JAAA 1:4-6 (1990)

3M/House Cochlear Implant in Children

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Abstract

Data on 265 children with the 3M/House single-channel cochlear implant have been collected and analyzed for presentation to FDA. Significant improvements from preimplant to postimplant in auditory detection, auditory discrimination/identification, and speech production have been demonstrated. Some children also demonstrate the ability to recognize words and sentences without the aid of speechreading.

Key Words: Cochlear implant, child, profound deafness, perception, speech production measurement

The 3M/House single-channel cochlear implant has been undergoing clinical trials in children aged 2 through 17 years since the first child was implanted in 1980 (Berliner et al, 1985). Recently, the Food and Drug Administration (FDA) Ear, Nose, and Throat Advisory Panel recommended that the FDA approve a PreMarket Approval Application submitted by the manufacturer. A final decision by the FDA is awaited. Considerable data regarding this auditory prosthesis in the pediatric population have been gathered and analyzed. Areas of evaluation included auditory detection, discrimination/identification (closed-set), and recognition (open-set), as well as speech production. Following is a very brief summary of study findings including data obtained to September, 1987, the date of database close. Additional details can be found in Berliner et al (1988).

RESULTS

Subject Characteristics

Demographic characteristics of the population, based on data for 265 children, include a mean age at time of surgery of 7.8 years, with a range from 2 years, 2 months to nearly 18 years. The majority (59 percent) were deafened by meningitis. Other causes include both acquired and congenital etiologies, with 34 percent congenitally deaf. The mean age at onset of deafness was 1.6 years, with a median of 1 year. Only 13 percent of the children were deafened after 3 years of age. Thus, the vast majority were prelingually deaf. Consistent with this fact, most (67 percent) used total communication. The average duration of deafness before implantation was 6.1 years and ranged from 6 months to nearly 18 years.

Auditory Detection

Preimplant auditory thresholds confirm that these children are profoundly deaf. Median thresholds were "no response" across the frequency range in the unaided condition for the implant ear and a median response of 99.5 dB HL at 250 Hz for the contralateral ear. With powerful hearing aids, median responses for the implant ear were 67 dB HL and 86.5 dB HL at 250 Hz and 500 Hz, respectively, and 63 dB HL and 75.5 dB HL for the contralateral ear. Only 28.7 percent of the subjects had a measurable response with hearing aids at 1000 Hz, 15 percent at 2000 Hz, 5 percent at 3000 Hz, and 1.6 percent at 4000 Hz for the implant ear. With the cochlear implant set at comfortable listening levels, median thresholds at the initial test interval ranged from 46.5 dB HL to 59.5 dB HL across the frequency range, with a median speech detection threshold of 39.5 dB HL. Functionally, this means that subjects can detect

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much of the acoustic speech signal and most medium- and high-intensity sounds in the environment.

Auditory Discrimination/Identification

With initial experience, the average implanted child can make simple auditory pattern and stress discriminations as measured by performance on the Discrimination After Training (DAT) test (Thielemeir, 1982). The DAT has 12 levels, starting with a visual discrimination task (Level 1), then detection of voice (Level 2), stress and pattern discriminations in increasing difficulty (Levels 3 through 8), and identification of spondees in sets of two, three, and four (Levels 9 through 12). Analysis of data from 70 children tested at each of three time intervals (preimplant and 1 and 2 years postimplant), all of whom had the cognitive skills required to pass Level 1, showed significant improvement from pre- to postimplant.

For statistical analysis, the 70 children were stratified by age at time of surgery (2 to 5 yrs, >5 to 11 yrs, >11 yrs), age at onset of deafness (0, >0 to 3 yrs, >3 yrs), and length of auditory deprivation (≤3 yrs, >3 to 5 yrs, >5 yrs). Scores were significantly higher postimplant with the cochlear implant than preimplant with a hearing aid for all age groups, and were higher at the second annual visit than the first annual visit for the two younger age groups. The youngest children (2 through 5 years) improved most rapidly. All age-at-onset groups showed significant improvement from preimplant to postimplant. Children deafened later typically, showed higher overall levels of performance, but even congenitally deaf children showed significant improvement. As expected, analyses showed that children with a shorter duration of deafness generally improved at a faster rate.

As Table 1 indicates, 36 percent of the sample could correctly identify spondees in small closed sets by 1 year postimplant. Few could do so preimplant with hearing aids. This percentage increases with length of use of the implant (43 percent at 2 years). Many researchers consider the ability to identify spondees in closed sets to be highly predictive of the ability to develop usable oral communication skills (Geers and Moog, 1987). A longitudinal matched-control group study provides evidence that the improvements in auditory performance postimplant are not likely a matter of maturation or continued training (Berliner et al, 1988; Tonokawa and Bell, 1987).

