Outcome of Early Cochlear Implantation

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Abstract

Introduction: Universal newborn hearing screening facilitates early detection of congenital hearing loss. A child found to have severe to profound hearing loss may require a cochlear implant to access sounds in the speech frequency range. Materials and Methods: This retrospective study compared the speech perception outcomes of children implanted at 2 years and below (C1) with those implanted later (C3). Baseline and post-implant speech perception scores were recorded using IT-MAIS, TACL-R or PPVT. The percentage of improvement was calculated for each group and statistical significance was determined using the Student's *t*-test. Results: The median follow-up period for C1 (n = 29) and C3 (n = 29) was 29 months (range, 6 to 29 months) and 20 months (range, 5 to 32 months) respectively, which was not statistically significant. Although both groups recorded post-implant improvement of speech reception scores, the difference in the degrees of improvement was statistically significant (*P* = 0.034). Conclusion: More rapid development of speech perceptive skills was achieved in children who were implanted early. Early implantation therefore, enables children to develop good core listening skills and to potentially develop spoken language at a young age. This enhances successful integration into mainstream pre-schools which provide the environment for the early nurturing of social and cognitive skills.

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Introduction

In Singapore, about 4 in 1000 babies are born with hearing loss.[1] Childhood hearing screening in Singapore was traditionally conducted at the primary healthcare level when the child was due for vaccination and subjective free-field methods of screening were generally used. This resulted in congenital deafness being detected and intervened relatively late, at a mean age of 20.8 months (range, 0 to 86) and 42.2 months (range, 1 to 120) respectively.[2] Since 2001, a national universal newborn hearing screening (UNHS) programme has been implemented, providing the opportunity for early detection and intervention of congenital hearing loss. At about the same time, the Listen and Talk Programme was launched at the Singapore General Hospital.[1] This Programme provided cochlear implants for selected children with severe to profound hearing loss, and offered a hospital-based auditory-verbal therapy habilitation service. This paper studied children managed by the Programme, comparing those who had received cochlear implants early with those who were implanted later.

Materials and Methods

Our database on children who had received cochlear implants was reviewed and the speech receptive scores were analysed. The children studied were categorised as early implantees (C1) if they were aged 2 years and below or late implantees (C3) if they were above this age. Children lacking in family support and motivation were excluded.

In our Centre, the post-implant audiological and auditory-verbal interventions received by the 2 groups are similar. Depending on the age of the child, the appropriate testing tool was used to assess speech reception ability for each child. The IT-MAIS (*Infant Toddler Meaningful Auditory Integration Scale*), TACL-R (*Test for Auditory Comprehension of Language Revised Edition*) and PPVT (*Peabody Picture Vocabulary Test 3rd Edition*) were used and the tests were administered by Audiologists or Auditory-Verbal Therapists. The results of all the 3 tests were converted to age-equivalent percentage scores. As far as possible, each test was administered by the same assessor to minimise inter-rater variation. Final assessments were made only after a stable MAP had been achieved.

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The base-line and final post-implant percentage scores for each child were obtained and the percentage of improvement was determined. Statistical significance was determined using the Student's t-test.

Results

Children in C1 (n = 29) and C3 (n = 29) have median ages of 19 months (range, 13 to 24 months) and 57 months (range, 29 to 165 months) respectively. The final assessment was done at a median of 29 months(range, 6 to 29 months) and 20 months (range, 5 to 32 months) post-implant for C1 and C3 respectively, which was not statistically significant. The sex, race, implant model and processing strategies used were also comparable between the 2 groups (Table 1). Although both groups recorded an improvement of speech reception scores after implantation, early implantees experienced a statistically significantly higher rate of post-implantation speech reception improvement compared to late implantees (P = 0.034) (Fig. 1).

Discussion

UNHS provides an opportunity for early detection and intervention for congenital hearing loss. Children with significant cochlear hair cell loss may have hearing loss in the speech frequencies that could not be adequately amplified by hearing aids. These children are potential candidates for cochlear implants which by stimulating the auditory neural elements directly, allows early auditory access to the whole speech frequency range. It is well established that auditory stimulation is a prerequisite for appropriate auditory development.[3] Providing a child with an implant at an early age decreases the effects that auditory deprivation can have on the development of speech and language skills and maximises the amount of auditory information available to the child during this critical period.[4] The argument for early implantation has been supported by the results of animal studies. Hsu et al[5] found that electrical stimulation of the inner ear was more effective in younger rats than in older rats in eliciting gene expression associated with development of a functional network in the auditory pathways. Leake et al[6] observed that neuronal survival in the spiral ganglion was enhanced when electrical stimulation was applied shortly after deafening and that spiral ganglion cell size was larger in stimulated than in non-stimulated ears.

