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Original Research Article

IMPACT OF EARLY COCHLEAR IMPLANTATION ON LANGUAGE ACQUISITION AND COGNITIVE DEVELOPMENT IN CHILDREN WITH PROFOUND CONGENITAL HEARING LOSS

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ABSTRACT

Background: Early cochlear implantation plays a vital role in improving auditory perception, speech development, language acquisition, and cognitive functioning in children with profound congenital sensorineural hearing loss. The timing of implantation is considered an important factor influencing postoperative outcomes. **Materials and Methods:** A retrospective cohort study was conducted among children with profound congenital hearing loss who underwent cochlear implantation between 2015 and 2022 at Kanyakumari Government Medical College and Hospital. Children implanted before 3 years of age were included in Group A, while those implanted after 3 years were included in Group B. Category of Auditory Perception (CAP), Common Objective Token (COT), and Speech Intelligibility Rating (SIR) scores were assessed at 6 months, 1 year, and 2 years post-implantation. **Result:** At 6 months, Group A showed significantly higher COT scores than Group B (3.533 vs 2; p = 0.025), while CAP and SIR scores were not statistically significant. At 1 year, Group A demonstrated significantly better CAP (3.8 vs 2.45; p = 0.015), COT (5.633 vs 3; p = 0.0004), and SIR (2.5 vs 1; p = 0.0001) scores. Similar findings were observed at 2 years, with higher CAP (4.967 vs 3; p = 0.0023), COT (7.533 vs 5; p = 0.0078), and SIR (3.467 vs 2; p = 0.006) scores in Group A. **Conclusion:** Children who underwent cochlear implantation before 3 years of age demonstrated superior auditory, speech, language, and cognitive outcomes compared to those implanted after 3 years of age.

INTRODUCTION

Profound congenital sensorineural hearing loss is one of the major causes of delayed speech, language, and cognitive development in children. Hearing is essential for the development of communication skills, learning ability, and social interaction during early childhood. Children with severe to profound hearing loss often face significant difficulties in speech perception, language acquisition, and auditory development, particularly during the critical early years of brain maturation.[1,2] Structural abnormalities such as inner ear malformations and cochlear nerve deficiency can further impair the development of auditory-language networks in these children.[1]

Cochlear implantation is considered one of the most effective treatment options for children with severe to profound sensorineural hearing loss. Unlike conventional hearing aids, cochlear implants bypass the damaged cochlea and directly stimulate the auditory nerve, thereby improving hearing and speech perception. Since their introduction, cochlear implants have significantly improved auditory performance, speech intelligibility, and quality of life in hearing-impaired children.[2]

Several studies have shown that the age at cochlear implantation plays a crucial role in determining postoperative outcomes. Children implanted at an earlier age demonstrate better spoken language development and communication skills compared to those implanted later.[3] Speech and auditory outcomes following cochlear implantation are commonly assessed using reliable tools such as the Speech Intelligibility Rating (SIR) and Categories of Auditory Performance (CAP) scores.[4,5]

In recent years, increasing attention has been given to the cognitive benefits of early cochlear implantation. Improved auditory input through early implantation supports executive functioning, cognitive control, and memory skills.[6] Long-term studies have also shown better speech and language outcomes in children who received cochlear implants during early childhood, along with positive effects on overall cognitive functioning.[7,8]

The importance of early implantation is further supported by evidence on auditory and language development. The first three years of life represent a sensitive period for the development of the central auditory system, and implantation during this period leads to superior auditory outcomes.[9] Younger age at implantation is consistently associated with better speech perception and language development.[10,11] Follow-up studies have also reported significant improvements in speech recognition after cochlear implantation.[12]

Despite its benefits, delayed diagnosis and limited rehabilitation still lead to late cochlear implantation, and studies comparing outcomes before and after 3 years of age remain limited.

Therefore, the present study was undertaken to compare the audiological development, speech intelligibility, language acquisition, and cognitive outcomes among children who underwent cochlear implantation before 3 years of age and those implanted after 3 years of age.

MATERIALS AND METHODS

A retrospective cohort study was conducted in the Department of Otorhinolaryngology and Head and Neck Surgery at Kanyakumari Government Medical College and Hospital to analyse the importance of the age at cochlear implantation surgery among children diagnosed with profound congenital hearing loss. All children (seventy-seven) who underwent cochlear implantation between 2015 and 2022 and satisfied the inclusion and exclusion criteria were included in this study.

Inclusion Criteria

Children who received cochlear implant surgery before 6 years of age and had an adequate follow-up duration of at least 2 years post-implantation for assessment were included in the study.

Exclusion Criteria

Children who underwent cochlear implantation surgery after 6 years of age, those with additional significant developmental disorders or comorbidities affecting speech and language development such as Autism, ADHD, mental retardation, or seizure disorders, cases where revision surgeries were performed or major complications occurred post-implantation potentially confounding outcomes, and children with inadequate follow-up or auditory verbal therapy (AVT) sessions were excluded from the study.

