



# Long-term functional and behavioral–emotional outcomes in children with early cochlear implants: Parental testimonies



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## ABSTRACT

**Objectives:** (1) To assess the long-term effects of cochlear implantation (CI) on speech perception and school life, and (2) to evaluate behavioral and emotional development, including social skills, post-implantation.

**Methods:** We telephoned caregivers and asked them a standardized questionnaire. We used the data to explore the daily lives (including school life) of children who had undergone CI before the age of 4 years and who had used the device for >10 years. We also evaluated behavioral/emotional development.

**Results:** Most children used CI devices for virtually all their waking moments and attended mainstream schools. Moreover, more than 75% of them could comprehend common phrases or conversations without lip-reading and carry out a telephone conversation with a person known to them. The mean T-scores for all scales of behavioral/emotional assessment, including those concerning social skills, were within the normal ranges, although scores on the competence scale were lower than those on other scales.

**Conclusions:** This long-term study of early-CI children shows that CI improves not only speech perception, but also behavioral/emotional development, including social skills.

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## 1. Introduction

Since 1990, cochlear implantation (CI) has been accepted as a useful method of rehabilitating deaf children [1]. Most studies have shown that CI accelerates the development of oral language skills [2–6]; children use the devices continuously during their waking hours [7,8].

Meanwhile, any effect of CI on behavioral and emotional development (including social skills) remains controversial. Several studies have shown that the social skills of deaf children improve after CI [9,10], but other researchers suggest that the

social skills of CI children might remain impaired compared to normal-hearing children. For example, in several peer-engagement studies CI children failed to participate in group activities, as assessed by direct observation [11–13].

One study showed that peer relationship was closely related to several factors, such as self-confidence and peer acceptance, as well as oral communication skills [10]. However, only children aged between 6 and 10 years were included, and the sample size was relatively small. As early CI is now common, being cost-effective, and as increasing numbers of implanted children have already reached or are reaching adulthood, it is important to understand the long-term effects of early CI [10].

The objectives of this study were twofold: first, we aimed to evaluate the long-term effect of CI device use on speech perception and school life; and second, we assessed the extent of any behavioral or emotional development, including social skills.

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## 2. Materials and methods

### 2.1. Sample

There were 117 children met the following inclusion criteria: underwent CI at Seoul National University Hospital before the age of 4 years, and used a CI device for >10 years. The families of each child were contacted by telephone to request permission for their child to participate. Due to out-of-date contact information, only 93 of the 117 families were reachable; of these, 67 participated in the telephone survey. A mail-out enclosing a checklist concerning behavioral and emotional problems was then sent to these families, 32 of whom returned a completed questionnaire. Written informed consent was obtained from all primary caregivers. The work was approved by the Institutional Review Board of Seoul National University Hospital (approval no. 2014-2264).

### 2.2. Measures

#### 2.2.1. Telephone survey

To evaluate how effectively children who underwent CI used their devices, and whether the devices improved speech perception, primary caregivers were asked to answer questionnaire shown in Table 1 (formulated in-house). The first author telephoned all caregivers. After establishing a rapport, the interviewer asked the standard questions and also provided cues eliciting more detailed information on the child's daily life. The interviewer moved on to the next question only after a clear picture of the child's activity had been obtained.

In addition, Categories of Auditory Performance (CAP) of each child were evaluated (the sets of CAP scores are shown in Table 1). With a telephone survey, final CAP scores were determined by asking caregivers which categories their children fell under. Although the CAPs cannot substitute for formulaic measurements, they yield a global measure that can be readily applied and easily

