Mode of Communication and Classroom Placement Impact on Speech Intelligibility

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Objective: To examine the impact of classroom placement and mode of communication on speech intelligibility scores in children aged 8 to 9 years using multichannel cochlear implants.

Design: Classroom placement (special education, partial mainstream, and full mainstream) and mode of communication (total communication and auditory-oral) reported via parental rating scales before and 4 times after implantation were the independent variables. Speech intelligibility scores obtained at 8 to 9 years of age were the dependent variables.

Participants: The study included 131 congenitally deafened children between the ages of 8 and 9 years who received a multichannel cochlear implant before the age of 5 years.

Results: Higher speech intelligibility scores at 8 to 9 years of age were significantly associated with enrollment in auditory-oral programs rather than enrollment in total communication programs, regardless of when the mode of communication was used (before or after implantation). Speech intelligibility at 8 to 9 years of age was not significantly influenced by classroom placement before implantation, regardless of mode of communication. After implantation, however, there were significant associations between classroom placement and speech intelligibility scores at 8 to 9 years of age. Higher speech intelligibility scores at 8 to 9 years of age were associated with classroom exposure to normal-hearing peers in full or partial mainstream placements than in self-contained, special education placements.

Conclusions: Higher speech intelligibility scores in 8- to 9-year-old congenitally deafened cochlear implant recipients were associated with educational settings that emphasize oral communication development. Educational environments that incorporate exposure to normal-hearing peers were also associated with higher speech intelligibility scores at 8 to 9 years of age.


Speech intelligibility appears to be a major contributor to determining whether children with hearing impairments will be effective oral communicators.1-3 Severe-to-profound hearing losses negatively affect overall speech intelligibility in many children.4,5 Speech intelligibility scores average 17% to 21% in children who are profoundly hearing impaired.2 Intervention via cochlear implants appears to provide significant improvements in speech intelligibility.1,6,8,9 Continued increases in overall speech intelligibility are associated with increased experience with cochlear implants.4,6,7 Moreover, postimplantation levels of speech intelligibility often exceed levels observed in children with severe-to-profound hearing losses who use conventional hearing aids.7,8 Speech intelligibility serves as a strong independent predictor of language performance, and higher speech intelligibility scores are associated with higher language scores.9

A nationwide study that examined specific outcome measures in a large population of 8- and 9-year-old children who had used implants for at least 4 years was conducted between 1997 and 2000.10 The study carefully examined the characteristics of cochlear implant recipients, their families, their implants, and their educational intervention to determine the impact of these variables on communication outcome measures, including speech intelligibility. Initial examination of the data revealed that 2 educational variables appeared to account for a significant proportion of variance in speech intelligibility performance once variables related to the children, their families, and implant characteristics were factored out.10 These variables were the mode of communica-
METHODS

Subjects

Institutional review board guidelines regarding human subjects were followed to obtain consent from the parents and the children. A total of 131 congenitally deaf children (65 girls and 66 boys) using multichannel cochlear implants were selected from a larger group of 181 children who had hearing loss by 36 months of age. Children with Wechsler Performance IQs below 80 and those who had reportedly lost hearing after birth were eliminated from the larger group. According to the parents, the cause of deafness was unknown in the majority of the congenitally deaf children (n=77). The cause of deafness in the remaining children included genetic factors (n=32), maternal cytomegalovirus (n=10), and other medical conditions at birth, particularly low birth weight (n=12). The children ranged in age from 8 year 0 months to 9 years 11 months at the time of testing. The mean age at implantation was 3.63 years (range, 2.06–5.38 years). The children averaged 3.33 years of implant experience (range, 3.76–6.81 years). The majority of children received a Nucleus 22-channel cochlear implant (Cochlear Americas, Englewood, Colo) between 1990 and 1996 (2 children used a Clarion device [Advanced Bionics Corp, Sylmar, Calif]), 1 child used a Nucleus 24-channel implant [Cochlear Americas], and 12 children used a Mini Speech Processor [Cochlear Americas]. At the time of testing, the majority of children used a Spectra processor (Cochlear Americas) with a SPEAK coding strategy (n=117). The group averaged 3.66 years of SPEAK strategy use (range of use, 1 month to 6.43 years), with 12 children having no experience with the strategy (ie, they continued to use the MSP processor).

