

The Impact of Cochlear Implant in the Oral Language of Children with Congenital Deafness



O Impacto do Implante Coclear na Linguagem Oral das Crianças com Surdez Congénita

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ABSTRACT

Introduction: Children with severe to profound sensorineural deafness can acquire vocabulary and syntactic structures to communicate by oral language, after cochlear implant.

Aim: Identify the linguistic skills of children with cochlear implant.

Material and Methods: Eighteen children of both gender, between 9 and 10 years, with congenital bilateral deafness, using cochlear implant, were studied. The evaluation instrument used was Observation Chart of Language-School Level. The results were compared with standard of normal-hearing children with the same hearing age.

Results: The scores registered in the linguistics structures studied, comparing implanted children and standard, was: phonology, 29.44 ± 8.4 vs. 29.68 ± 5.90 , $p = 0.91$; semantics, 18.55 ± 8.89 vs. 19.20 ± 4.85 , $p = 0.76$; morpho-syntax 21.89 ± 12.85 vs. 26.35 ± 10.36 , $p = 0.159$. Regarding the tests of semantics, there was no significant difference. Concerning the tests of morpho-syntactic structure, the difference was significant in the derivation of words, 2.83 ± 2.81 vs. 4.65 ± 1.64 , $p = 0.014$. In the phonology, a significant difference was found comparing implanted children and standard, in the discrimination of pseudo words, 6.6 ± 2.8 vs. 8.37 ± 2.32 , $p = 0.023$. However, in syllabic segmentation, implanted children had a mean score 8.56 ± 1.6 significantly higher than standard, 5.9 ± 1.58 , $p < 0.001$.

Discussion: The similarity of the scores obtained by children with cochlear implants with the standard, in the language components studied confirms that cochlear implant promotes the development of oral verbal language in children with congenital deafness.

Conclusions: Implanted children had acquired language skills similar to normal-hearing children with the same hearing age.

Keywords: Child; Cochlear Implants; Hearing Loss, Sensorineural; Language Development; Speech Acoustics; Speech Perception.

RESUMO

Introdução: As crianças com surdez neurossensorial severa a profunda podem adquirir vocabulário e estruturas sintáticas para comunicarem pela linguagem oral, após implante coclear.

Objetivo: Identificar as capacidades linguísticas em crianças, com implante coclear.

Material e Métodos: Estudou-se a linguagem oral em 18 crianças, entre nove e 10 anos, com surdez neurossensorial profunda bilateral congénita, com implante coclear, avaliadas com a Grelha de Observação da Linguagem-Nível Escolar. As pontuações obtidas foram comparadas com as das crianças normo-ouvintes com igual idade auditiva.

Resultados: As pontuações nas estruturas linguísticas estudadas, crianças implantadas vs. padrão das normo-ouvintes foram: fonologia $29,44 \pm 8,4$ vs. $29,68 \pm 5,90$, $p = 0,91$; semântica $18,55 \pm 8,89$ vs. $19,20 \pm 4,85$, $p = 0,76$; morfossintaxe $21,89 \pm 12,85$ vs. $26,35 \pm 10,36$, $p = 0,159$. Nas provas da estrutura semântica, não se registaram diferenças estatisticamente significativas. Na morfossintaxe, a diferença foi estatisticamente significativa na derivação das palavras, $2,83 \pm 2,81$ vs. $4,65 \pm 1,64$, $p = 0,014$. Na fonologia, verificou-se diferença significativa, na prova de discriminação de pseudopalavras, $6,6 \pm 2,8$ vs. $8,37 \pm 2,32$, $p = 0,023$. Na segmentação silábica, as crianças implantadas tiveram uma pontuação significativamente superior ao padrão $8,56 \pm 1,6$ vs. $5,9 \pm 1,58$, $p < 0,001$.

Discussão: A semelhança das pontuações obtidas pelas crianças com implante coclear em relação ao padrão nas componentes linguísticas estudadas, confirma que o implante coclear promove o desenvolvimento da linguagem verbal oral nas crianças com surdez congénita.

Conclusão: As crianças implantadas obtiveram ganhos de linguagem similares às normo-ouvintes com igual idade auditiva.

