Clinical Validation of the Muse Wireless CROS System

Ashley Hughes, Au.D., & Chad Parrish

Introduction

Fitting individuals with unilateral hearing loss (UHL) or asymmetrical hearing loss can pose unique challenges in the clinic. For example, the attenuation of some sounds as a result of head shadow effects can reduce the detection of sounds arriving to the ear opposite from the sound source (Fletcher, 1953; Shaw, Newman, & Hirsh, 1947; Taylor, 2010; Tillman, Kasten, & Horner, 1963). The subsequent reduction in audibility can make speech understanding challenging for individuals with UHL, particularly when the speech signal is presented from the side of the poorer-hearing ear. Contralateral routing of signal (CROS) and bilateral CROS (BiCROS) systems help to overcome these physical limitations and are commonly used in the treatment of UHL.

CROS systems are best suited for individuals with one normal-hearing ear and one unaidable ear. An ear can be deemed unaidable if traditional amplification can no longer provide sufficient benefit due to severity of the audiometric thresholds, or if there is unacceptable distortion of the sound (Kuk, Korhonen, Crose, & Lau, 2014). A CROS system is composed of a transmitting device, or transmitter, and a receiving device, or receiver. The transmitter is fit on the side of the unaidable ear and acts only as a microphone to pick up sounds originating from that side of the head. The signal is then streamed to the receiving device, which is worn on the side of the normal hearing ear. In a CROS fitting, the patient will hear the streamed signal from the unaidable side in addition to hearing all other natural incoming sound in their normal hearing ear.

BiCROS systems are designed for individuals with bilateral asymmetric hearing loss, in which one ear is aidable and the other ear is unaidable. Similar to a CROS system, the transmitter is worn on the unaidable ear and has a microphone that picks up sound and transmits it to the receiving device on the better-hearing ear. In contrast to the CROS system, the receiving device in a BiCROS System also acts as a fully functioning hearing aid. The signals from the transmitter and receiving device are summed and amplified through the receiving device in the aidable ear. In other words, sounds from both sides of the patient’s head are combined and then amplified to ensure audibility of both signals in the patient’s better-hearing ear.

Muse Wireless CROS System

The new Muse™ Wireless CROS System (Figure 1), developed by Starkey® Hearing Technologies, integrates the convenience of 900sync™ wireless technology and the full performance of the Muse product line to provide the patient both CROS and BiCROS functionality in one system. Any Muse Receiver-In-Canal (RIC) or Behind-The-Ear (BTE) style hearing aid can be used as a CROS receiver. The clinician simply pairs a receiver with a transmitter during the fitting session and configures CROS or BiCROS functionality as desired in the Inspire® X software.
The transmitting device looks identical to Muse hearing aids, however contains only a microphone and wireless antenna, no functional receiver. To help the patient and clinician differentiate the transmitter from the receiver, the transmitter is labeled CROS.

For BiCROS fittings, it may be necessary to adjust the ratio between the streamed audio from the transmitter and the audio from the microphones on the receiver. This can be done via the Balance Control on the CROS/BiCROS screen in Inspire X. Shifting the balance towards the transmitter side increases the sensitivity of the transmitter microphone while decreasing the sensitivity of the receiver microphone. Shifting the balance towards the receiver results in the opposite effect. Once the Balance Control is set in the fitting software, it applies to all BiCROS memories. Additionally, there is an option to provide the patient with a user-controlled Balance Control. When this function is enabled, it allows the patient to adjust the balance with the hearing aid user controls. When the user-controlled Balance Control is enabled, the Balance Control settings in the software will be the patient’s default setting.

The Muse Wireless CROS System works with all SurfLink® accessories, including the SurfLink Mobile 2, SurfLink Media 2, SurfLink Remote, SurfLink Remote Microphone 2, and the SurfLink Mini Mobile (Figure 2). When listening to music, taking a phone call, or using the SurfLink Media 2, the wireless CROS signal is paused while the accessory stream is active. When the accessory stream is no longer active, the wireless CROS signal is restored automatically.

