Wireless products and functionality have become ubiquitous in all aspects of our everyday life. Even hearing aids wirelessly share information with each other as well as with other electronic accessories, enhancing a patient’s experience in a variety of listening environments. While it is easy to get excited about the benefits provided by wireless hearing aid technology, it can also be overwhelming for professionals and patients alike. A technology solution needs to be simple and provide a clear benefit.

Wireless remote microphones have been around for many years. Studies confirm the improvement of speech recognition in noise when using a remote microphone (Boothroyd, 2004; Lewis et al., 2004; Rodemerk & Galster, 2015). The FM (frequency modulation) system, in which sound from a remote microphone is transmitted to a hearing aid receiver, is the original wireless microphone for hearing aids. As FM systems add considerable bulk to hearing aids and cost thousands of dollars, hearing aid companies have developed a variety of lower cost remote microphone options that leverage different types of wireless technology. To satisfy a patient’s need for improved speech understanding in challenging environments, Starkey Hearing Technologies developed an improved, cost-effective, discrete SurfLink® Remote Microphone (Figure 1) to transmit distant audio directly to Z Series™, Muse™ and wireless SoundLens® Synergy® hearing aids.

Challenging Environments

When positioned horizontally, the SurfLink Remote Microphone gathers sound from all directions. This can be useful for listening to multiple nearby talkers in quieter environments. Hearing aid wearers have found that placing the Remote Microphone in the middle of a conference table (Figure 2) allows them to better comprehend and participate during around-the-table business discussions. Its small, stylish design does not attract attention, as it reminds many people of a portable USB memory drive. Listeners have also successfully set the Remote Microphone in front of their television speakers while watching their favorite shows. Listeners noted that use of the Remote Microphone improved television audio clarity and allowed television volume to be reduced to a level comfortable for their partner. Where the SurfLink Remote Microphone really excels is in noisier environments. When worn by a partner (talker) in a restaurant or in a car, the Remote Microphone automatically prioritizes sound from above while reducing sound levels from other directions (Figure 3). This directional mode is useful for focusing on the talker of interest when
background noise is present. The Remote Microphone contains an integrated clip (Figure 4, Item 6), allowing it to be affixed to clothing. If used with an optional lanyard, it can be conveniently worn around the neck. The optimal operating range is up to 20 feet (7 meters), which allows listeners and talkers to communicate from across the room even if the talker is not facing the listener. Longer operational distances are achievable, though audio quality and performance may diminish.

**Easy to Use**

The SurfLink Remote Microphone is easy to set up and use. To associate hearing aids with a Remote Microphone, simply press the sync button (Figure 4, Item 3) for five seconds and then sequentially close each hearing aid battery door. Once the hearing aids are synced, turning on the Remote Microphone automatically starts the audio streaming. To turn off the Remote Microphone, move the slider control (Figure 4, Item 2) to the off position. For ease-of-use, the Remote Microphone does not contain an integrated volume control; rather, the listener can make volume adjustments via the hearing aid user control or an optional remote control.

The SurfLink Remote Microphone is designed to operate for a full afternoon of meetings and still be ready for a dinner appointment. For extended use, it supports concurrent recharging and audio streaming. To recharge the battery, connect the Remote Microphone (Figure 4, Item 1) to a USB jack on a computer, wall power adaptor, car charger adaptor, or USB instant-charger battery pack. The integrated LED (Figure 4, Item 5) provides helpful information about the battery charge and other operational states.

1. Micro USB Jack for Recharging
2. Power On/Off Slider
3. Sync Button
4. Built-In Microphones
5. LED Indicator
6. Clip

![Figure 2: When placed on a table, the SurfLink Remote Microphone gathers sound from all directions.](image2)

![Figure 3: When worn by a partner in noisy situations, the SurfLink Remote Microphone prioritizes sound from the talker.](image3)

![Figure 4: Overview of the SurfLink Remote Microphone features.](image4)
Clinical Validation

A research study was completed to evaluate the benefits hearing aid wearers received when using the SurfLink Remote Microphone. In the study, participants attended three laboratory sessions as well as used the hearing aids and Remote Microphone for three to four weeks in real-world situations. Sixteen individuals participated in the clinical trial (Figure 5). During the study, eight participants wore Muse i2400 micro RIC 312t hearing aids and the other eight wore Z Series i110 RIC 312 hearing aids. One participant in the Z Series group had an unaidable ear and wore only one hearing aid. The participants were fit with venting and earmold options appropriate for their hearing losses.

The hearing aids were Best Fit to Starkey Hearing Technologies’ proprietary e-STAT targets during the initial session (Scheller & Rosenthal, 2012). Stream Boost, which is a special hearing aid response designed to enhance the sound quality experience during audio streaming, was enabled. The Stream Boost memory automatically activated when the Remote Microphone was turned on.

Using the Audioscan® Verifit® system, the Real Ear Aided Response (REAR) was measured to ensure audibility. The International Speech Test Signal [ISTS; Holube, Fredelake, Vlaming & Kollmeier, 2010] stimulus was used for all real-ear measurements and was presented at levels of 50, 65 and 75dB SPL. Additionally, an 85dB SPL pure-tone sweep was presented to verify maximum output. The gain and frequency response of the hearing aids were adjusted as needed at subsequent visits based on participant requests.

