

Reference	Intervention	Type	Participants	Test(s)	Intervention Conditions	Test Conditions	Results	Conclusions	Comments
Kenworthy, Klee, & Tharpe (1990)	RM CROS	Laboratory	6 children (6–12 years old); normal hearing in one ear; moderate to profound hearing loss in one ear (PTAs range: 56 to > 120 dB HL)	Nonsense syllable recognition Sentence recognition	1) Unaided; 2) CROS (microphone on ear with hearing loss; receiver on ear with normal hearing); 3) RM (microphone near primary loudspeaker, receiver on ear with normal hearing)	In all conditions, speech level was 62 dB A and noise level was 56 dB A (+6 dB SNR) 1) <u>Monaural direct</u> (speech: +45° relative to ear with normal hearing; noise: +45° relative to ear with hearing loss); 2) <u>Monaural indirect</u> (speech: +45° relative to ear with hearing loss; noise: +45° relative to ear with normal hearing); 3) <u>Midline</u> (speech: 0°; noise: 135, 180, 225° relative to midline)	1) <u>Monaural direct</u> : Significant detriment of CROS use relative to FM and unaided (~30 percentage points); 2) <u>Monaural indirect</u> : FM better than unaided (~55 percentage points); CROS better than unaided (~45 percentage points); 3) <u>Midline</u> : FM benefit (12 percentage points) and CROS detriment (11 percentage points) relative to unaided with nonsense syllables	1) RM provides most consistent benefits 2) CROS only provides benefits in monaural indirect conditions 3) CROS can significantly impair speech recognition in monaural direct and some midline conditions	Stimuli were prerecorded, limiting the role of head movement RM microphone was always near the speech loudspeaker Noise was mostly directional, rather than diffuse
Miller (1967)	CROS (body worn)	Survey	13 children (7–13 years old); normal hearing in one ear; moderate to severe hearing loss in one ear; demonstrated listening difficulties at home and school	Parent and teacher report	CROS system with body aid positioned on the shoulder near the ear with hearing loss; custom earmold with snap ring and maximum venting	Teachers and parents reported on participants' progress relative to unaided after 1 semester of CROS use	12 of 13 children demonstrated "favorable adjustment" Teachers reported greater alertness of children and fewer misunderstandings Children reported better sound awareness	CROS systems can provide benefits and should be considered an option for children with unilateral hearing loss	Evidence is difficult to interpret because data are not presented and methodology details are missing

<p>Noh & Park (2012)</p>	<p>Seating</p>	<p>Laboratory</p>	<p>1) 25 children (10–19 years) with <u>unilateral hearing loss</u>; normal hearing in one ear; PTA greater than 60 dB HL in the other ear 2) 25 children with <u>normal hearing</u> (10–19 years) 3) 25 young adults with <u>normal hearing</u></p>	<p>Nonsense syllable recognition (Korean)</p>	<p>Speech loudspeaker 3 m from participant (58.3 dB A); in quiet Speech loudspeaker 3 m, 4 m, 6 m, 8 m, and 10 m from participant; in babble</p>	<p>In all conditions, speech loudspeaker was midline (0°) and presented speech 65 dB A at 1 m; noise level was 55 dB A; speech levels varied with listener distance (58.5 to 52.5 dB); conference room with RT60 = 430 ms</p>	<p>1) Children with hearing loss were more sensitive to the effects of noise at 3m (10.2%) compared to adults and children (4.8% and 3.8%, respectively) 2) Children with normal hearing outperformed their peers with hearing loss at all loudspeaker locations. 3) To achieve 80% speech recognition, a student with unilateral hearing loss would need to sit within 3 m</p>	<p>Children with limited useable hearing unilaterally need to be seated closer to the teacher (within 6.3 m) to perform similarly in noise to their peers with normal hearing</p>	<p>Preferential seating focused on the teacher as the signal of interest Moving the child closer to the teacher will move them farther from peers, who are also potential talkers of interest</p>
<p>Purcell, Jones-Goodrich, Wisneski, Edwards, & Sie (2016)</p>	<p>Amplification</p>	<p>Survey</p>	<p>50 families of children 5–19 years; children had normal hearing in one ear and mild ranging to profound, permanent hearing loss in the other ear</p>	<p>Questionnaires regarding amplification use completed by families Interviews with children 16 children (11–19 years)</p>	<p>Children were fit with conventional amplification, CROS, or RM systems as deemed appropriate based on their hearing status</p>	<p>n/a</p>	<p>1) 80% had access to preferential seating 2) 40% reported use of FM systems 3) 50% reported difficulties associated with preferential seating 4) 68% of children tried amplification 5) CROS retention rate was 69% 6) Most common reason for lack of use was discomfort (47%), followed by lack of benefit (33%)</p>	<p>1) Retention rates are relatively high and independent of degree of hearing loss 2) CROS useful if unilateral hearing loss is severe-profound and/or word recognition scores worse than 60%</p>	<p>Highlights the risk of "low cost" interventions, such as the social stigma associated with preferential seating</p>

