

smart technology
smart people



Great discoveries and
improvements invariably
involve the cooperation
of many minds.

Alexander Graham Bell

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It's no coincidence that so many engineers, researchers, scientists, and other self-described "technology-savvy folks" choose a MED-EL cochlear implant for themselves or their children.

They recognize and understand the obsession with technology that makes us tick. Even if you don't personally adore quantum physics, write code, or study the genome, you too can appreciate the technological difference of our cochlear implants.

Read on to get a genius-level understanding of what makes MED-EL so exceptional.

An invisible wave

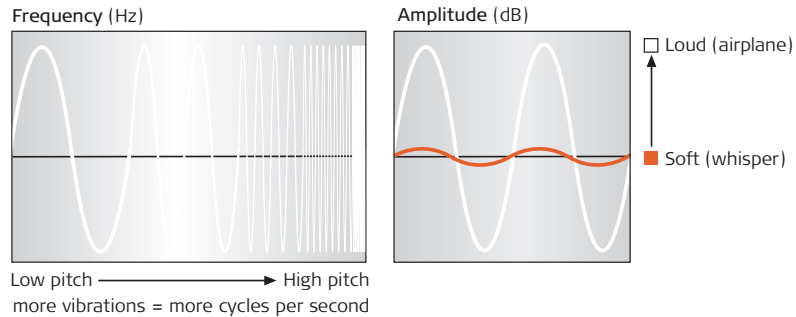
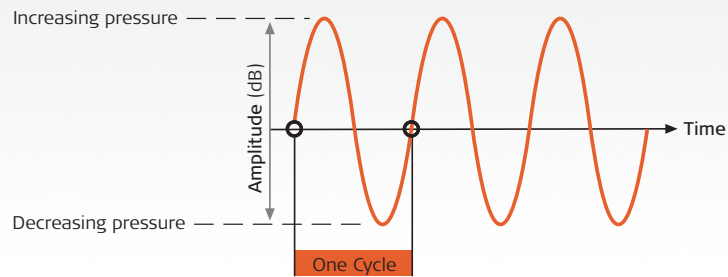
Breaking the Sound Barrier

First things first. Like all breakthrough technologies, ours began with a true understanding of the complex function of the human ear and how it perceives and translates sound.

As any engineer can tell you, when you develop a laser focus on the intricate details of how things work, inspiration and innovation ensue.



MED-EL's hearing implant technology uses the latest innovations developed to enhance the entire hearing experience.