Figure 1 illustrates the speech intelligibility scores at the ages of 8 and 9 years as a function of the children’s current mode of communication and classroom setting. To make the data useful for clinicians, box plot statistics were computed to determine the 75th (top), 25th (bottom), and 50th (median) percentiles. Whisker bars were calculated to represent the 10th (bottom decile) and 90th (top decile) percentiles.

Figure 1. Speech intelligibility scores obtained in 8- to 9-year-old children are plotted relative to their current classroom placement and mode of communication. Box plot statistics for speech intelligibility illustrate the 75th (top line of box), 25th (bottom line of box), and 50th (line in box) percentiles. Whisker bars represent the 10th (bottom) and 90th (top) percentiles.

Procedure

Mode of communication and classroom placement were assessed using parental questionnaires that asked what emphasis was placed on speech and auditory development before implantation; at 1, 2, and 3 years after implantation; and at the time of testing (designated current) in the children’s educational classrooms/settings. A total communication designation was used for children who participated in sign emphasis programs, equal speech and sign emphasis programs, and speech emphasis programs using sign only a portion of the time. An auditory-oral designation was used for children who participated in cued-speech, auditory-oral, or auditory-verbal programs with no sign language input. Mode of communication was determined for each child at each of the periods. Three classroom settings were reported: (1) special education settings (exclusive enrollment in a self-contained classroom), (2) partial mainstream (part-time enrollment in classes with normal-hearing children), and (3) full mainstream (exclusive enrollment in classes with normal-hearing children). Educational placement data were examined individually for each of the 5 reporting periods.

Intelligibility measures were obtained by having the children repeat 36 sentences varying in length from 3 to 5 syllables. Embedded in the sentences were key words selected from a corpus of words known to predict speech intelligibility in deaf children. The speech samples were recorded, edited under computer control, and played to judges who designated by questionnaire that they had had no exposure to deaf speech. All judges signed consent forms approved by the University of Texas at Dallas institutional review board. Judges were allowed to hear a child speak only once and a sentence only once to avoid familiarity effects. Judges wrote the entire sentence. Correct key words were determined and averaged across the 3 judges per sentence per child. Therefore, the average speech intelligibility scores reported were obtained from 108 judges (36 key words times 3 judges) per child.
At the time of the study, 29 of the children were enrolled in self-contained special education classrooms, 31 children were partially mainstreamed, and 71 children were fully mainstreamed. Fifty-seven children were in educational programs using both speech and sign (total communication), and 74 children were in programs using exclusively spoken communication (auditory-oral).

Statistical analyses were conducted using analysis of variance with Bonferroni multiple comparison tests to determine reliability of effects. The mean speech intelligibility score was higher for the children who were enrolled in an auditory-oral program than for those who were enrolled in total communication program, regardless of classroom placement (39.4% for total communication and 70.8% for auditory-oral programs) ($F_{1,130} = 42.00; P < .001$). The mean values of speech intelligibility increased significantly across classroom settings with greater exposure to normal-hearing children (40.3% for special education, 52.2% for partially mainstreamed, and 72.9% for fully mainstreamed placements) ($F_{2,130} = 19.28; P < .001$). Higher levels of speech intelligibility were found in children who were enrolled in fully mainstream classrooms, regardless of mode of communication (70.3% for total communication and 85% for auditory-oral programs). There were no significant interactions of mode by classroom placement ($F_{2,131} = 0.7; P = .49$).

