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Early Educational Placement and Later Language Outcomes for Children With Cochlear Implants

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Hypothesis: This investigation examined the hypothesis that the type of preschool intervention provided to children who receive a cochlear implant affects their language scores at school entry.
Background: Recent research has documented faster language acquisition when children attend specialized preschool programs beginning at age 3 years. We hypothesized that if similar intervention were initiated before age 3 years, the rate of language acquisition might increase even more.
Methods: Thirty-nine listening and spoken language (LSL) programs located in 20 different states across the United States contributed language test scores for 141 five- and six-year-olds who had used a cochlear implant for at least 1 year. A retrospective analysis compared outcomes at 5 to 6 years based on interventions received each year before age 5 years: 1) individual parent-infant intervention; 2) LSL class with only deaf children, or 3) LSL class with 1 or more hearing children.
Results: The specific type of intervention at ages 1 and 2 years provided a lasting positive impact on language, at least until kindergarten. The probability that a child would reach normal language levels by kindergarten increased significantly if, at age 1 year, intervention included a combination of cochlear implant use and parent-infant intervention and, at age 2 years, a LSL class with other deaf children was added.
Conclusion: These results favor providing a cochlear implant by age 1 year and supplementing early parent-infant intervention with an intensive toddler class designed specifically for developing spoken language in children with hearing loss by age 2 years. **Key Words:** Cochlear implants in children—Early intervention—Spoken language outcomes.

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Significant delays in language development have long been documented in children with hearing loss, whether measured in speech or in sign (1). However, recent changes in the treatment of early childhood hearing loss have had a significant impact on educating deaf children and on the expected outcomes (2). Earlier diagnosis and intervention in combination with improved access to sound through cochlear implantation has made it possible for even severely and profoundly deaf children to develop spoken language skills that approach those of their hearing age-mates, an essential component of successful mainstreaming (3).

The 3 factors most responsible for this acceleration in language development are as follows: a) newborn hearing screening and early intervention (4), b) advances in hearing technology (5), and c) teaching strategies that capitalize on the first two (6). Early identification and fitting with appropriate hearing aids or cochlear implants during a critical period for language development provides essential auditory input to minimize the initial delay associated with hearing loss. If there is indeed a critical or "sensitive" period in early childhood within which language is optimally acquired, then the earlier auditory access is provided, the better (7–9). Appropriate intervention serves to accelerate language acquisition to permit children with hearing loss to catch up in language with hearing age-mates. Therefore, a goal of virtually all early listening and spoken language (LSL) intervention for children with hearing loss is to help them to develop age-appropriate spoken language as early as possible. If a child does not have competence in understanding and using words and syntactic structures to express communicative functions intelligibly, his/her ability to interact successfully with hearing age-mates will be limited. Furthermore, achieving age-appropriate mastery of vocabulary and syntax is critical to developing reading and writing skills in the elementary grades.

The importance of getting intervention started early has been well documented (3,10,11). However, the impact that early intervention has on progress in language

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development for children with hearing loss may be influenced by the nature of the intervention. Early intervention for children with hearing loss may be provided solely by working with parents and guiding them in ways to help their child learn to listen and talk or a combination of working with parents and direct teaching of the child. At the youngest ages, weekly parent counseling sessions are designed to enrich the child's language environment and enhance everyday communication. Beginning at approximately 36 months of age, intervention may include placement in a preschool class, and the makeup of that class may take various forms. Proponents of auditory-verbal therapy maintain that children with hearing loss do best when placed in regular preschool classrooms with typical hearing peers (12). Some children are placed in classes that include a few to a majority of hearing age-mates. Other children receive speech and language intervention in small groups consisting of only children with hearing loss. Recent research has documented an increase in the rate of language acquisition when children with hearing loss attend these specialized preschool programs (2). We hypothesized that, if similar intervention were initiated before 36 months, it might serve to increase the rate of language acquisition sooner and thus promote catching up with hearing age-mates in time for kindergarten.

We asked whether early use of a cochlear implant (i.e., before age 4 yr) combined with specific educational intervention significantly affects language scores at school entry (ages 5 and 6 yr). Do some intervention approaches increase the probability that children will catch up with their hearing age-mates in language skills by kindergarten?

MATERIALS AND METHODS

Thirty-nine education programs located in 20 different states across the United States contributed test scores to this study. All of the participating intervention programs provide an emphasis on LSL and strong parent support and follow-through. Most of the children were enrolled in private LSL school programs, although 4 public school programs and 3 auditory-verbal practices were represented.

