

## **THE PROGRESS OF CHILDREN USING THE MULTICHANNEL COCHLEAR IMPLANT IN MELBOURNE**

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Multi-channel cochlear implantation in children began in Australia in 1985 and there are now close to 4000 profoundly deaf children and adolescents using the Australian implant system around the world. The aim of the implant procedure is to provide adequate hearing for speech and language development through auditory input. This contrasts with the situation for adults with acquired deafness where the cochlear implant aims to restore hearing for someone with well-developed auditory processing and language skills. As with adults, results vary over a wide range for children using the Multi-channel implant. Many factors have been suggested that may contribute to differences in speech perception for implanted children. In an attempt to better understand these factors, the speech perception results for children implanted in Melbourne were reviewed and subjected to statistical analysis. This has indicated that the amount of experience with the implant and the length of sensory deprivation are strongly correlated with perceptual results. This means that younger children are likely to perform better with an implant and that a number of years of experience are required for children to reach their full potential.

The results have also indicated that educational placement and management play a crucial role in children reaching their potential. Overall, 60% of the children and adolescents in the study have reached a level of open-set speech understanding using the cochlear implant without lipreading.

It is now accepted that multiple-channel intracochlear implants can significantly improve speech perception for postlinguistically deafened adults (Dowell et al 1986). Developments in speech processing strategies employed for the Minisystem 22 multiple-channel cochlear implant have resulted in improved scores on tests of speech

perception using open-set words and sentences (Dowell et al 1990). While benefit from implantation is well-accepted for adult patients, many clinicians and educators are focusing on assessing benefits for profoundly hearing-impaired children, particularly those with congenital hearing impairment, who often show significant delays in development of communication skills (Geers and Moog 1988). Since 1985, when the first implantation of a ten year old child with the mini-implant developed by Cochlear Pty Limited was performed at the Cochlear Implant Clinic of the Royal Victorian Eye and Ear Hospital, there has been rapid expansion in numbers of children using the device both in Australia and worldwide, and an increasing proportion of clinic patients are now children.

The children as a group are more diverse than postlinguistically deafened adults in terms of congenital or acquired aetiologies of hearing impairment, age of onset, duration of profound hearing loss, residual hearing thresholds and history of hearing aid use in the pre-implant period, age (18 months to 18 years), and communication and social skill development. These and other factors such as educational program, method of communication, parental motivation and family support present difficulties in statistically assessing benefits from cochlear implant use, and identifying contributing factors to maximum benefit from use of the device. Carefully controlled studies of benefits of implants for profoundly deaf children are now currently underway in many countries, and recent results from the Melbourne clinic have shown that 60% of the children are achieving some understanding of open-set words and sentences using their cochlear implant alone, without the aid of lipreading (Cowan et al 1993, Dawson et al 1992). However, the

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results also suggest that improvements, particularly in the development of implant-alone understanding of words and sentences, are gradual in many cases, and may not develop for several years. This contrasts with results for postlinguistically deafened adults who often show significant open-set word and sentence perception scores within a few months of implantation.

While these studies will establish the range of potential speech perception benefits for the wide range of paediatric patients, the effect of improved speech perception abilities on the development of receptive and expressive language is of particular concern to clinicians involved in the management and habilitation of young children. For these patients, the aim of clinical management should be to ensure successful device use aimed at promoting language growth through listening. Only with acquisition of functional language skills will children be integrated fully into their educational setting and community. Management and habilitation must encourage this goal, with a focus on specific programme planning for individual children based on factors such as chronological age, language skills, and speech perception abilities of the child.

This paper presents speech perception and language results measured over time for children implanted in the Melbourne clinic. In addition, we will focus on several children in more depth. The implications of achieved benefits to language with the device are then discussed in the perspective of patient selection, habilitation and management.

### Method

Subjects for this study were 63 children implanted in the RVEEH/University of Melbourne cochlear implant programme which has used the Minisystem 22 multiple-channel cochlear implant for more than one year. In order to examine changes in performance over time with more detail, results for three children who represent a range of hearing impairment, age at implant, aetiology, and age at onset were analysed in order to establish representative trends. Specific details for these three children are shown in Table 1.

Table 1

#### SUBJECT DETAILS FOR THREE CASE STUDIES

|                | Child 1           | Child 2           | Child 3          |
|----------------|-------------------|-------------------|------------------|
| Age at Implant | 2 years, 6 months | 5 years, 2 months | 5 years 5 months |
| Aetiology      | unknown           | rubella           | meningitis       |
| Age at Onset   | congenital        | congenital        | 2 years          |
| Years post-op  | 3 years           | 5 years           | 7 years          |

As shown, Child 1 received her implant at an earlier age than either Child 2 or Child 3. Children 1 and 2 both had congenital hearing impairment, whereas Child 3 had meningitis at age two years. Although total years post-operative with the implant varies, each of the three children have significant experience with their devices, with Child 3 having seven years of device use.

