

TITLE: Adult SNHL: Aids and Assistive Devices
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Introduction

Hearing loss is a very common problem. Approximately 28 million people in the United States suffer from hearing loss. Several authors have demonstrated that people with hearing loss suffer significant emotional, social, and communication dysfunction. Other studies have shown that people who use hearing aids had a significant improvement in social and emotional function, communication and cognitive function, and depression over those who do not.

Although hearing aids of many types have been available for hundreds of years many people still do not use them due to many factors including education about hearing aids, cost, cosmetics, failure to accept hearing loss, poor experience with prior use and many more. Only an estimated 4.5 million Americans use hearing aids. Of those that own hearing aids 12% report never using them and of those that do wear them only 58% report being fully satisfied. As hearing aid technology advances hopefully some advances will be made in increasing the use of hearing aids and patient satisfaction with them.

Types of Hearing Aids

There are many types of hearing aids available today. All air conduction hearing aids have the same basic components, which include a microphone that transduces sound to electrical energy, and amplification stage, an output transducer called a receiver, and a battery to power the electronics.

The first type is the behind the ear or BTE hearing aid. This device consists of an ear mold that sits in the concha connected to the unit that is worn behind the ear. Advantages of this type of aid are that generally the larger the device the greater the number of circuitry options available, fewer repair problems in analog devices, ability to produce more powerful amplification, the ability to use open ear molds which can benefit those in whom moisture buildup is a problem and in those with chronic otitis externa because of the ease of cleaning the

ear mold, and less manual dexterity needed to insert them. Disadvantages include large size, more noticeable, microphone in poor location for localization of sound, and loss of the benefit of using the acoustic properties of the pinna and concha. As smaller hearing aids have begun to offer more options this type has become less popular.

The second type is the in the ear or ITE hearing aid. This type of aid fits into the concha. This device is smaller than the BTE, without the unit behind the ear, but generally still offers many circuitry and venting options. The microphone is at the level of the meatus but the advantages of using the pinna and concha are still lost. This is one of the most popular hearing aid choices.

A third type of hearing aid is the in the canal or ITC type. This device fits almost completely in the external auditory canal with a small protrusion lateral to the meatus. This type provides better cosmesis than the types mentioned above and is able to take advantage of the natural influences of the pinna and concha. It requires more dexterity to use and some circuitry and venting options are not available with this type of aid.

A fourth type of hearing aid is the completely in the canal or CIC type. This relatively new type takes advantage of micro circuitry to fit all of the hearing aid components into a device that fits into the external auditory canal just lateral to the tympanic membrane. It is removed by grasping a small plastic string or wire attached to its lateral aspect. This type of aid obviously provides the best cosmesis of any type. It also is able to fully use the benefits of the pinna and concha. The medial end is within 2mm of the tympanic membrane so gain requirements are lower. Disadvantages include the need for manual dexterity to handle, some limitation in circuitry available (although this is rapidly changing), and the proximity of the microphone to the receiver making feedback a problem.

The last two types of hearing aids are used in patients with special situations. People with poor hearing in one ear and good hearing in the other ear may benefit from using a contra lateral routing of signal or CROS aid. This places a microphone at the impaired ear and routes the signal via a wire or radio signal to the other ear where signal output occurs. This allows the hearing ear to receive signals from the other side. This device prevents the head shadow effect which is the decrease in signal presented to one side of the head when it is measured on the opposite side of the head. In a patient with hearing loss in both ears but worse on one side may benefit from a biCROS aid. This provides amplification to the better ear as well as routing the signal from the poorer hearing ear.

Binaural amplification

Most patients with bilateral hearing loss will benefit from binaural hearing aids. The benefits of binaural amplification are binaural summation, which is hearing threshold improvement listening with two ears instead of one, binaural squelch which helps to tune out unwanted noise, and better sound localization.