Language test scores were recorded for all children enrolled between 2003 and 2006 who met the following selection criteria: 1) 5;0 to 6;11 years of age at testing; 2) age at onset of profound deafness 20 months or younger; 3) age at cochlear implant (CI) activation before 5 years; 4) duration of CI use 12 months or greater; 5) nonverbal IQ of 70 or higher; and 6) enrolled in an intervention program by 2 years of age.

A total of 141 children met these sample selection criteria. Sample characteristics are summarized in Table 1. Eighty-four percent of the participants had onset of deafness at birth. Nine percent (13) of the children acquired deafness between 1 and 12 months, and the remaining 7% (10) acquired deafness between 13 and 19 months of age. This group of children was of average nonverbal intelligence, and the mean highest educational level completed by either parent was close to completion of a 4-year college program. Children received implants between 1998 and 2004 and had used an implant for at least a year at the time of testing. The proportion of children who had received a cochlear implant increased with age—44% were implanted before their second birthday, 77% before their third birthday, and 93% before their fourth birthday. The following devices were represented in this group: 5 Med-El, 66 Advanced Bionics (26 were C1.2, 38 were CII, and 2 were HiRes) and 78 Nucleus (22 were Nucleus-24, 17 were Nucleus 24-R, and 39 were Nucleus-24M). Device type was unknown for four of the children. Four children had bilateral implants. Children who had experienced device failures lasting more than 30 days were excluded from the sample.

TABLE 1. *Sample characteristics*

Characteristic	Mean	Standard deviation	Range
Age at test	5;10	0;6	5;0–7;0 years
Age at onset (mo)	2	5	0–19
Age at implant	2;2	0;10	0;10–4;8
Duration of implant use	3;7	0;10	1–5 years
WISC-Performance IQ	106	15	65–140

WISC indicates Wechsler Intelligence Scale for Children.

In addition to providing consent for their child's participation, parents completed questionnaires in which they reported the age at which their child received an implant and the type of intervention program in which their child was enrolled at 1, 2, 3, 4 and 5 years of age. Three different types of intervention settings were described on the questionnaire. Individual parent-infant program (PIP) sessions occurred when the child and 1 or both parents met with a teacher, usually 1 hour a week, for education and language stimulation. LSL classes consisted of a small group of similarly aged children with hearing loss who met with a teacher of the deaf or SLP 9 or more hours per week. The mainstream (MS) placement category combined all classroom settings that included normal hearing children—whether they were in the minority (reverse mainstreaming) or the majority (partial or full mainstreaming).

A comprehensive battery of standardized tests of language skills and verbal knowledge was administered to each child. Participating programs either provided the requested test results from their records or obtained parent consent for our research staff to travel to their facility to test all children who met the sample selection criteria. All tests were administered individually by qualified speech-language pathologists, teachers of the deaf, or psychological examiners who had received training in standardized administration procedures. The spoken language skill areas evaluated were as follows: vocabulary (receptive and expressive), global language skills (receptive and expressive), and intelligence (performance and verbal). The test battery typically consisted of the following measures: Peabody Picture Vocabulary Test (13), Expressive One-Word Picture Vocabulary Test (14), Clinical Evaluation of Language Fundamentals–Preschool Level (15), and the Wechsler Preschool and Primary Scale of Intelligence (16). On all tests, items increase in difficulty, and testing proceeds until the child reaches a specified ceiling of incorrect responses. Standard scores were expressed in relation to the normative sample of age-matched hearing children, where the group mean is set at 100 and scores between 85 and 115 represent ±1 standard deviation (SD).

RESULTS

Table 2 summarizes the mean and SD of scores for each of the language skills measured, along with the percentage of children scoring within normal limits for

TABLE 2. *Language test standard scores*

Measure	Mean	Standard deviation	Range	%Within normal limits
Expressive vocabulary	92	19	54–134	65
Receptive vocabulary	87	18	46–124	56
WISC-Verbal IQ	85	17	50–127	51
CELF-Receptive	84	20	45–122	54
CELF-Expressive	80	18	45–128	44

CELF indicates Clinical Evaluation of Language Fundamentals; WISC, Wechsler Intelligence Scale for Children.

their age. These results are similar to those reported for a slightly larger sample including these same children (3). Language skills did not all develop at the same rate in these children, and some skills (e.g., vocabulary) were better developed by age 5 to 6 years than others (e.g., syntax). It became apparent that no one measure adequately captured the child's real facility with language. Therefore, an average score across all tests was used to represent an overall language outcome for each child. The average standard score was 86—just within 1 SD of hearing age-mates.

