Binaural Hearing: Cochlear Implants & Single-Sided Deafness

Hearing loss in just one ear—known as unilateral hearing loss (UHL) or single-sided deafness (SSD)—is surprisingly common. Today, we’re going to look at why it’s so important to hear with both ears. This in-depth article is slightly longer than usual, but we’ve got a great video with 3D audio to help you understand the benefits of binaural hearing.

Often, individuals with single-sided deafness have nearly normal speech understanding in quiet. This can give friends & family the impression that single-sided deafness is only a minor issue. However, single-sided deafness has a significant impact on quality of life, and should be recognized as serious burden on individuals affected.

In everyday noisy settings, speech can be very difficult to understand with only one hearing ear. Sounds from the side with hearing loss are significantly muffled by the “head shadow” effect. Unilateral hearing loss also makes it very challenging, if not impossible, to tell where sounds are coming from.¹

Imagine struggling to follow conversations at work, or always having to turn your ear to understand a friend, or worrying that you won’t notice sudden warning noises when crossing the street. Now, try to picture focusing on a conversation with one ear while tinnitus is incessantly ringing in your other ear. Even with “one good ear”, everyday life with single-sided deafness can be exhausting.

“Hearing with only one ear is like living in a black and white world, without knowing that somewhere else colors exist.”

Today, we’re going to look at how cochlear implants can restore binaural hearing, making them an ideal treatment option for single-sided deafness. This introduction to binaural hearing is part one in...
our series on single-sided deafness & cochlear implants. Later in this series, we’ll go through how a cochlear implant can significantly improve speech understanding, restore sound localization, and even suppress tinnitus.

**Monaural Treatment Options for Unilateral Hearing Loss**

Currently, there are several treatment options for single-sided deafness. Let’s start with the monaural options, which utilize only one hearing ear. Essentially, with monaural solutions, sounds from both sides are being added together and presented to the hearing ear.

CROS hearing aids send sounds from a microphone on the deafened side to a hearing aid in the hearing ear. Bone conduction implants use an implant & audio processor on the deafened side to send sounds through the head to the functional cochlea on the hearing side.

These systems are able to reduce the head shadow effect by providing sounds from both sides of the head. This can provide improved speech understanding and greatly improve awareness of sounds from all sides.

However, these monaural treatment methods can have several disadvantages. Sound localization is generally not improved, because the ability to hear where a sound is coming from relies on binaural input from both ears. Furthermore, background noise picked up from the microphone on the deafened side and routed to the hearing ear can reduce speech understanding if noise is presented on the deafened side.

**Cochlear Implants for Single-Sided Deafness**

In contrast to monaural solutions, a cochlear implant can restore binaural hearing—that is, hearing with both ears. By bypassing the non-functioning hair cells in the affected cochlea, a cochlear implant can restore hearing to the deafened ear. With two hearing cochleae, a cochlear implant recipient can appreciate significant benefits in speech understanding, sound localization, and tinnitus reduction.

Let’s look at how a cochlear implant for single-sided deafness offers improved speech understanding in both quiet and noise.
In noisy environments, the advantages of a cochlear implant for single-sided deafness are especially prominent. With two hearing cochleae, there are three main mechanisms for improving speech understanding in noise: binaural summation, the squelch effect, and the head shadow effect.\(^1\)

**Binaural summation:** Hearing with both ears provides a louder and more robust sound signal for the brain. This offers a 1–2 dB SNR improvement in noise for both normal-hearing and bilateral cochlear implant listeners, and can reduce listening effort in general.\(^1,7,8,9,10\)

**Squelch effect:** By comparing sounds received in both ears, central auditory processing in the brain can improve the quality of a sound and filter out noise. This primarily uses redundant information of the sound as received by the two ears. Even an ear hearing mostly noise will still provide an SNR benefit of ~3 dB in normal-hearing listeners, as binaural listening provides a more complete sound signal for auditory processing.\(^1,11\)

**Head shadow effect:** The head is a natural barrier between the ears that muffles higher frequencies (1000 Hz and up) by as much as 20 dB when sounds arriving from the opposite side travel around the head to reach the ear. Without an implant or CROS system, sounds on the deafened side are very difficult to hear.\(^1,12\)

A CROS or bone conduction system restores sound awareness to both sides, but in settings with background noise, these systems may not always be as advantageous as expected. If noise is presented to the CROS or bone conduction device and speech to the naturally hearing ear, the CROS or bone conduction system would add the noise to the hearing cochlea, creating a significant reduction in speech understanding.\(^1,4,5,6\)

In contrast, a cochlear implant provides significant benefit in any noise configuration, without the speech understanding reduction seen with CROS. Using two physically separate cochleae allows noise presented on either side of the head to be filtered out using central auditory processing of the brain.

Therefore, a cochlear implant offers significantly better speech understanding in noise than monaural hearing with a CROS or bone conduction system, especially when noise is presented on the implanted side.\(^1\)

What’s the practical benefit of binaural hearing? Check out this simulation we created using 3D binaural microphones to compare single-sided deafness and binaural listening.

**Closest to Natural Hearing**

The auditory benefits of binaural hearing with a cochlear implant are significantly better than hearing with a CROS or bone conduction system. Therefore, a cochlear implant should generally be the considered the first-choice treatment option for single-sided deafness.\(^1\)

However, it’s also important to remember that a person with single-sided deafness still has natural hearing in one ear. This makes sound quality an especially important consideration, as a mismatch in sound quality may distort the binaural auditory processing of those sounds in the brain.\(^13\)

Unlike any other cochlear implant, only a MED-EL cochlear implant can offer a sound quality that is truly the closest to natural hearing.\(^13\) This is only possible through the proven combination of atraumatic insertion, electrode arrays that better cover the whole cochlea, and pitch-matched sound coding.
What are the potential benefits of this more natural sound quality for your patients?

- Better hearing performance \textsuperscript{14,15}
- Faster adaptation \textsuperscript{14,15}
- Better music appreciation \textsuperscript{16,17}

“When I went to choir after getting my cochlear implant and could hear with both ears, I realized just how much sound there was, and how grand the choir really was! I had always been missing out on this before and being able to experience that now is truly amazing.”

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Thanks for checking out our introduction to single-sided deafness & cochlear implants. Next in this series, we’ll be looking at sound localization with binaural hearing and tinnitus suppression with cochlear implants, so stay tuned!

Don’t miss any of our articles—subscribe now!

Have a question about cochlear implants for single-sided deafness? Comment below or use our simple contact form for an answer from our in-house experts.

*Not all products, indications, and features shown are available in all areas. Please contact your local MED-EL representative for more information.
References:


4. Arndt S; Laszig R; Aschendorff A; Hassepass F; Beck R; Wesarg T (2017). Cochlear implant treatment of patients with single-sided deafness or asymmetric hearing loss. HNO, 2017 Feb 10 [epub ahead of print]