**Table 1**  
Telephone survey items.

| Device use  |
|---|
| 1. Who answers the telephone? (1) Father (2) Mother   |
| How long does the child wear his or her CI per day (waking hours only)?                                 |
| (1) < 4 h (2) 4–8 h (3) 8–12 h (4) 13–17 h  |
| What domain does the child typically communicate in?  |
| (1) oral (2) oral + lip reading   |
| (3) oral + sign (4) oral + lip reading + sign   |
| 4. What do you think are the biggest problems associated with CI use?                                   |
| 5. What are the biggest advantages of CI use?   |
| 6. What are the biggest disadvantages of CI use?  |
| 7. Which of the following applies with respect to the child's awareness, response to and use of sounds? |
| (0) No awareness of environmental sounds  |
| (1) Awareness of environmental sounds   |
| (2) Response to speech sounds   |
| (3) Identification of environmental sounds  |
| (4) Discrimination of certain speech sounds without lip-reading   |
| (5) Comprehension of common phrases without lip-reading   |
| (6) Comprehension of conversations without lip-reading  |
| (7) Able to conduct a telephone conversation with a known listener                                      |
| Academic status   |
| 8. School status  |
| (1) Mainstream school: regular classes, (2) mainstream school: special classes,                         |
| (3) school for the deaf (home-schooling), (4) school for the deaf (living in a                          |
| dormitory) (5) college (with assistance), (6) college (without assistance)                              |
| (7) no schooling, (8) a working member of society.  |
| 9. Location of desk within the classroom (1) front third, (2) middle third and                          |
| (3) rear third  |
| 10. Have you ever used an FM system? (1) Yes (2) No   |
| 11. In which subjects does the child experience difficulties despite CI device use?                     |

FM, frequency-modulated; CI, cochlear implantation.

understood by non-specialist professionals and parents, revealing the benefits of CI and the time over which such benefits are realized [14].

#### 2.2.2. Child behavior checklist for children between 6 and 18 years of age (CBCL/6-18)

Psychological assessment was performed using the Child Behavior Checklist suitable for children aged 6–18 years (CBCL/6-18) [15]. The CBCL is a questionnaire completed by caregivers that assesses behavioral and emotional problems in children and adolescents. It consists of 113 questions, scored using three-item scales (0 = not true; 1 = somewhat or sometimes true; and 2 = very true or often true). The CBCL/6-18 comprises syndrome, diagnostic statistical manual (DSM)-oriented and special, and competence scales [15]. Studies performed over several decades have shown that the CBCL is the best screen to use when evaluating behavioral and emotional aspects of children [16]. Also, the Korean CBCL manual indicates that the Korean translation of the CBCL has good reliability and validity [17].

The syndrome scale can be further divided into eight subscales: anxious/depressed, depressed, with somatic complaints (internalizing elements), with social problems, with thought and attentional problems, and exhibiting rule-breaking and aggressive behavior (externalizing elements). The DSM-oriented scale deals with DSM-recognized mental conditions; these are affective, anxiety, and somatic disorders, attention deficit hyperactivity disorder (ADHD), oppositional defiant problems (ODPs), and conduct problems. The special scales are concerned with obsessive-compulsive disorder (OCD) and posttraumatic stress disorder (PTSD). Finally, the competence scale is concerned with activities, social relationships, schooling, and overall competence [15]. Social skill levels were inferred from scores on the 'social problems' item of the syndrome scale and the 'social relationships' item of the competence scale.

The profile obtained from each caregiver was interpreted according to the standard formula: (1) All raw scores on scales were converted to T-scores to estimate child performance compared to other children within the same age group (according to the scale, the raw score will independently match the T-score), (2) All T-scores correspond to a percentile with a uniform distribution, and (3) Scores below the 95th percentile were normal and those above the 98th percentile were of clinical interest. Scores

**Table 2**  
Telephone survey responses pertaining to CI use.

| Item                                       | Answer   | Number of respondents (n) |
|--|--|---------------------------|
| Inconveniences associated with CI use (40) | Humidity (sweat)                                     | 21                        |
|  | Physical discomfort                                  | 9                         |
|  | Battery replacement                                  | 4                         |
|  | Heavy weight/large size                              | 7                         |
|  | Cost   | 4                         |
|  | Long-distance travel to the hospital                 | 1                         |
| Advantages of CI* (34)                     | Benefits hearing significantly                       | 12                        |
|  | Benefits determination of sound direction            | 2                         |
|  | Benefits speech discrimination in noisy environments | 1                         |
| Disadvantages of CI* (12)                  | Provision of a spare device                          | 2                         |
|  | Minimal benefit to hearing                           | 4                         |
|  | Requirement for adaptation period                    | 3                         |
|  | Cost   | 1                         |
|  | Appearance, weight                                   | 5                         |

\* Denotes multiple answers; numbers in brackets represent number of respondents.

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