**Figure 2** depicts speech intelligibility scores at 8 and 9 years of age as a function of mode of communication and classroom placement during the first year of implant use (ie, before the age of 5 years). Sixty children were reported to be using total communication, and 71 children were reported to be using auditory-oral modes of communication. The majority of children were enrolled in either individual parent-infant sessions or self-contained preschool classrooms ($n = 92$), with 18 and 21 children enrolled in partial or full mainstream preschool classrooms, respectively. Speech intelligibility scores at the ages of 8 to 9 years were significantly lower for children using total communication than for children using auditory-oral communication modes, regardless of classroom settings before implantation ($F_{1,130} = 8.91; P < .001$). Speech intelligibility at the age of 8 to 9 years was not significantly influenced by classroom placement before implantation, regardless of mode of communication ($F_{2,131} = 0.57; P < .04$).

To examine how changes in mode of communication and classroom placement over time might influence speech intelligibility, we then examined the data as a function of the 3 yearly postimplantation periods. **Figure 3** summarizes speech intelligibility scores between the ages of 8 and 9 years as a function of mode of communication and classroom placement during the first year of experience with a cochlear implant. Fifty-five children used total communication, and 71 used auditory-oral communication. Self-contained classrooms provided services to 80 children, while mainstream classrooms provided services to 43 children (22 partial, 23 full). Higher speech intelligibility scores at 8 to 9 years of age were associated with children enrolled in auditory-oral programs during the first year of implant use compared with those enrolled in total communication programs (76.7% vs 47.8%, respectively) ($F_{1,130} = 23.06; P < .001$). Speech intelligibility scores between the ages of 8 and 9 years were not significantly influenced by classroom placement during the first year of implant use for either communication mode group ($F_{2,131} = 0.54; P < .13$).

Two years after implantation, 61 children were enrolled in classrooms using total communication and 70 children were enrolled in classrooms using auditory-oral modes of communication (Figure 4). Special education classrooms serviced 64 children, and mainstream classrooms serviced 67 children. More accurate speech intelligibility at the ages of 8 to 9 years was associated with auditory-oral communication compared with total communication 2 years after implantation, regardless of classroom placement (47.8% for total communication and 78% for auditory-oral modes of communication) ($F_{1,130} = 35.31; P < .001$). Also, more accurate speech intelligibility between the ages of 8 and 9 years was significantly
related to classroom placement (64% for self-contained, special education classrooms; 60.8% for partial mainstream settings, and 73.1% for fully mainstream settings) \(F_{1,130} = 4.68; P < .01\). This relationship is particularly evident in the measures of the 25th percentile (represented by the bottom line of the boxes) for the auditory-oral children, which falls around 62% for children enrolled in special education and partial mainstream classrooms at 2 years after implantation and around 90% for children who were fully mainstreamed at this interval. Measures of the 25th percentile for total communication children at 2 years after implantation were 4%, 22%, and 30% for children in special, partial, and full mainstream classrooms, respectively.

Three years after implantation, 72 children were enrolled in classrooms in which auditory-oral modes of communication were used, and 59 children were enrolled in total communication classrooms (Figure 5). Thirty-nine children attended self-contained, special education classes, and 92 children were mainstreamed (n = 37 for partial and n = 55 for full). Speech intelligibility scores at 8 to 9 years of age continued to be significantly influenced by mode of communication 3 years after implantation (42.4% for total communication and 60.3% for auditory-oral) \(F_{1,130} = 52.17; P < .001\). Speech intelligibility scores at the ages of 8 to 9 years were more accurate for children who were enrolled in classroom settings with normal-hearing peers during their third year of implant use than for children in self-contained, special education settings \(F_{1,130} = 12.68; P < .001\). Speech intelligibility scores averaged 44.6%, 60.2%, and 72.4% for children aged 8 to 9 years in special, partial, and full mainstream settings during their third postimplantation year.

