INVISIBLE-IN-THE-CANAL (IIC) HEARING AIDS

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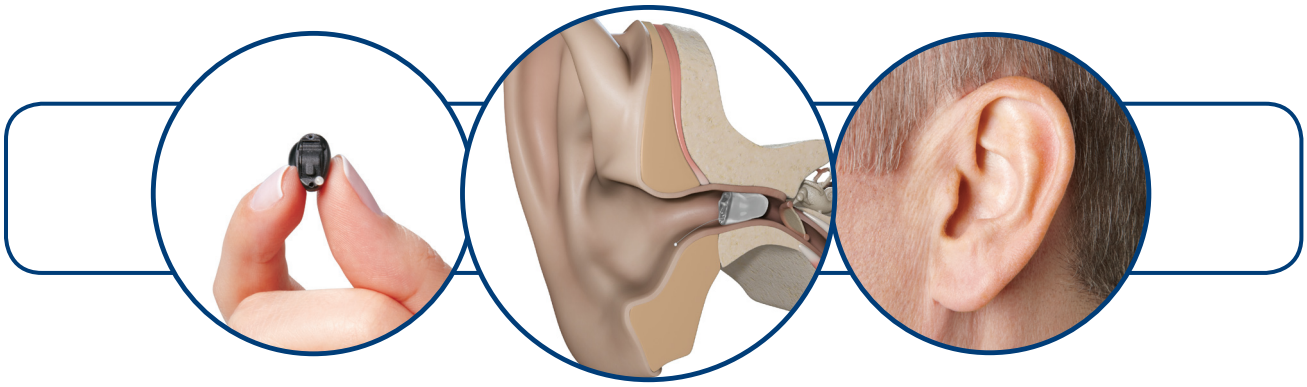

A Completely-In-The-Canal (CIC) hearing aid can be defined by the location of the faceplate, 1-2 mm inside the aperture of the ear canal (Gudmundsen, 1994). For years the CIC has been the benchmark for small, near-invisible hearing aids. Publications have documented the benefits of CIC fittings, including decreased occlusion (Mueller, 1994), increased satisfaction (Ebinger, Mueller, Holland & Holland, 1994), decreased amplification of wind noise (Fortune & Preves, 1994), and improved localization when compared to Behind-The-Ear (BTE) fittings (Best, Kalluri, McLachlan, Valentine, Edwards & Carlile, 2010). All of these benefits were realized as a result of the fitting style.

Advances in digital modeling, laser-shell fabrication and modern microchip packaging techniques have resulted in hearing aids that are smaller and more powerful than those of the past. Today, custom hearing aids that fit deeply into the ear canal can be built on a routine basis. In fact, hearing aids can now be built to fit past the second bend of the ear canal, allowing the faceplate to be seated deeply in the ear, providing an invisible hearing aid fitting. The performance and cosmetic advantages of this fitting style appeal to a wide variety of hearing aid candidates, many of whom may not consider more visible hearing aid options.

A new category of hearing aid

The convergence of hearing-related technologies allows the CIC to be made smaller than ever; small enough that they can be fit past the second bend of the ear canal. These deeply inserted hearing aids are effectively invisible to others (Figure 1). When the hearing aid is fit to the second bend of the ear canal, it may be considered an Invisible-In-The-Canal, or IIC, a new category with respect to size and position of the device. An IIC hearing aid is one in which the faceplate is at or near the second bend of the ear canal, and the medial aspect of the shell is much closer to the eardrum. The deeper position of the hearing aid allows for several technical advantages.

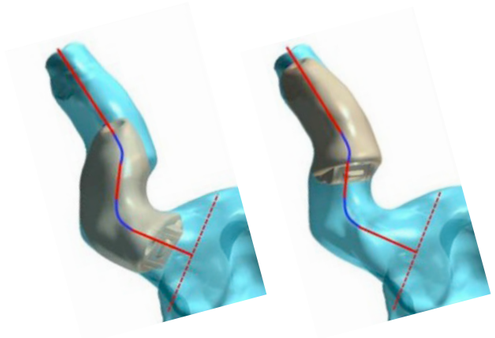

Figure 1. The left panel shows a traditional CIC hearing aid fitting that terminates at the aperture of the ear canal. The right panel shows the position of the IIC, fit to the second bend of the same ear canal.

