

# BRIEF UPDATE ON HEARING AIDS

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This article provides a concise update on personal amplification (ie, hearing aids). Mention is made of popular hearing aid styles, technology, and selected special features, along with information on earmolds. Contemporary and future hearing aid alternatives are listed. Fitting concerns relating to symmetry of bilateral hearing ability, type of hearing impairment, age of hearing aid user, and the advantages of binaural hearing are reviewed.

Insidious in its onset and progression, hearing loss has a significant impact on communication. Hearing aids are critical tools for the treatment of hearing loss, a process that is as much an art as a science. Selecting and fitting hearing aids involves striking a balance between adequate hearing loss compensation and the user's subjective preferences. This article provides a brief overview of current hearing aid technology and the directions it will take in the foreseeable future. Some special issues in candidacy and selection are also considered.

The experience of hearing aid use is not identical for everyone, and, at the present time, there is no reliable way to predict an individual's success. Potential users should be made aware of the benefits of amplification, tempered with realistic expectations. Perhaps the most important thing to remember is that getting accustomed to the device is a process that takes time and effort.

## TRADITIONAL HEARING AIDS

### STYLE

The four primary hearing aid styles vary in size, appearance, features, power capacity, and the ease with which the device can be operated. A behind-the-ear (BTE) hearing aid is a shrimp-shaped device that hangs on the pinna by an earhook. Sound is directed to the ear canal via a tube and earmold. BTE aids are appropriate for any degree of hearing loss, and are also the best option for children and infants whose pinnae and ear canals grow quickly. In-the-ear hearing aids fill most or all of the concha. They are the most widely recommended style of hearing aid and are appropriate for mild-to-severe hearing loss. In-the-canal (ITC) aids fill only a small portion of the cavum concha. They are relatively inconspicuous but visible in the ear. ITC aids are best for persons with mild-to-moderate hearing loss but may sometimes accommodate a severe loss. Finally, completely-in-the-canal (CIC) aids do not protrude into the concha at all and are practically invisible to the casual observer. Their size does not permit the inclu-

sion of many features, but CIC aids make the best use of the natural acoustic properties of the pinna. CIC aids can accommodate only a mild-to-moderate hearing loss, and may be unsuitable for those with straight and narrow ear canals that compromise device retention.

### TECHNOLOGY

Hearing aid technology may be classified along 2 dimensions: signal processing strategy (analog versus digital) and programmability. Analog hearing aids consume less battery power than digital devices and sometimes use very simple noise reduction strategies. Digital hearing aids provide better sound quality than analog processing, multiple programs for different listening situations, advanced noise reduction strategies, and electronic reduction of acoustic feedback. The parameters and features for non-programmable hearing aids must be carefully selected when ordering the hearing aid because of limited flexibility in the clinic once the device has been built, and because of the limited availability of space on the faceplate for controls to operate them. Because the characteristics of a programmable hearing aid are adjusted via computer interface, this allows for better customization of the device to individual needs, higher flexibility in accommodating progressive and/or fluctuating hearing loss, and no theoretical limit to the number of features that can be made available.

### SPECIAL FEATURES

#### Direct Audio Input

Direct audio input allows the user to connect an external sound source (eg, television) or assistive listening device (eg, FM system) to the hearing aid via an audioshoe. Picking up the signal closer to the source improves the signal-to-noise ratio and sound quality. This feature is especially useful for children in the classroom, or anytime there is one primary sound source in a noisy or reverberant environment (eg, at a lecture or religious service).

#### Directional Microphones

These microphones are designed to aid speech recognition in noise by focusing on signals coming from a certain direction (eg, in front of the user) and reducing the intensity of background noise coming from other directions (eg, behind the user). The efficacy of this technology varies with device type, listening condition, and the individual's

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1043-1810/03/1404-0009\$30.00/0

doi:10.1053/S1043-1810(03)00063-0

intrinsic ability to understand speech in background noise.<sup>1</sup> Directional microphones can be either built into hearing aids or used as an external accessory.

### Electronic Feedback Management

Acoustic feedback oscillation is the technical term for the whistling sound that occurs when the sound leaving the receiver reenters the microphone. Although the best counter-measure is a tight-fitting earmold or hearing aid, several electronic means of reducing feedback are now available. This feature is particularly useful when high gain or minimal occlusion is required and for persons with hypermobile ear canal walls.

### Telephone Coil (T-coil)

A T-coil is a coil of copper wire that picks up signals via electromagnetic induction. It is most useful for telephone communication but is also compatible with some assistive listening devices (ALD). Some hearing aids now offer automatic switching between T-coil and microphone inputs, a feature that is convenient for those people with limited manual dexterity.

