

RECENT FITTING OPTIONS FOR SINGLE SIDED DEAFNESS

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Single sided deafness (SSD) is defined as unaidable hearing in one ear and normal hearing (20 dB HL or better at 500 to 3000 Hz) in the opposite ear. "Unaidable" is defined as severe-to-profound sensorineural hearing loss, poor word recognition, and/or marked intolerance for amplified sounds. Patients with SSD experience difficulty a) localizing; b) understanding speech arriving at the poorer ear; and c) understanding speech in background noise when the noise is directed at the better ear. For these reasons, patients with SSD can present challenges for selecting the most effective amplification.

Contralateral Routing of the Signal (CROS)

In the past, audiologists typically provided counseling and/or recommended **C**ontralateral **R**outing **o**f the **S**ignal amplification to the better ear in patients with SSD. But, often patients have been dissatisfied with this configuration. For example, when a patient has unaidable hearing in one ear and normal hearing in the other, the patient learns to position him/herself so the ear facing the "desired" signal is the normal hearing ear while the poor hearing ear is facing the "noise." This allows the patient to take advantage of the head shadow effect to help suppress the interfering noise. Although this strategy may work part of the time, the patient may become tired of constantly having to be aware of the need of proper head positioning in order to hear. The typical CROS fitting for this patient is a system where the microphone is on the poor hearing ear and the amplifier and receiver are on the better ear and sound is directed into the better hearing ear – which is typically coupled to an open-type earmold. Now, what was once tolerable may become intolerable because the microphone is actually detecting the noise on the poor side and sending noise to the better hearing ear. To the patient, this may not be worth the cost and

inconvenience of the CROS fitting and the patient may decide to return the aid. What might improve this situation is a noise reduction feature added to the microphone on the non-hearing side so when a continuous signal is present to the poorer ear, the hearing aid senses that the signal is noise and attenuates it accordingly. When a modulated signal is present on that side, it is not interpreted as noise and the CROS system then amplifies the signal. Yet, in spite of this concern, CROS amplification is still a viable option in either wired or wireless versions.

Several additional fitting options include *transcranial CROS*, the *bone anchored hearing aid (Baha)*, and *The TransEar* all of which have noise reduction (suppression) capability.

Transcranial CROS

The transcranial CROS was introduced by Sullivan (1988), and further described by Miller (1989) and Chartrand (1991). Today's transcranial CROS is a high gain/high output air conduction (AC) hearing aid fit to the impaired or "dead" ear to take advantage of the fact that the cochlea of each ear are not acoustically isolated. That is, if an AC signal of sufficient output is presented to the cochlea of the impaired ear, that signal will be heard in the cochlea of the better ear by bone conduction as it overcomes the acoustic isolation (interaural attenuation (IA)) between the two cochleas. It may be counterintuitive to fit a hearing aid on a "dead" ear, but it is important to recognize that the purpose of the transcranial CROS is not to amplify sound to the "dead" ear, but rather the "dead" ear is used as a conduit to transmit the signal to the cochlea of the better ear.

The theory behind the transcranial CROS technique is similar to the clinical evaluation of a patient via AC with normal hearing in one ear and a moderate-to-severe hearing loss in the opposite ear. The initial unmasked AC threshold for the impaired

ear represents the magnitude of IA (i.e., “shadow curve”). This is the lowest intensity where stimuli passes through the temporal bone and around the head by AC and is heard by the cochlea of the normal ear. In much the same way, the output from a “power” hearing aid placed on the impaired ear can deliver sound to the cochlea of the normal ear via bone conduction (BC) and AC. More than a decade ago, Valente et al (1995) reported limited success with fitting transcranial CROS due to the inability to achieve sufficient output to reach the cochlea of the better ear because of feedback. Thus, transcranial fitting by the present authors lay dormant for over a decade.

However, with the introduction of multichannel digital signal processing (DSP), excellent feedback cancellation strategies, and reduced size, the transcranial CROS has returned as a viable fitting option for SSD. There are a large number of options for multichannel DSP power behind-the ear (BTE), in-the-ear (ITE) and completely-in-the-canal (CIC) hearing instruments and recently, high power Receiver-In-the-Canal (RIC) hearing aids are now available such as Starkey’s 71 dB gain Absolute Power RIC product. The receiver unit of this power RIC hearing aid is completely encased inside a custom earmold. Each of these transcranial CROS hearing aid styles is capable of providing sufficient output to cross the skull and be heard in the cochlea of the better ear. However, verification of the fitting should be utilized for every fitting.