Speech perception benefits were assessed by open-set Phonetically-Balanced Kindergarten (PBK) words or Bamford-Kowal-Bench (BKB) sentences, dependent on the age and linguistic skill of the particular child. Results were categorised according to the percentage of children able to perceive open-set words and sentences, as compared with perception of suprasegmental information only.

For the more detailed study of the three children, results on open-set word and sentence materials were obtained both with the implant-alone, and with the implant plus lipreading. Receptive language was assessed using the Peabody Picture Vocabulary Test (PPVT). This test was administered orally using lipreading and listening.

### Results

Speech perception results measured for the Melbourne paediatric patient group are shown in Figure 1.

As shown, individual results showed a wide range in performance, with some children able to perceive only closed-set syllable and word discrimination, while others demonstrated high open-set speech perception scores on monosyllabic words and sentences. Performance has tended to increase for the group over time, with the proportion of children achieving open-set benefits continuing to show an increase with further device experience.

Speech perception and language results for the three specific representative children are shown in Table 2. As shown, Child 1, implanted at age two, is now nearly six years of age. She has shown rapid improvement in speech perception since implantation, and is now obtaining significant benefit as measured from use of the cochlear implant alone without the aid of lipreading, or with the cochlear implant used in combination with lipreading. Her receptive language scores measured on the PPVT have also shown rapid gain since implantation. Table 2 shows both PPVT language age, and chronological age. It would be expected that a normally-hearing child, in the absence of other learning difficulties, would have age-appropriate language (ie. the measured PPVT language age would be equivalent to the chronological age). Pre-implant, Child 1 showed little language ability on the PPVT, with an effective "gap" of two years between PPVT age and chronological age. This gap has now narrowed considerably.

Child 2, with congenital deafness was implanted at age two, and is now nine years of age. Although Child 2 now has significant implant-alone scores on open-set word or sentence tests, these benefits were not obtained until approximately three years post-implant. Prior to this time, benefits were limited to supplementation of lipreading. Overall progress has been gradual. Similarly, language progress has been gradual. At implantation, Child 2 showed a gap of approximately five years between chronological age and PPVT language age (i.e. language age of near zero at chronological age five). While there has been improvement in language age, a significant delay is still evident in the results of Table 2.

Child 3 was deafened at age two due to meningitis, implanted at age five, and is now 12 years of age. Child three showed limited benefits for the first four years of