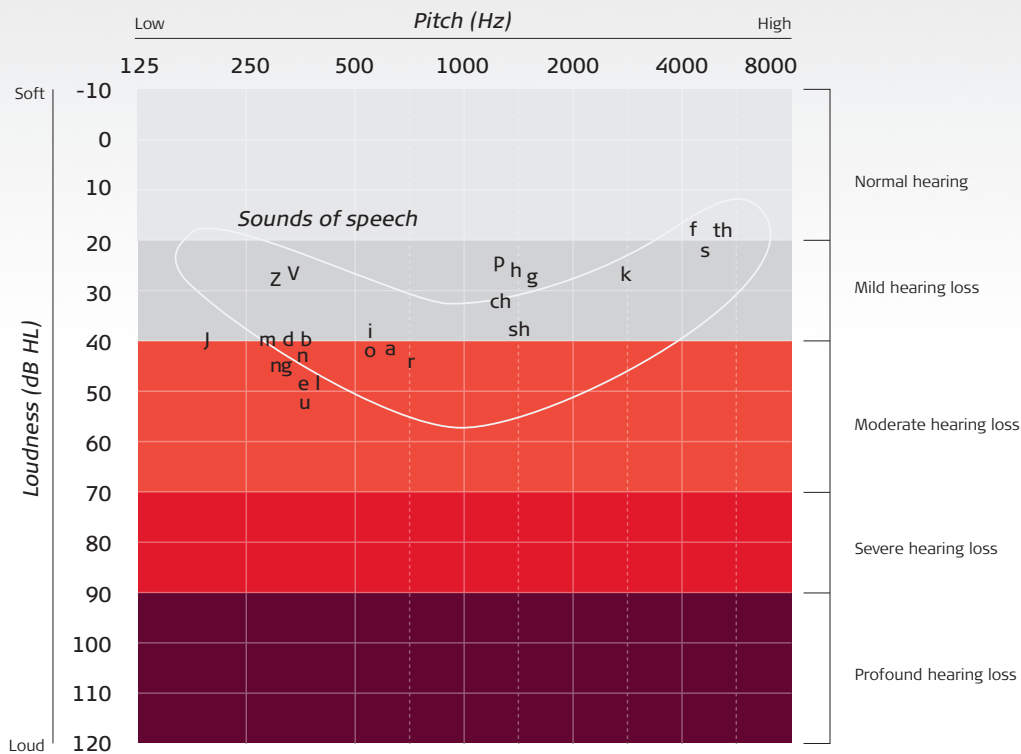


The Physics and Acoustics of Sound

Sound consists of a pressure wave, varying above and below the ambient pressure. Properties such as frequency, wavelength, amplitude, speed and direction are used to characterize these waves.

The **amplitude**, or sound level, corresponds to the loudness of sound, and is measured in decibels (dB) whereas the **frequency**, which corresponds to pitch, is measured in cycles per second – also called Hertz (Hz).

The quietest sounds that humans are able to hear correspond to a hearing level of approximately 0 dB, the average hearing threshold.



How Hearing Works

Our sense of hearing allows us to perceive the loudness, pitch and timbre of a sound, as well as to localize where a sound is coming from.

The outer ear helps to 'gather' sound which passes down the ear canal until it reaches the eardrum. The eardrum and middle ear systems convert the pressure wave into a pattern of vibration. This vibration is transferred to the inner ear, or cochlea, where it causes a pressure wave in the cochlear fluid. This pressure wave sets a membrane in the cochlea in motion. Hair cells located on the membrane detect the motion, and in turn, cause activity in the fibers of the auditory (hearing) nerve. The brain interprets this nerve activity as sound.

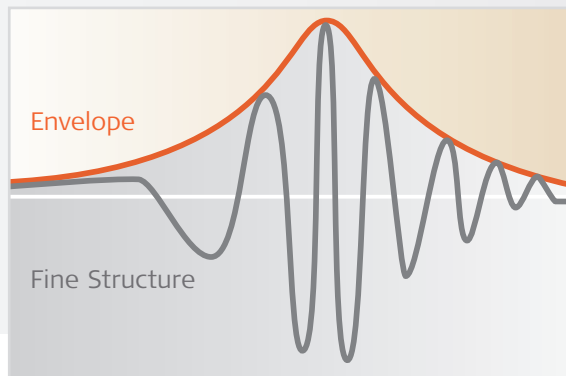
Normal hearing covers a frequency range of sounds between 20 Hz and 20,000 Hz (20 kHz). However, this range varies significantly with age. Usually, the sensitivity for high frequencies diminishes with advancing age. The majority of speech sounds are within a frequency range of between 100 and 8000 Hz. The human ear is most sensitive to frequencies around 1000–3500 Hz. Sound frequencies above the hearing range are known as ultrasound.

The brain also exploits the fact that we have two ears. Having two independent listening points on either side of our head allows nerve pathways in the brain to compare and contrast the signal from both sides. This can help us to hear more easily in noisy situations, and helps us to determine which direction a sound is coming from.

Way Beyond Pushing the Envelope

A sound signal can be deconstructed into two components, the **envelope** and the **fine structure**. The **envelope** represents the “outline,” or “broad brush strokes” of the sound signal. It mainly carries information about the relatively slow changes in sound level over time, and contributes to our perception of loudness. The envelope of a signal alone is sufficient for speech understanding in quiet conditions (for western, non-tonal languages). For more challenging situations, such as listening to music, or speech in noisy background conditions, research has demonstrated that normal hearing subjects are using an additional component of sound: fine structure.

Fine structure conveys the subtle details of a sound’s timing structure. It seems to be very important in the perception of pitch, which has an influence on our ability to appreciate music, and recognize the emotional tone of speech, as well as recognize the gender of the person speaking to us. Having the fine structure of signals available at both ears allows greater precision in sound localization for individuals with normal hearing.




Elements of Sound

Envelope

The envelope is the “loudness contour” of the sound signal and is essential for speech understanding.

