Interventions for Speech Perception in Noise in Children with Single-Sided Deafness: A Systematic Review

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Objective

To systematically review the literature on air conduction hearing aids, bone conduction hearing aids, CROS hearing aids, and cochlear implantation as an intervention to improve hearing in noise outcomes in children with single-sided deafness.

Introduction

Unilateral sensorineural hearing loss (UHL) in children can have a significant effect on language development, educational outcomes, and performance on localization tasks and speech perception in noise. Although the effects of bilateral hearing loss in children have been well-documented, less research has focused on the effects of unilateral hearing loss and single-sided deafness in this population.

Children with UHL are unable to take advantage of binaural benefits, and therefore have shown decreased performance on tests of speech perception in noise and localization tasks (Reeder, Cadieux, & Firszt, 2015). These challenges are evident in their educational performance and speech and language outcomes (Bess & Tharpe, 1986; Lieu et al., 2010).

Although several intervention options exist for UHL, in our experience the most common recommendation for children with UHL is preferential seating in the classroom combined with a “watch and wait” approach. For those with severe to profound UHL, also known as single-sided deafness, intervention in the form of air conduction hearing aids has often been unsuccessful. Current treatment options for SSD in adults include contralateral routing of signal (CROS) hearing aids and bone conduction hearing aids. Cochlear implantation is also becoming a more popular treatment for adults and investigations are beginning with children.

Methods

The three authors performed a comprehensive search of the PubMed, Web of Science, and CINAHL databases. A search of the databases was performed using the following search string: (child* OR adolescen* OR youth OR preschool) AND (single sided deafness OR unilateral hearing loss) AND (cochlear implant* OR bone anchored hearing aid* OR hearing aid* OR contralateral routing of signal) AND noise. The inclusion criteria were as follows: children (birth-18 years); single-sided deafness (PTA in the poorer ear of ≥70 dB HL and PTA in the better ear of ≤20 dB HL); sensorineural hearing loss; hearing in noise or speech in noise testing; and intervention of a CROS hearing aid, air conduction hearing aid, bone conduction hearing aid, or cochlear implant. Twenty percent of the articles were screened by two authors to determine inter-rater reliability.

Articles that met the inclusion criteria were read in their entirety to ensure applicability to the authors’ clinical question. These articles were appraised using Let Evidence Guide Every New Decision (LEGEND) Clinical Appraisal forms from Cincinnati Children’s Hospital. Single Case Experimental Designs were appraised using The Quality Indicator Checklist: Single Subject Studies form from National Secondary Transition Technical Assistance Center, as this study design is not included in the Cincinnati Children’s Hospital clinical appraisal forms. Thirty percent of included articles were appraised by two reviewers and inter-rater reliability was determined.

Results

Our search identified 219 articles and 39 articles were provided by experts in the field, for a total of 258. One hundred twenty-eight articles were unique studies. After exclusion process, 11 articles were left to read in their entirety. The critical appraisal and main findings are presented in Table 1. The majority of the studies were longitudinal designs. Table 2 includes the appraisal results for these six studies. In general, the studies were found to be of lesser quality due to small sample size, low external validity, and lack of statistical analysis.

All three bone conduction studies found benefit with regards to speech perception in noise, with the exception of one study (Hassepass et al., 2015) that found detriment when noise was presented to the ear with the bone conduction hearing aid. Studies that examined CROS hearing aids found mixed results. While Kenworthy et al. (1990) found benefit when speech was presented to the poorer ear and detriment when noise was presented to the poorer ear, Updike (1994) did not find any benefit of the CROS over the unaided condition. Cochlear implantation appears to improve hearing in noise in subjects with SSD when duration of deafness is short.

Table 1. Study Overview and Final Appraisal

Author	Year	Type of Study	Number of Participants	Interventions Examined	Quality of Evidence
Arndt, S.	2015	Longitudinal	20	CI	4a (Good quality)
Christensen, L.	2008	Longitudinal	3	BAHA	4b (Lesser quality)
Christensen, L.	2010	Longitudinal	23	BAHA	4b (Lesser quality)
Friedmann, D.R.	2016	Longitudinal	4	CI	4b (Lesser quality)
Hassepass, F.	2013	Single Case Experimental Design	2	CI	Good quality
Hassepass, F.	2015	Longitudinal	1	BoneBridge	4b (Lesser quality)
Kenworthy, O.T.	1990	Pretest-Posttest RCT/CCT	5	CROS	2b (Lesser quality)
Peters, J.P.	2015	Systematic Review	11	CI	1b (Lesser quality)
Plontke, S.K.	2013	Case Study	1	CI	5b (Lesser quality)
Tavora-Vieria, D.	2015	Longitudinal	4	CI	4b (Lesser quality)
Updike, C.D.	1994	Pretest-Posttest RCT/CCT	3	CROS	3b (Lesser quality)

Table 2. Appraisal Information for Longitudinal Studies

Question	Article					
	1	2	3	4	5	6
1. Were the study methods appropriate for the question?	✓	✓	✓	✓	✓	✓
2. Were the instruments used to measure the outcomes valid and reliable?	?	?	?	?	?	?
3. Were all appropriate variables and interventions clearly described?	✓			✓		✓
4. Were all appropriate outcomes clearly described?	✓			✓		✓
5. Was there freedom from conflict of interest?	✓	?		?	✓	✓
6. Were the statistical analysis methods appropriate?	✓					
7. Did the study have a sufficiently large sample size?	?	?	?	?	?	?
8. Were the results statistically significant?	✓	?	?	?	?	?
9. Were the results clinically significant?	?	?	?	?	?	?
10. Were any adverse events assessed?	✓		✓	✓	✓	✓
11. Can the results be applied to my population of interest?	✓	✓	✓	✓	✓	✓

1. Arndt et al., 2015; 2. Christensen & Dornhoffer, 2008; 3. Christensen et al., 2010; 4. Friedmann et al., 2016; 5. Hassepass et al., 2015; 6. Tavora-Vieria & Rajan, 2015

✓ = Yes; ? = Unknown; Blank = No

Discussion / Conclusion

No firm conclusions about intervention in this population can be made due to the heterogeneity of the studies. The test conditions, including speaker set-up, speech perception materials, type of noise, and signal and noise intensity levels, varied across studies. Future research should include greater sample size and uniform test conditions.

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