Palavras-chave: Acústica da Fala; Criança; Desenvolvimento da Linguagem; Implantes Cocleares; Percepção da Fala; Perda Auditiva Neurossensorial.

INTRODUCTION

Severe to profound sensorineural hearing loss has a significant impact on oral language acquisition and development as well as school performance in affected children.¹

Cochlear implants enable language development in children with severe to profound congenital sensorineural hearing loss, in whom the benefit from electroacoustic hearing aids is limited.²⁻⁵ Several studies have supported the effects of this rehabilitation method in reducing the impact

of hearing loss, leading to the recovery of hearing capacity, sound perception and segmental speech parameters and therefore allowing for oral language development in early implanted children.^{1,6-10} A cochlear implant is more beneficial when applied before the age of three, allowing the young child to be exposed to sounds during the so-called critical period, in which neurological abilities are developed, allowing for a better learning of language and

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speech.^{11,12} An increasing number of studies involving implanted children shows that these are able to acquire the necessary vocabulary and syntactic structures in order to communicate through oral language, in a similar fashion to normally hearing children.¹³⁻¹⁷

Some of the methods aiming to assess the benefits of cochlear implantation in children with profound sensorineural hearing loss include the use of comparison patterns allowing for the confrontation of current linguistic performance of the implanted child with his own linguistic performance obtained in previous stages.^{14,15,18} Others relate the language of implanted children with non-implanted children with profound hearing loss^{19-21,26} or compare a child's current performance with their normally hearing equivalents with the same chronological or hearing age.^{1,22-26,28,29}

Different assessment instruments used in the analysis of language development allow for children language development to be examined.^{27,30} In Portugal, there are few studies on this issue and data regarding the results of implanted school-age children's linguistic skills assessment are scarce.

Our study aimed to identify the linguistic abilities of implanted children aged between nine and one month and 10 years of age and to compare these with standards for the normally-hearing Portuguese population with the same hearing age.

MATERIAL AND METHODS

Our study was approved by the Ethics Committee of the *Centro Hospitalar e Universitário de Coimbra (CHUC)*.

Eighteen children (eight young girls) were enrolled in the study, from a total of 58 implanted children aged between nine and one month and 10 years of age (average chronological age: nine years and six months) and hearing age between six years and one month and six years and 10 months (average hearing age: six years and five months), with bilateral profound sensorineural congenital hearing loss. All underwent surgery at the ENT Department of the *Unidade Funcional de Implantes Cocleares* in the *Centro Hospitalar e Universitário de Coimbra*. The average age at the time when hearing loss was diagnosed was 23.37 months in these children. Following the confirmation of sensorineural hearing loss, conventional hearing aids were applied and used for four months, on average. No child was submitted to any other form of communication before implantation. Implantation surgery was applied at an average of 33.93 months old, varying between 21 and 50 months. One month upon surgery, following cochlear implant's speech processor activation, all children attended speech therapy sessions on a daily basis. These had an average three-month duration, with at least four sessions per week, according to the CHUC Unit's protocol.

Patients were randomly selected from a group of previously implanted children under routine attendance. The data collection instrument were applied during the post-implantation re-evaluation speech therapy sessions.

Data were collected using the *Grelha de Observação da Linguagem - nível escolar (GOL-E)* (Language Observation Grid – school level) assessment instrument.³¹ This instrument assesses three linguistic structures - semantic, morphosyntax and phonology - and is included in a study protocol "*Protocolo de Avaliação de Crianças com Implantes Cocleares de Coimbra*" (PAC-IC). The GOL-E is suited to Portuguese primary school-age children aged between five years and seven months and 10 years and zero months. Each linguistic structure is assessed by different tests. The first test of semantic structure is *word definition*, aimed to assess the ability to describe concepts. Vocabulary range related to superordinate terms is assessed by the second test – *naming classes*. Knowledge of the opposite terms is assessed by the third test – *opposites*. Morphosyntactic structure's assessment is based on four tests. The ability to make grammatical judgements is assessed by the first one – *ungrammatical sentence recognition*. The ability to build complex subordinate and coordinate sentences from two simple sentences is assessed by the second – *coordination and subordination of sentences*. The capacities to order words to form sentences and the use of morphological rules to create derived words are assessed by a third and fourth tests – *word order in a sentence and derivation of words*. The phonological structure is assessed by four tests. The first two – *selection of words and selection of pseudo-words* – test the auditory discrimination ability. The abilities to identify rhymes and to segment words into syllables are assessed by the other two tests.³¹

The hearing age of implanted children was used as a reference to compare and analyse the score obtained by implanted vs. normally-hearing children and is the time between the activation of the speech processor in the cochlear implant and the last linguistic assessment of the implanted child. Their scores were compared to standards obtained from the GOL-E³¹ for normally-hearing children aged 6 years and 1 month to 7 years.