Figure 1 depicts the percentage of children enrolled in each of the reported intervention settings at 1, 2, 3, 4, and 5 years of age. At age 1 year, most of the children who were placed in any program were receiving parent-infant services. Parent-infant intervention continued for half of the children at age 2 years, but almost 40% of the children were placed in special toddler LSL classes for hearing-impaired children at 2 years of age. By ages 3 and 4 years, approximately 65% of children were in LSL preschool classes. Mainstreaming occurred for only 10% of the sample at age 2 years but increased to 40% at age 5 years.

Figure 2 compares mean language scores recorded when the children were 5 or 6 years old based on their intervention status at 1 year of age. At age 1 year, 79 of the children had not yet received a CI. Among that no-CI group, 52 had enrolled in parent-infant intervention, and 27 were not yet receiving any intervention (probably because they were not yet diagnosed). All of the children who had received a CI by age 1 year were enrolled in intervention; 55 of these were in a PIP. Analysis of variance was used to compare language scores at age 5 to

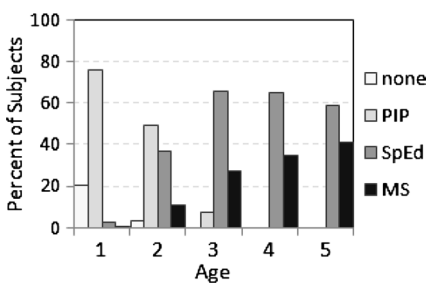

FIG. 1. The percentage of children enrolled in each educational setting is plotted for each age group examined: PIP, LSL, and MS classes.

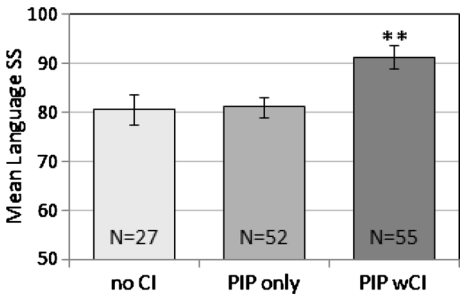

FIG. 2. Mean standard score across a battery of language tests at ages 5 to 6 years is plotted for 3 different interventions at age 1 year: no CI (no CI or intervention), PIP only (PIP without a CI), and PIPwCI (PIP with a CI).

6 years based on the type of intervention they received at age 1 year: 1) no CI or early intervention, 2) parent-infant intervention without a CI, and 3) parent-infant intervention with a CI. There was a significant overall effect of intervention group ($F_{2,131} = 6.23$, $p < 0.003$). Post hoc testing (Fisher's protected least significant difference test) confirmed that children with both a CI and intervention at age 1 year scored closer to their normal age-mates by kindergarten than those who did not have this combination of device and intervention at age 1 year ($p < 0.01$). On average, early CI users who received early intervention caught up with hearing age-mates by kindergarten, whereas the other groups did not. Average nonverbal IQ on the Wechsler Preschool and Primary Scale of Intelligence (17) did not differ significantly among the 3 groups (no CI group = 104; intervention only group = 106; CI plus intervention group = 107)

Figure 3 depicts mean language scores at age 5 to 6 years based on educational setting at age 2 years. By age 2 years, 108 of the children had received a cochlear implant. The lowest mean outcome score (79) was for the 33 children who had no implant and no intervention at age 2 years. Somewhat (although not significantly) higher average scores were observed for children who had received a cochlear implant by age 2 years and were either placed in an MS classroom with hearing children (n = 13) or received only weekly parent-infant intervention (n = 31).

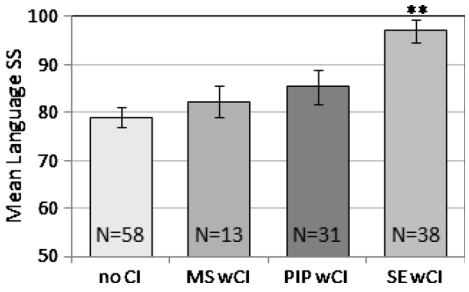

FIG. 3. Mean standard score across a battery of language tests at ages 5 to 6 years is plotted for 4 different interventions at age 2 years: no CI (no CI or intervention), MSwCI (MS class with CI), PIPwCI (PIP with a CI), and LSLwCI (LSL class with a CI).

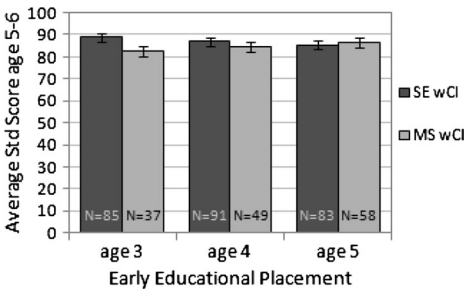

FIG. 4. Mean standard score across a battery of language tests at ages 5 to 6 years is plotted for 2 different interventions at ages 3, 4, and 5 years: LSLwCI (LSL class with a CI), MSwCI (MS class with a CI).

