Bilateral Cochlear Implantation in the United States: Two ears ARE better than one!

Research and clinical experience over the last two or three decades has shown that the use of one cochlear implant, or unilateral implantation, provides significant benefit over the use of hearing aids for adults and children who have severe and profound hearing loss. Consequently, unilateral cochlear implantation has become accepted as standard of care for those with such hearing loss. This technology has helped tens of thousands of people. So if unilateral implantation can make such a huge difference in the lives of so many, wouldn't TWO cochlear implants prove even better?

In the same way that bilateral hearing aids are standard of care to remediate bilateral hearing loss, the use of two cochlear implants, or bilateral implantation, should also be the standard of care. As a result, potential recipients and parents seek information about bilateral implantation, which can be done either sequentially or simultaneously, and the medical benefits associated with two implants versus one.

Normal Hearing is Bilateral
As effective as unilateral cochlear implantation is, recipients still face significant challenges related to hearing function. For a number of reasons related to technological and physiological limitations, cochlear implants are not capable of restoring completely “normal” hearing. Having one cochlear implant is much like transforming someone with a profound hearing loss in both ears into someone with some level of auditory function in one ear and a profound hearing loss in the other. This has potential consequences in a variety of listening and communication situations for adults and children.

It’s important to note that it cannot be claimed that bilateral cochlear implantation restores hearing function to normal. However, one aspect of normal hearing that unilateral cochlear implantation does not address is the fact that people with normal hearing rely on input from TWO ears. In fact, our brains are built to process and analyze sound from two ears to maximize our ability to fully use the auditory information we receive. The information from the two ears combines in the brain in such a way that makes it easy for the person to cope with the various listening situations encountered in the real auditory environment.

Bilateral Benefits
So, since normal hearing is based on two ears, it seems sensible that bilateral cochlear implantation would prove more beneficial than unilateral. Here are some specifics on bilateral benefits.

Listening with two ears: This is an important listening mode which makes it easier for speech from both sides of the head to be heard and processed by the
brain. Hearing with two ears results in a small, but measurable improvement, even though both ears are receiving identical signals.

**Hearing in noise:** Hearing with two ears allows us the remarkable ability to “tune in” to someone we are trying to hear and understand when we are surrounded by background noise, which is usually the sound of other people talking! Our auditory system is able to combine and compare the signals from each ear, and our brain is able to “filter” out what we are trying hear from what we are trying to ignore.

**Always having at least one ear receiving a “good” signal:** A person with a single cochlear implant must always be aware of the location of the person talking. That is, the implant user must be sure to position him/herself so that the person talking is on the implanted side. People with hearing in both ears can listen at ease without having to think about the location of the speaker. In addition, when there is more than one talker communicating with a unilateral cochlear implant user, there will always be someone positioned away from the implanted side, making group conversation more challenging.

**Localization:** Hearing with two ears is essential for humans and animals in identifying the direction of sounds. The ability to localize sounds has obvious safety implications for a child or adult in that he/she could hear someone calling out a warning or being able to tell from which direction a car is coming while crossing the street.

**Subjective, qualitative advantages:** Binaural hearing also offers more natural, balanced sound and can improve the “ease of listening” in the same way that vision in both eyes eases and improves the ability to see. When there is hearing only in one ear, there are many challenging situations that can be frustrating. This frustration often leads to eventual social isolation, resulting in a poorer quality of life. Research study subjects using bilateral hearing aids typically report sound to be clearer, fuller, more natural, and more balanced.⁴,⁵ Therefore, it stands to reason that bilateral cochlear implantation may lead to similar qualitative advantages, ultimately resulting in a better quality of life.