Data Collection Procedure

The children were divided into two groups: Group A included children who underwent cochlear implantation before 3 years of age, while Group B included children who underwent cochlear implantation after 3 years of age.

The age, gender, age at cochlear implantation, associated factors, regularity of AVT classes, family support, and socioeconomic status were recorded. Category of Auditory Perception (CAP) score (0–7), Common Object Token (COT) score (0–10), and Speech Intelligence Rating (SIR) score (0–5) at 6 months, 1 year, and 2 years were documented. Expressive language and receptive language were assessed at 2 years post-implantation.

Speech Intelligence Rating (SIR), scored from one to five, was used to analyse language acquisition. A score of 1 indicated pre-recognizable words in spoken language; 2 indicated connected speech that was unintelligible; 3 indicated connected speech intelligible to a listener who concentrates and lip-reads within a known context; 4 indicated connected speech intelligible to a listener with little experience of deaf speech; and 5 indicated connected speech intelligible to all listeners without undue concentration.4

Category of Auditory Perception (CAP), scored from zero to seven, was used to analyse auditory or hearing improvement in children. A score of 0 indicated no awareness of environmental sounds; 1 indicated awareness of environmental sounds; 2 indicated response to speech sounds; 3 indicated recognition of environmental sounds; 4 indicated discrimination of at least two speech sounds without lip-reading; 5 indicated understanding of common phrases without lip-reading; 6 indicated understanding of conversation without lip-reading with a familiar talker; and 7 indicated the ability to use a telephone with a familiar talker.5

The Common Objective Token Test (COT), scored from one to ten, was used to evaluate cognitive development. It is a sentence-level test for children with hearing loss that measures speech perception and auditory memory skills. The test is a closed-set task of higher complexity than most and aims to assess a child at the transition between basic closed-set tasks and open-set tasks. It is suitable for children with cochlear implants as young as three years of age.

RESULTS

Out of the 30 children in Group A, 17 were males and 13 were females. In Group B, among the 20 children, 10 were males and 10 were females (Table 1).

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Table 1: Distribution of Sex

Group	Male	Female
Group A (≤ 3 years)	17	13
Group B (> 3 years)	10	10

The mean age at which the children underwent cochlear implantation surgery was 2.52 years in Group A and 4.825 years in Group B (Table 2)

Table 2: Distribution Of Age At Surgery

Group	Mean Age
Group A (≤ 3 years)	2.52
Group B (> 3 years)	4.825

There was a significant improvement in the COT score ($p = 0.025$) at six months in Group A. However, there was no statistically significant improvement in the CAP score and SIR score (Table 3)

Table 3: Distribution At 6 Months Post Surgery

Scores	Group A (≤ 3 years)	Group B (> 3 years)	p-value
CAP – 6 months	2.067 ± 1.015	1.35 ± 0.587	0.344
COT – 6 months	3.533 ± 1.592	2 ± 1.509	0.025
SIR – 6 months	1.433 ± 0.728	1 ± 0.459	0.645

Group A showed significantly better outcomes than Group B at both 1 and 2 years post-implantation, with higher CAP (3.8 vs 2.45; 4.967 vs 3), COT (5.633 vs 3; 7.533 vs 5), and SIR (2.5 vs 1; 3.467 vs 2) scores ($p < 0.05$) (Table 4)

Table 4: Comparison of CAP, COT, and SIR Scores at 1 and 2 Years Post Implantation

Follow-up Period	Score	Group A (≤ 3 years) Mean ± SD	Group B (> 3 years) Mean ± SD	p-value
1 Year	CAP	3.8 ± 1.424	2.45 ± 1.234	0.015
	COT	5.633 ± 1.920	3 ± 2.114	0.0004
	SIR	2.5 ± 0.820	1 ± 0.696	0.0001
2 Years	CAP	4.967 ± 1.473	3 ± 1.618	0.0023
	COT	7.533 ± 2.285	5 ± 2.646	0.0078
	SIR	3.467 ± 1.042	2 ± 1.218	0.006

At 2 years post-implantation, there was no statistically significant difference between Group A and Group B in receptive language (6.133 vs 6; $p = 0.59$) and expressive language (4.333 vs 4; $p = 0.805$) scores (Table 5)

Table 5 Distribution of Receptive And Expressive Language At 2 Years

Scores	Group A (≤ 3 years)	Group B (> 3 years)	p-value
RL – 2 years	6.133 ± 1.569	6 ± 2.739	0.59
EL – 2 years	4.333 ± 1.590	4 ± 2.706	0.805

DISCUSSION

In our study, we evaluated audiological development, language acquisition, and cognitive development among children who underwent cochlear implantation before 3 years of age (Group A) and those who underwent surgery after 3 years of age (Group B).

