, hearing aids, and at-home speech and language therapy equipment. CIs are thought to improve speech perception [25].

In fact, it has been demonstrated that some of the pervasive neurocognitive effects of sensory loss can be reversed or rearranged when CIs restore sensory function [26]. Many hearing-impaired children achieve speaking abilities that are comparable to those of their hearing peers following CI; there is significant variation [27]. Age at implantation is a significant factor in the heterogeneity of results in children who are congenitally deaf [28]. In fact, children who receive CIs before the age of 24 months had better phonological skill development [29]. CI, however, is insufficient for a youngster to acquire sufficient hearing abilities. One explanation for this is that the CI's acoustic signals are still deteriorated [30]. The CI provides only partial acoustic information, which can result in difficulties perceiving some phonetic contrasts. The limited phonological skills may, in turn, impact spoken language development [31].

In acoustically degraded conditions, lip reading has been shown to improve auditory speech perception. However, lip reading alone is not enough for deaf children to develop perfect speech perception. Lip reading only provides access to 10 to 30% of a word or a sentence [32]. The use of a complementary communication tool is often recommended to families and professionals to sustain the development of speech perception. Poor speech perception is often associated with special education placements. Placement in special education settings has similarly been related to lower receptive vocabulary scores in bilateral cochlear recipients [33]. The relationship between age at mainstream and speech perception can be explained by stronger speech perception skills permitting access to mainstream education or resulting from earlier access to mainstream education. Positive parent-child interactions, placement in a mainstream education setting, and AVT are the microsystem factors associated with better speech perception outcomes.

The study demonstrated a correlation between robust parent-child interactions and enhanced speech perception, with improved language outcomes [34]. In addition, the mode of communication was not a significant predictor of speech perception. The disparity in outcomes may be attributed to variations in analysis and measurement techniques used across studies. The choice of communication mode may also reflect other contextual factors in the ecology of the child, such as education setting or parental language. A bilingual home environment may be at greater risk for speech perception [35]. Bilingual bilaterally implanted children show significantly worse outcomes than monolingual bilaterally implanted children in a composite German language measure [36]. However, this study does not comment on duration, quality, or quantity of the language input that the children received in the language testing; the nature of the relationship between bilingualism and speech perception requires more examination of effect strength, significance, and direction before conclusions can be drawn. The duration of AVT after pediatric CI has an impact on the hearing and speech development of a child. The regular follow-up and active participation by parents are needed to maximize the outcomes [37]. Early CI in a congenitally deafened child with strict AVT provides satisfactory hearing and language development. Duration of AVT after pediatric CI has an impact on the hearing and language development of a child [38].

Language development in pediatric age

Even with advancements in the technology of CI, language development following pediatric CI remains highly variable across several domains. With respect to speech perception, many children achieve open-set word and sentence recognition, whereas others progress only to recognizing environmental sounds [39]. The performance of students in complex classrooms varies greatly in terms of listening effort, spatial hearing, and noise. It includes speech-in-noise comprehension, precise sound localization with little fatigue, and noticeable challenges in noisy environments. Daily learning possibilities may be limited by significant weariness and inadequate localization [40]. Intelligible connected speech and persistent articulation faults are among the criteria of language expressive skills that are measured, along with speech production and articulation [39].

Large variability in language development across receptive and expressive domains is reflected in these differences in spoken language comprehension and production, ranging from near-age-appropriate skills to persistent delays, with longitudinal data showing continuous improvement throughout the early school years [39,40]. Early age CI is very critical for achieving favorable language development [41]. Post-implant language development is influenced by additional elements that can be classified as either intrinsic or external (Figure 2). These elements work together to contribute to the variation in postoperative language development among young cochlear transplants [42].

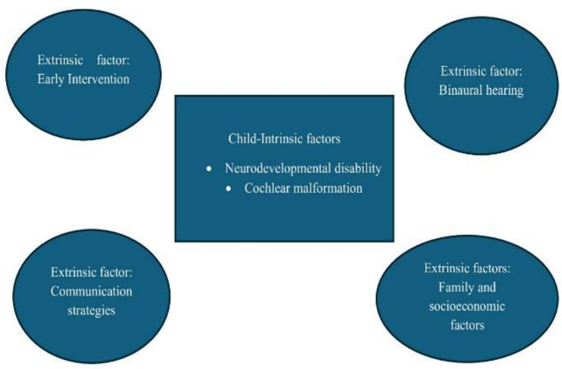

Figure 2. Determinants of language outcomes after pediatric cochlear implantation.

Assessment of language development

Prosody, syntax, and semantics are used to establish language structure. The effectiveness of the CI for language development is now assessed using metrics of prosody, syntax, and semantics development [43]. CIs in prelingual children are helpful to promote the development of language in the prelingually deaf child [43,44]. The language development in prelingual children following CI also affects the broader issues of quality of life, including educational, economic, and social attainment. Measures of language expression abilities and speech generation and articulation range from continuous articulation faults to intelligible connected speech [45].

