Fitting individuals with severe-to-profound sensorineural hearing loss can pose various challenges in the clinic.

One challenge is restoring audibility in the high frequencies. Voiceless consonants, such as /s/, which are important for clarity and understanding, fall into the frequency range of 6.3 to 8.8 kHz (Stelmachowicz, Lewis, Choi & Hoover, 2007). Restoring audibility for these high-frequency speech sounds is further complicated by the natural high-frequency roll-off of microphones and receivers used in today’s hearing aids (typically 4,000 Hz and above) (Dillon, 2001). Additionally, providing sufficient gain in the high frequencies to restore audibility may result in feedback. In total, these issues may affect the clinician’s ability to allow access to high-frequency speech cues in patients with severe-to-profound hearing loss. Through use of powerful hearing devices that provide ample amounts of gain, frequency lowering technology, such as Spectral iQ, and advanced feedback cancellation algorithms, restoring audibility for individuals with severe hearing loss is a much more realistic goal now than it was even just several years ago (Galster, Valentine, Dundas & Fitz, 2011).

Despite restoring audibility, the complaint of difficulty understanding speech in background noise often persists, thus leading to a second challenge of improving signal-to-noise ratio (SNR) loss. SNR loss is defined as “the dB increase in SNR required for 50 percent correct word recognition, over the average SNR required by those with normal hearing to achieve a 50 percent correct score” (Killion, 1997). A positive relationship between audiometric loss and SNR loss has been documented, such that, on average, SNR loss increases with worsening hearing...
loss. SNR loss can be measured with tests such as the Hearing-in-Noise-Test (HINT) or the QuickSIN (Nilsson, Soli & Sullivan, 1994; Killion, Niquette, Gudmundsen, Revit & Banerjee, 2004). Use of directional microphones is a widely accepted method for improving SNR in situations with background noise. In addition to directional hearing aids, wireless accessories are another option for overcoming the negative effects of severe and profound SNR loss, which is defined by Killion and Niquette (2000) as SNR loss ranging from 11–20 dB.

Unfortunately, patients with severe-to-profound hearing loss and severe and profound SNR loss may avoid difficult listening situations, especially those in which directionality and wireless accessories are of greatest benefit (e.g., restaurants, phone). In order to accommodate the everyday listening needs of this patient population, especially in adverse listening conditions, Starkey Hearing Technologies now offers a 3 Series™ Power Plus* behind-the-ear (BTE) hearing aid with a matrix of 138/80 and features such as Spectral iQ, Voice iQ², and full wireless compatibility. This article describes the clinical validation of the 3 Series Power Plus BTE hearing aids, pictured in Figure 1, with particular focus on directional benefit and use of wireless accessories among a group of experienced hearing aid users with severe-to-profound hearing loss.

Fittings and Real-Ear Measurements

Twelve individuals, three females and nine males, participated in the clinical trial of the 3 Series Power Plus BTE hearing aids. The study consisted of a minimum of four visits over a total of six to eight weeks. The mean age of all participants was 71.1 years, with a range of 45 to 88 years. Mean audiometric data, as well as group minimum and maximum thresholds, are shown in Figure 2. Prior to the start of the clinical trial, the QuickSIN was completed under headphones on all participants and administered according to test instructions (Etymotic Research, Inc., 2006). Mean SNR loss of all participants (24 ears) was 16.5 dB with a standard deviation of 4.7 dB, indicating severe or profound SNR loss for the majority of participants.

Participants were fit with standard tubing and earmolds, and the hearing aids were Best Fit to Starkey Hearing Technologies’ proprietary e-STAT® targets at the initial session (Scheller & Rosenthal, 2012). REAR measurements were then completed using the Audioscan Verifit system, with a purpose of measuring the output of the devices in the ear canal and ensuring audibility. The International Speech Test Signal (ISTS) stimulus was used for all real-ear measurements and was presented at levels of 50 dB,

