International Journal of Pediatric Otorhinolaryngology 78 (2014) 1327–1331

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Pre-school children have better spoken language when early implanted

Domenico Cuda [a,*], Alessandra Murri [a], Letizia Guerzoni [a], Enrico Fabrizi [b], Valeria Mariani [a]

[a] Department of Otorhinolaryngology, "Guglielmo da Saliceto" Hospital, Via Cantone del Cristo 40, Piacenza 29121, Italy
[b] Department of Economics and Social Sciences, Università Cattolica del S. Cuore, Via Emilia Parmense 84, Piacenza 29122, Italy

ARTICLE INFO

Article history:
Received 7 April 2014
Received in revised form 17 May 2014
Accepted 20 May 2014
Available online 2 June 2014

Keywords:
Spoken language development
Hearing loss
Cochlear implant
MacArthur-Bates Communicative Development inventory
Language skills

ABSTRACT

Objectives: The objectives of this study were: (1) to investigate the effect of age at cochlear implantation (CI) on vocabulary development; (2) to evaluate the age effect at CI surgery on the syntactic development; and (3) to examine the role of gender, age at first diagnosis and maternal education level on spoken language development.
Material and methods: Retrospective study. Thirty children with congenital severe- to -profound sensorineural hearing loss (SNHL) were sampled. They were diagnosed and fitted with hearing aids through six months of age. They were implanted between 8 and 17 months of age. The MacArthur-Bates Communicative Development Inventory (MCDI) was administrated at the age of 36 months. The total productive vocabulary (word number raw score), the mean length of utterance (M3L) and the sentences complexity were analysed.
Results: The average word number raw score was 566.3 for the children implanted before 12 months of age versus 355 for those implanted later. The M3L was 8.3 for those implanted under 1 year versus 4.2 of those implanted later. The average sentences complexity was 82.3% for those receiving CI before 12 months, while it was 24.4% for those underwent at CI after 12 months. Regression analysis revealed a highly significant and negative linear effect of age at CI surgery on all outcomes. Females had better outcomes. Age at diagnosis was not correlated with the linguistic results. The mother's education level had a positive significant effect on sentences complexity.
Conclusion: The CI in pre-school children with SNHL implanted under 1 year has a positive effect on spoken language. Females seem to have better linguistic results. Finally high maternal educational level appears to have some positive effect on language development.

1. Introduction

It is well recognized that the age at cochlear implant (CI) is an important factor for the spoken language development in congenital deaf children [1–5]. In particular a positive relationship between early age at implantation and improved speech and language abilities seems to exist [6]. The early CI restores the auditory feedback and facilitates the development of preverbal and vocal skills, essential precursors of aural and oral communication [7,8]. Restoring hearing gives to the deaf children the opportunity to develop the language at a near normal rate and to minimize the language delay compared to normal hearing children.

However, there are some controversies about the best age for providing the CI. It is well known that in very young children the peri-operative audiologic evaluation is difficult and there may be diagnostic errors with subsequent under or over treatment. Furthermore, anaesthetic risk is an important consideration for children younger than 1 year of age, although data in the CI literature support perioperative safety in this population [9,10]. Finally, some authors suggest that the benefits of performing CI in the first year of age instead of the second age are very small [11]. Therefore, some further evidence to assess what is the correct age at which children might receive CI seems necessary and, in particular, it's important to explore the age around 1 year.

The objectives of this study were: (1) to investigate the effect of age at CI on vocabulary language development in a group of children implanted between 8 and 17 months of age when they are 36 months old; (2) to evaluate the effect of age on the syntactic development; and (3) to examine the role of gender, age at first diagnosis and maternal education level on spoken language development.

* Corresponding author. Tel.: +39 523303262; fax: +39 523303273.
E-mail address: domcuda@libero.it (D. Cuda).

http://dx.doi.org/10.1016/j.ijporl.2014.05.021
0165-5876/

2. Methods

2.1. Study design

This was a retrospective nonrandomized group study. The local ethic committee of the first author's affiliation approved the study protocol.

2.2. Subjects

Thirty children (17 females; 13 males) with congenital bilateral severe- to -profound sensorineural hearing loss (SNHL) were included in this study. All of them were treated and followed at "Guglielmo da Saliceto" Hospital. In particular, the sample included all cases consecutively observed who fulfilled the following criteria: (1) SNHL identified with universal newborn hearing screening programme; (2) age at amplification and enrolment in intervention services below 6 months of age; (3) genetic SNHL due to mutations of connexin 26 genes; (4) no evidence of inner ear malformations at either high-resolution CT scan and MRI evaluation; (5) no significant visual, motor or cognitive problems that might interfere with speech and language development; (6) inclusion in an auditory-verbal (AVT) rehabilitation programme; (7) normal hearing parents and Italian as the native language.

The age at SNHL identification ranged from two to six months of age, with a mean of 3.7 months (SD $\pm$ 1.4). Age at first amplification and intervention enrolment ranged from three to six months, with a mean of 4.8 (SD $\pm$ 1.2).