These variations in spoken language comprehension and production are indicative of a broad range in language development across receptive and expressive domains, from near-age-appropriate abilities to enduring delays, with longitudinal data showing continuous improvement throughout the early school years. For most congenitally deaf children implanted before the age of one year, the CI is effective in improving receptive and expressive language deficiencies [39].

Limitation and future recommendation

Bilateral CI in pediatric patients can develop complex expressive and receptive spoken language [43]. In bilateral CI, children use significantly more audition and vocalization in communication in the early post-implantation time than their unilateral implanted child. Bilateral CI enhances the development of the central auditory system by bilateral cortical stimulation, ensures that the better ear is often implanted, and provides recipients with a backup if one device fails [49]. Although there are some limitations in choosing bilateral, including more time for surgery or two different surgeries, higher expenses, and the inability to preserve one ear for newer treatment.

CONCLUSION

Children with congenital severe to profound hearing loss can counteract the detrimental effects of hearing and language acquisition by constant use of CIs. Prompt CI among children followed by early AVT is helpful for optimum speech and language development. Regular follow-up and active participation by parents are required to optimize the outcomes.

REFERENCES

1. Swain SK. Cochlear implant and tinnitus: A review. Int J Otorhinolaryngol Head Neck Surg. 2021;7(12):1960-1964.
2. Swain SK. Hybrid cochlear implant: A scoping review. Int J Otorhinolaryngol Head Neck Surg. 2025;11(1):95-100.
3. Ramsden RT. Cochlear implants and brain stem implants. Br Med Bull.2000; 63(1):183-193.
4. Niparko JK, Tobey EA, Thal DJ, Eisenberg LS, Wang N-Y, Quittner AL, et al. Spoken language development in children

following cochlear implantation. Jama. 2010; 303:1498-1506.