Fine structure

The fine structure contains the subtle details of a sound signal and enhances pitch and sound quality.



By including the fine structure,
the normal hearing process
can be represented with
greater accuracy than with
the envelope alone.

It's in the details.

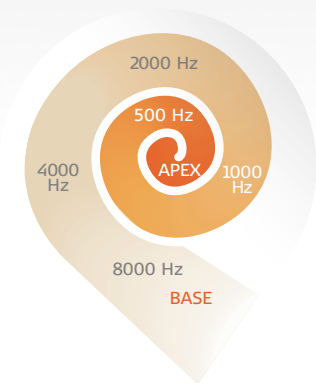
FineHearing™ Technology

Normal hearing employs two main mechanisms for coding the frequency of sounds: **Coding by place** (tonotopicity) and **coding by rate** (phase locking).

In general, both the place and rate code are used by the auditory system to hear lower frequency sounds. As sounds increase in frequency, the ability to use the rate code diminishes, and for very high frequency sounds the auditory system uses mainly the place code.



FineHearing™ provides the fine details of sound that can help cochlear implant users recognize individual musical instruments.



Coding by Place

Coding by place corresponds to the tonotopic arrangement of the cochlea. Like the keys of a piano (see page 18), the cochlea is arranged in order of frequency – and in normal hearing, each place along the cochlea responds best to a certain frequency. The base of the cochlea responds best to high frequencies, whereas the apex (deepest part) responds best to low frequencies. The pattern of activity in both the auditory nerve and the brain match this arrangement.

Coding by Rate

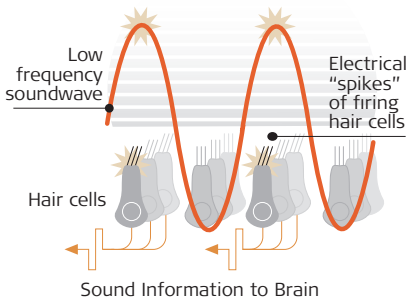
The second fundamental mechanism of sound coding in normal hearing is coding by rate. In the cochlea the hair cells are responsible for converting the movements of the membrane in the cochlea into electrical impulses. Due to the way the hair cells respond to this movement, the firing pattern of the auditory nerve activity closely corresponds to the timing pattern (fine structure) of the sound signal.

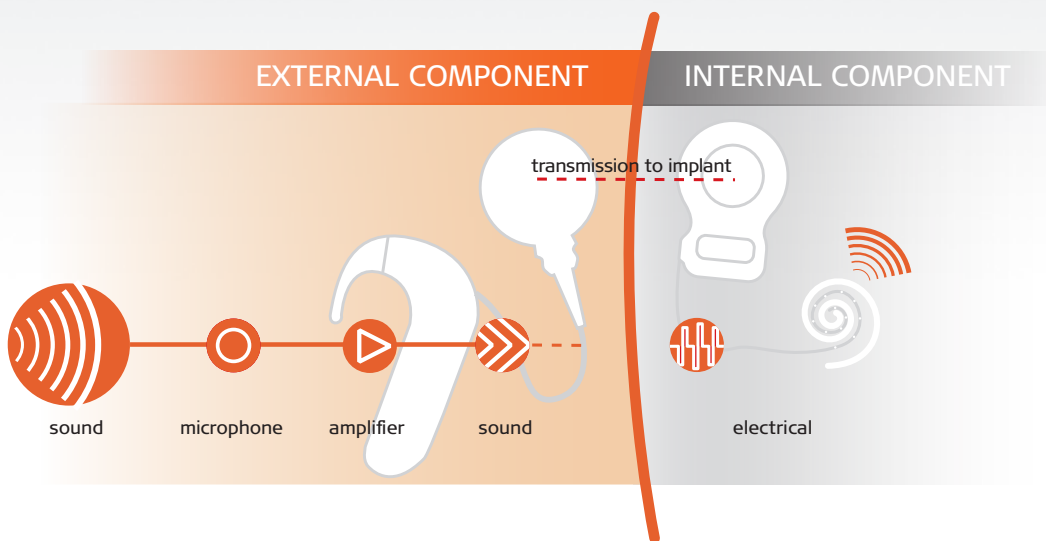
This process works well in normal hearing for frequencies up to ~1 kHz. As frequency increases, the efficiency of phase locking decreases, until about 4–5 kHz, where phase locking no longer operates.