**Hearing in Noise With CROS**

The Muse Wireless CROS System supports a variety of directional modes to help patients hear in difficult environments. The following microphone modes are supported on both the transmitter and receiver:

- Adaptive Directional
- Dynamic Directional
- Static Directional
- Omnidirectional

Manual control of CROS audio transmission is achieved through simple memory configurations in the Muse Wireless CROS System. Each individual memory may be independently configured as follows:

- CROS (transmitter microphone only)
- BiCROS (transmitter and receiver microphones active)
- Hearing aid only (transmitter off)

Independent memory configuration puts the power of optimal hearing in a patient’s hands. As an example, consider a scenario for a BiCROS user in which speech is presented to the better-hearing ear and noise is presented to the poorer-hearing ear. If BiCROS streaming is maintained, the patient may experience increased hearing difficulty. However, if the patient switches to a hearing aid only setting, the noise will be blocked and the speech will be heard with optimal clarity.
aid-only memory, which disables the transmitter, the patient’s speech understanding and comfort for this particular situation will likely improve (Crukley & Goyette, 2016).

**Clinical Trial Results**

**Fittings and Real-Ear Measurements**

Ten individuals, three females and seven males, participated in the clinical trial of the Muse Wireless CROS System. Seven participants were fit with a CROS configuration and three were fit with a BiCROS configuration. The study consisted of a minimum of three visits over a total of four to six weeks. The mean age of all participants was 60.6 years, with a range of 28.1 to 78.3 years. Mean audiometric data, as well as group minimum and maximum thresholds, are shown in Figure 3. Four participants were fit with BTE devices coupled to domes via thin tubes, and six participants were fit with RIC devices coupled to domes via SnapFit receivers. The hearing aids were Best Fit to Starkey Hearing Technologies’ proprietary e-STAT targets at the initial session (Scheller & Rosenthal, 2012). Real-ear aided response (REAR) measurements were then completed using the Audioscan Verifit system, with the purpose of measuring the output of the devices in the ear canal and ensuring audibility. The International Speech Test Signal (ISTS; Holube, Fredelake, Vlaming & Kollmeier, 2010) was used for all real-ear measurements and presented at levels of 50, 65 and 75dB SPL through a speaker positioned at 45 degrees azimuth to both the better-hearing ear and poorer-hearing ear to verify appropriate compensation for the head shadow effect. An 85dB SPL pure-tone sweep was used to verify maximum output. The gain and frequency response of the devices were adjusted as needed at subsequent visits in order to optimize listening comfort for each participant.

**Speech-In-Noise Testing**

Participants completed the Hearing in Noise Test (HINT) to evaluate benefit with the CROS system on a speech-in-noise task. The HINT is a standardized speech test that adaptively arrives at the SNR required for correct repetition of 50 percent of the sentences presented in a background of competing speech-shaped noise at a fixed level of 65dB SPL (Nilsson, Soli & Sullivan, 1994). The level of speech is adapted based on participant response. After a correct response, the speech presentation level is decreased for the next sentence (lowering SNR and increasing difficulty). After an incorrect response, the speech presentation level is increased for the next sentence (raising SNR and decreasing difficulty). A lower threshold indicates better performance, and the final score is recorded in dB SNR.

During HINT administration, speech material was presented from +/-90 degrees on the side of the poorer-hearing ear and the noise was presented from the side of the better-hearing ear. This particular configuration was chosen because it is the most challenging condition for someone with UHL or asymmetrical hearing loss. Testing with this configuration was completed in the unaided and CROS/BiCROS conditions. The CROS/BiCROS condition included adaptive directionality, the default microphone mode for the Muse Wireless CROS System. Twenty sentences were administered in each of the mentioned conditions and the order of conditions was randomized for each participant.