The click-evoked auditory brainstem response (ABR) was absent at 90 dB nHL in all cases. All children were evaluated with visual reinforcement audiometry (VRA) using insert phones before CI surgery; the PTA (250–1000 Hz) was 101.6 dB on CI ear and 98.7 dB on contralateral ear. In particular, there was not a significant PTA difference between children implanted before and those implanted after one year of age ($p = 0.92$).

All children were implanted with a Nucleus multichannel device (Cochlear Ltd., Sydney, Australia). The mean age at CI surgery was 11.8 months (SD $\pm$ 3.2). In particular, 14 children received CI before twelve months of age and 16 children at or after twelve months of age. The activation of speech processor was achieved an average of 21 days (SD $\pm$ 3.5) after the CI surgery. Twenty-seven subjects used bimodal stimulation (CI on one ear and hearing aid on the opposite ear). Three children had a sequential bilateral cochlear implant after 23 months on average of their first surgery. All subjects used the CI throughout the day. The MacArthur-Bates Communicative Development Inventory (MCDI) [12] was administrated at the age of 36 months, so the mean time of CI use was 24.2 months (SD $\pm$ 3.2).

Participants' parental education level was measured by the number of years legally required to attain the education levels they declare. In the Italian formal education system compulsory education lasts 8 years; 13 years are needed to obtain a high school diploma and 18 to reach a full degree. Some special schools may have intermediate lengths. The mean years of formal education system was substantially equivalent between mothers (15.5 years) and fathers (16.3 years). Approximately 53% of children had mothers who had graduated from university, 40% of them had mothers with high school graduation and finally, the mothers of two children had just graduated from middle school.

2.3. Spoken language measurement

The MCDI, Italian edition [13], was used to analyse the language development. This is a widely recognized parent report tool used to assess the early language skills development of children for clinical and research purpose. It comprises two separate forms based on the age of children:

- "Gesture and Word" form addressed to children between 8 and 17 months of age explores vocabulary development and early production of communicative gestures;
- "Words and Sentences" form for children between 18 and 36 months evaluates the words and phrases production of vocabulary, grammatical development and the length of the sentence. This form included 3 parts: part I is a 680 word vocabulary production checklist; part II assesses how children use the grammar; part III focuses how children use the phrases in terms of the complexity of the sentence and utterance length.

2.4. Procedure

All children were evaluated at chronological age of 36 months with the MCDI "Word and Sentences" form. The parents received the inventory some days before the compilation because they had to observe the language behaviour of their child. Parents completed the inventory during a clinical session under the speech and language therapist overseeing. In most of cases, mothers completed the inventory because in this sample they had a greater availability of time in accompanying children to the clinical sessions (25 mothers and 5 fathers). The following subsections of "Word and Sentences" form, part I and III, were then analysed: total productive vocabulary, mean of three longest utterances (M3L) and the sentences complexity.

2.5. Statistical analysis

The relationship between age at cochlear implantation and total productive vocabulary, M3L and sentences complexity were analysed using regression models. The exploratory scatter plots (Figs. 1–3) highlighted a negative relationship in all the three cases and justified the assumption of a linear functional form for the regression equation. Gender of the child, age at diagnosis, and maternal educational level were also considered in the regression equations. A quadratic function of age at cochlear implantation has also been considered to explore the presence of non-linear relationships.

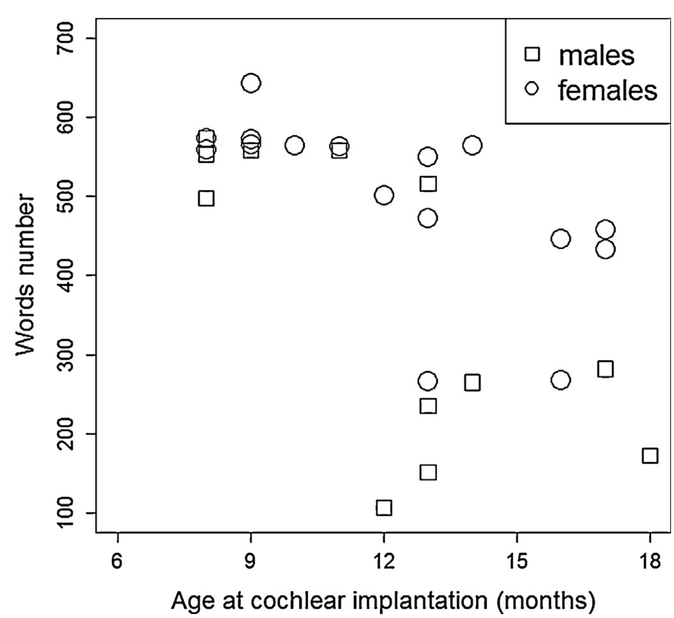

Fig. 1. Age at cochlear implantation (months) versus words number measured at the age of 36 months with MacArthur-Bates Communicative Development Inventory (MCDI) in a sample of 30 children with congenital severe- to -profound SNHL.