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Effectiveness of cochlear implants in children: Long term results

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ABSTRACT

Objectives: This study aimed to evaluate the effectiveness, according to the hearing threshold and language performance, of cochlear implants through a period of 10 or more years of follow-up.
Methods: A retrospective chart review was conducted. 132 patients were selected from the children's population that underwent cochlear implantation at the Department of Otorhinolaryngology, Centro Hospitalar e Universitário de Coimbra, from 1992 to 2001, with a minimum follow-up period of 10 years.

A comparison of the pure-tone and speech audiometric thresholds between two periods (T0 and T1) was performed. T0 refers to the initial evaluation, immediately after the rehabilitation programme, within the first year after cochlear implantation. T1 refers to the most recent annual assessment, carried out in 2010 and 2011. Speech understanding was also evaluated through word and sentence recognition tests.
Results: No statistically significant differences were found between early and late assessments, in paediatric cochlear implants users, after a 10 years period of cochlear implantation. Both speech and pure-tone audiometry seem to stabilize except for 2000 Hz where the results were even better after 10 years. Factors such as age at time of implantation, duration of deafness, aetiology and exchange of the speech processor do not seem to have a role in auditory performance after a long rehabilitation period. In tests of verbal discrimination rates of words and phrases recognition were of 84.6% and 65.1%, respectively.
Conclusions: Cochlear implant is an effective treatment for severe to profound hearing loss in children, contributing to a hearing performance and an appropriate language acquisition, currently comparable to normal hearing children. These benefits appear to keep stable over the years. No deterioration was identified.

1. Introduction

Cochlear implants (CI) are nowadays a widely accepted treatment for sensorineural hearing loss [1,2].

Since the 1990s, after the *Food and Drug Administration* (FDA) approval of CI in children above 2 years of age, the number of paediatrics implants has greatly increased. More recently, under the scenery of expansion of the indications criteria for CI in the paediatric population together with the technological developments in the processes of both fabrication and assessment of the CI function, conducted to the publication of several studies aiming the evaluation of the results involved, but most of them with a short follow-up not exceeding 5 years after implantation [3,4].

The benefits of the CI towards the several areas of hearing development and the acquisition of language are presently unquestionable. The actual status of development and efficacy is such that the results and the improvement in the capacity of the communication of the implantees are nowadays analyzed against their peers with normal hearing, and no more against with children with moderate to severe deafness with hearing aids, as a few years ago [2,5]. Nevertheless, children with CI show an important variability. Several factors, such as the aetiology of deafness, the age of the child at the time of the CI, the presence of residual hearing, the process of the auditory rehabilitation, the family participation in the therapeutic process, all may influence the final performance [6–8].

However, it is still not known if these factors also have influence in the medium and long term results, nor if these benefits are stable in the long-range. At the present moment there are still very few studies evaluating the results of the CI longer than 7 years [9,10].

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Besides the individual variability and the role of the factors mentioned previously, multiple aspects should be taken in consideration: the CI is an electro-medical equipment, subject to failures and deterioration [4,11]; also, a possible non-detected pre-surgery lesion or a later disease of the central or peripheral auditory pathways, may influence the hearing performance, sometimes only detected after years of evolution [4]. As such, studies evaluating the performance of children with CI in the long-terms are required. Only with this data will be possible to inform professionals and families about the necessary interventions and clarification of expectations, as well as to better understand the factors involved in the process of development of communicative, academic and occupational skills of children who grew up using the CI [4,12,13].

The aim of this study is to assess the auditory effectiveness of the children who underwent a CI longer than 10 years ago. Considering the biological and technological variables involved, it is intended to evaluate if the auditory function remains stable or if it is deteriorates in users of CI.

2. Patients and methods

2.1. Characterization of the population and sample

Data was collected from all the paediatric patients (below 18 years old, at the implantation time) with severe to profound sensorineural hearing loss, pre or post-lingual, who underwent cochlear implantation in the period between 1992 and 2011, performing a total of 365 patients. From this study, only the children who had a CI for at least 10 years, 1992 and 2001, were selected. This time limit was established because it was considered to be the reasonable working time for an electronic device as well as it also represents the warranty period of the CI provided by the commercial companies.