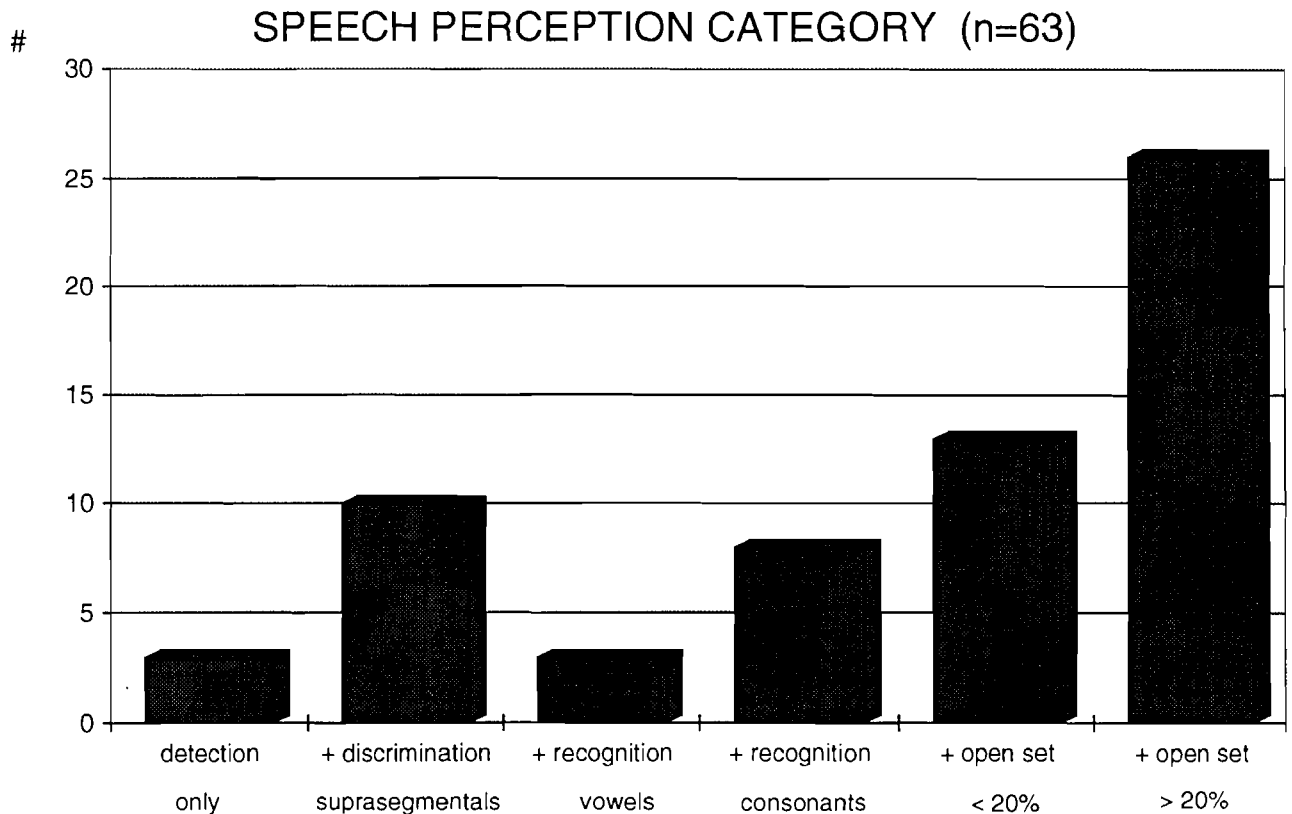


FIG. 1. Speech Perception Category.

device use, primarily being some supplementation of lipreading. Subsequently, consistent gains in speech perception ability have been shown on open-set word and sentence tests, and Child 3 now shows significant implant-alone speech perception. Language scores at implant showed a delay of approximately three years. After seven years of experience with the cochlear implant, Child 3's language is now at age-appropriate levels.

### Discussion

Overall, the children show a wide range of performance, from a lower level of minimal assistance to lipreading and

awareness of environmental sounds to significant levels of perception of words and sentences using the cochlear implant alone without the aid of lipreading. The results show that the proportion of children showing open-set benefits is increasing with added experience. However, it must be noted that some children with extensive experience are still unable to achieve open-set levels of perception. In general, these children were implanted at an older age after longer periods of pre-implant profound deafness. Even in this finding there are exceptions, with open-set results now being reported for two congenitally deaf adolescents who received their implants as adolescents.

Child 1 shows simultaneous development of speech

Table 2

### SPEECH PERCEPTION AND LANGUAGE TEST SCORES FOR 3 CHILDREN

| Test Administered  | Condition      | Child 1           | Child 2 | Child 3 |      |
|--------------------|----------------|-------------------|---------|---------|------|
| Speech Perception  | – pre-implant  | 0%                | 0%      | 0%      |      |
|                    | – post-implant | CI alone          | 63%     | 41%     | 52%  |
|                    |                | CI + lipreading   | 72%     | 62%     | 98%  |
| Receptive Language | – pre-implant  | PPVT age          | 0       | 0.2     | 1.8  |
|                    |                | chronological age | 2.6     | 5.2     | 5.5  |
|                    | – post-implant | PPVT age          | 4.5     | 4.2     | 12.1 |
|                    |                | chronological age | 5.8     | 9.2     | 12.1 |

perception and language. Some delay in language is still evident. With children implanted at a very young age, it is reasonable to expect improvements in language to occur within the first few years of implant use. Intensive habilitation encouraging language development may result in growth of independent functional communication skills at a much earlier time following implantation.

Results for Child 2 show a more gradual development of speech perception and language, with significant improvements occurring only after several years of experience with the implant. Habilitation needs for this child will differ from Child 1 in that long-term support is required, and the emphasis of the programme should be primarily on language training as well as listening.

Child 3 shows results for a longer-term user. Although benefits were limited during the first four years following implantation, significant open-set listening skills are now evident. Similarly, benefits in terms of language were limited during the first four years of device use, but Child 3 has subsequently developed age-appropriate language. Habilitation for Child 3 was long-term, extending over six years with an emphasis on listening and development of language at all stages. Child 3 is now fully integrated at school, and requires only minimal support and device maintenance.

### Summary

Children implanted at a very young age may show rapid increase in both speech perception ability and in growth of language. Management of these children must focus on the need for intensive habilitation to help them in language acquisition. Children implanted at an older age may require a more extended habilitation programme focusing on achieving good speech perception abilities,

and on longer-term acquisition of language. It is important that parents are made aware of, and plan for, these differing habilitation needs prior to implantation. Parents must also be counselled that full benefits to speech perception and language may not become fully evident for many children until after several years of implantation, and that patience and support for the children is a critical factor in the longer term outcomes. However, age appropriate language and full educational integration may be realistic goals for implanted children if long-term habilitation can be provided.

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