Speech-in-Noise Testing

Participants completed the Hearing in Noise Test (HINT), which assessed the benefit with the SurfLink Remote Microphone on a speech-in-noise task. The HINT is a standardized speech test that adaptively arrives at the signal-to-noise ratio (SNR) required for correct repetition of 50 percent of the sentences presented in a background of 65dB SPL speech-shaped noise [Nilsson, Soli & Sullivan, 1994]. The speech level adapts based on each correct (or incorrect) response, resulting in a calculated HINT score. Speech is presented from a front loudspeaker with diffuse noise presented from seven other loudspeakers surrounding the participant. The HINT was completed with only the hearing aids, as well as with the Remote Microphone. For test conditions using the Remote Microphone, it was placed 6 inches [15 cm] below the loudspeaker. The microphones on the hearing aids were set to one of three offsets: Mic On, Mic -6dB, Mic Off. These offsets were tested to determine what, if any, effect the microphone offset would have on speech recognition in noise. The Mic Off and Mic -6dB offsets are the default settings for open and non-open fittings, respectively.

Results (Figure 6) indicate the SurfLink Remote Microphone provided a statistically significant 15dB improvement in speech recognition in noise over the hearing aids alone. Results from the HINT were used in a linear mixed-effects model, which predicts results for the general population. The model predicts that, for all conditions using the Remote Microphone, participants performed significantly better than with the hearing aids alone.
alone \(p<0.001\), and participants performed significantly better with hearing aid microphone off than with the hearing aid microphone on \(p=0.012\).

**Sound Quality Comparison**

In order to ensure satisfactory sound quality with Stream Boost, participants noted their sound quality preference between the *Normal and Stream Boost memories in a laboratory evaluation. Participants were seated in a reverberant room, facing a Head and Torso Simulator (HATS) about 3 feet (1 m) away (Figure 7). The SurfLink Remote Microphone was affixed 6 inches below the mouth of the HATS. The speech was presented from the HATS at 75dB SPL and a diffuse babble noise was presented from four other loudspeakers at 70dB SPL. Participants, blinded to the current memory setting, switched between the two memories and indicated their preference. They completed the task eight times. Results (Figure 8) indicated that participants preferred the Stream Boost memory over *Normal by more than a 2:1 margin. These results validate the use of the Stream Boost memory when the Remote Microphone is active.

**Overall Satisfaction**

Participants also completed multiple questionnaires during their time using the SurfLink Remote Microphone in their everyday listening environments. For ratings of speech understanding in various environments, participants used a five-point scale, ranging from “very poor” to “very good.” In quiet environments, 100 percent of participants rated speech understanding as “okay” to “very good.” When using the Remote Microphone in noisy environments, 87 percent of participants rated speech understanding as “okay” to “very good” (Figure 9). This is encouraging, as according to MarkeTrak data, speech understanding in noise is ranked as one of the greatest difficulties for hearing aid users (Abrams & Kihm, 2015). Participants also rated their overall satisfaction with the Remote Microphone using a scale from 0 (“very dissatisfied”) to 10 (“very satisfied”). Nearly 90 percent of participants rated their overall satisfaction as “very satisfied” to “very good.” These results indicate that the SurfLink Remote Microphone provides excellent performance in various listening environments.

Figure 6: HINT results shown as a SNR score in dB as a function of hearing aid condition. Data is representative of results from all 16 participants. A lower score indicates better performance. HINT scores indicate about a 15dB improvement in speech recognition for the test conditions.

Figure 7: HATS in reverberant room with the SurfLink Remote Microphone affixed about 6 inches (15 cm) below the speaker.

Figure 8: Participant sound quality preference for the Stream Boost and *Normal memory. Data is representative of results from all 16 participants for a total of 128 trials. Participants preferred automatic switching to Stream Boost memory during SurfLink Remote Microphone use.
93 percent of participants rated their satisfaction as a 7 or greater (Figure 10).

Figure 9: Participant subjective rating of speech understanding in quiet and in noise. Data is representative of 14 participants for the ratings in noise and 15 for the rating in quiet; some participants failed to respond to the questions. Participants reported notable benefit in understanding speech in both quiet and noisy environments.

Figure 10: Participant rating of overall satisfaction while using the SurfLink Remote Microphone. Data is representative of 15 participant responses, as one participant failed to respond to the question. Participants were very satisfied with the Remote Microphone.
Conclusion

For some people, integrated hearing aid features such as digital noise reduction and directional microphones provide sufficient benefit even in the most troublesome environments. However, for many individuals, hearing aids alone are insufficient. For these individuals, an FM system was once the only choice, and it is still often considered the best choice. Rodemerk and Galster (2015) compared a traditional FM system to remote microphones from three different hearing aid manufacturers. Their results indicated the remote microphone options performed as well as the FM system. Current research, as presented in this article, using a comparable test setup, demonstrated a similar 15dB improvement in speech understanding in noise when using the SurfLink Remote Microphone.

Clinical research confirms that the SurfLink Remote Microphone can mitigate the effects of distance and noise to improve speech understanding in the most difficult listening situations. Interestingly, many study participants also found the Remote Microphone equally helpful in quiet settings. The Remote Microphone’s portable design encourages listeners to carry it in their pockets or purses, so it is readily available when encountering challenging listening situations. Setup is easy and the Remote Microphone’s unique auto-orientation feature always delivers an optimized audio experience for the listener. It can reduce the isolation many people experience when they cannot fully engage with others in challenging environments. The simple addition of a SurfLink Remote Microphone to a hearing aid fitting can make a significant difference in a hearing aid wearer’s life.

References


