

## **Critical Review: Are there benefits to binaural-bimodal fittings compared to a unilateral cochlear implant alone?**

Haskins, T.

M.Cl.Sc. (Aud) Candidate

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

With advancements in cochlear implant technology, individuals with a greater amount of residual hearing are being considered candidates for implantation. The present review article evaluates research that investigates the usefulness of a unilateral cochlear implant being combined with a hearing aid in the opposite ear. Evidence shows that a significant number of individuals who wear a hearing aid in the contralateral ear achieve measurable and perceived benefit in speech perception and localization, when compared to wearing the cochlear implant alone. This knowledge is valuable to clinicians for counseling clients and arriving at informed decisions surrounding amplification options.

### ***Introduction***

The benefits of binaural amplification have been widely researched and have shown consistent improvements over unilateral stimulation. Two main improvements are in speech perception and sound localization. Because of these known advantages, individuals with bilateral hearing loss are often encouraged to receive amplification in both ears in order to maximize their residual hearing ability.

Individuals who show minimal benefit with traditional amplification may qualify for a cochlear implant. Candidacy for such intervention has become more lenient with improvements in cochlear implant technology and outcomes. As a result, over the years individuals no longer require the absence of residual hearing to be considered candidates (Tyler, Parkinson, Wilson, et al., 2002). An option for unilaterally implanted patients is to provide a hearing aid to an opposite ear with some residual hearing (i.e., bimodal-binaural fitting). There have been concerns with the use of bimodal-binaural fittings due to the difference in technology. That is, the electrical input from an implant conflicting with the acoustic input from the hearing aid. A practical concern is whether the benefit from the addition of a hearing aid would be enough to surpass the additional burden of the hearing aid. Despite these concerns, research has shown that there can be significant improvement in speech perception and localization with bimodal-binaural fittings. A nontrivial consequence of leaving one ear unaided is the possibility of a more rapid decline in hearing in that ear than if it were receiving stimulation (Luntz, Shpak, & Weiss, 2005).

### ***Objectives***

This review summarizes the evidence surrounding the consequences of bimodal-binaural

amplification. The goal is to educate clinicians on the evidence surrounding multimodal amplification. This knowledge will ultimately lead to their clients being able to make an informed decision when determining their amplification needs.

### ***Methods***

#### **Search Strategy**

Computerized databases, including Proquest, Web of Knowledge, MedLine and OVID, were searched using the following search strategy: (binaural-bimodal) OR ((cochlear implant) AND (hearing aids))

The search was not limited to a range of published year, as the total number of search results was of reasonable length. Results were limited to English only.

#### **Selection Criteria**

Studies selected for the review include those that involve a direct comparison of functional outcomes between binaural-bimodal fittings and a single cochlear implant. Studies that used bilateral cochlear implants as a comparison group were not included. Literature was chosen from a variety of researchers rather than a selection from common researchers in order to reduce any biases.

#### **Data Collection**

The literature search using these selection criteria led to the following research type: within-subject group comparison in an experimental design.

### **Results**

Ching, Psarros, Hill, Dillon and Incerti (2001) compared the performance of children on auditory skills when using a cochlear implant and a hearing aid in the opposite ear (CI+HA), compared to a cochlear implant alone (CI). Three skills were evaluated: speech perception, localization and communicative functioning. Researchers set the frequency response of the hearing aid to optimize speech intelligibility in quiet. They also did a loudness balancing procedure between the hearing aid and the cochlear implant. Another comparison they made was between these optimized settings and their original settings. Speech perception was done using two sets of stimuli; recorded sentences and VCV nonsense syllables. The children were required to repeat what they heard (sentences) or point to the correct syllable on a card. For the localization task, the children would have to identify one of eleven loudspeakers to localize pink noise at 65 dB SPL. To assess communicative functioning, a parent questionnaire was administered after each condition to assess areas such as listening in quiet, in small groups, listening in noise and alertness to environmental sounds. Each task was performed using CI+HA and CI alone.

The participants used in this study included 11 congenitally hearing impaired children who had a unilateral cochlear implant (6-18 years of age). These children were all a part of the Children's Cochlear Implant Centre in Sydney, Australia. They limited the type of cochlear implant to either a Nucleus 22 or Nucleus 24 system, and programmed with the SPEAK strategy. They also controlled for the form of education they received. The hearing aid that was used during the study was a Bernafon AF120 behind the ear.

Statistical analysis was conducted to analyze the results, however only the probability values were recorded in this paper. It would be preferable that the *F* ratio values were recorded as well for the Analysis of Variance procedures. A mixed ANOVA with repeated measures was conducted to analyze the three within-subject conditions: material (sentences or nonsense syllables), condition (quiet or noise) and device (CIHA, CI alone, HA alone, CIHA(adjusted)). Tukey's post-hoc comparisons were made to compare between each condition.

Each of the three factors that they analyzed produced significant results. Post-hoc comparisons revealed that the sentence perception in quiet and in noise was better in the adjusted CI+HA than CI alone, HA alone, or CI+HA at original settings. They also calculated CI+HA benefit by calculating the differences between CI+HA(adjusted) and a CI alone. Three of the participants showed significant benefit

for speech recognition. Localization analysis showed that CI+HA(adjusted) produced significantly better horizontal localization than a CI alone. This was not the case for CI+HA(non-adjusted). The parent questionnaire revealed a significant improvement for CI+HA(adjusted) over the other conditions. Careful analysis of the results showed that bimodal-binaural stimulation did not produce any detrimental effects compared to unilateral stimulation. This study provides strong evidence that should be considered as an option for individuals with contralateral residual hearing.