The statistical analysis used the One Sample t-test from the SPSS 20 software, with a significance level of $p = 0.05$.

RESULTS

The following results were found by general assessment of the three linguistic structures:

An average score statistically similar to the standard was obtained (18.55 ± 8.89 vs. 19.20 ± 4.85 , $p = 0.76$) by implanted children in the semantic structure, reaching a 96.3% percentage when compared to the linguistic abilities of normally-hearing children.

A 21.89 ± 12.85 score was found in implanted children regarding morphosyntax, which was lower to the standard value for normally-hearing children (26.35 ± 10.36), corresponding to 83.07% of the standard value. This difference was not statistically significant ($p = 0.159$).

The average score (29.44 ± 8.4) obtained by implanted children in phonology was statistically similar to the standard value in normally-hearing children (29.68 ± 5.90 , $p = 0.91$), corresponding to 99.1% of the standard average value in

normally-hearing children. These data are shown in Fig. 1.

We found that the results were statistically similar to the standard values through the analysis of the three tests included in the semantic structure, as shown in Fig. 2. The implanted children obtained a 7.1 ± 4.2 score in the word definition test vs. 8.13 ± 2.20 in normally-hearing children ($p = 0.29$). The average score in naming classes test was higher in implanted children, although statistically similar to the standard value (5.9 ± 2.8 vs. 5.15 ± 1.96 , $p = 0.28$). A 5.3 ± 2.45 score was found in implanted children in the opposites test, a value similar to the standard (5.93 ± 2.59 , $p = 0.38$).

As regards the morphosyntactic structure, a 9.6 ± 6.0 score was obtained by implanted children in the ungrammatical sentence recognition test vs. 12.43 ± 4.73 , $p = 0.065$, when compared to the standard in normally-hearing children. The results were very similar to the standard in the test of coordination and subordination of sentences (3.8 ± 2.7 vs. 3.53 ± 3.11 , $p = 0.63$ and 5.6 ± 3.5 vs. 5.73 ± 3.69 , $p = 0.86$). In contrast, the test of word order in a sentence and derivation of words was significantly lower in implanted children, when compared to normally-

hearing children. A 2.83 ± 2.81 average score was obtained in the test and the reference scores were 4.65 ± 1.64 , $p = 0.014$. The comparison of scores obtained in the tests of the morphosyntactic structure by the implanted children in our study vs. the standard values are shown in Fig. 3.

The scores in subtest of word pairs obtained by implanted children in the tests of phonological structure were statistically similar to the standard (7.33 ± 2.76 vs. 8.35 ± 2.55 , $p = 0.137$), unlike the pseudo-word discrimination subtest, where scores were significantly lower than the reference (6.6 ± 2.8 vs. 8.37 ± 2.32 , $p = 0.023$). The implanted children obtained statistically similar results to normally-hearing children in the subtest of rhyme identification (6.7 ± 3.7 vs. 7.05 ± 2.30 , $p = 0.712$). The test of the ability to segment words into syllables showed the highest scores obtained by implanted children, when compared to normally-hearing children (8.56 ± 1.6 vs. 5.9 ± 1.58 , $p = 0.001$). The results of the phonology tests are shown in Fig. 4.

DISCUSSION

The small number of children in our study was its

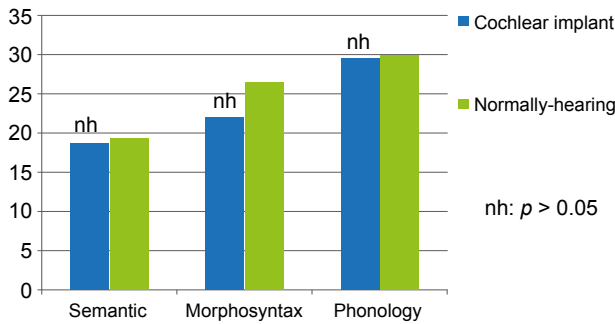


Figure 1 – Comparison of average score obtained by implanted vs. normally-hearing children in the three structures included in the *Grelha de Observação da Linguagem – nível escolar*.

