

**Critical Review: In children with bilateral severe-to-profound hearing loss, is there any evidence that bilateral cochlear implants, improve speech perception in noise compared to that provided by a single implant?**

Escobar, C.

M.Cl.Sc. (Aud) Candidate

School of Communication Sciences and Disorders, U.W.O.

This critical review intended to determine the benefit provided by bilateral implantation in terms of speech in noise perception when compared to unilateral conditions in children. Overall, the four studies examined in this review indicated variable results that ranged from 1.1 dB to 6 dB of improvement in speech discrimination noise tasks with a second implant. However, results can not be generalized due to different testing conditions and methodologies used in the studies reviewed.

***Introduction***

Parents who have children with severe to profound sensorineural hearing loss that are not receiving adequate benefit from hearing aid amplification, face difficult decisions when confronted with the possibility of bilateral cochlear implantation for their child. Cochlear implantation is an invasive and extensively expensive procedure; for this reason, a decision to implant a child should be well justified. Additionally, children generally grow and develop within significantly noisy environments; depending on the level of noise, speech might not be heard adequately in order to generate normal language development. Also, children with unilateral cochlear implantation have specific difficulties when listening in noisy conditions.

***Objective***

This review is intended to critically appraise existing published studies that evaluate speech in noise discrimination in children who have been implanted with bilateral cochlear implants; in search of concluding information that pediatric audiologists can use in order to provide appropriate advice to parents with children who present severe to profound hearing impairment and are being considered for bilateral cochlear implantation.

***Method***

Search Strategy

Computerized databases including PubMed, Medline and Google scholar were consulted in relation to the topic by using the following search strategies: ((bilateral cochlear implants) OR (sequential cochlear implantation) AND (speech in noise discrimination) OR (speech in noise recognition) and (children) OR (pediatrics)

This search strategy was successful and four current articles were found.

Selection Criteria

The studies selected to be included in the present critical review were expected to define the benefit provided by bilateral cochlear implantation, relative to unilateral implants, in speech in noise discrimination listening conditions. The studies were limited to children with sequential implantation; however, there was no limit in terms of age ranges, age of implantation, period of time between first and second implantation, outcome measure, stimulus or listening conditions. Limit was set to information in terms of speech in noise discrimination improvement, so other benefits arising from bilateral implantations, such as localization, binaural squelch and head shadow effect have not been included in this review.

Data Collection

Results on published literature search yielded (generated) the following articles that are congruent with aforementioned selection criteria: case control studies without randomization (4).

***Results***

Schaefer and Thibodeau (2006), conducted a case control study without randomization in which they intended to determine speech recognition in a simulated classroom environment in children with bilateral implants compared to a single unilateral implant and other conditions that were not relevant to the present review.

For the purpose of this study, a group of (12) children with severe-to-profound hearing loss were sequentially implanted. This study controlled for language proficiency as all the children included in

this study spoke English as a first language. The same internal implant was used by most of the subjects and all children received their first implant before 5 years of age and were prelingually deafened before 1 year of age. Also, most children attended mainstream classrooms.

The majority of children were girls and duration between first and second implant ranged from 6 months to 9 years old.

First, this study determined speech recognition in noise performance with a material created specially for the age range group, based on Bamford-Kowal-Bench (BKB) Speech in Noise test. An intensity adjustment procedure was applied, in which 10 phrases about body parts were presented and varied systematically in intensity, during four sessions. As a response, the children were expected to act out the phrases with a doll. Then, speech in noise thresholds were identified through the clinical method of limits. Phrases initiated at +18 SNR to -18 SNR decreasing in intensity by 3 dB, on the other hand, the noise was presented at 60 dBA. Thresholds were determined after 50% performance level. This study employed, live voice phrases and fixed intensity concatenated classroom noise as a stimulus. In terms of signal speaker location it was positioned 0 degrees azimuth and noise speaker was located at 135 and 225 degrees relative to the straight-ahead condition.

Two partially repeated ANOVAs were employed to determine the difference between groups. Results for this study revealed no significant differences in speech in noise thresholds for bilateral cochlear input relative to a single cochlear implant. Average differences for both groups showed a difference of 1.1 dB, about 5.5% to 11% in favor of bilateral cochlear implants when compared to unilateral implantation alone.