**Putting Bilateral Implantation to the Test**
Adults with two cochlear implants describe the experience as giving them sound that is “outside the head” in the real world; they feel less disoriented, better able to attend to multiple events or people in the environment, and generally report feeling less stressed when trying to function. Children who have two implants report that they love having “both ears” just like their friends. They also say that being in the classroom is easier, and they miss much less information and exchanges from the teachers and among their friends. As important as these subjective impressions are, objective data are also important.
**Results in Adults**

Cochlear Americas has recently completed a study involving 33 subjects who received bilateral cochlear implants during the same surgical procedure, known as simultaneous bilateral cochlear implantation. Figure 1 shows average sentence and word recognition scores, preoperatively with hearing aids, as well as for unilateral and bilateral cochlear implant conditions six months after device activation. These patients scored poorly with hearing aids in each ear alone and when wearing two. With one hearing aid, the average scores for each ear were around nine percent, and with two hearing aids it was 13.5 percent.

After six months of implant use, these patients scored an average of 82 percent for each ear and 90 percent when using bilateral cochlear implants. More importantly, the average improvement with bilateral cochlear implants compared with bilateral hearing aids was 69 percent! In addition, the average score with two cochlear implants was significantly better than with either unilateral cochlear implant alone (Arcaroli, Parkinson, Litovsky, & Sammeth, submitted for publication).

Significant improvements in word recognition scores were also observed. Before surgery, the average scores were less than five percent, whether the subjects used one or two hearing aids. After six months of implant use, the mean scores with either the left or the right implants were just around 48 percent and 59 percent with two cochlear implants.


Subjects using bilateral cochlear implants have also been found to have significantly-improved abilities to identify source locations (directionality or localization ability) compared with unilateral cochlear implant use (Gantz *et al.*, 2002; van Hoesel & Tyler, 2003; Litovsky *et al.*, 2004; Nopp, Schleich, & D’Haese, 2004).

**Results in Children**

Recently reported pediatric study results suggest that similar benefits for hearing in noise can be expected for children receiving a second cochlear implant (e.g., Kuhn-Inacker, Shehata-Deiler, Muller, & Helms, 2004; Litovsky *et al.*, 2004). Kuhn-Inacker et al. reported significantly-reduced communication difficulties for
the children and stressed the importance of a good rehabilitation program in helping the children integrate the second implant.

Cochlear Americas initiated the first multicenter study of bilateral cochlear implantation in children in the United States. This investigation involved the implantation of children ages three to 13 years with a minimum of six months experience with one cochlear implant, who then received an implant in the other ear. Preliminary data indicate improved hearing with two cochlear implants for children in all age groups. However, the children receiving the second implant before the age of eight years generally acquire a greater degree of speech recognition in the second ear and more rapidly than children over the age of eight. This trend follows the more general trend in implantation that shows slower gains in performance as the age at implantation and duration of deafness increase. It is expected that with more time, these children will demonstrate the binaural advantage seen in adults.

A group of 12 children have been studied at the University of Wisconsin in Madison. These are the highlights from this research led by Ruth Litovsky, Ph.D (Litovskya@waisman.wisc.edu):

- Bilaterally implanted children can hear speech in noise better, sometimes as early as three months after activation of their second implant.
- Bilaterally implanted children can use information about the locations of sounds to separate speech from noise much better with two implants compared with one. This is similar to a situation in a classroom in which a child has to hear the teacher in the background of other children talking or other background noise.
- Many of the bilaterally implanted children can, by 12 months after the second implant is received, correctly identify sounds coming from their right or their left that are 30 degrees apart (imagine two hands on a clock placed at the numbers 1 and 11). In comparison, when they listen with a single implant, they often cannot do the test, or need separations of 90 degrees or larger (i.e., hands on a clock at the numbers 3 and 9). As shown in Figure 1, on average, the children who have worn bilateral implants can distinguish sounds to the right or left that are just under 20 degrees apart when listening with both implants. Interestingly, with only one implant, they can also now do the test, but the sounds must be twice as far apart, with over 40 degrees separation.
- The bilaterally implanted children were also better at the right versus left task than severe to profoundly hearing-impaired children using a cochlear implant in one ear with a hearing aid in the other ear (Figure 2) for this small subject group. These results are encouraging but need to be confirmed in a larger group of children across a wider range of hearing loss in the aided ear.
Frequently Asked Questions:

1) If I choose bilateral implantation for myself or for my child, what about access to future technology?