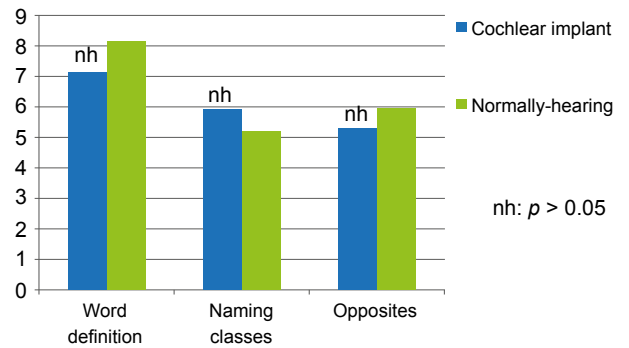


Figure 2 – Comparison of the average score obtained by implanted vs. normally-hearing children in semantic tests included in the *Grelha de Observação da Linguagem – nível escolar*.

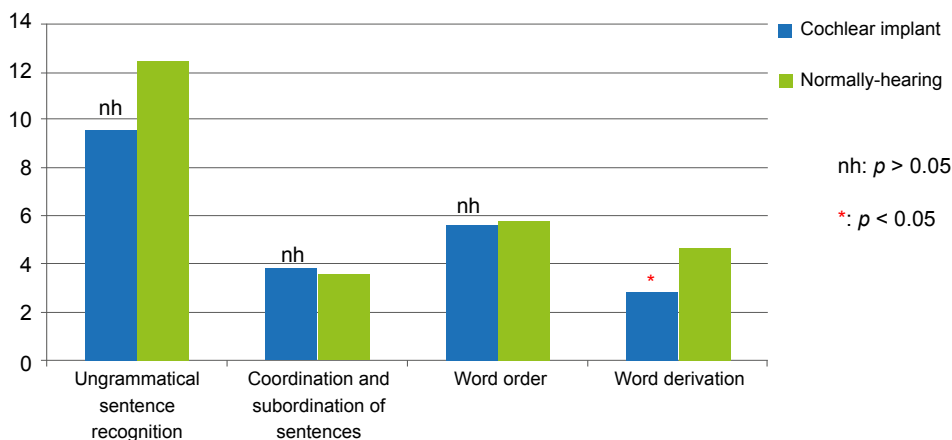


Figure 3 – Comparison of the average score obtained by implanted vs. normally-hearing children in morphosyntactic tests included in the *Grelha de Observação da Linguagem – nível escolar*.

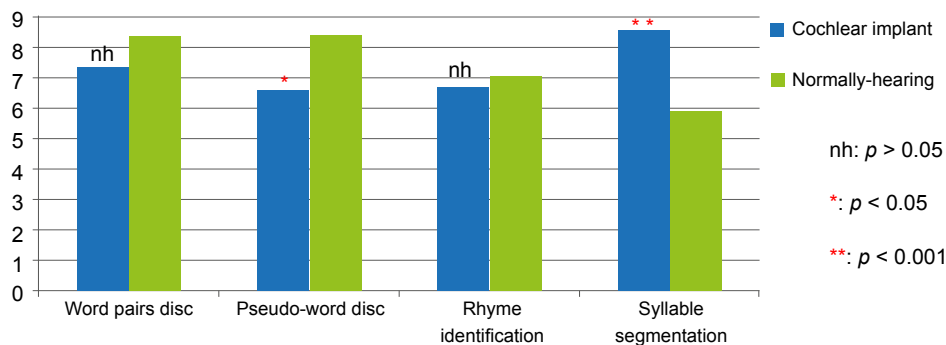


Figure 4 – Comparison of average score obtained by implanted vs. normally-hearing children in phonology tests included in the *Grelha de Observação da Linguagem – nível escolar*.

major limitation. Nevertheless, the results allow for some interesting conclusions to be reached.

