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Children with cochlear implants and developmental disabilities: A language skills study with developmentally matched hearing peers

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ABSTRACT

The number of children receiving cochlear implants (CIs) with significant disabilities in addition to their deafness has increased substantially. Unfortunately, children with additional disabilities receiving CIs have largely been excluded from studies on cochlear implant outcomes. Thus limited data exists on outcomes in this population to guide pre-implant counseling for anticipated benefits. The study objectives were: (1) evaluate differences in post-cochlear implant language skills between children with cochlear implants and developmental disabilities and age/cognitively matched controls; (2) quantify possible discrepancies between language level and cognitive level. Fifteen children with a developmental disability who received a CI were matched 1:1 on nonverbal cognitive ability and age to hearing controls. Language was evaluated using Preschool Language Scale-IV and reported as language quotients. Multivariable mixed models for matched pairs analyzed differences in language levels between groups. No significant differences were seen between CI and control groups regarding insurance, maternal education, or family income level. Results of the multivariable models indicated that compared to matched controls, the CI group had significantly lower mean receptive (24.6 points, $p = 0.002$) and mean expressive (21.9 points, $p = 0.001$) language quotients after controlling for confounders such as number of therapies and weekly hours in therapy. Significant discrepancies between language level and cognitive level were seen among CI participants only. Compared to age- and cognitively matched controls, children with CIs had significantly lower language levels with delays disproportionate to their cognitive potential. Mechanisms behind this performance-functional gap need to be understood to deliver appropriate intervention strategies for this special population.

1. Introduction

Hearing loss is one of the most common pediatric health conditions in the United States. Moderate to profound bilateral hearing loss is identified in 2–3 infants per 1000 births, increasing to approximately 6 per 1000 children by school age (American Speech-Language-Hearing Association, 2010; Centers for Disease Control and Prevention, 2010; National Institute on Deafness and other Communication Disorders). Approximately 30–40% of children with sensorineural hearing loss demonstrate additional or multiple disabilities that can have profound effects on communication and related cognitive,

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visual, motor, and behavioral development (Fortnum, Marshall, & Summerfield, 2002; Gallaudet Research Institute, 2008; Roberts & Hindley, 1999; Van Naarden, Decoufle, & Caldwell, 1999).

A cochlear implant (CI) is a widely embraced technological device used for the deaf child's auditory system to gain access to a quality of sound experience not available with hearing aids alone. Studies addressing language development of children with implants at early ages (≤36 months old) have found that the rate of language development after a CI exceeded that expected from deaf children without an implant, with the most rapid language growth occurring among children who received the CI at the youngest ages (Anderson et al., 2004; Fryauf-Bertschy, Tyler, Kelsay, Gantz, & Woodworth, 1997; Geers, 2004; Kirk et al., 2002; McConkey Robbins, Koch, Osberger, Zimmerman-Phillips, & Kishon-Rabin, 2004; Miyamoto, Kirk, Svirsky, & Sehgal, 1999; Osberger, 1997; Svirsky, Teoh, & Neuburger, 2004; Tomblin, Barker, Spencer, Zhang, & Gantz, 2005; Waltzman & Cohen, 1998). In addition, upon receiving an implant, language growth rates of children are close to rates of children with normal hearing (Bollard, Chute, Popp, & Parisier, 1999; Kirk et al., 2002; McConkey Robbins et al., 2004; Svirsky & Meyer, 1999; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000; Svirsky et al., 2004), with the biggest leap in language development happening during the first year post-implant (Cheng, Grant, & Niparko, 1999; Tomblin, Spencer, Flock, Tyler, & Gantz, 1999). While children with CIs approach the language development of their hearing matched peers, language delays may continue to exist in some children post-implant (Bollard et al., 1999; Geers, 2004; Manrique, Cervera-Paz, Huarte, & Molina, 2004; Miyamoto, Svirsky, & Robbins, 1997; Stacey, Fortnum, Barton, & Summerfield, 2006). In the early years of pediatric cochlear implantation, it was typical for children with known disabilities to be considered unsuitable for the procedure. Although the number of children with additional disabilities who are receiving cochlear implants has been increasing over the years (Edwards, 2007), appropriate outcomes in this population are still relatively unknown.

The impact of hearing loss on children with developmental disabilities or delays has never truly been quantified, yet it has been assumed to be profound. Until recently, most research on deafness and additional disabilities have been qualitative (e.g., surveys, case studies, observations). The few quantitative studies on children with cochlear implants and disabilities have reported on a variety of outcomes, often regarding speech perception or intelligibility (Daneshi & Hassanzadeh, 2007; Dettman et al., 2004; Edwards, Frost, & Witham, 2006; Hamzavi et al., 2000; Nikolopoulos, Archbold, Wever, & Lloyd, 2008; Pyman, Blamey, Lacy, Clark, & Dowell, 2000; Vlahovic & Sindija, 2004; Waltzman, Scalchunes, & Cohen, 2000). Control populations, when available, consist of typically developing children (Holt & Kirk, 2005; Nikolopoulos et al., 2008; Pyman et al., 2000), which are not necessarily appropriate comparisons for this particular group of children. Children with developmental disabilities who received cochlear implants do not meet their typically developing peers in auditory skill development, speech perception, or language skills. Unfortunately, control populations of typically developing children with implants will never help us understand the skills set we would expect to see in context of the developmental concerns of the child.

In light of the lack of developmentally appropriate control groups for children with cochlear implants and additional disabilities, the current study utilized a design that allowed for a control population of hearing children with disabilities. Our cochlear implant center has routinely implemented an evaluation by a developmental pediatrician since 2001 which has been discussed in detail previously (Wiley, Meinzen-Derr, & Choo, 2008). Anticipated expectations for child outcomes are discussed candidly with families during this pre-implantation evaluation. The addition of a developmental pediatrician has allowed the otologists, speech-language therapists, audiologists, and aural rehabilitation therapists an increased comfort level in serving children with additional disabilities. It has also allowed for continuity of care and guidance in altering strategies for interventions as children continue to follow up with the team's pediatrician. Being extremely aware of the needs for outcomes research in this population of children, the objectives of this study were (1) to evaluate the differences in post-implant language skills among children with cochlear implants and developmental disabilities as compared to hearing children who were matched on age and cognitive abilities; and (2) quantify the gap between language abilities and cognitive abilities in this population.

2. Materials and methods

2.1. Participants

Children identified with a developmental disability who were ≤6 years of age were eligible for the study. Children with a cochlear implant were identified through a clinical cochlear implant registry. Hearing children (controls) with similar age and developmental abilities were identified through a review of clinical charts within the Division of Developmental and Behavioral Pediatrics. Parents of eligible study participants were contacted by letter and follow-up phone call. Parents could also actively contact study personnel through information listed on advertisements posted throughout the medical center. All enrolled participants had completed developmental evaluations by 3 years of age. Children with hearing were matched (1:1) to children with cochlear implants within 12 months of age and within 5 quotient points (per nonverbal cognitive assessment). The nonverbal cognitive abilities, over chronologic age, were considered the priority regarding matching criteria. This study was approved by the institution's Institutional Review Board. Consent was obtained from all parents prior to study participation.

2.2. Developmental evaluation

All children had been evaluated by a developmental pediatrician prior to the study using the Revised Gesell Developmental Schedules (Ball, 1977). This tool is routinely administered to children under the age of 3 years who are seen