Figure 4 displays the HINT scores (dB SNR) for the two conditions. A repeated measures analysis of
variance (RM-ANOVA) indicated that participants performed significantly better with the Muse Wireless CROS System with adaptive directionality when compared to their unaided performance \( F(2, 18)=12.8, p<0.001 \). These results support the expectation that directionality on both the CRoS transmitter and receiver is valuable in improving speech understanding in noise. Additionally, this demonstrates the benefit of the Muse Wireless CROS System in difficult listening situations for individuals with UHL or asymmetrical hearing loss.

In addition to testing the hearing devices, four participants were also asked to evaluate either the SurfLink Mobile 2 or the SurfLink Media 2. The SurfLink Mobile 2 can function as a hearing aid remote control, a remote microphone and a device for wirelessly transmitting phone call audio from a cell phone. The SurfLink Media 2 is used specifically for streaming media from a television or audio device to the hearing aids. The commonality between these two devices lies in the wireless transmission of the audio signal to the receiver via 900 MHz wireless technology, which improves the SNR for the listener through elimination of the distance between the sound source and the hearing aid microphones. Participants were asked to complete multiple questionnaires regarding sound quality and speech understanding while using these devices. On a five-point scale, ranging from very poor to very good, all four participants rated the sound quality of the streamed audio signal from the streaming device as good or very good. Participant comments regarding SurfLink Mobile 2 and SurfLink Media 2 are provided below.

“I was able to hear more words than I could previously hear. Good, helpful system.”

“Easy to use and a must-have for TV watchers!”

**Overall Hearing Aid Satisfaction**

Participants were asked to complete the Device-Oriented Subjective Outcome Scale (DOSO) [Cox, Alexander, & Xu, 2014] once at the beginning of the study, answering questions about their own hearing aids, and a second time at the conclusion of the study regarding the test devices. Data was only collected for those participants who had their own hearing aids. The DOSO is designed to examine six subscales (speech cues, listening effort, pleasantness, quietness, convenience, and use) related to the hearing devices. Participant responses were analyzed with point-polyserial correlations and are provided in Figure 5. Results indicated significantly better subjective outcomes on the speech cues, listening effort, and
pleasantness subscales ($p<0.001$, $p=0.002$, and $p=0.008$, respectively) with the Muse Wireless CROS System relative to the participants’ own devices. Examples of questions on the DOSO that specifically relate to these subscales are 1) “How good are the hearing aids at picking up what strangers say the first time?” 2) “How good are the hearing aids at helping to reduce misunderstandings during conversations?” and 3) “How good are the hearing aids at providing a pleasing sound quality?”

**Pro Tips**

1. **In a BiCROS fitting, consider setting one memory to hearing aid only.** This can provide benefit to the patient when speech is presented to the better ear and noise is presented to the poorer ear.

2. **In a BiCROS fitting, consider setting one memory to CROS.** This can provide benefit to the patient when speech is presented to the poorer ear and noise is presented to the better ear.

3. **CROS or BiCROS streaming is not active during the fitting session unless the clinician utilizes the “Demo” button in Inspire X.** This button can be found on the CROS/BiCROS screen and allows the clinician to live demo CROS or BiCROS streaming to their patient, without having to exit Inspire® X. Remember that the microphone on the receiver of the better hearing ear is active during the fitting session on both CROS and BiCROS devices.

4. **The directional mode on the transmitter follows the directional mode on the receiver:** Omnidirectional, Directional, Dynamic or Adaptive.

**Conclusion**

Clinical trial results suggest that the memory options, user control flexibility, directionality and full wireless compatibility provided by the Muse Wireless CROS System can help those suffering from the negative effects of UHL or asymmetrical hearing loss. The Muse Wireless CROS System allows individuals with UHL or asymmetrical hearing loss the opportunity to stay active and involved in everyday listening situations, even in the most challenging of environments.
References


