International Journal of Pediatric Otorhinolaryngology 74 (2010) 206–211

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Bilateral versus unilateral cochlear implantation in young children

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ARTICLE INFO

Article history:
Received 27 September 2009
Received in revised form 15 November 2009
Accepted 20 November 2009

Keywords:
Language development
Cochlear implant
Outcomes
Vocal
Auditory
Communication
Preverbal
Observation
Interaction
Deaf
Young
Children
Outcome
Early
Bilateral
Implantation

ABSTRACT

Objectives: To compare the preverbal communication skills of two groups of young implanted children: those with unilateral implantation and those with bilateral implantation.
Material and methods: The study assessed 69 children: 42 unilaterally and 27 bilaterally implanted with age at implantation less than 3 years. The preverbal skills of these children were measured before and 1 year after implantation, using Tait Video Analysis that has been found able to predict later speech outcomes in young implanted children.
Results: Before implantation there was no significant difference between the unilateral group and the bilateral group. There was still no difference at 12 months following implantation where *vocal autonomy* is concerned, but a strongly significant difference between the groups for *vocal turn-taking* and *non-looking vocal turns*, the bilateral group outperforming the unilateral group. Regarding *gestural turn-taking* and *gestural autonomy*, there was a strongly significant difference between the two groups at the 12 month interval, and also a difference before implantation for *gestural autonomy*, the unilateral group having the higher scores. Multiple regression of *non-looking vocal turns* revealed that 1 year following implantation, bilateral implantation contributed to 51% of the variance ($p < 0.0001$), after controlling for the influence of age at implantation and length of deafness which did not reach statistical significance.
Conclusions: Profoundly deaf bilaterally implanted children are significantly more likely to use vocalisation to communicate, and to use audition when interacting vocally with an adult, compared with unilaterally implanted children. These results are independent of age at implantation and length of deafness.

1. Introduction

The last 20 years have brought about a remarkable change in the providing of useful auditory experience for profoundly deaf children, the most significant contributor to this change being cochlear implantation, the implants giving access to high frequencies which cannot be provided by acoustic hearing aids. The significant benefit derived by profoundly deaf children has resulted in wide-spread provision of cochlear implants in all developed countries, with over half the population of profoundly deaf school-age children being implanted.

Research worldwide has shown that the age at which children are implanted is an important factor in the development of speech perception and intelligibility [1–4], so the availability of Newborn Hearing Screening has been another significant contributor to change, enabling children to be given cochlear implants at an earlier age. Relatively speaking, the provision of two implants is still fairly recent, though this provision is happening worldwide. In the UK the government organisation: National Institute of Clinical Excellence (NICE) has thoroughly investigated the viability of the procedure and has recommended bilateral implantation for all very young profoundly deaf children. There is, naturally, great interest in the outcomes of bilateral implantation, not least

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0165-5876/$ – see front matter © 2009 Published by Elsevier Ireland Ltd.
doi:10.1016/j.ijporl.2009.11.015

because of the extra expense involved in providing two implants, and many research projects are taking place. Some of the research projects that have been undertaken are detailed case studies and therefore necessarily involve low numbers [5,6], though there are others with more numerous subjects, for example the study by Kuhn-Inacker et al. which involved 39 bilaterally implanted children [7]. Most studies are of sequential implantations [8–10]. For example, Galvin et al. [9] looked at 9 young children with a gap of between 6 months and 3 years 2 months between implants.

The main findings of recent research have been the benefits given by bilateral implantation for localisation of sound [11,12] and speech discrimination in noise [7–10,13–15]. Almost all of these studies have concerned children after their acquisition of spoken language, and in some cases adults, for example the study by Zeitler et al. [8] which looked at speech perception benefits in both adults and children. From studies such as these we know that the use of two ears is important in an educational setting, where children are often in noisy rooms and working in groups: being able to use both ears enables easier identification of the speaker and hence greater likelihood that they will understand the speech. This effect is illustrated in the results given in the papers cited above. However, knowledge of spoken language is clearly necessary for the performance of tests of speech perception. Two questions arise: is the use of two ears important for the development of early communication skills? And is it possible to obtain any indications of benefit from two implants rather than one *before* understanding and use of spoken language have developed? One way of doing this is to ask the parents, and a questionnaire has been developed for this purpose by The Ear Foundation in Nottingham [16], covering, for example, localisation of sound and response to voice when in a group of people. Parent interviews yield information on very young children's behaviour at an age when it is difficult to get it in other ways, the children being too young to perform listening tasks; but it must be borne in mind that parental interviews are limited because they are subjective.