Table 1. The Number (percentage) of Subjects for Each Characteristic in the Young (C1) and Older (C3) Implantee Groups

Group	C1	C3
Sex		
Male	17 (59%)	14(48%)
Female	12 (41%)	15(52%)
Race		
Chinese	22(77%)	24(83%)
Malay	3(9%)	2(7%)
Indian	2(7%)	2(7%)
Others	2(7%)	1(3%)
Model of implant		
Nucleus freedom	27(93%)	25(86%)
Nucleus CI24RCS	2(7%)	4(14%)
Processing strategy		
ACE	28(97%)	28(97%)
SPEAK	1(3%)	1(3%)

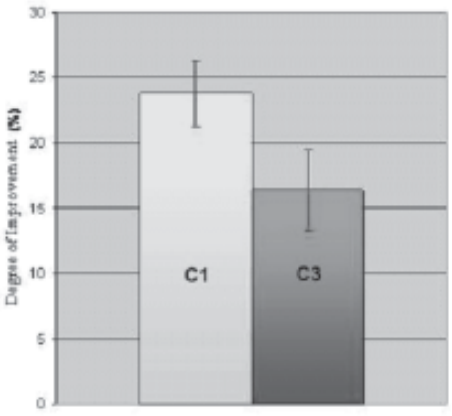

Fig. 1. Chart comparing the mean percentage improvement of post-implant speech perception scores in early (C1) and late (C3) implantees.

The present study demonstrated an improvement in speech perception scores in both young and older aged groups, although a statistically significantly higher rate of post-implantation improvement was found in the younger group. This was consistent with the observations made by Manrique et al,[7] who reported that a higher level of performance was attained at a faster rate by children implanted early compared to those who were implanted later.

An area of continuous interest is whether the advantages of earlier implantation will be maintained over a relatively long time course. It is possible that the children who receive an implant later may eventually catch up to this group in terms of language skills. At least one previous study found that children implanted between 2 and 4 years of age did not differ among themselves in language performance measured at ages 8 and 9 years.[8] Nevertheless, a distinct advantage for earlier implantation is that these children are able to achieve good core listening skills at a younger age, providing the a foundation of skills for these children to be fully and satisfactorily integrated into an oral social environment.[9] With the potential of achieving spoken language competency

early, it facilitates successful integration into mainstream pre-schools which provides the environment for the nurturing of social and cognitive skills.[7]

With UNHS, it becomes feasible to diagnose congenital hearing loss by 3 months and start intervention by 6 months of age, which are the recommendations of the American Academy of Pediatric Joint Committee on Infant Hearing.[10] Intervention should include hearing amplification with the use of appropriate hearing aids, although the amount of benefit depends on the degree of existing residual hearing. In children who did not receive significant hearing amplification from hearing aids, Nicholas & Geer[11] found that the amount of pre-implant intervention with a hearing aid did not affect spoken language outcomes at the age of 3.5 years. Rather, it was cochlear implantation at a younger age that served to reduce the gap between a deaf child's chronological age and his or her language level. Therefore, early cochlear implantation should be considered for children who need them. What then, is the optimal age for early implantation?

The US Food and Drugs Administration approves the use of cochlear implant only in children aged 12 months of age and above. In recent years, emphasis on the importance of early implantation has lead to growing interest in implanting children below the age of 12 months.[12,13] It is however, cautioned that cochlear implantation in young infants may not necessarily be the best practice.[14,15] Pre-operatively, besides a higher possibility of misdiagnosing the degree of hearing loss, maturation of the central pathways within the first few months of life may unexpectedly improve the patient's hearing performance.[11,14] Intra-operatively, the higher surgical and anaesthetic risks encountered in surgeries on infants are well known, although these risks can potentially be lessened by availability of relevant expertise.[13] Post-operatively, the auditory performance of implanted young infants can be difficult to reliably assess, although the use of intra-operative NRT nowadays has alleviated this problem to some extent.[14] More importantly, the benefits of cochlear implantation in children less than 12 months of age compared to those aged say between 12 to 18 months, are still unclear. Speech perception results as reported by Holt et al[15] found no advantage for these children compared to those implanted at 13 to 24 months of age. Therefore, it has been rightly pointed out that before advocating cochlear implantation in children less than 12 months of age as standard practice, the expected benefits derived from such practice should be further studied.[11,14,15] Nevertheless, a notable exception is in post-meningitic deafened infants with signs of cochlear obliteration. In these children, very early implantation can enhance successful insertion of the implant electrode with better outcomes.

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Conclusion

UNHS provides the opportunity for early detection and intervention of congenital hearing loss. In severe to profound deafness, children who received their cochlear implants at the age of 2 years or younger experienced faster rate of improvement compared to those implanted later. Although it may be possible that children who receive an implant later may eventually catch up with this group in terms of language skills, a definite advantage for earlier implantation is that these children are able to potentially achieve good core listening skills and develop spoken language at a much younger age. This facilitates successful integration into mainstream pre-schools which provide the environment for the early nurturing of social and cognitive skills.

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