In order to achieve a successful transcranial CROS fit, it is important that clinicians measure the transcranial threshold (TCT) as described by Valente et al (1995). TCTs are used in hearing aid fitting through a combination of real-ear measures and pure-tone audiometry. The TCT is measured by placing a probe tube from a probe microphone system in the ear canal of the “dead” ear. Pure-tone thresholds are then measured for octave and mid-octave pure-tone signals from 250 to 6000 Hz by presenting the test signal to the “dead” ear using an audiometer and conventional or insert earphones. Threshold for these stimuli will be determined by the response of the better ear. As the audiometric response is obtained at each frequency a TCT should be recorded. The TCT is established through a real-ear measurement in dB SPL near the eardrum while the pure tone is presented. By turning off the loudspeaker of

the real-ear system and using the equipment as a spectrum analyzer, the measured TCTs in dB SPL can be used as “targets.” These output levels verify that the hearing aid fit to the dead ear has sufficient output for input levels of 50, 65 and 80 dB SPL to exceed the TCT and therefore be heard in the cochlea of the better ear. If verified in this manner, patient satisfaction and performance with the transcranial CROS is quite high. Finally, it is important to fit the custom hearing aid or earmold using a long bore and a pressure vent. Both of these characteristics of the earmold or custom case will significantly reduce the possibility of acoustic feedback.

Bone Anchored Hearing Aid (Baha)

In 2002, the Food and Drug Administration (FDA) approved the bone anchored hearing aid (Baha) for patients with SSD (Bosman et al, 2006; 2009). In January 2005, Medicare allowed for coverage of the Baha. It is worthy to note that Medicare reimburses the surgical procedure and processor, but does not reimburse for audiology professional services! Our procedure is to have the patient sign an ABN (Advanced Beneficiary Notice) that clearly states their awareness that audiological services (hearing aid evaluation, hearing aid selection, hearing aid fitting, counseling, and all follow-up care relative to the processor) are not covered by Medicare and, therefore, the patient agrees to pay for these services as necessary.

With the Baha, the patient undergoes outpatient surgery where a titanium fixture (screw) is anchored into the skull and a percutaneous titanium abutment is attached to the titanium fixture and penetrates the skin. The Baha processor is coupled to this abutment, these titanium components transmit amplified sound directly to the skull without interference from the intermediate tissue. For adults, it takes approximately three months for the implant to osseointegrate with the mastoid bone before the Baha processor is coupled to the abutment and fit. In the authors’ experience, if the BC thresholds in the better ear are ≤ 20 dB HL at 500-3000 Hz, then there is good probability that the patient will have a high level of benefit and satisfaction with the Baha. This is important because the authors have documented several patients fit with the Baha device where the BC thresholds

in the better ear exceeded these recommended guideline limitations resulting in poor patient satisfaction with the performance of the Baha devices.

Currently, the Baha is available from Cochlear Corporation based on a DSP platform with a directional microphone or omnidirectional microphone. Cochlear Corporation also recently introduced the BP100 model which includes the ability to measure BC auditory thresholds through the Baha, three memory programs, 12-channel signal processing, wide dynamic range compression (WDRC), an automatic adaptive directional microphone, noise management, feedback cancellation, and NOAH programmability. Alternative devices are available from Oticon Medical (Ponto and Ponto Pro), offering ten-channel DSP, automatic multichannel adaptive directional microphones, digital noise reduction, data logging, a self-learning volume control, NOAH programmability, four memory programs, and direct auditory input. The Oticon Medical processors can be coupled to the current Cochlear Corporation abutment.

TransEar

The TransEar for SSD patients was developed by Ear Technologies. With this device, acoustical signals are processed through the DSP BTE hearing aid and transferred to a small BC vibrator encased in a shell-type earmold via a wire through the faceplate. This entire earmold is deeply inserted into the ear canal of the poorer ear. The amplified BC signal in the poorer ear is transferred to the cochlea of the better ear via BC. In order for the bone-conducted transfer to occur efficiently, the bore length of the custom mold must be sufficiently long so the tip of the earmold is in the osseous segment (inner 1/3) of the ear canal. The stand-alone NOAH programming software allows the audiologist to make numerous changes to the amplified signal. Recently, the TransEar BC vibrator was modified so the maximum output peak occurs around 2000 Hz rather than the previous version where the curve peaked at around 600 Hz. This change, according to the manufacturer, significantly improved a) aided sound field thresholds in the higher frequencies; b) speech reception threshold; and c) word recognition scores in quiet and noise. In addition, automatic noise reduction, more

effective feedback management, and automatic adaptive directional microphones have been added as features.

Conclusion

The goal of this paper is to describe current single sided deafness (SSD) hearing aid fitting techniques and to reinforce the idea that new fitting options are available for patients with severe-to-profound deafness in one ear and normal or near-normal hearing in the opposite ear. The authors have gained considerable experience with the fitting options outlined in this paper and urge audiologists to consider transcranial CROS, Baha, and TransEar as viable fitting options for patients with SSD.

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