Statistically non-significant differences were found in scores obtained by implanted vs. normally-hearing children in the three linguistic components analysed in our study, supporting the conclusion that the use of cochlear implant allows children with congenital profound hearing loss to obtain major improvements in oral language development. The option for cochlear implantation in children with congenital profound hearing loss has enabled improvements in language development that the previous methods would probably never obtain. The use of conventional hearing aids, although enabling considerable improvements in oral language, may present some limitations. The studies comparing the language improvements in children with hearing aids to those obtained by implanted children have previously shown higher oral linguistic skills in the latter.^{15,32-34}

The age of implantation and the time of use of cochlear implantation are two significant factors that influence oral language skills acquired by children with profound hearing loss.³⁵⁻³⁷ The fact that the children in our study had a hearing age between six years and one month and six years and 10 months may have had a relevant influence on the results. An increase in the time of use of cochlear implantation and obviously in children's age showed higher linguistic improvements in children upon implantation, as supported by several authors.^{38,39}

The language improvements in certain tests showed differences when compared to standards, some of which were very significant. In the semantic structure, the scores obtained by implanted children in word definition, naming classes and opposite test were very similar to the standard scores. These language improvements correspond, even partially, to speech therapy follow-up, as well as to the child's frequent family and school predominant exposure to oral language.

As regards morphosyntax, implanted children showed significantly lower improvements in derivation of words when compared to normally-hearing children, with the lowest

score in all the tests. This data confirmed that derivation of words was one domain in which implanted children show more difficulties, in line with what was described by other authors. Boons et al.⁴⁰ confirmed these difficulties in approximately 50% of the implanted children in their study. Geers and Sedey⁴¹ obtained similar results in a study involving 112 children aged 10 or above, implanted between two and five years of chronological age. However, the score obtained by implanted children in the other subtests within the same structure – ungrammatical sentence recognition and coordination and subordination of sentences – did not show statistically significant differences. The implanted children also showed a good ability in word order in a sentence. Morphosyntactic linguistic skills reflect learning at school and its association to daily knowledge.

In phonology, implanted children showed a low score in the test of selection of pseudo-words, despite having obtained an average score statistically similar to normal, in line with the study by Bouton, Colé and Serniclaes, involving 25 implanted children, in whom they also found this to be a difficult domain.⁴² In contrast, implanted children obtained results significantly above standards in syllable segmentation. A requirement for special need education in school in association with follow-up in speech therapy has a great relevance in this domain^{43,44} and is therefore expected to support major improvements.

Our results show that the use of cochlear implants in children with severe to profound hearing loss is an important way to obtain significant improvements in learning and use of oral language, as described by Niparko *et al.*¹⁸ and Ostojčić *et al.*²⁸ Progression may be slower in some aspects of language, namely in selection of pseudo-words and in word derivation, in the early stages of the hearing age and fall short of perfection.⁴² This demands for a reflection focused to search for solutions aiming at progressive language improvement in implanted children. This solution may include more attention to these aspects by speech therapists in close collaboration with the teacher's intervention, warned about these children's special language requirements at

school. Nevertheless, as described by Martini *et al.*,¹¹ the use of this element in making language development easier for children with hearing loss should be encouraged as it has proven its benefits for children whose disability might otherwise jeopardize their social integration and personal development.

We consider that further larger studies will allow for a better assessment of these parameters.

CONCLUSIONS

Implanted children involved in our study generally obtained good performance in phonology, morphosyntactic and semantic tests, with similar scores to normally-hearing children standards. The language improvements in implanted children showed to be significantly lower in the word derivation morphosyntactic test as well as in phonology pseudo-word selection test. Our study, despite involving a small number of participants, showed, in line with the literature, that cochlear implants are an efficient hearing rehabilitation method in reducing the impact of sensorineural severe to profound hearing loss and in the promotion of oral language development in children with bilateral congenital profound hearing loss.

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HUMAN AND ANIMAL PROTECTION / DATA CONFIDENTIALITY

The authors declare that the study was approved by the Ethics Committee of the *Centro Hospitalar e Universitário de Coimbra*. The authors declare that they have followed the protocols of their work centre on the publication of patient data.

CONFLICTS OF INTEREST

The authors declare that there were no conflicts of interest in writing this manuscript.

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