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Auditory and language performance of children with bilateral profound hearing loss following simultaneous bilateral cochlear implantation: An observational study

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ABSTRACT

Profound prelingual sensorineural hearing loss affects oral language development. Cochlear implants, especially at an early age, enable the acquisition of functional auditory and language skills. This observational, retrospective, longitudinal study evaluated the auditory-language performance of 15 children with profound bilateral prelingual hearing loss who underwent bilateral cochlear implantation before the age of 5 and were followed up at 2 and 5 years after activation. We used an *ad hoc* functional scale to classify performance. The median age at implantation was 1.8 years (0.7-3.7). At 2 years, three patients showed excellent performance; at 5 years, 10 achieved this. Eleven children showed improvement between the two assessments, with no deterioration in any case.

Keywords: *cochlear implantation; sensorineural hearing loss; language development; pediatrics; treatment outcome.*

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INTRODUCTION

Profound bilateral sensorineural hearing loss in childhood has a significant impact on language development, communication, and social integration. Neonatal screening has enabled early detection and early access to therapeutic strategies. Cochlear implants (CI), primarily when performed bilaterally and simultaneously, have proven to be an effective tool, and early placement is associated with better auditory and language outcomes.[1,2]

Several studies indicate that age at implantation is a key factor: intervention before the age of 2, and particularly before 12 months, is associated with better language development and greater similarity to children with normal hearing.[3,4] This is related to a "sensitive period" in central auditory development, where acoustic afferents shape cortical organization. Outside this period, auditory deprivation can induce reorganizations that limit the benefits of CI.[5,6]

In addition to surgical age, other factors such as etiology, comorbidities, quality of rehabilitation, family environment, and device use also influence outcomes. Some authors propose functional classifications that integrate clinical and environmental variables (attention, verbal production, adjustment of the individualized electrical stimulation program, social participation) to assess the impact of CI more comprehensively.[7]

Longitudinal follow-up reveals diverse evolutionary trajectories. Although most improve progressively, a proportion maintain suboptimal performance, underscoring the need to integrate multiple clinical and social variables into their analysis.[2,3]

In this context, the objective of this study is to describe the auditory-linguistic evolution of children with profound bilateral prelingual hearing loss who received implants at a tertiary hospital, at 2 and 5 years after activation, and to explore possible factors associated with performance.

POPULATION AND METHODS

An observational, retrospective, longitudinal study was conducted at the Hospital Italiano de Buenos Aires (Argentina). Patients with profound bilateral prelingual sensorineural hearing loss who received bilateral implants before the age of 5 between 2010 and 2020 were included, with a 5-year follow-up. Clinical, technical, and follow-up variables were recorded. Performance was classified into four levels using an *ad hoc* functional scale (*Table 1*). Nonparametric statistical tests were applied to explore associations and outcome. The protocol was approved by the Institutional Research Ethics Committee (No. 7324 PRIISA 14799), and data confidentiality was guaranteed.

RESULTS

Fifteen patients with profound bilateral prelingual sensorineural hearing loss were included, who had received bilateral implants simultaneously before the age of 5, with clinical and speech therapy follow-up at 2 and 5 years after activation. Patients were divided into two groups according to age at implantation: younger than and older than or equal to 24 months (*Table 2*). Performance is shown in *Figure 1*.

The comparison between the scores at 2 and 5 years showed a significant improvement (Wilcoxon test, $p = 0.006$); 11 children showed improvement between the two evaluations, with no deterioration in any case.

DISCUSSION

This study analyzed a cohort of 15 pediatric patients with profound bilateral sensorineural hearing loss before speech acquisition, who received bilateral implants at a single institution with documented clinical and speech-language

Table 1. *Ad hoc* classification

Level	Description
Excellent	Nearly 100% comprehension, fluent speech, good attention, stable IEPS, full functional integration.
Good	Comprehension 70-90%, understandable language with errors, good/moderate attention, relatively stable IEPS, good integration.
Fair	Comprehension 30-70%, limited verbal production, variable attention, IEPS with difficulties, partial integration, requires intensive support.
Poor	Comprehension <30%, poor verbal production, poor attention, persistent difficulties with the device, and poor functional integration.

