Listening with our teeth! The SoundBite Hearing Aid: a new technology for single-sided deafness

Melissa J. MacPherson (Meds 2014), Mayoorendra Ravichandiran (Meds 2013)
Faculty Reviewer: Dr. Lorne Parnes, MD (Department of Otolaryngology)

Hearing loss is a significant and common disability that affects approximately 9% of the Canadian population. This disability is more prevalent in older populations and if uncorrected can lead to social isolation and communication difficulties. There are two distinct types of hearing loss; each with a characteristic pathophysiology. Sensorineural hearing loss (SNHL) arises from conditions affecting the inner ear or the cochlear nerve, whereas conductive hearing loss develops from conditions affecting the outer ear, the middle ear and the tympanic membrane. These distinctions are important since hearing aid technologies address the different types of hearing loss using different strategies. Patients with a conductive hearing loss require the amplification of all sound wave frequencies. In contrast, patients affected by sensorineural hearing loss present a much more complicated technological problem since these patients may have decreased audibility of certain sound frequencies as opposed to an overall decrease in the audibility of all sound frequencies. Most patients with sensorineural hearing loss have decreased audibility of high frequencies; however, in the case of Ménière’s disease there is a decreased audibility of low frequencies. This results in the ability to hear sound but the inability to understand speech since speech amplitude (loudness) is caused by low frequency sound waves which the patient can detect but speech comprehension is poor due to the loss in detection of the high frequency sound wave components. Speech comprehension is more difficult in the presence of background noise and consequently hearing aid technologies address this issue by increasing the signal-to-noise ratio to bring out speech from noise.

HEARING AID TECHNOLOGIES FOR UNILATERAL SENSORINEURAL HEARING LOSS

Patients with unilateral sensorineural hearing loss (single-sided deafness) also face difficulties localizing the direction of unseen sounds and detecting sounds localizing from the direction of the affected ear, in addition to the difficulties previously mentioned. The head shadow effect causes a particular difficulty for these patients since sound waves originating from the affected side are attenuated by the head before reaching the functional ear. Several technological strategies used to address some of these problems include the routing of sound from the disabled ear to the fully functional ear using air conduction contralateral routing of sound (CROS) devices or bone-anchored hearing aids (BAHA).

While CROS devices do not allow for sound localization, they do aid a patient to overcome the head shadow effect. CROS devices consist of essentially two hearing aids. One hearing aid acts as a microphone in the affected ear and transmits the auditory signal to a second hearing aid that acts as a receiver in the functional ear. The CROS hearing aids in current use are wireless devices that use FM or Bluetooth technology to transmit the auditory signal to the external receiver.

BAHA devices take advantage of the physical property of bone to conduct sound. The first BAHA device was developed by a Swedish anatomist, Per-Ingvar Brømérk, and implanted in three patients in 1977. The device has achieved international recognition as a solution to conductive hearing loss with more than 80,000 devices currently in use worldwide. The device also has a second application for the treatment of unilateral sensorineural hearing loss. The BAHA system consists of three components: a titanium post implant, an external abutment and an electronic sound processor. It is important to note that the BAHA system requires surgical implantation of the titanium post followed by the integration of the implant into the bony architecture. The device works by transmitting sound through bone to the inner ear thus, skipping both the external auditory canal and the middle ear. In the case of unilateral sensorineural hearing loss the sound is transmitted transcranially and stimulates the cochlear fluid of the unaffected inner ear. The titanium screw is implanted directly into the mastoid bone in order to overcome the loss of energy during the transcutaneous transmission of sound. The electronic sound processor is responsible for the transmission of sound vibrations via the external abutment to the titanium implant. Despite its value and popularity, there are a number of complications associated with the BAHA device. The most common complication is skin irritation at the site of the implant. In most cases, this can be managed using topical therapy. A more serious complication is the failure of the titanium post to osseointegrate. This complication can lead to poor function or failure of the implant. In addition, several less common but potentially dangerous complications such as skin flap necrosis, wound dehiscence, bleeding and pain have been reported. The sound conduction property of bone exploited in the BAHA technology has also been applied in the most recent technological advancement for the treatment of unilateral sensorineural hearing loss; the SoundBite Hearing Aid.

THE SOUNDBITE HEARING AID

A unique technological approach for the treatment of unilateral sensorineural hearing loss is the use of a removable oral device called the SoundBite hearing system developed by Sonitus Medical. The SoundBite hearing system also makes use of the sound conduction properties of bone; yet, unlike the BAHA system, does not require the use of surgery. The SoundBite hearing system uses a microphone unit housing a receiver and wireless transmitter to receive sound. The microphone portion of the unit sits in the affected ear canal to take advantage of the ability of the ear’s pinna and external ear canal to capture and direct sound into the microphone, while the receiver and the transmitter sit in a unit behind the affected ear. The unit then transmits the captured sound wirelessly to a
removable oral device similar to a retainer that sits over the maxillary molars in the mouth. The oral device touches several structures in the mouth including the gingiva, teeth and the inner cheek. The electrical signal from the behind the ear transmitter is captured by the oral device and is transduced into vibrational energy using a piezoelectric transducer.9 The vibrations are conducted by way of the teeth to the bone and transcranially to the cochlea of the ear. One of the advantages of the piezoelectric transducer is that it allows a much wider frequency range to be conducted through the teeth than the traditional electrodynamic transducers used in the BAHA systems.9

The oral device does not require the modification of the maxillary molars and is custom fitted for each patient by taking a dental imprint of the maxillary arch.3 Since the device vibrates the maxillary molars to transmit vibrations to the bone, the force of the oral device was tested to determine if it wears the teeth. Interestingly, the force of the oral device is four orders of magnitude lower than the forces exerted on the teeth by normal mastication and is within the force range of normal orthodontic devices and does not damage the surface of the maxillary molars.9 Moreover, the oral device is comfortable, well tolerated in most patients, does not affect the speech and can even be worn while eating.3,9 There are several advantages of the SoundBite hearing system which are outlined in Box 1. The most striking advantage of the SoundBite hearing system when compared to bone anchored hearing aids (BAHA) is the avoidance of surgery.9 A patient can be fitted quickly for the oral device and begin using the hearing aid immediately. With BAHA, surgery is required to implant a titanium post. The surgery is followed by 3 months of healing to ensure osseointegration of the implant before the patient can begin to use the device.2 The SoundBite hearing system avoids this delay and avoids potential surgical complications seen with the BAHA procedure. The SoundBite hearing system is a truly unique and novel technological approach to address unilateral sensorineural hearing loss. The next time you see a patient with unilateral sensorineural hearing loss, take a look in their mouth and chew on this possibility; they might be listening through their teeth!

REFERENCES


Box 1: Advantages and Disadvantages of the SoundBite Hearing System

Advantages

• Avoidance of surgery and surgical complications
• No need to wait 3 months before use since osseointegration is not required
• Discreet oral device and discreet behind the ear unit
• Optimized microphone location
• Delivers high-fidelity sound with a wide frequency range
• Removable devices

Disadvantages

• Cannot drink alcohol while wearing the oral device
• Risk of aspiration of the oral device if the patient's physical responses are impaired
• Risk of swallowing the oral device if the patient's physical responses are impaired
• Healthy teeth are needed to fit the device properly and good oral anatomy for full benefit; the last 3 teeth in the maxillary arch are usually the abutment teeth and must be free of active caries, periodontal and endodontic conditions

References (3,9)