Shapiro (1977)	CROS	Survey	10 children (7–17 years) who were fit with CROS system; normal hearing in one ear; hearing loss greater than 55 dB in the other ear; identified as having as having difficulty in school	CROS use rate and parent-reported benefit for academics and/or social behavior	Children were fit with CROS following a trial period Surveys were mailed to the families	Retrospective reports of changes seen with CROS systems	1) 8 of 9 remaining participants were considered "successful" users of CROS or BiCROS 2) 1 of 9 participants did not do well with amplification 3) Half of the participants' families returned the questionnaire— children wore CROS at school and sometimes at home; all parents reported they would recommend the system	CROS systems can provide benefits for children with "unaidable" hearing in one ear CROS should be used at school full-time and at home if desired by the child	Selection bias evident; only those exhibiting difficulty in school and those who exhibited benefit during a trial period were fit with CROS; "difficulty in school" not clearly defined
Updike (1994)	CROS, RM, conventional hearing aid	Laboratory	6 children with unilateral hearing loss (5–12 years); normal hearing in one ear and unilateral hearing loss in the other ear (1 mild, 1 moderate, 1 moderately severe, 1 severe, and 2 profound in degree)	Word recognition performance with closed set response	1) Unaided; 2) Hearing aid (only for 4 participants); 3) CROS; 4) RM (microphone near primary loudspeaker, circumaural headphone)	In all conditions, speech level was 77 dB SPL and noise level was 71 dB SPL (+6 dB SNR) 1) <u>Quiet</u> (speech at 0°, 4.5 m from participant) 2) <u>Noise</u> (speech at 0°, speech-shaped noise at +90 and +270°)	FM improved word recognition in <u>noise</u> for all 6 participants and in <u>quiet</u> for 3 participants CROS improved word recognition in <u>quiet</u> for 1 participant (mild loss) and impaired performance for 1 participant (moderately severe loss) CROS significantly impaired word recognition in <u>noise</u> for 2 participants and improved performance for 0 participants	1) Fitting CROS does not enhance speech recognition and can make it worse in noisy environments 2) RM system significant improved word recognition, especially in background noise	Directional noise Speech loudspeaker in front with RM microphone near the loudspeaker of interest

Note. RM = remote microphone systems; CROS = contralateral routing of signal aids; SNR = signal-to-noise ratio; FM = frequency modulation; BiCROS = bilateral microphones with contralateral routing of signal.

References

- Kenworthy, O., Klee, T., & Tharpe, A. (1990). Speech recognition ability of children with unilateral sensorineural hearing loss as a function of amplification, speech stimuli and listening condition. *Ear and Hearing, 11*, 264–270.
- Miller, A. L. (1967). Body type hearing aids for unilateral hearing losses. *Journal of Speech and Hearing Disorders, 32*, 268–269.
- Noh, H., & Park, Y.-G. (2012). How close should a student with unilateral hearing loss stay to a teacher in a noisy classroom. *International Journal of Audiology, 51*, 426–432.
- Purcell, P. L., Jones-Goodrich, R., Wisneski, M., Edwards, T. C., & Sie, K. C. (2016). Hearing devices for children with unilateral hearing loss: Patient- and parent-reported perspectives. *International Journal of Pediatric Otorhinolaryngology, 90*, 43–48.
- Shapiro, I. (1977). Children's use of CROS hearing aids. *Archives of Otolaryngology (Chicago, Ill.: 1960), 103*, 712–716.
- Updike, C. D. (1994). Comparison of FM auditory trainers, CROS aids, and personal amplification in unilaterally hearing impaired children. *Journal of the American Academy of Audiology, 5*, 204–209.