### EARMOLDS

Earmolds direct the sound from a BTE aid to the ear canal and also help retain the device on the head. They can be made of hard or soft materials. Compared with hard earmolds, soft materials provide a tighter seal to the ear and more comfort, but are more difficult to insert/remove and modify. The different styles of earmolds vary in terms of the degree of ear canal occlusion and the ease with which they are held in the ear. Acoustic modifications of the earmold are often used to alter amplification characteristics. Custom-built earmolds are preferred in the interest of increased comfort and the reduced likelihood of feedback. However, premolded eartips are available for short-term use.

### ALTERNATIVES TO TRADITIONAL HEARING AIDS

Not all individuals with impaired hearing are good candidates for, or satisfied with, traditional hearing aids. The alternative approaches presented in this section have been developed to serve this population.

#### Disposable Hearing Aids

These modular units have encapsulated batteries that cannot be replaced. Although they do offer digital processing, they do not have the advanced features commonly available in traditional hearing aids; customization of physical fit and amplification characteristics is limited. Disposable hearing aids are targeted toward those people unsure of the benefits of hearing aids or are reluctant to make the necessary financial commitment. Contrary to popular belief, these devices are cost-effective in the short-term only.

#### Contralateral Routing of Signals (CROS)

In its simplest form, a CROS aid consists of a microphone worn on one side of the head, and an amplifier and receiver to deliver the sound to the opposite ear (Figure 1).

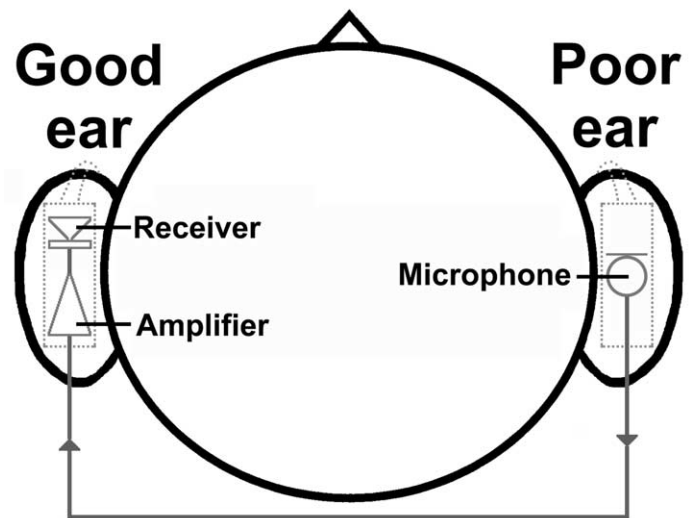


FIGURE 1. Contralateral routing of signals (CROS) hearing aid.

The device is targeted towards those patients with unilateral hearing loss in which the poor ear is unaidable due to the severity of hearing loss, poor speech recognition ability, infection, or malformation. The microphone picks up sound coming from the side of the poorer ear and transfers the signal to the opposite ear. Additional configurations, such as BiCROS and stereo CROS, are available for asymmetric and bilateral hearing loss, respectively.

#### Bone Conduction Aid

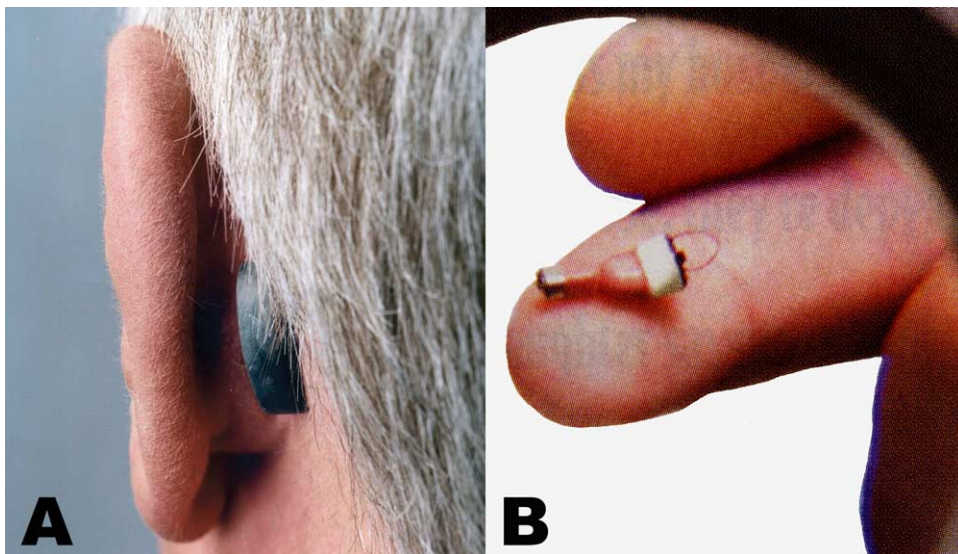
A bone conduction aid is based on the same principle as audiometric bone conduction testing. It consists of a hearing aid attached to a bone vibrator, which is held in place by a headband. This device is targeted towards persons with infected or malformed outer/middle ears, and those with large conductive hearing losses. Disadvantages of a bone conduction aid include discomfort, poor cosmetic appeal, limited amplification, and dislodging of the headband. (See the chapter on the Bone-Anchored Hearing Aid.)

