Review Article

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Prelingual deafness: Benefits from cochlear implants versus conventional hearing aids

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Summary

Introduction: The majority of patients with hearing loss, including those with severe hearing loss, benefits from the use of hearing aids. The cochlear implant is believed to achieve better results in a child with hearing loss in cases where the severity of disability renders hearing aids incapable of providing adequate sound information, as they require sufficient cochlear reserve so that acoustic detention occurs.
Objective: To assess if cochlear implants provide more benefit than conventional hearing aids in prelingually deaf patients.
Summary of the findings: The study was a systematic review of scientific papers selected by a search of the SciELO, Cochrane, MEDLINE, and LILACS-BIREME databases. Among the 2169 articles found, 12 studies proved relevant to the issue and presented an evidence strength rating of B. No publications rated evidence strength A. Seven of the studies analyzed were prospective cohorts and 5 were cross-sectional studies.
Conclusion: Based on several studies, cochlear implants were demonstrated to be the best current alternative for bilateral severe or profound hearing loss, achieving better results in speech perception and development in prelingual children when compared to conventional hearing aids.
Keywords: cochlear implants, hearing loss, sensorineural, deafness, hearing aids.

Introduction

Most patients with hearing loss, including severe loss, benefit from the use of hearing aids (HA) (1). In cases where the severity of the deficiency renders HA incapable of providing appropriate acoustic information, it is believed that a cochlear implant (CI) produces the best results in the rehabilitation of children with hearing loss, since they require sufficient cochlear reserve for sound detection (1).

Cochlear implants directly stimulate the cochlear nerve fibers and enable better perception and discrimination of speech, sounds of the environment, and alerts (2). Patients can acquire auditory performance comparable with that of individuals with mild/moderate hearing loss; however, the performance and evolution depend on age and the duration of deafness (1,2). Previously, some authors supported the idea that better speech perception would be achieved only by children who received CI at young ages, which has been contradicted in the last few years, when good results were obtained in children with prelingual deafness undergoing implantation at older ages (3).

In recent years, many studies were published comparing the hearing results obtained in patients with severe to profound hearing loss that used HA or CI (1). The aim of this study was to evaluate, by using as reference articles available from the worldwide literature, whether CI confer superior benefits than HA do in patients with prelingual deafness.

Literature Review

This study was a systematic review of the medical literature following a search made in June 2010 that included articles in Portuguese, English, and Spanish from the last 10 years. The search for relevant references was made through the SciELO, Cochrane, MEDLINE, and LILACS-BIREME databases. We selected papers that presented A or B strengths of evidence addressing the comparison between HA or CI in the pediatric population with prelingual deafness. The following mesh terms (keywords and delimiters) and their corresponding translations and varying combinations were used: cochlear implants/cochlear implantation; hearing aid; therapy; prognosis; comparative study.

Of the 2169 articles retrieved, 12 proved relevant to the theme and presented B strength of evidence (11 demonstrated 2b strength of evidence (2-12) and one, 2c (1)). We did not find papers with A strength of evidence. Among the study designs analyzed in the review, 7 were prospective cohorts (2-4,7,9-11) and 5 were transversal studies (1,5,6,8,12) (Table 1).

Children that present sufficient hearing to permit HA use develop a characteristically vocal pre-verbal style of conversation and hearing, may acquire good understanding, and use spoken language. Tait and Lutman (4) investigated pre-verbal conversation in 27 children that used CI or HA through videotape recordings and their subsequent analysis. They affirmed that the CI appeared to promote similar development of pre-verbal behavior in children with profound deafness that was not produced with regular HA. Thus, it could be possible that children implanted at too young an age may continue to develop age-appropriate understanding of speech and intelligible speech.

Through the Gestel-Nijmegen test of speech perception applied in 64 children, Vermeulen et al. (5) observed that CI users obtained better results than those with HA did.