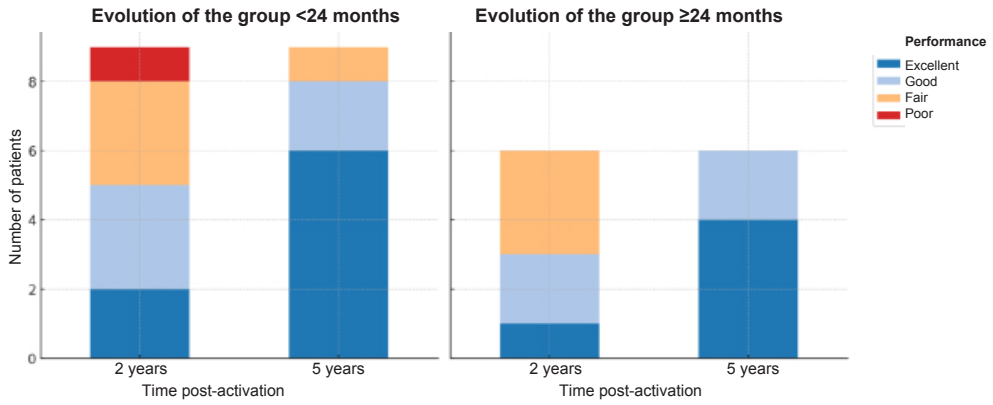
IEPS: individualized electrical stimulation program.

Table 2. Comparison of study groups

Category	Group <24 months	Group ≥24 months
N	9	6
Male	5	3
Previous use of hearing aids		
Yes	7	5
No	2	0
No data	0	1
Age (months) at the time of implantation; median (range)	15 (8-22)	32.5 (24-41)
Cochlear implant model used		
CI 422	1	0
Nucleus Contour advanced	7	5
MedEl Flex 28®	0	1
AB Mid Scala®	1	0

N: number.

Figure 1. 2- and 5-year performance of device activation



follow-up at 5 years after activation. Unlike studies focusing on large populations or complex statistical analyses, this series concentrated on cases with complete clinical records, enabling a functional and qualitative approach to post-implantation performance.

Most patients achieved excellent overall performance at 5 years, as assessed by the *ad hoc* functional scale used. However, these results should be interpreted with caution. The limited sample size does not allow for an analysis of differences between groups divided by age at implantation, both in overall performance and in specific variables such as word comprehension or Ling test results. However, the observations suggest better performance in those who were implanted earlier.

Multiple studies highlight the influence of surgical age on the prognosis of cochlear implants. Nicholas and Geers demonstrated that children implanted before 18 months of age achieved higher language scores than those implanted later, with differences that remained over time.[2] In another study, they observed that although children implanted in the first year of life achieved better speech intelligibility and more typical language development, significant differences were not always found in specific tests such as open word recognition.[4] This situation is comparable to that of our cohort, where good overall results limited the dispersion in performance categories, making statistical analysis difficult. Recent studies, such as those conducted by Sharma et al., have incorporated objective assessments using the P1 or the P300 components of the cortical auditory evoked potentials (CAEPs), to evaluate central auditory maturation.[5] Although our series did not include these studies due to equipment limitations, their future incorporation could add a relevant neurophysiological dimension to conventional clinical analysis.

In a systematic review, Forli et al. reported that, although many studies show clinical benefits

of implantation in the first year of life, not all of them manage to establish statistically significant differences, especially in small series or those with methodological variability.[3] This reinforces the notion that the impact of surgical age may be more clearly expressed in longitudinal functional evolution than in cross-sectional or structured point tests.

A noteworthy aspect is that most patients had used hearing aids bilaterally before surgery, which may have favored early auditory stimulation during the surgical waiting period. However, the multifactorial nature of the prognosis could explain differences in evolution. In line with this, Mosaed et al. (2024) found no statistically significant differences between prior hearing aid use and post-implant performance. They emphasized that surgery should not be postponed while waiting for results with hearing aids.

Another relevant finding was the positive individual evolution: all patients maintained or improved their performance between 2 and 5 years after activation. None showed deterioration. This progression was reflected in the graphical analysis and in the paired statistical comparison, which showed a significant improvement in favor of performance at 5 years (Wilcoxon test, $p = 0.006$). This supports the usefulness of longitudinal follow-ups in small cohorts, as they allow the identification of clinical transformations that may not be evident in cross-sectional analyses. Studies such as that by Muller et al. (2023) have demonstrated sustained improvements in quality of life and school integration in the long term, reinforcing the need for prolonged evaluations.[9]

Among the limitations of this study is the use of an unvalidated *ad hoc* scale. Its lack of standardization restricts comparability with other series. Additionally, the absence of contextual variables, such as socioeconomic status, caregiver education, or therapeutic adherence, represents a potential bias. Finally, the retrospective design and strict filtering for data completeness reduced the sample size, although they ensured the validity of the functional analyses. Future studies should incorporate standardized tools, expand the sample size, and utilize statistical models that simultaneously consider multiple clinical and contextual factors.

CONCLUSION

In this cohort with complete 5-year follow-up, most patients demonstrated satisfactory auditory-language performance, with a predominance of excellent results, as assessed by an *ad hoc* clinical scale. ■

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