Luntz, et al. (2005) investigated the degree of improvement in speech perception in individuals with binaural-bimodal amplification following their implantation. Changes in ability with increased exposure to the devices were also investigated. Subjects included twelve individuals with unilateral cochlear implants with residual hearing pre-implantation. Participant recruitment was not discussed. A loudness balance procedure between CI and HA was performed, and the hearing aids were fitted to user preference levels. With 1-6 months post-implantation, there was no significant difference between CI+HA and CI alone. However, after 7-12 months, there was a significant improvement in speech perception in noise with a hearing aid in the opposite ear.

The statistical analysis used in the study was the Friedman test followed by pairwise comparisons between categories using a Bonferroni correction. An appropriate paired Wilcoxon signed-rank test was used to assess improvement between the earlier and later sessions. Here, only the probability values were included in the statistical results. Concise charts were also provided which gave a good depiction of the improvement in the results.

The p-value at  $<0.075$  in combination with the small sample size might lessen the external validity of the results.

Subjective tests were also performed, revealing three individuals who were not found to have benefit, but who did have perceived benefit and chose to continue wearing the aid. The combination of the objective test results and the participants' perceived improvement provides strong evidence for the use of a contralateral hearing aid.

Tyler, et al. (2002) performed a study on a sample of three individuals with unilateral cochlear implants who were each using a contralateral hearing aid for more than 5 years. They obtained their participants through a questionnaire distributed at a research centre. They also looked at the three conditions: CI, HA, and CI+HA. They measured speech perception in quiet and in noise using word recognition and key word recognition in sentences.

Localization of speech sounds was also compared between the conditions. In the speech perception task, two of the three individuals showed significant CI+HA benefit with speech and noise originating from the front. One patient showed improvement in the binaural condition with noise originating from the implant side. All three subjects showed significant improvements in the localization task. There was no discussion of statistical analysis, which can be seen as a limitation to this research article. Given the small sample size and lack of written statistical results, this study is considered a moderate level of evidence for the implementation of the multimodal devices.

### *Possible Limitations*

In the study by Ching et al. (2001), a key component of their findings was that a combination of a cochlear implant and a hearing aid adjusted to optimal frequency and loudness settings produced superior speech perception abilities over the cochlear implant alone. In a real life situation, a child might not be provided with the frequency shaping in their hearing aid required to optimize speech intelligibility in quiet. In addition, they might not be given the test to produce equal balance in their two devices. Ching et al. revealed that upon entering the study, there were differences in how each person's hearing aid was set to provide optimal performance. Upon further testing, no significant differences in performance were found when the original frequency response was used. However, this was not the case with the gain provided by the hearing aid. Therefore, it will be necessary that loudness balancing is conducted between CI and HA. Consequently, it is likely that this study overestimated the benefit of CI+HA when optimal loudness settings are not applied.

Across studies, there are inconsistencies as to how the hearing aid settings are adjusted. For example, specific adjustments are made to meet predetermined criteria or user settings are kept. This discrepancy might limit the external validity of these results.

A weakness common to these studies, as well as many others, is the lack of controlling for age of implantation and type of implant. The relatively small population of individuals with cochlear implants that are also willing to partake in a research study makes it difficult to carefully control for these variables. Age of implant could potentially be a confounding variable with children participants. Earlier stimulation of the auditory system could result in stronger auditory skills than someone who is implanted later.

### *Conclusions*

The benefits of binaural stimulation are well understood and clinicians are reasonably confident to recommend two hearing aids to clients with appropriate bilateral losses. Lesser research in the area of bilateral-binaural fittings does not allow the clinician to approach their recommendations with the same degree of confidence. There have been concerns involving the mismatch in technology and potential detrimental effects. However, current research has clearly demonstrated that by using a hearing aid contralateral to the implant produces benefit in the area of speech perception and localization of sound. Interestingly, individuals have shown to benefit from bilateral-binaural fittings regardless of their hearing thresholds pre-implantation (Luntz, et al., 2005). In those cases where no measurable improvements were made, there was no deterioration in abilities either. In some cases there were only perceived improvements, which alone can be argued as a reason to implement multimodal fittings. The clinician may want to suggest a hearing aid trial to see if they perceive benefit from the bilateral stimulation. This review has provided a summary of research that has been done in the area of binaural-bimodal fittings, in the hopes that they will collaborate with their clients to make informed amplification decisions.

### *Recommendations*

For patients who have a unilateral cochlear implant and have residual hearing in the opposite ear, it would be worthwhile to pursue a hearing aid for the aidable side. Evidence has shown that the majority of individuals demonstrate improved speech perception and sound localization abilities when they have contralateral stimulation. This benefit may be measurable, perceived or, both. Preservation of the ear with residual hearing is another important reason to use a hearing aid. Without stimulation, it is likely there will be a more rapid decline in hearing threshold, which will likely augment the negative outcomes of the hearing loss. One of our goals as clinicians is to help our clients reach their maximum communicative potential knowing their hearing status. Therefore, clinicians should explain to their clients the benefits of contralateral stimulation and how it could ultimately improve their communication abilities.

### *References*

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