The indication for CI was a severe or profound neurosensory bilateral hearing loss, assessed by behavioural methods (pure-tone audiometry) and electrophysiologic methods (brainstem evoked potentials), showing benefits from the use of hearing aids for a period of at least 3 months, with no medical, surgical or psychological contraindications, and with realistic expectations from the children and their families in what concerns the auditory results and their evolution. Children who, by clinical assessment at the otolaryngology consultation of pre-implantation, presented with polymalformative syndromes or cognitive alterations clinically relevant which would influence the limitations in the hearing rehabilitation ability were excluded.

2.2. Studied variables

1. Speech and pure-tone audiometric thresholds of the timings 0 (T0) and 1 (T1)

   Speech and pure-tone audiometric thresholds of the timings 0 (T0) and 1 (T1), obtained on open field (the average tonal auditory threshold is calculated through the sum of the averages of the frequencies of 500, 1000, 2000 and 4000 Hz divided by four).

   T0 – time of audiological evaluation at the end of the process of rehabilitation, within the first year after the cochlear implantation, between 1992 and 2001.

   T1 – moment of the more recent audiometric evaluation, undertaken by the end of 2011. The protocol in us at the department establishes an annual evaluation for all the patients who receive a CI, after the first year.
2. Language and Speech Perception tests

   It was assessed using several tests: recognizing monosyllables, words (100 words test) and sentences; recognizing phonemes and numbers [14]; Categories of Auditory Perception (CAP) [15]; Speech Intelligibility Ratio (SIR) [15]; Meaningful Auditory Integration Scale (MAIS) [16] and Meaningful Use of Speech Scale (MUSS) [16]. These more specific tests were performed at the Department of Audiology and Speech Therapy, Centro Hospitalar e Universitário de Coimbra, only after 2010.

The Monosyllables Test is an open election test. It consists of three lists with 20 monosyllables, presented according to age. The results are recorded in two ways: rates of words and phonemes correctly repeated.

The Numbers Test is an open election test. It comprises two lists of numbers presented as a function of age. The results are recorded in two ways: percentage of words and phonemes correctly repeated.

The Phrases Test and test phrases on the phone is a test of open election. It comprises a list of phrases, which are highlighted keywords presented as a function of age. The results are accounted for by the number of keywords correctly repeated.

The 100 words test consists of a disyllabic word list presented according to age. The results are accounted for by the percentage of correctly repeated words.

The Categories of Auditory Performance (CAP) is a scale of eight categories of increasing difficulty and is intended to assess the level of auditory performance, with zero corresponding to the absence of any response and seven and ability to use the phone with a known caller.

The Speech Intelligibility Ratio (SIR) is a scale with five categories of increasing difficulty and is intended to evaluate the intelligibility of speech. The level 1 corresponds to a speech unintelligible and five to a speech intelligible to all listeners.

The Meaningful Auditory Integration Scale (MAIS) is aimed for parents and designed to assess the child's spontaneous reactions to the sound in your daily environment. The performance is scored in a total of 40 points.

The Meaningful Use of Speech Scale (MUSS) is aimed for parents and designed to evaluate the use of speech by children in everyday situations. The performance is scored in a total of 40 points.

All collected and studied results were analyzed against factors considered to be important in auditory performance, such as: time of deafness, age at implantation, aetiology of deafness and return of the speech processor. The goal was to assess whether the overall relationship of pure-tone and speech audiometry, at T1 and T0, and the speech perception were influenced by those factors.

The audiological data reported to the results of pure-tone audiometry (frequency range 250–6000 Hz) and speech audiometry, in sound field, using the IC. The presentation of stimuli was performed in a soundproof room with the use of audiometer GSI61 (Clinical Audiometer®, USA), equipped with the evaluation system in the open field. The evaluation of speech recognition and discrimination was made by open-set of distinct vocal stimuli integrated in several tests, using auditory stimuli lists, with or without visual cues, depending on the age. Tests using the monosyllables, phrases and numbers were presented in a soundproof room at 65 dB SPL (average intensity of normal speech – calibration standard: ISO 8253-3).

2.3. Statistical analysis

All data were entered in a database table of SPSS – Statistical Programme for Social Sciences, version 17.0 – for the statistical analysis [17]. The sample's characteristics were described using summary appropriate statistics measures: frequencies, absolute and relative, and continuous variables through the measures of central tendency and dispersion measures.