Sequential bilateral cochlear implantation in children

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Abstract. Binaural hearing offers several advantages over monaural hearing including improved speech understanding in the presence of background noise and the ability to localize the source of sounds. Patients who have undergone unilateral cochlear implantation perform poorly at these binaural tasks despite their improved hearing capabilities. Bilateral cochlear implants have restored these abilities in many adult patients. This study is designed to evaluate the degree to which similar benefits are realized by children who receive a second cochlear implant after successful experience with a first device. Twenty-five children aged 3–13 years underwent sequential bilateral cochlear implantation followed by a series of age appropriate speech reception tasks administered in quiet and in background noise. Some also underwent sound localization testing. The children demonstrated improved speech understanding in quiet and in noise using two cochlear implants when compared with either implant alone. Sound localization ability was poor in all subjects even after 9 months of bilateral implant use. We conclude that bilateral cochlear implantation offers potential benefits to children, especially with regard to hearing speech in noise. © 2004 Elsevier B.V. All rights reserved.

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1. Introduction

Recent studies in adults have shown that bilateral cochlear implantation provides significant advantages over the unilateral implant condition, demonstrated by improved speech understanding in background noise and improved sound localization ability [1,2]. Children may also receive great benefits from bilateral implantation. The first step towards assessing the benefit of bilateral implantation in children is to study sequentially implanted...
children (i.e., addition of a second device after experience with unilateral implantation). This study evaluates the benefits of sequential bilateral cochlear implantation in children. In this paper, we present preliminary speech perception and localization results for a group of 25 sequentially implanted children.

2. Methods

2.1. Subjects

Twenty-five children 3–13 years of age with at least 6 months of unilateral cochlear implant experience underwent sequential implantation in the opposite ear. It was required that they had received their first implant device prior to 5 years of age and that they were engaged in a habilitation/educational program with an emphasis on spoken language adjustment. Six children in the 8–13-year age group had a Nucleus 22 device on the side of first implantation. All other children had either a Nucleus CI24M or Nucleus 24 Contour on their first side. All children received a Nucleus 24 Contour on their second side.

2.2. Preoperative testing

Preoperative testing included age-appropriate speech perception testing, speech detection measures and patient/parent questionnaires to assess perceived performance and quality of life benefits attained with the child’s first cochlear implant. Subjects were required to score \( \geq 30\% \) on word recognition testing in the implanted ear and \( \geq 30\% \) in the ear to be implanted using an optimally fitted hearing aid.

2.3. Postoperative testing

Postoperative testing included age-appropriate speech perception testing, sound localization testing, speech detection measures and patient/parent questionnaires to assess perceived performance and quality of life benefits. Subjects are evaluated postoperatively at 3, 6, 9 and 12 months after activation in both the unilateral and bilateral conditions. Children who were 3–5 years of age at the time of the second-side implantation will also be assessed at 18 and 24 months postactivation. Speech perception was measured using the Multisyllabic Lexical Neighborhood Test (MLNT) for the 3–5-year-old group, the Lexical Neighborhood Test [3] (LNT) for both the 5–8-year-old and 8–13-year-old groups, and using sentence material from the Hearing in Noise Test for Children [4] (HINT-C) for the 8–13-year-old age group.

Speech (Spondees) recognition in noise was measured using the Children’s Realistic Index of Speech Perception (CRISP) test [5] (four alternative forced-choice) in three speech/noise conditions.

Sound localization ability for children in group I was tested with the Minimum Audible Angle (MAA) task, a computer game designed to determine the younger child’s ability to distinguish between two sounds that are spatially separated. Children in groups II and III underwent localization testing with an eight-speaker array placed 10° apart using a computer game designed to test their accuracy in identifying the source of sound in the unilateral and bilateral conditions.
3. Results and conclusions

In general, the children implanted thus far have adapted well to the second side after a variable period of adjustment. Younger children appear to adapt more quickly. The older age groups’ longer duration of deafness in the second ear appears to correlate with their subjective difficulty adapting to that implant. As shown in Fig. 1, the children in all three age groups show improved open-set speech understanding, on average, in the second ear. However, the younger children (under 8 years) clearly acquire speech understanding in the second ear more quickly. By 6 months postactivation, the gap in speech understanding, as measured by open-set word recognition, between the first and second ear has almost closed. On the other hand, this trend is not apparent for the older children (8–13 years), or it may be that they need more experience with bilateral implants.

The children demonstrated significantly better speech perception in noise (speech babble) using two implants together compared to one implant alone (Fig. 1). Bilateral implantation primarily allowed the children to take advantage of the head shadow benefit, attending to the ear with the better signal-to-noise ratio. Overall, the children were less affected by competing noise than in the unilateral condition. In addition, performance was better than had been found at 3 months postoperative [6]. Theoretically, this may be the most practical benefit children stand to receive from bilateral implantation. Since real-
world listening conditions nearly always contain competing background noise, it could be expected from this study that bilaterally implanted children will “hear” better in adverse listening environments in which they frequently find themselves.

Of the children tested thus far, none have shown significant localization abilities for sound sources within a 15-speaker array, unilaterally or bilaterally. Since these children have essentially never had bilateral auditory input, it may be that more time and/or training is required for this important skill to develop. The findings of this study support early bilateral implantation in children. If children are given binaural hearing at a young age (under 3 years old), there may be gains seen in the rate of language acquisition (which was not addressed in this study) and the early development of true sound localization ability. Based on our results, such studies of bilateral implantation in infancy appear justifiable [7].

Future plans include further exploration of localization abilities. Children will be assessed using a left–right discrimination task. This task is easier for the children to understand and complete. Children who perform well on this task will also be tested using a speaker array. The role of training will also be explored to ensure that results are not negatively affected by task-related difficulties and to encourage development of localization skills.

References