Acoustic benefits of canal hearing aid fitting

The ear canal and pinna filter the natural spectrum of sound before it reaches the eardrum. Microphone placement on BTE hearing aids reduces some of these beneficial effects. The loss of these acoustic cues results in degradation of the wearer's ability to localize sounds. Data collected at Starkey Laboratories, Inc. suggest that canal placement of the hearing aid microphone retains some aspects of the ears' natural filtering as compared to the microphone placement of a BTE style hearing aid. Figure 2 shows three measurements of directivity index (ANSI S3.35, 2004): an open or unaided ear, an IIC hearing aid, and a BTE hearing aid. Compared to the open ear, the BTE hearing aid fitting reduces directivity. Measures from the IIC hearing aid were similar to the open ear. Data such as these support the expectation that canal placement of the microphone, as provided by the IIC hearing aid, will allow for improved localization ability when compared to a BTE hearing aid fitting (Best et al., 2010).

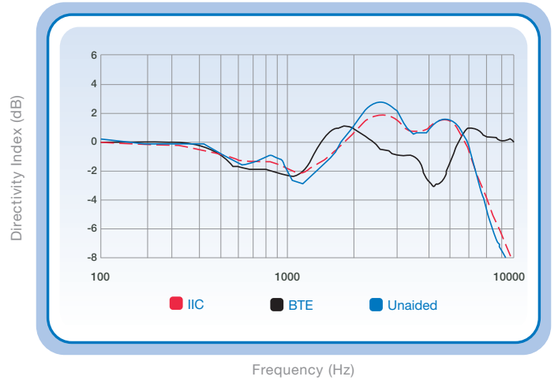

Figure 2. KEMAR based measurements of directivity index using an open ear canal, Invisible-In-The-Canal hearing aid and a Behind-The-Ear hearing aid are shown.

The reduced residual ear canal volume associated with an IIC fitting also affects the sound pressure level at the eardrum, effectively increasing the overall efficiency of the hearing aid. As illustrated in Figure 3, Boyle's law states that, as volume decreases, pressure increases. Thus, a smaller volume between the end of the hearing aid and the tympanic membrane yields a greater sound pressure level for equal receiver output.

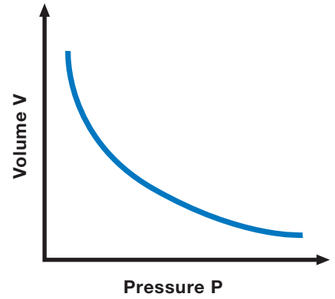

Figure 3. Illustration of Boyle's Law. When referenced to the ear canal, decreasing residual ear canal volume results in greater hearing aid output.

Impressions for the IIC

The key to an accurate and comfortable fit with IIC hearing aids is an ear impression that extends 10-12 mm beyond the second bend. A good understanding of the anatomy and physiology of the ear canal along with deliberate technique make it possible to safely and easily obtain the impressions necessary for building IIC hearing aids. No special equipment is necessary for IIC impressions. However, instrumentation to illuminate and view the ear canal beyond the second bend is valuable. Silicone impressions taken with a high flow, low viscosity material will typically fill the entire canal accurately and completely.

After taking a careful patient history and observing clinically appropriate safety precautions, a flattened oto-dam is placed deep in the canal, very near to the tympanic membrane. Lubrication of the oto-dam with Oto-Ease or a similar agent will improve comfort while placing the oto-dam and ease release of the silicone impression from the ear. Starkey has developed a vented cotton oto-dam that can be used to equalize pressure during the removal of the cured impression, shown in Figure 4. With proper counseling, the patient experience during impression taking and removal is very similar to standard impressions.

Figure 4. Two specially designed oto-dams are shown. A small tube allows for equalization of pressure while taking the earmold impression.

Summary

Modern hearing aid processing and laser shell fabrication have made the creation of small, deep-fitting hearing aids a possibility. Existing worries of feedback have been addressed with feedback cancellation and the patient's experience is being improved by advanced noise reduction technologies. The end result is a highly-featured, premium hearing aid that is invisible when worn, meets the needs of the most discriminating patient.

References

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