Van den Borne et al. (2) analyzed the capacity to detect daily sounds that were measured on a scale of 1–4 points. The scale was applied before the patients received the CI and at 6, 12, 24, and 36 months after the devices were introduced. In the same period, there was improvement in the obtained score by 3.5 and 1.9 points in CI recipients and HA users, respectively. In the same study, the authors reported on speech perception by means of the Scales of Early Communication Skills for Hearing-Impaired Children that evaluate speech and language development in deaf children aged 2–9 years. In these scales, HA users obtained better scores than those with CI, but the authors discussed whether its use and sensibility were adequate.

Osberger et al. (6) evaluated 30 children above 5 years old. Speech perception was measured with 3 tests (Early Speech Perception (ESP), Glendonald Auditory Screening Procedure (GASP), and Phonetically Balanced Kindergarten Test (PB-Ktest)) before CI implantation and HA use and at 3 and 6 months after the introduction of each

Table 1. Characteristics of the studies included in the review.

Study	Year	Type of Study Sample	Size	Age Group	Assessment Tool	Strength of Evidence
Tait and Lutman	1994	Prospective Cohort	27	3–4 years	Video Recording	B/2b
Vermeulen et al.	1997	Transversal	64	4–8 years	Speech Perception Test	B/2b
Van den Borne et al.	1998	Prospective Cohort	43	2–9 years	Scales of Early Communication Skills for Hearing-Impaired Children Detection of everyday sounds	B/2b
Osberger et al.	1998	Transversal	30	>5 years	Early Speech Perception (ESP), Glendonald Auditory Screening Procedure (GASP), Phonetically Balanced Kindergarten Test (PB-Ktest)	B/2b
Osberger et al.	1999	Transversal	58	2–17 years	PB-Ktest, GASP, ESP, Mr. Potato Head Task, Test of regular phrases	B/2b
Svirsky and Meyer	1999	Prospective Cohort	297	<12 years	PB-Ktest	B/2b
Tomblin et al.	1999	Prospective Cohort	58	2–14 years	Index of Productive Syntax	B/2b
Mildner et al.	2006	Transversal	49	<2 years	Visual/words comprehension	B/2c
Ibertsson et al.	2008	Prospective Cohort	39	5–8 years	Discrimination of words	B/2b
Most et al.	2009	Prospective Cohort	30	10–19 years	Hearing and audio-visual perception of phonemes	B/2b
Most and Aviner	2009	Prospective Cohort	40	10–17 years	36 items recorded on video and 6 presentations of each of the following emotions: anger, fear, sadness, happiness, disgust, and surprise	B/2b
Baudonck et al.	2010	Transversal	73	6–15 years	Speech Perception Test	B/2b

device. All results revealed better responses for the CI group.

In the prospective cohort study performed by Tomblin et al. in 1999 (7), the authors reported measures of speech production using the Index of Productive Syntax (IPSyn) to analyze children recounting stories. The results revealed an average difference of total scores of 19.6 in 5 years in favor of CI. However, the results may have been influenced by biases: the group of implanted patients had the advantage of repeated exposure to the test. Analysis of regression showed that when age was included, time of CI use was the main factor of the IPSyn score.

Osberger et al. (8) studied the speech perception of 58 pre- and post-implant patients through 5 tests (PB-Ktest, GASP, ESP, Mr. Potato Head Task, and regular phrases test). All patients obtained gains in all tests after more than 18 months, with an average difference of scores between pre- and post-implant testing of 19.9 for the regular phrases test to 56.5 for the ESP. All evaluations favored CI ($p < 0.0001$).

In 1999, Svirsky and Meyer (9) applied the PB-Ktest in 297 children using CI or HA. In the children, aged between 6 and 12 years, the average score of the CI-implanted group improved by 6.3% in 18 months, that in children aged below 6 years was in 6.5 in 12 months. However, the authors reported insufficient information to calculate the difference in the scores for the HA group.