**COMMENT**

Significantly higher speech intelligibility scores in 8- to 9-year-old cochlear implant recipients were associated with enrollment in programs using auditory-oral modes of communication rather than total communication modes before implantation and at various times after implantation. Children enrolled in total communication programs before receiving a cochlear implant demonstrated speech intelligibility scores at the ages of 8 to 9 years that averaged below 53%, regardless of whether they were grouped with hearing children in a mainstream setting or received special education before implantation. Children enrolled in auditory-oral programs before implantation achieved better than 70% intelligibility by the ages of 8 to 9 years. The impact of classroom placement before implantation on speech intelligibility measures obtained in 8- to 9-year-old implant recipients was minimal, with no reliable differences in intelligibility associated with mainstream or special education placement. As shown in the “Results” section, there are statistically reliable associations between mode of communication during the first 3 years after a cochlear implant is received and speech intelligibility scores obtained at the end of 4 to 6 years of implant use. Higher speech intelligibility in children aged 8 to 9 years was associated with communication methods that emphasize listening and talking after implantation. Poorer speech intelligibility in cochlear implant recipients at the ages of 8 to 9 years was significantly associated with modes of communication that place greater emphasis on language learning via communication modes that incorporate signs. Before implantation, 60 children were enrolled in total communication programs and 71 children were enrolled in auditory-oral programs. In children aged 8 to 9 years, these numbers changed very little by 3 years after implantation (59 total communication and 72 auditory-oral) and at the time of testing (57 total communication and 74 auditory-oral).

Many cochlear implant recipients from both communication mode groups shifted classroom placements after implantation. Before implantation, only 17% of total communication students and 15% of auditory-oral students were fully mainstreamed. By the ages of 8 to 9 years, 42% of the children in total communication programs...
and 63% of the children in auditory-oral programs were in classes with hearing children all day. Classroom placement before and after implantation was significantly related to speech intelligibility scores obtained at 8 to 9 years of age. Intelligibility scores between the ages of 8 and 9 years were higher for children in classroom environments with normal-hearing peers than in self-contained, special education classrooms. The absence of significant interactions between mode of communication and classroom placement on speech intelligibility acquired at 8 to 9 years of age suggests that children in both oral and total communication settings exhibit better speech if they are in mainstream classrooms. Lower speech intelligibility scores at 8 to 9 years of age are associated with placement in self-contained, special education settings. Classroom placement decisions are usually made by a combination of parental preference and teacher recommendations, and children whose speech is difficult to understand may be deemed to learn better in a special education setting. Such settings may place greater emphasis on language and reading than on developing and refining oral communication skills.

One cannot conclude from these results that oral communication mode or mainstream class placement causes children with cochlear implants to develop high levels of speech intelligibility. Children with a propensity for spoken language may be guided toward oral and mainstream programs. Mainstream classroom placement before and immediately after cochlear implantation was not a significant predictor of later speech development. However, mainstreaming became a significant predictor of speech acquisition with increased cochlear implant use. This result suggests that as children became more intelligible, mainstream placement and greater interaction with normal-hearing peers was the result.

Communication mode, on the other hand, was consistently predictive of speech outcome. The children in our study came from 33 different states and 5 Canadian provinces and did not represent any one program or method. Communication mode, at least during the early years, was most often determined by geographical availability. The vast majority of children did not have both oral and total communication options available in their local communities. The finding that the communication mode used with the child before he or she received a cochlear implant (at the age of 2, 3, or 4 years) was a significant predictor of speech outcomes 4 to 6 years later suggests that this early emphasis on speech and auditory skill development may have a later impact on the child’s ability to make use of the auditory information provided by the cochlear implant to produce intelligible speech. Further longitudinal studies of speech development in both oral and total communication settings would provide important additional information regarding the impact of communication mode on speech production benefits achieved after cochlear implantation.

In summary, higher speech intelligibility scores acquired in 8- to 9-year-old congenitally deafened cochlear implant recipients were associated with educational settings that emphasize oral communication development and placement with hearing peers. Less accurate speech intelligibility scores at 8 to 9 years of age were associated with educational programs that emphasize the development of language via signs and placement in special education classes.

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