Early improvement in cognitive development was observed in children who underwent cochlear implantation before 3 years of age, as evidenced by statistically significant improvement in the COT score as early as 6 months post-implantation, which persisted at 1 year and 2 years following implantation. These findings are consistent with studies by Pisoni et al., Ruffin et al., and Fidaa Almomani et al. Early implantation positively influences cognitive functions such as memory, attention, and executive functioning due to enhanced auditory input provided by cochlear implants.[6-8]

Significant improvement in audiological development and language acquisition was also observed in children who underwent cochlear implantation before 3 years of age, based on significant improvements in CAP and SIR scores at 1 year and 2 years post-implantation. These findings are consistent with the studies conducted by Sharma et al., Svirsky et al., Nicholas et al., Niparko et al., and Eisenberg et al. The first three years of life represent a sensitive period for the development of the central auditory system, and cochlear implantation within this period leads to more favourable auditory and language outcomes. Children implanted before 3 years of age demonstrated superior language skills, which continued to improve over time.[3,9-12]

Our findings are also supported by the systematic review conducted by McCann et al. and the meta-analysis performed by Robertson et al.[13,14] McCann et al. concluded that earlier cochlear implantation consistently resulted in better language outcomes, supporting the critical period hypothesis for language development.[13] Robertson et al. demonstrated that early implantation was associated with significant

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improvements across multiple cognitive domains, further emphasizing the benefits of early auditory intervention.[14]

Limitations

The study was limited by its small sample size and retrospective design. Variations in family support, socioeconomic status, and compliance with auditory verbal therapy may have influenced outcomes. Additionally, the follow-up period was limited to two years and may not reflect long-term auditory, speech, and cognitive development after cochlear implantation.

CONCLUSION

Children who underwent cochlear implantation before 3 years of age demonstrated significantly better audiological development, cognitive development, and language acquisition compared to those who underwent implantation after 3 years of age

REFERENCES

1. Wang Y, Jiang M, Zhu Y, Xue L, Shu W, Li X, et al. Impact of inner ear malformation and cochlear nerve deficiency on the development of auditory-language network in children with profound sensorineural hearing loss. Elife 2023;12:e85983. https://doi.org/10.7554/eLife.85983.
2. Clark GM. Cochlear Implants: Fundamentals and Applications. 2003rd ed. New York, NY: Springer; 2003. https://doi.org/10.1007/b97263.
3. Nicholas JG, Geers AE. Will they catch up? The role of age at cochlear implantation in the spoken language development of children with severe to profound hearing loss. J Speech Lang Hear Res 2007;50:1048–62. https://doi.org/10.1044/1092-4388(2007/073)
4. Al-Shawi YA, Mesallam TA, Albakheet NM, Alshawi MA, Alfallaj RM, Aldrees TM, et al. Validation and inter-rater reliability testing of the Arabic version of speech intelligibility rating among children with cochlear implant. Saudi Med J 2020;41:1139–43. https://doi.org/10.15537/smj.2020.10.25342
5. Archbold S, Lutman ME, Nikolopoulos T. Categories of auditory performance: inter-user reliability. Br J Audiol 1998;32:7–12. https://doi.org/10.3109/03005364000000045.
6. Pisoni DB, Conway CM, Kronenberger W, Henning S, Anaya E. Executive function, cognitive control, and sequence learning in deaf children with cochlear implants. Oxford University Press; 2010. https://doi.org/10.1093/oxfordhb/9780195390032.013.0029
7. Ruffin CV, Kronenberger WG, Colson BG, Henning SC, Pisoni DB. Long-term speech and language outcomes in prelingually deaf children, adolescents and young adults who received cochlear implants in childhood. Audiol Neurootol 2013;18:289–96. https://doi.org/10.1159/000353405
8. Almomani F, Al-Momani MO, Garadat S, Alqudah S, Kassab M, Hamadneh S, et al. Cognitive functioning in Deaf children using Cochlear implants. BMC Pediatr 2021;21:71. https://doi.org/10.1186/s12887-021-02534-1.
9. Sharma A, Dorman MF, Spahr AJ. A sensitive period for the development of the central auditory system in children with cochlear implants: implications for age of implantation. Ear Hear 2002;23:532–9. https://doi.org/10.1097/00003446-200212000-00004.
10. Svirsky MA, Teoh S-W, Neuburger H. Development of language and speech perception in congenitally, profoundly deaf children as a function of age at cochlear implantation. Audiol Neurootol 2004;9:224–33. https://doi.org/10.1159/000078392
11. 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;303:1498–506. https://doi.org/10.1001/jama.2010.451.
12. Eisenberg LS, Johnson KC, Martinez AS, Cokely CG, Tobey EA, Quittner AL, et al. Speech recognition at 1-year follow-up in the childhood development after cochlear implantation study: Methods and preliminary findings. Audiol Neurootol 2006;11:259–68. https://doi.org/10.1159/000093302.
13. McCormack J, McLeod S, McAllister L, Harrison LJ. A systematic review of the association between childhood speech impairment and participation across the lifespan. Int J Speech Lang Pathol 2009;11:155–70. https://doi.org/10.1080/17549500802676859.
14. Robertson, J., Green, W., & Nevison, C. (2013). Cognitive development in children with early cochlear implantation: A meta-analysis. Developmental Science, 16(3), 356-363.