Another investigation by Kuhn-Inacker et al (2004) attempted to measure how bilateral implantation optimizes perception abilities in deaf children. This case control study included (18) children tested for speech discrimination in noise, the children ranged from 2 years 11 months to 9 years 1 month. Most of these children were prelingually deaf. Additionally, all children were implanted with the same cochlear implant and speech processor. In order to find a relation between speech in noise discrimination and bilateral cochlear implantation, speech discrimination was tested by employing two lists of bisyllabic words containing 30 words each. They were presented in an open format for children and in a closed format for toddlers. The percentage of correct responses was determined.

In this study, speech shaped noise stimuli were delivered at a fixed SNR of +15dB and speech material was delivered at the child's most

comfortable level. Four loudspeakers were positioned such that speech was delivered through two loudspeakers at 45 and 135 degrees azimuth, and the noise was delivered through the other two at 225 and 315 degrees azimuth.

After application of statistical measures (i.e., Wilcoxon test and the paired t-test) to evaluate the performance difference in these two conditions, the researchers concluded that children scored better on the bilateral condition improving in average by a range of 22% to 25% or 1.5 to 2.3 dB in noisy conditions

Through linear regression analysis, the researchers were able to confirm that age effects at the time of the first cochlear implantation as well as the time lag between the two implants, did not significantly influence speech discrimination in noise performance.

The next study performed by Wolfe et al. (2007) was intended to evaluate speech recognition in quiet and noise. Assessed for each ear separately and for bilateral conditions, in (12) children who underwent bilateral cochlear implantation, 11 of these children were prelingually deafened and underwent activation of their first cochlear implant at/or before 3 years old; age of activation of second implant ranged from 22 months to 9.5 years. All children participated in intensive auditory-verbal therapy. This case control study assessed speech in noise recognition by obtaining a speech recognition threshold in the presence of steady-state, speech-weighted noise, presented at 45 dB HL. Speech spondaic stimuli were provided randomly through monitored live voice, adaptively varied, to acquire a signal to noise ratio (SNR). Threshold was obtained when the child was able to identify the desired stimuli accurately 50% of the time, (SNR-50), which is determined by the difference in level between the presentation of the noise signal and the speech recognition in noise threshold.

Loudspeakers were located at 0 degrees azimuth for the speech signal and at 180 degrees for the noise signal.

Linear regression and correlation analyses were performed to analyze the data, which revealed a 6 dB mean improvement (30% to 60%) was achieved in noisy environments under bilateral cochlear implantation condition.

The last study reviewed was conducted by Galvin et al. (2007), were they intended to evaluate additional perceptual benefit obtained from bilateral cochlear implantation on (11) children from 4 to 15 years of age who had been sequentially implanted.

In this study, the mean average for obtaining the first implant was 2 years, 1 month, for the second implant, 8 years 4 months, and the mean time

between implants was 6 years 2 months. All children underwent oral/aural rehabilitation. Most children were assessed six months after surgery. Both subjective and objective measures were performed for this purpose. As an objective measure of speech perception, a new test was developed specifically for this study. It consisted of a four alternative forced choice adaptive spondee discrimination test to determine SNR; and a subjective measure of speech perception of child's performance in specific situations administered as a questionnaire to the parents (SSQ Speech, Spatial, and Qualities of Hearing Scale).

Speech stimuli consisted of 20 spondaic words which varied in level and were initially presented at 62 dBA. The Noise stimulus consisted of continuous speech shaped noise presented at 42 dBA, which was raised no more than 62 dBA.

The speech signal was presented from one loudspeaker located in front of the listener, and two loudspeakers were located at 90 degrees to the left or right to present the adaptive noise in both first implant and bilateral conditions.

Although there was great intersubject variation in the results; one-tailed paired t-tests indicated no difference in the mean SNR when noise was presented contralaterally to the first implant.

Other paired t-tests indicated superior performance (lower SNR) in the bilateral conditions when noise was presented ipsilaterally to the first implant when compared with unilateral conditions with a group difference of 3.1 dB. In addition, subjective reports indicated superior performance for the first implant during bilateral testing conditions.