5. Swain SK. Intracochlear electrode insertion of cochlear implant: a scoping review. Int J Otorhinolaryngol Head Neck Surg. 2025;11(3):335-341.
6. Sanju HK, Jain T, Kumar P. Is early cochlear implantation leads to better speech and language outcomes?. Indian Journal of Otolaryngology and Head & Neck Surgery. 2022 ;74 (3):3906-3910.
7. World Health Organization. Deafness and hearing impairment – fact sheet. March, Available from: https://www.who.int/news-room/fact-sheets/detail/deafness-andhearing-loss; 2019.
8. Shave S, Botti C, Kwong K. Congenital sensorineural hearing loss. Pediatric Clinics. 2022 ;69(2):221-234.
9. Swain SK. Intracochlear electrode insertion of cochlear implant: a scoping review. Int J Otorhinolaryngol Head Neck Surg. 2025;11(3):335-341.
10. Moore DR, Shannon RV. Beyond cochlear implants: awakening the deafened brain. Nat Neurosci.2009; 12(6): 686-691.
11. Holt RF, Svirsky MA. An exploratory look at pediatric cochlear implantation: is earliest always best? Ear Hear. 2008;29(4):492-511.
12. Sharma A, Tobey E, Dorman M, Bharadwaj S, Martin K, Gilley P, et al. Central auditory maturation and babbling development in infants with cochlear implants. Archives of Otolaryngology-Head & Neck Surgery. 2004;130(5):511-516.
13. Wie OB. Language development in children after receiving bilateral cochlear implants between 5 and 18 months. Int J Pediatr Otorhinolaryngol. 2010; 74:1258-1266.
14. Yamazaki H, Yamamoto R, Moroto S, Yamazaki T, Fujiwara K, Nakai M, et al. Cochlear implantation in children with congenital cytomegalovirus infection accompanied by psycho-neurological disorders. Acta oto-laryngologica. 2012;132: 420-427.
15. Swain SK. Quality of Life among Cochlear Implant Recipients. Matrix Science Medica. 2025;9(4):83-87.
16. Tomblin JB, Oleson JJ, Ambrose SE, Walker E, Moeller MP.The influence of hearing aids on the speech and language development of children with hearing loss. JAMA Otolaryngol Head Neck Surg.2014; 140:403-409.
17. Halliday LF, Tuomainen O, Rosen S. Language development and impairment in children with mild to moderate sensorineural hearing loss. J Speech Lang Hear Res.2017; 60: 1551-1567.
18. Dettman SJ, Pinder D, Briggs RJS, Dowell RC, Leigh JR. Communication development in children who receive the cochlear implant younger than 12 months: risks versus benefits. Ear Hear. 2007; 28:11-18.
19. Robinson K. Implications of developmental plasticity for the language acquisition of deaf children with cochlear implants. Int J Pediatr Otorhinolaryngol.1998; 46:71-80.
20. Farah C, Roman S, D'Imperio M. Prosodic focus acquisition in French Early Cochlear Implanted Children. Interspeech.2018; 28:2977-2981.
21. Binos P, Loizou E. Vocalization frequency as a prognostic marker of language development following early cochlear implantation. Audiol Res.2019; 9:217-223.
22. Dettman SJ, Dowell RC, Choo D, Arnott W, Abrahams Y, Davis A, et al. Long-term communication outcomes for children receiving cochlear implants younger than 12 months: A multicenter study. Otology & Neurotology. 2016; 37:82-95.
23. Kronenberger WG, Colson BG, Henning SC, Pisoni DB. Executive functioning and speech-language skills following long-term use of cochlear implants. Journal of deaf studies and deaf education. 2014;19(4):456-70.
24. Bubbico L, Di Castelbianco FB, Tangucci M, Salvinelli F. Early hearing detection and intervention in children with prelingual deafness, effects on language development. Minerva Pediatr.2007; 59, 307-313.
25. Kelsall D, Lupo J, Biever A. Longitudinal outcomes of cochlear implantation and bimodal hearing in a large group of adults: A multicenter clinical study. Am J Otolaryngol.2021; 42:102773.
26. Kral A, Kronenberger WG, Pisoni DB, O'Donoghue GM. Neurocognitive factors in sensory restoration of early deafness: A connectome model. Lancet Neurol.2016; 15: 610-621.
27. Geers AE, Nicholas J, Tobey E, Davidson L. Persistent language delay versus late language emergence in children with early cochlear implantation. J Speech Lang Hear Res.2016; 59: 155-170.
28. Boons T, Brokx JPL, Dhooge I, Frijns JHM, Peeraer L, Vermeulen A, et al. Predictors of spoken language development following pediatric cochlear implantation. Ear Hear.2012;33: 617-639.
29. Colin S, Ecalle J, Truy E, Lina-Granade G, Magnan A. Effect of age at cochlear implantation and at exposure to Cued Speech on literacy skills in deaf children. Res Dev Disabil.2017; 71, 61-69.
30. Bouton S, Serniclaes W, Colé P, Bertoncini J. Categorical perception of speech sounds in French-speaking children with cochlear implant. J Speech Lang Hear Res. 2012;55, 139-153.
31. Hansson K, Ibertsson T, Asker-Árnason L, Sahlén B. Language impairment in children with CI: An investigation of Swedish. Lingua. 2018;213, 63-77.
32. Bernstein LE, Tucker PE, Demorest M E. Speech perception without hearing. Percept. Psychophys. 2000; 62:233-252.
33. Kleijbergen WJ, Sparreboom M, Mylanus EAM, de Koning G, Helleman HW, Boermans P, et al. Benefit of sequential bilateral cochlear implantation in children between 5 to 18 years old: A prospective cohort study. PLoS One. 2022; 17: e0271497.
34. Sininger YS, Grimes A, Christensen E. Auditory development in early amplified children: factors influencing auditory-based communication outcomes in children with hearing loss. Ear Hear. 2010; 31:166-185.
35. Dean C, Felder G, Kim AH. Analysis of speech perception outcomes among patients receiving cochlear implants with auditory neuropathy spectrum disorder. Otol. Neurol. 2013; 34:1610-1614.
36. Glaubitz C, Liebscher T, Hoppe U. Age-related language performance and device use in children with very early bilateral cochlear implantation. Int J Pediatr Otorhinolaryngol. 2021; 147:110780.
37. Swain SK. Hybrid cochlear implant: A scoping review. Int J Otorhinolaryngol Head Neck Surg. 2025;11(1):95-100.
38. Swain SK. Current criteria for selecting cochlear implants in deaf patients: A review. Int J Adv Med. 2022; 9: 50-55.
39. Dettman SJ, Dowell RC, Choo D, Arnott W, Abrahams Y, Davis A, et al. Long-term communication outcomes for children receiving cochlear implants younger than 12 months: A multicenter study. Otology & Neurotology. 2016; 37:82-95.
40. Schafer EC, Kirby B, Miller S. Remote microphone technology for children with hearing loss or auditory processing issues. In Seminars in Hearing 2020 Nov (Vol. 41, No. 04, pp. 277-290).

Thieme Medical Publishers, Inc.

41. Ching TY, Cupples L, Seeto M, Zhang V, Hou S, Wong A, et al. Early Intervention Influences 9-Year Speech, Language, Cognitive, and Quality-of-Life Outcomes in Deaf or Hard-of-Hearing Children. Ear and Hearing. 2025; 10:1097.
42. Thompson NJ, Park LR, O'Connell BP, Zdanski CJ, Brown KD, Anderson MR. Factors that influence performance in pediatric cochlear implant recipients with cochlear nerve deficiency. Cochlear Implants International. 2024; 25:191-196.
43. Ruben RJ. Language development in the pediatric cochlear implant patient. Laryngoscope investigative otolaryngology. 2018;3(3):209-213.
44. Swain SK. Vertigo following cochlear implantation: A review. Int J Res Med Sci. 2022 ;10(2):572-577.
45. Swain SK. Quality of Life among Cochlear Implant Recipients. Matrix Science Medica. 2025;9(4):83-87.

Funding: None; Conflicts of Interest: None Stated.

How to cite this article: Swain SK, MS(ORL), DNB(ORL), MNAMS. Development of language in children after cochlear implantation: A narrative review. Indian J Child Health. 2026; 13(5):59-64.