Table 1 Percentage of Subjects Scoring in Each Category of the Discrimination After Training (DAT) Test*

DAT Level	*Task*	*Preimplant (HA)* %	*Postimplant 1* %	*2* %
1	Visual Task	64	0	0
2	Auditory Detection	13	3	3
3-8	Stress/Pattern Recognition	20	61	54
9-12	Word Recognition (spondees)	3	36	43
		100	100	100

*Children tested at three times (preimplant, 1 year, and 2 years postimplant). N = 70.

Auditory Recognition (Open-Set)

With the implant, some children develop the ability for speech recognition without the aid of speechreading (Berliner and Eisenberg, 1987; Berliner et al, 1989). Word and sentence stimuli were administered in an open-set, auditory-only mode. Fifty children were tested on the word recognition task. Fifty-two percent (26/50) scored some level of open-set word recognition, with a mean score, for those who did obtain something greater than zero, of 33.3 percent correct and a range from 8.3 percent to 75 percent. Similarly, 41 were tested on the sentence comprehension task, and 41.5 percent (17/41) obtained open-set sentence comprehension, with a mean score of 39.0 percent correct and a range from 10 to 100 percent. Although a larger proportion of the children who demonstrated open-set performance on both words and sentences have an acquired hearing loss, some congenitally deaf children were also able to obtain non-zero scores.

Speech Production

Results of the Ling Phonetic Level Speech Evaluation (Ling, 1976) on 85 children tested preimplant and at 1 and 2 years postimplant indicate that implanted children do show significant improvements in speech production skills when postimplant scores are compared to preimplant scores. All age groups showed improve-

ment in speech from pre- to postimplant. In general, children implanted at a younger age showed a greater rate of improvement in speech production, as did children who were deaf for a shorter time before implantation. Congenitally deaf children as well as children deafened later made significant improvements.

Table 2 shows the distribution of subjects over time for the phonetic (imitative) segmental scores. Preimplant, 74 percent of the children had poor speech. Overall, there was a shift in the percentage of children with fair to good (usable) or very good imitative segmental speech skills from 26 percent preimplant to 61 percent at the second annual postimplant visit. A cross-sectional study confirmed that speech of implanted children was significantly better than that of age-matched controls (Berliner et al, 1988; Hill-Brown, 1987).

CONCLUSION

Results to date show that the 3M/House single-channel cochlear implant can provide very profoundly deaf children with the ability to detect much of the acoustic speech signal and to make stress and pattern discriminations. Many of these children can discriminate between spondees in closed sets and can obtain non-zero scores on tasks requiring the open-set recognition of words and sentences. As might be expected, these auditory abilities are reflected in the development of improved speech production skills.

Table 2 Percentage of Subjects Scoring in Each Category of the Ling Phonetic Level Speech Evaluation—Segmentals*

Speech Score	Category	Preimplant	Postimplant 1	Postimplant 2
		%	%	
0-80	Poor	74	48	39
81-200	Fair-Good	20	44	46
>200	Very Good	6	8	15
		100	100	100

*Children tested at three times (preimplant, 1 year, and 2 years postimplant). N = 85.

REFERENCES

Berliner KI, Eisenberg LS. (1987). Our experience with cochlear implants: have we erred in our expectations? *Am J Otol* 8:222-229.

Berliner KI, Eisenberg LS, House WF, eds. (1985). The Cochlear Implant: an auditory prosthesis for the profoundly deaf child. *Ear Hear* 6(Suppl):1S-69S.

Berliner KI, Tonokawa LL, Brown CJ, Dye LM. (1988). Cochlear implants in children: benefits and concerns. *Am J Otol* 9(Suppl):86-92.

Berliner KI, Tonokawa LL, Dye LM, House WF. (1989). Open-set speech recognition in children with a single-channel cochlear implant. *Ear Hear* 10:237-242.

Geers AE, Moog JS. (1987). Predicting spoken language acquisition of profoundly hearing-impaired children. *J Speech Hear Disord* 2:84-94.

Hill-Brown CJ. (1987). *Comparison of speech productions of implanted and unimplanted deaf children.* Presented at American Speech Language Hearing Association Annual Convention, New Orleans, LA.

Ling D. (1976). *Speech and the hearing impaired child: theory and practice.* Washington, DC: Alexander Graham Bell Association for the Deaf.

Thielemeir MA. (1982). *Discrimination after training test.* Los Angeles: House Ear Institute.

Tonokawa LL, Bell BA. (1987). *Comparative study of hearing aids and cochlear implants in children.* Presented at American Auditory Society, Chicago. September.