The authors concluded that children over 4 years of age might benefit from a second implant, although, the benefit of gain was dependent on the noise condition and on the relative experience with the cochlear implant.

### *Discussion*

The investigations reviewed in this document attempted to find evidence of the benefit of bilateral cochlear implantation in comparison to one single cochlear implant using measures of speech perception in noise. It has been found that a person with cochlear implants loses about 20 to 35% or 2 to 3 dB in speech in noise performance when compared to quiet conditions (Litovsky et al, 2004). This information can provide an idea of what amount of improvement would be considered significant improvement in listening in noisy conditions when compared to optimal listening conditions.

Out of the four studies described above, two reported significant benefit of bilateral implants and

the remaining two, found mixed results that did not provide compelling evidence of the benefit of bilateral implantation. One of these studies focused only on the benefit provided in speech recognition in noise, whereas the other three studies intended to evaluate bilateral benefit in different areas which at the time, are not the focus of this review.

Results from these studies identified an improvement of bilateral implantation in speech in noise discrimination tasks that ranged from 1.1 dB (11%) of improvement to 6 dB (60%) of improvement.

In terms of the inclusion criteria used in the four investigations it was considered acceptable taking into account the difficulties presenting in finding a large randomized sample in this area of study.

On the other hand, none of the study conditions where speech in noise discrimination was assessed, replicated appropriately typical noise situations experienced by children in daily life. Additionally, different types of speech stimuli, noise stimuli, loudspeaker arrangement and assessment instruments, were employed for assessments in each of the studies. This could explain the variability in findings from each of the research investigations. Moreover, the sample groups on the studies were heterogeneous in terms of age, age of first implantation, age of second implantation and time lag between first and second implant or acclimatization period with the second implant; which may have contributed to the difference in results.

In view of the methodological factors discussed above, it is difficult to use the findings of these studies to predict the amount of benefit in speech perception that may result from bilateral implantation. The quality of the studies corresponds to a level III-2 of evidence, which provides moderate scientific evidence, not robust enough to recommend application to clinical practice.

### *Conclusions*

Recent literature in general, suggests that bilateral cochlear implantation can provide somewhere between a 1.1 dB to 6 dB range of improvement in speech to noise discrimination in comparison to unilateral testing conditions. Variability between the findings of the different research studies may have resulted from the different testing conditions and methodologies employed within each of the investigations. Moreover, the overall amount of benefit resulting from bilateral implantation is not clear at this time, since results of this critical review, do not include a measure of other benefits inherent to bilateral cochlear implantation,

such as localization, binaural squelch, head shadow and overall ease in communication.

### ***Recommendations***

In terms of the evidence found on this critical review, careful recommendations should be provided to parents in terms of the amount of benefit that bilateral cochlear implants provide, relative to listening to speech information in noisy situations.

More research is needed and should be conducted that include measures of other benefits obtained with bilateral fittings and the effects of experience or acclimatization, age of implantation and time between first and second cochlear implant.

### ***References***

- Galvyn, K. L., Mok, M. & Dowell R. C. (2007). Perceptual benefit and functional outcomes for children using sequential bilateral cochlear implants. *Ear and Hearing*, 28 (4), 470-482.
- Kuhn-Inacker, H., Shehata-dieler, Muller, J. & Helms, J. (2004). Bilateral cochlear implants: a way to optimize auditory perception abilities in deaf children? *International Journal of Pediatric Otorhinolaryngology*, 68 (10), 1257-126.
- Litovsky, R. Y., Parkinson, A., Arcaroli, J., Peters, R., Lake, J., & Johnstine, P. (2004). Bilateral cochlear implants in adults and children. *Archives of Otolaryngology Head and Neck Surgery*, 130, 648-655.
- Schafer, E. C. & Thibodeau, L. M (2006). Speech recognition in noise in children with cochlear implants while listening in bilateral, bimodal, and FM-system arrangements. *American Journal of Audiology*, 15, 114-126.
- Wolf, J., Baker, S., Caraway, T., Kasulis, H., Mears, A., Smith, J., Swim, L. & Wood, M. (2007). 1-Year postactivation results for sequentially implanted bilateral cochlear implant users. *Otology & Neurotology*, 28 (5), 589-596.