#### Assistive Listening Devices (ALD)

ALD can be broadly classified as being for personal or group communication, telecommunication, alerting to warning signals, and radio and television reception. They can be used independently or in conjunction with a hearing aid. In addition to signal delivery in the auditory mode, it may also be conveyed in the visual (via captions) or tactile (via vibrations) mode. Of particular interest to the medical community is the amplified stethoscope, which provides higher amplification than a regular stethoscope and is compatible with hearing aids.

#### Recent Innovations

Amplification technology is constantly changing, and several types of devices have been recently released for clinical trials or introduced in the market. As such, the manufacturers' claims have yet to be independently substantiated. We describe 2 of these devices. Developed in Germany, the RetroX system (Auric Hörsysteme, Rheine, Germany) (Figure 2A) consists of a microphone placed behind the pinna that picks up sound, an amplifier, and a titanium tube that directs sound to the ear canal. The



**FIGURE 2.** (A) RetroX system. (Reprinted with permission from Theo Weisendahl, system creator.) (B) InSound XT extended-wear hearing device. (Reprinted with permission from Cherish Oberzut, InSound Manager for Clinical Research.)

system uses a programmable digital signal processor with multiple memories and is designed for persons with a mild-to-moderate loss only in the high frequencies. The InSound XT (InSound Medical, Inc, Newark, CA) (Figure 2B) is the first extended-wear device that can be used continuously for 3 to 4 months, after which the otolaryngologist replaces it. The device is placed in the bony portion of the ear canal during a 5-minute, nonsurgical office procedure and can be programmed wirelessly. Expected benefits include the fact that it is inconspicuous, hassle-free, eliminates the occlusion effect, and improves the use of natural ear canal acoustics.

### SPECIAL CONSIDERATIONS

The preceding discussion applies primarily to adults with bilaterally symmetrical sensorineural hearing loss. Additional candidacy considerations required for populations not fitting this profile are presented later. In all cases, it is assumed that the necessary medical clearance has been obtained before hearing aid use.

#### Unilateral or Asymmetric Hearing Loss

These hearing losses create difficulties with auditory localization<sup>2</sup> and understanding speech in the presence of background noise,<sup>3</sup> especially when noise is on the side with less/no hearing loss. Because hearing aid selection is geared towards restoration of binaural hearing, persons with unilateral hearing loss may be fit with traditional or CROS hearing aids. A BiCROS system or a binaural fitting of traditional hearing aids should be considered for persons with asymmetric hearing loss. Success with a hearing aid is related to the user's motivation and the demands on listening.

#### Conductive or Mixed Hearing Loss

Amplification may be appropriate for persons with correctable conductive loss as a temporary solution until surgery is performed, or when they are unable or unwilling to undergo surgery. Because a conductive (or mixed) hearing loss attenuates the intensity of the incoming sound, optimal amplification characteristics are different from those required for sensorineural hearing loss.<sup>4</sup> Apart

from traditional hearing aids, bone conduction and bone-anchored hearing aids are viable options for those patients with conductive (or mixed) hearing losses.

#### Infants and Children

For children, even a mild hearing loss indicates candidacy for amplification because it is likely to impede language development. Hearing aids for children should be as versatile as possible to accommodate every listening and/or learning opportunity. Bilateral amplification in instances of bilateral hearing loss minimizes localization problems and enhances opportunities for following group conversation. BTE devices are preferred for children up to 8 to 10 years of age because they are compatible with ALD that are useful for classroom instruction, and the earmolds can be fabricated out of soft material to minimize potential injury. During the first 2 years of hearing aid use, it is good practice to schedule audiometric and hearing aid appraisals at 6-month intervals.

#### Binaural Amplification

Binaural listening offers advantages in sound localization and speech recognition in noise.<sup>2,3</sup> Persons with bilateral hearing loss frequently opt to use a hearing aid in only one ear due to cost, uncertainty regarding benefit, or poor self-image. Apart from the few reported cases of binaural interference in which the user benefited more from amplification in one ear only,<sup>5</sup> it is best to fit hearing aids in both ears at the same time. Besides restoring the advantages of binaural listening, this also avoids late-onset auditory deprivation,<sup>6</sup> and the user acclimates to the amplified sound only once.

Although the ultimate decision of whether or not to purchase and use a hearing aid lays with the individual with impaired hearing, he/she often looks to professionals for a recommendation. In addition to the degree and configuration of hearing loss, speech recognition ability, self-reported hearing disability and handicap, communication needs and interests, acceptance and perceived benefits of hearing aid use, ability to afford hearing aid purchase and upkeep costs, and interest in taking control over hearing health matters must all be considered.<sup>7</sup> The sine qua non is that individuals have different priorities and concerns,

and individual results vary widely. Attention to candidacy is important for ensuring a high degree of hearing aid acceptance and use.

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