

Bimodal Hearing: The Increasing Use of Amplification With a Cochlear Implant

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The age-old argument of bilateral hearing amplification has taken on new meaning in the past five years with the use of cochlear implants and amplification. There is a considerable body of research dating back over 30–35 years that has determined the benefits of binaural hearing in humans.

There are clear benefits to having bilateral input to the auditory system and these are well documented in psychoacoustics literature. When listening to speech in only one ear in a difficult listening situation or with one ear with greater sensorineural hearing loss than the other, there is a loss of redundancy in cues across the ears that may reduce performance. Fortunately, the auditory nervous system is wired to help in noisy situations as long as there is functional input from both ears. The key words here are “functional input from both ears.” The auditory system and brain can combine information from both ears so that there is a better central representation than would be had with only information from one ear. These benefits include better understanding of speech in quiet and in noise, improved sound localization, and the general concept of fuller, three-dimensional hearing.

What has come about in the past five years is the overwhelming evidence and research done outside the United States on combining implants with amplification in an individual. For both adults and children, studies investigating cochlear implantation and its effect on binaural processing have found that patients using a unilateral implant plus the opposite ear benefiting from amplification do better than with an implant only or a hearing aid only. In recent years, cochlear implant technology has improved and

the criteria for candidacy have changed. We are now implanting patients with moderate to severe hearing loss with hybrid units (electrical and acoustical) and some of these patients can continue to use a contralateral hearing aid after implantation. We also have found out in recent research that poorly fit contralateral amplification can be more of a detriment to the patient trying to achieve bilateral stimulation. The newer digital signal processing power units are a great contribution to the improvement of bilateral stimulation and should be used whenever appropriate over older technology. It is imperative that the contralateral ear to the implant gets functional benefit. To achieve this, higher technology input is necessary.

So, what is bimodal hearing? Are two ears really better than one? Does bimodal hearing confuse the patient? Bimodal hearing is achieved in the human ear by using two different devices sending sound to the auditory system. Cochlear implants send coded electrical signals to the spiral ganglion cells and the electrical transmission continues up the auditory tract and is interpreted by the brain. Amplification sends an acoustic signal that is modified/amplified to the outer hair cells and then to the spiral ganglion cells that convert the acoustic signal to electric signals and travels up the same auditory tract. The mode of transmission is different between the two devices but the signal arrives at the same place and must be interpreted by the brain or auditory cortex. Cochlear implants are merely more efficient in the transmission of the signal on a severe to profound

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deaf individual than amplification is. But what about the fact that we see improved performance in noise when we combine the electrical and acoustic systems using the hybrid implant? There is clear and overwhelming evidence in Europe that using electric/acoustic stimulation (EAS) when speech is in noise or with music appreciation. The low and mid-frequency information that is conveyed by the amplification system has a synergistic effect over cochlear implant condition alone. It is also this low- and mid-frequency information that is important in fine structure and music appreciation. So if the technology is there to improve a hearing impaired patient's speech in noise and music, then it falls upon us to do just that. The delay in amplification past the cochlear implant surgery does not appear to be a factor in performance. The marriage between cochlear implants and higher tier DSP technology allows us that opportunity and studies have shown the benefit to patients, using both objective and subjective measurements.

The National Acoustic Laboratories (NAL) in Australia have run numerous studies in both adults and children showing that horizontal localization is improved in the bimodal mode over amplification-only mode or cochlear implant-only mode. The parents of the children reported the children to be happier, alert to the environment, and more "normal" in the bimodal mode. Some children in these studies had not worn any amplification for up to eight years. The studies also showed that the duration of use of the device was *not* a factor in word recognition. Also, it was found that fitting either an adult or child after the cochlear implant surgery should be considered to improve their binaural potential. If a hearing instrument specialist is working with a cochlear implant patient, they must never ignore the opposite ear, despite the patient's performance with the implant. Retrospective studies in children and adults were also done in Spain and Israel and indicated the same as the NAL studies. Bimodal hearing improves the human hearing condition.

Bilateral cochlear implantation in the U.S. is increasing but still not considered to be the norm. The cost of the surgery and the insurance barriers prohibit the majority of patients from taking advantage of this technology. However, we can achieve some degree of the binaural advantage by maintaining or improving the amplification on the contralateral ear. The clear advantage of bimodal hearing is the improvement of speech in quiet and noise, improved localization abilities, improved sound quality, and avoidance of auditory deprivation. Bimodal hearing does not confuse the patient and should be considered whenever possible, despite it occurring after the cochlear implant surgery. It is both good for the patient and good for the industry that promotes better hearing for all individuals. *THP*

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1. Cochlear implantation involves:

- surgery.
- surgery and fitting an external speech processor.
- surgery, fitting an external speech processor and rehabilitation program.
- fitting an external speech processor and amplification.
- amplification and surgery.

2. Bimodal hearing is:

- hearing two different things.
- hearing one thing in both ears.
- hearing two different things in one ear.
- two modes of transmission to the ears.
- a CROS mode of amplification.

3. Cochlear implant speech processor sends the coded electric signal directly to:

- outer hair cells.
- Organ of Corti.
- spiral ganglion cells.
- ossicles.
- hearing nerve.

4. Does the binaural advantage include?

- improved localization
- improved word recognition in quiet and noise
- both a and b
- improved localization, improved word recognition in quiet and noise, better sound quality
- improved sound quality and improved localization

5. Cochlear implant surgery can be considered on adults and children who have:

- mild hearing loss.
- severe and profound deafness.
- moderate hearing loss.
- anytime a person fails to benefit from amplification.
- bilateral severe and profound hearing loss.

6. If a person has an implant in one ear they should:

- never consider amplification in the contralateral ear.
- amplification will only confuse the patient further.
- consider linear amplification only.

- seek a high level DSP hearing instrument.
- stop using the implant and use a hearing instrument.

7. If a patient has an implant on one side and amplification on the contralateral side:

- they may achieve the binaural advantage.
- they will never be able to localize sound.
- they will never understand speech.
- they will not be able to use the telephone.
- they will hear speech but not understand speech in noise.

8. If a patient receives a cochlear implant on one side and wants a hearing aid on the opposite side, and they also indicate they have not worn a hearing aid on that side for five years, their options are:

- they should be told never to wear a hearing aid on that side.
- they should be told that it has been too long to help their hearing on that side.
- a hearing aid is not a good idea after cochlear implant surgery.
- a high powered DSP instrument should be suggested and tried.
- after five years of auditory deprivation there is no need to amplify that side.

9. The auditory nervous system:

- cannot combine the data from the cochlear implant and hearing aid.
- integrates the two signals very well and aids in speech understanding in noise.
- the person will achieve no benefit from amplification opposite the cochlear implant.
- the cochlear implant will block the hearing aid signal from getting through.
- the timing cues are too different between the signal from the implant and the hearing instrument.

10. The EAS implant:

- is an implant in one ear and amplification on the contralateral ear.
- is a short implant that uses the electric signal coupled to a hearing aid in the same ear.
- allows residual hearing to be preserved.
- destroys all useable hearing and relies totally on electrical signal.
- both b and c.

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