However, children with cochlear implants who were enrolled in an LSL class for oral hearing-impaired children at 2 years of age (n = 38) performed more than 10 standard score points better at age 5 to 6 years than any of the other groups. Analysis of variance revealed a significant overall effect of group ($F_{3,136} = 9.73$, $p < 0.0001$). Post hoc tests indicated significantly higher scores for the LSL class group than for any other group ($p < 0.01$).

Figure 4 summarizes average standard scores by educational placement at ages 3, 4, and 5 years. By this age, all of the children were using cochlear implants, and the majority of children were either enrolled in LSL or MS classes. There was no significant difference in language outcomes based on type of classroom placement after age 2 years (i.e., between children enrolled in MS or special education classes). Throughout the preschool years, MS placement did not result in the advantage that many educators have anticipated, nor did it seem to have a detrimental effect on language levels achieved by kindergarten.

Figure 5 compares the average outcome scores (at age 5 or 6 yr) of 38 children who had been enrolled in LSL toddler class at age 2 years, with 44 children who had not been enrolled in an LSL preschool class until 3 years of age. Children in a toddler class exhibited almost a 10-point language advantage, which was statistically significant ($F_{1,80} = 5.47$, $p < 0.02$). More importantly, 71% of those who remained in an LSL preschool class from age 2 to 4 years had language scores within normal limits for hearing age-mates by kindergarten, whereas only 41% of those who did not start preschool until age 3 years did so. These groups did not differ in IQ (toddler class + preschool mean, 104.6; SD, 14.9; and preschool class only mean, 107.5; SD, 16.1). Nor did they differ in age at implant (toddler class mean, 2.3 yr; SD, 0.9; and preschool class mean, 2.1 yr; SD, 0.9).

DISCUSSION

These results are consistent with previous studies that have reported a negative correlation between age of enrollment and language outcomes (4,11). Moeller (11) studied 112 children with various degrees of hearing loss and communication modalities and found that those who were enrolled earliest (e.g., by 11 mo of age) demonstrated significantly better vocabulary and verbal reasoning skills at 5 years of age than did later-enrolled children. Furthermore, family involvement also was predictive of language outcome so that children who received both early intervention and high family involvement were most likely to exhibit normal language skills by 5 years of age.

The current investigation focused on children with severe-to-profound deafness who received early intervention in LSL settings. These data indicated that the specific type of intervention provided at ages 1 and 2 years was associated with language outcome at ages 5 and 6 years. At age 1 year, a combination of early cochlear implantation and parent-infant intervention significantly increased the probability that a child would reach normal language levels by kindergarten. At age 2 years, it was the combination of cochlear implant use and an LSL class with other deaf children that produced the best results. These results favor providing a cochlear implant by 1 year of age and supplementing early parent-infant intervention with a more intensive toddler class designed specifically for developing spoken language in children with hearing loss by 2 years of age. Parent involvement was not a measured variable in this study, so there is no way to know whether that factor also may have played a role in these results. However, all of the families were receiving parent counseling and support, yet it was the addition of a toddler class at age 2 years that provided a lasting positive impact on language, at least until kindergarten. The observed benefits for special education at age 2 years were not associated with differences in performance intelligence or age at implant. Furthermore, the advantage did not extend to classroom placement at 3, 4, or 5 years of age, where similar results at ages 5 and 6 years were observed for children enrolled in either special education or MS classes. Further research into the benefits of enrolling children with hearing loss in special education toddler classes at age 2 years is indicated, given that more than 70% of such children caught up with hearing age-mates in language scores in time for kindergarten.

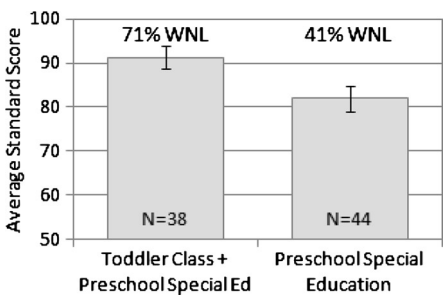

FIG. 5. Average standard scores across a battery of language tests at ages 5 to 6 years are plotted for children enrolled in a preschool listening and spoken class at ages 2 to 4 years and at ages 3 to 4 years. The percentage of children scoring within or above the average range for hearing age-mates (i.e., standard score of ≥85) also is provided.

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