A concern some have regarding bilateral implantation is that it prevents the possibility of a recipient taking advantage of future technology and/or therapy. This is of particular concern for parents, as children have greater potential to experience such advances down the road. Significant strides in science have been made over the last 20 years, and further discoveries and improvements are likely to happen over the next 20. However, parents must also consider what their child’s auditory needs are now in terms of speech and language development.

The decision process with regards to bilateral implantation – and unilateral implantation for that matter – is taking place at a time when the child is actively acquiring speech and language. It is also at a time when the brain is still very “plastic” and amenable to making use of cochlear implants, unilaterally or bilaterally. It can be argued that for a child to maximize the potential advantage of bilateral implantation, the earlier this takes place, the better - to take advantage of a more plastic auditory system, as well as critical learning periods for speech and language.

The two most talked-about future technologies include hair cell regeneration and the totally implantable system. While interventions such as hair cell regeneration may become a reality at some time during a child’s lifetime, no one can say with any certainty that such approaches will be of help when the child becomes an adult – when such technology may become available.

Although a totally implantable cochlear implant system is likely to become available to adults within the next five to 10 years, it is unlikely that children will be considered appropriate candidates for this more invasive technology in the near future. The decision to wait for such technology or other future technology needs to be weighed against the consideration of present auditory needs – for adults and for children.

2) If I or my child already has one implant and a decision is made to receive a second implant, should use of the first side be discontinued to “force” the new ear to hear?

Professional opinions differ on whether or not a newly-implanted bilateral recipient should immediately wear both devices or wear only the second implant for a period of time. In general, those who have received bilateral cochlear implants wear both devices from the start. A primary reason for implanting the
second side is to foster development of hearing from both ears. Denying access to the first side for an extended period of time may be difficult for both adults and children and may result in rejection of the second side. Having said this, there may be benefit in working with the second ear only during therapy sessions in addition to working with both ears. This should be discussed with your cochlear implant audiologist and/or therapist.

3) How do you program two devices?

For the most part, programming two cochlear implants is similar to the situation where only one is being programmed, except that some care must be taken to ensure that the sound is comfortably loud and “balanced” on both sides. In cases where the individual has received a second implant after using one for some period of time, programming the second side is relatively straightforward. The recipient is already well-practiced for the task, as he/she has typically been “tuned up” many times before on the first side. For those who receive two cochlear implants during one surgical procedure, the initial activation is similar to that experienced by unilaterally-implanted children, but does take considerably more time.

Conclusions
Overall, the results for bilateral cochlear implantation in adults have shown significant improvement for hearing and communicating in the everyday world. This is evidenced by improved speech recognition abilities in quiet and in noise, as well as localization abilities. Results obtained for children are also very promising with similar benefits to those observed in adults.

The potential impact of bilateral implantation on the educational outcomes for children with bilateral severe and profound hearing loss should not be underestimated. Adults who elect to receive two implants and parents of children using bilateral cochlear implants are generally very pleased with the decision to receive two implants, as are the children themselves. And any intervention that has the potential to facilitate better hearing and communication is worth getting excited about!

References


Figure 1: Average pre- and postoperative scores for sentence (top) and word (bottom) recognition for 33 adult bilateral cochlear implant recipients.
Figure 2: Recent data from the University of Wisconsin, showing the smallest detectable right/left difference (localization task) from 12 children with bilateral cochlear implants, and 6 children using a cochlear implant in one ear with a hearing aid in the other severe to profoundly hearing impaired ear. Bilaterally implanted children were tested at approximately 9 to 12 months after activation of the second cochlear implant, and their results when listening with two cochlear implants, is compared with their first cochlear implant alone.