Signal Processing

Although all hearing aids consist of the same basic component there are a wide variety of differences. The classical hearing aid is an analog device. The sound is converted to an electrical signal by the microphone, amplified and then sent to the receiver where the electrical signal is converted back to sound waves. These devices require adjustment of the hearing aid by screws or knobs on the device itself. A newer type of technology is the digitally controlled analog processor. This continues to convert sound to electric signal but has a higher range of programming options, which can be controlled from a computer or hand device. The newest devices are the digital signal processing hearing aids. These convert sound waves to numerical values for digital processing directly and generally are capable of higher fidelity and more programming options.

All hearing aids provide the benefit of gain, which is the difference in the intensity (loudness) of the input signal and the output signal at a given frequency. The problem with sensorineural hearing loss is that not only is there attenuation of signal there is also distortion of signal. The phenomenon of recruitment is associated with SNHL. This narrows the range of intensity between the level at which sound is audible to the patient and the level where the sound is uncomfortable. The distortion of signal is most often a problem for patients when there is background noise. One method of dealing with this is the use of directional instead of omnidirectional microphones. This allows the listener to narrow the focus of input to the hearing aid in some situations.

Older hearing aids use linear amplification of sound, which means that the ratio of input to output is one to one. This does not address the nonlinear nature of loudness growth in SNHL. This causes a problem when a high intensity sound is amplified reaching an uncomfortable level. In order to limit output a technique called peak clipping was used. This is where output is limited at a predetermined level, which causes a great deal of distortion. Newer advances have led to the technique of compression, which limits output within the dynamic range of the user in a nonlinear fashion.

Assistive listening devices

Some people with hearing loss need assistance only in special situations like talking on the telephone, watching television, listening in a classroom or hearing the doorbell ring. This need has led to the development of a host of products designed to help in particular situations. Some examples include headsets or earpieces worn to watch television, flashing lights to signal a ringing doorbell or fire alarm, or an amplified telephone. To aid in some situations a FM wireless system can be used where the speaker talks into a microphone and the output is to a headset the patient wears or directly to a personal hearing aid. This type of system is often used with children in classroom situations.

Implantable Hearing Aids

Implantable hearing aids are divided into three main categories, the temporal bone stimulators, the devices coupled to the ossicular chain, and cochlear implants. Temporal bone stimulators are the bone anchored hearing aids, which have a metallic implant directly in the temporal bone. This serves as an alternative to the classical bone conduction hearing aids which

have a temporal bone stimulator worn in a head band. These devices are useful not for sensorineural hearing loss but in patients with chronically draining ears or with congenital ear malformations. They are mentioned here for completeness of hearing aid review.

An exciting area of research and development for people with moderate to severe sensorineural hearing loss is in the area of middle ear implants, which are connected to the tympanic membrane, ossicular chain, or round window. One such device called the Vibrant Soundbridge uses an electromagnetic transducer held onto the long process of the incus connected to a magnet surrounded by a receiver coil, a demodulator package, and a conductor link, which are implanted in the skull above the mastoid. In a phase III clinical trial patients who wore this device showed improvements in satisfaction, performance, and preference over wearing their conventional hearing aids.

The last type of implantable hearing aid is the cochlear implant. This device is used for adults with severe sensorineural hearing loss. It consists of a microphone, a speech processor worn on the body connected to an external coil attached magnetically to an internal coil implanted on the skull, which sends the signal to an electrode, or series of electrodes implanted in the scala tympani of the cochlea. Most modern cochlear implants are have multiple electrodes to try to reproduce some of the tonotopic reception of the cochlea. Adult patients who benefit from a coclear implant generally have bilateral profound sensorineural hearing loss that have obtained no or minimal measurable benefit from a conventional hearing aid trial. Adults who are postlingually deaf, especially if they had hearing through age 6 tend to benefit most. Some prelingually deaf adults have been implanted but with poorer results.

Conclusion

Sensorineural hearing loss is a common problem among the adult population. Today there are now available a wide spectrum of hearing aids and assistive listening devices to help those with hearing deficits lead happier more productive lives. Each patient has a unique situation and set of desires when it comes to hearing. The choice of hearing aid should be tailored to the individual.

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