65 dB and 75 dB SPL through a speaker positioned at 0° azimuth (Holube, Fredelake, Vlaming & Kollmeier, 2010). Additionally, an 85 dB SPL pure-tone sweep was presented. The gain and frequency response of the devices were adjusted as needed at each subsequent visit in order to optimize listening comfort for each participant. In addition to measuring REARs with the 3 Series Power Plus BTEs, the same REAR measurements were made with the participants’ own devices to document the fitting parameters of those devices. Measurements of on-ear directivity were also completed with the 3 Series Power Plus BTEs at the initial session using the Audioscan Verifit system. With the hearing devices set to directional mode, a front speaker was positioned at 0° azimuth and a back speaker was positioned at the approximate null angle of the directional response. The Verifit directional stimulus was presented at a level of 65 dB SPL and recordings were made from the front and the null simultaneously. Figure 3 shows mean REAR (dB SPL) as a function of frequency, with the response from the front (blue line) and the response from the null (red line) as the parameters displayed within the figure. At the peak, the average response from the front is 16.5 dB SPL greater than the response from the null, indicating that the directional system was performing as expected, attenuating signals from the null.

Speech-in-Noise Testing

Participants completed the HINT to evaluate directional benefit 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 65 dB SPL (Nilsson, Soli & Sullivan, 1994). The level of speech adapts based on participant response, and the score is recorded as a signal-to-noise ratio (dB SNR). Unlike the QuickSIN, the unaided condition for the HINT could not be completed due to the severity of the participants’ hearing losses and the output limitations of the hardware used to present the stimuli. Twenty sentences were administered per condition and two conditions (omnidirectional and directional) were completed in a randomized order for each participant. Figure 4 displays the HINT scores (dB SNR) for those two conditions. The error bars represent one standard deviation. In summary, participants performed significantly better with directionality when compared to the omnidirectional mode (p<0.001), indicating that the directional system of these hearing aids performed as expected and resulted in significant directional benefit. These results support the theory that directionality is a valuable tool in overcoming SNR loss.
Wireless Accessories

In addition to testing the hearing devices, eight participants were also asked to evaluate either SurfLink® Mobile or SurfLink Media, both pictured in Figure 5, with the 3 Series Power Plus BTE devices. SurfLink Mobile has the capability of being used as a hearing aid remote control, a device for transmitting phone calls and streaming media and a remote microphone. SurfLink Media is used specifically for streaming a television audio signal to the hearing aids. The commonality between these two devices lies in the wireless transmission of the audio signal to both hearing aids 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, seven out of eight participants rated the sound quality of the streamed audio signal from either device as good or very good. Participant comments regarding SurfLink Mobile and SurfLink Media are provided to the right.

**SURFLINK MOBILE:**

“It works great for my cell phone and computer. I can hear and understand voices.”

“Phone conversations are easier to understand.”

“The SurfLink Mobile makes hearing easier.”

“I would absolutely recommend the SurfLink Mobile. It is a great hearing tool.”

“My ability to understand on the phone is better and you don’t have to keep the phone in the ‘sweet spot.’”

**SURFLINK MEDIA:**

“The ability to stream and hear other conversations is great.”

“You do not have to wear a headset, which is extremely nice.”

“I like the streamer very much. It is very easy for me to hear the television at the same time there is someone else watching with me.”

“I am able to process what is said much better now.”
Overall Hearing Aid Satisfaction

Participants were asked to complete the Device-Oriented Subjective Outcome Scale (DOSO) 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. The DOSO was developed by Cox, Alexander and Xu (in press) and is designed to examine six subscales (speech cues, listening effort, quietness, pleasantness, convenience and use) related to the hearing devices. Results are provided in Figure 6. The error bars represent one standard deviation. Results indicate significantly better (p<0.001) subjective outcomes on all subscales with the 3 Series Power Plus BTEs relative to the participants’ own devices. Two questions on the DOSO specifically relate to hearing in the presence of background noise: 1) “How good are the hearing aids at keeping background noise to a minimum?” and 2) “How good are the hearing aids at cutting out background noise in a restaurant?” Mean responses on these two questions indicated significantly better performance (p<0.05 and p<0.01, respectively) in situations with background noise with the 3 Series Power Plus BTEs when compared to performance with the participants’ own devices.

Final Thoughts

Clinical trial results suggest that the directionality and full wireless compatibility provided by the 3 Series Power Plus BTE can help those suffering from the negative effects of severe and profound SNR loss. Furthermore, this hearing aid allows individuals with severe-to-profound hearing loss the opportunity to stay active in everyday listening situations, even in the most challenging environments.

* 3 Series is a Starkey brand name.

References