Another method, TAIT video analysis, has enabled professionals to look at progress in the preverbal listening skills that underpin vocal and auditory development in all children, normally hearing and deaf alike. This objective, observational method involves looking at video recordings of children's interactions with someone they know well, such as a parent or carer. The recordings can be analysed to show whether, over time, children are becoming more vocal in their communications as compared with using silent sign or gesture, and whether there are indications that they are responding to the adult's speech through audition rather than vision. The analysis, as an assessment method, has been shown to be reliable across observers [17,18] and to have predictive potential with regard to later development of speech perception [19,20]. It is sufficiently sensitive to show whether age at implantation is a factor in children's progress [4], and whether children implanted under the age of 12 months differ significantly from normally hearing children [21]. It is independent of the particular language spoken and therefore can be used in any country.

The aim of the present study is to compare the preverbal communication skills of two groups of very young children: those with unilateral implantation and those with bilateral implantation.

2. Materials and methods

Using TAIT video analysis 42 unilaterally implanted and 27 bilaterally implanted children were assessed before implantation and 12 months following implantation. All the children in both groups met the criteria of being profoundly deaf with no responses to sound at levels better than 110 dB, and of having no known additional cognitive delay. The unilaterally implanted children were from the Nottingham Cochlear Implant Programme (28 children) and KIDS in Hasselt, Belgium (14 children), and were all those implanted since the year 2000 and met the criteria. The bilaterally implanted children were recruited from four different centres: the Nottingham Cochlear Implant Programme, UK (7 children); LUMC, Leiden (7 children), the Radboud University Nijmegen Medical Centre (5 children) in The Netherlands; and Enheten for Cochlea Implantet in Stockholm, Sweden (8 children). It was necessary to gain the collaboration of all these centres in order to recruit a sufficient number of very young bilaterally implanted children. All the children had full insertion of the electrode array apart from one bilaterally implanted child who had full insertion in the left ear and 15/16 electrodes of the Nucleus device in the right ear; this also was treated as a full insertion. Eighteen of the 27 bilateral children underwent simultaneous implantation. The remaining 9 were implanted sequentially, the gap between the two implantations ranging from 1 to 7 months. Tables 6 and 7 in the appendix show the demographic details for both groups of children. As the aim of the present study was to compare children with one implant with children bilaterally implanted (none of the children having sufficient residual hearing to use a hearing aid in either ear) no attempt was made to compare children with two implants with those with one implant plus a hearing aid in the contra-lateral ear.

Video recordings were made before implantation and 12 months after. The recordings were made by the four centres involved in the study. Initial discussion, and training for those centres not already using video analysis routinely for assessment, took place between the first author and the professionals at these centres to ensure that there was consistency both in the filming and in the analysis of the recordings, which were of the child and a parent or other well known adult, who used spoken language supported by signs and/or gestures. They took place in the child's home or other familiar environment; where the unilaterally implanted children were concerned every effort was made to see that the adult was positioned on the side of the implant. The recordings were around 10 min in length, from which a 2-minute section of good interaction was selected by the first author for analysis. If necessary, the 2-minute section was made up of two excerpts from the recording, very young children being apt to lose concentration and move away from the recording area. The recordings were made in well-lit rooms in reasonably quiet conditions. The camera recorded the child almost full-face, with a profile view of the adult if they were sitting opposite the child. No difficulty of observation arose if the child was sitting alongside or on the adult's knee. Activities were chosen that would be of interest to each particular child and which would also promote interaction. A picture book was always included. Transcripts were made of the recordings, and the preverbal skills assessed. The initial assessment was done by the first author, who then checked with the child's teacher or speech therapist to be sure that nothing had been missed or misinterpreted. This was particularly important in the case of the recordings from The Netherlands and Sweden.

Initially *turns* were identified where the child had an opportunity to communicate. This usually occurred where the adult had left a pause, but instances were also included where the child interrupted the adult's communication. Within these *turns*, preverbal skills were measured in three areas: *turn-taking*, *autonomy* and *auditory awareness*. *Turn-taking* and *autonomy* could be either *vocal*, with or without the addition of sign or gesture, or *gestural*, through silent sign or gesture. *Autonomy* was considered