Mildner et al. (1) used a transverse study to compare children using CI and those using HA. They found an average gain in visual understanding and in words orally presented of 82.8% and 60.4% in the CI and HA users, respectively (difference of 22.4%, $p < 0.01$).

Ibertsson et al. (10) investigated the discrimination of words in 3 groups of 13 individuals with hearing loss. The children with CI obtained an average of 38.5%, that of HA users was 79.5%, and that of children with specific language impairment was 61%.

In 2009, Most et al. (3) studied 3 groups of patients: CI users, HA patients with severe hearing loss, and HA users with profound hearing loss. They demonstrated that the performance in the CI users significantly overcame that of the patients who used HA due to profound hearing loss. The CI users achieved similar results to that of the HA users with severe hearing loss in phonemes perception and in low-intensity audio-visual sentence perception.

Most and Aviner (11) studied the perception of emotion in CI patients implanted at early and advanced ages, in patients using HA, and in teenagers with normal hearing. The stimulus was visual, hearing, and combined hearing-visual. The results revealed that the teenagers with normal hearing achieved the best hearing identification. Both groups of hearing-loss patients revealed comparable perception of emotions through the visual and hearing-visual stimulus. The advantage of CI over HA was not evident and the correlation between the ages of implantation was insignificant. Although the age of implantation did not demonstrate a statistical difference, the authors themselves discussed the fact that the youngest age for the CI surgery in their study was 2.6 years, and that the results may have been different if the procedure had been performed earlier.

In 2010, Baudonck et al. (12) compared the intelligibility between children with normal hearing and those with hearing loss rehabilitated through CI or HA. The HA group produced more replacements ($p = 0.021$), omissions ($p = 0.009$), and above all, more mistakes in total ($p = 0.005$). Distortions were the most common type of error in both hearing-impaired groups: 62% in CI and 52% in HA. In children with HA, the comparative number of omissions was greater than that in the children with CI ($p = 0.024$). The early implant children presented a better performance in different phonetic and phonological characteristics in comparison to the children using HA, similar to the performance of normal-hearing children.

Discussion

Research development in the areas of audiology and deafness diagnosis and treatment has extensively contributed to the advance of knowledge in this multidisciplinary field of action.

The present systematic review of the subject has revealed a wide range of material comparing the results obtained for CI or HA users, which mostly included the acquisition and perception of speech. On the other hand, only 1.8% of the studies presented relevant strength of evidence in a time when evidence-based medicine has become increasingly crucial, mainly so that conduct is standardized.

In general, the results of these studies demonstrated the unquestionable benefits of CI in linguistic development, perception of environmental sound, speech, the process of learning, and in emotional and social areas.

Our main critique of the articles is of a methodological nature, since many measures of analysis were found for pre- and post-operatory hearing outcomes (scales and tests), rendering it difficult to compare the results of each

author. However, some important tests were not mentioned, such as the Meaningful Use of Speech Scales and the Meaningful Auditory Integration Scale, and interview scripts used with the patient's parents, which would have provided information related to the frequency with which the children exhibited significant oral language behavior day by day.

Since 1990, the Food and Drug Administration approved the implementation of CI in children aged 2 years and up, and an increasing number of children have received CI. The CI has been established as the technological device with the greatest effectiveness for treatment of severe to profound sensorineural deafness currently available.

The benefits from CI in children under 6 years of age with bilateral severe to profound sensorineural deafness were not provided by HA use over a 3 month-period. In children aged 7–12 years, CI is indicated when there is bilateral severe to profound sensorineural hearing loss with open-set sentence recognition with HA use in both ears of 50% or less, and the presence of an established linguistic code.

Final Comments

Evaluation of the benefits received by hearing-impaired children through CI is of fundamental importance to conduct candidates through the procedure and familiarization orientation. After the analysis of strength of evidence and grade of scientific recommendation of the studies included in this systematic review, it was possible to conclude that there was consensus between the authors in that CI conferred greater benefits compared to conventional HA for the acquisition of linguistic and communicative skills in patients with prelingual deafness.

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