In normal hearing, the pitch caused by sounds where only place coding is available tends to be weak, and doesn't evoke a perception of 'musical pitch'. Rate coding seems to be highly important for producing strong pitch, and the sensation of musical pitch. A strong pitch sensation also requires the rate and place cues to match.

Sound Coding as a Central Function of a Cochlear Implant

In a cochlear implant (CI), an external sound processor (usually worn behind the ear) picks up sound signals using a microphone and converts them into a pattern of electrical signals. These signals are transmitted to an implanted electronics package under the skin, and transferred by wires to an electrode array implanted in the cochlea. The electrical signals cause activity of the fibers of the auditory nerve, and the brain interprets this as sound.





Different approaches are possible for the conversion of a sound signal into a pattern of electrical signals. A sound coding strategy describes in detail the way this is carried out. Sound coding strategies can vary in how efficiently aspects of the sound signal are transmitted, and what priority is given to these aspects. These variables of sound coding strategies have a direct effect on the quality of the hearing experience.

What Traditional Cochlear Implant Sound Coding Can Affect

All coding strategies that have been used in cochlear implants for the last 15 to 20 years provide place coding by splitting the sound into frequency bands, and sending this information to an implanted electrode array, mimicking the tonotopic arrangement of the cochlea. At the same time, the envelope of each of these frequency bands is presented. These envelope extraction strategies provide relatively good place coding of frequency, and good transmission of a signal's envelope, but they largely discard the fine structure.

In accordance with the description for normal hearing above, CI users with envelope extraction strategies tend to understand speech relatively well in quiet situations, but have more difficulty in background noise. They will typically have a poor sensation of pitch, and often struggle to appreciate music, although there can be exceptions. Furthermore, although western, non-tonal languages (such as English) can be well transmitted by envelope information alone, tonal languages (such as Mandarin) where the meaning of a word is also affected by voice pitch, are not well transmitted.

With the introduction of FineHearing technology, MED-EL overcomes the limitations of envelope-based, “traditional” coding strategies. Similar to frequency coding in normal hearing, FineHearing codes a sound signal both in rate and in place.



The additional rate coding in low to mid frequencies mimics natural hearing better than ever before and provides fine structure information important for more complex listening tasks and situations. As mentioned above, the fine structure information of a sound is highly important for good music perception and sound localization.

Thus, MED-EL's FineHearing better represents both components of a sound, the envelope and the fine structure. By including the fine structure, the normal hearing process can be represented with greater accuracy than with the envelope alone.

MED-EL's sound coding strategy to apply FineHearing technology is called **Fine Structure Processing*** (FSP).




* FSP is not indicated for use by pre-lingual children.

The Experience of Hearing with FineHearing™

The fine structure information of sound provided by FineHearing¹ may enable users to benefit from additional details, and may be particularly advantageous for the fulfillment of difficult listening tasks.

Users focus better on speech while filtering out the background. Better understanding of “tonal” languages such as Mandarin can become possible. Music perception, as well as sound localization, may considerably improve.

By combining rate and place coding, FineHearing technology improves pitch perception with cochlear implants. Moreover, the combination of both coding modalities allows the user to make the best use of both rate and place without adverse interference between the two.

| Listening Task or Situation | Sound component | | Traditional speech coding | FineHearing™ |
|-----------------------------|-----------------------------|---|---------------------------|--------------|
| Speech in quiet | Envelope |  | YES | YES |
| Music & tonal languages | Fine structure |  | NO | YES |
| Speech in noise | Envelope and fine structure |  | NO | YES |

Scientific Data

Scientific studies^{1,2} with FineHearing users show clear benefits for speech understanding in background noise. They also show that listeners are able to detect smaller differences in pitch and perceive a wider range of tones, which is critical for the perception of music and tonal speech elements.

Get the “whole piano.” Complete Cochlear Coverage

Complete coverage means the ability to stimulate all the available auditory nerve fibers. The neural tissues that can be stimulated by a cochlear implant extend all the way to the uppermost region of the cochlea via long nerve fibers.

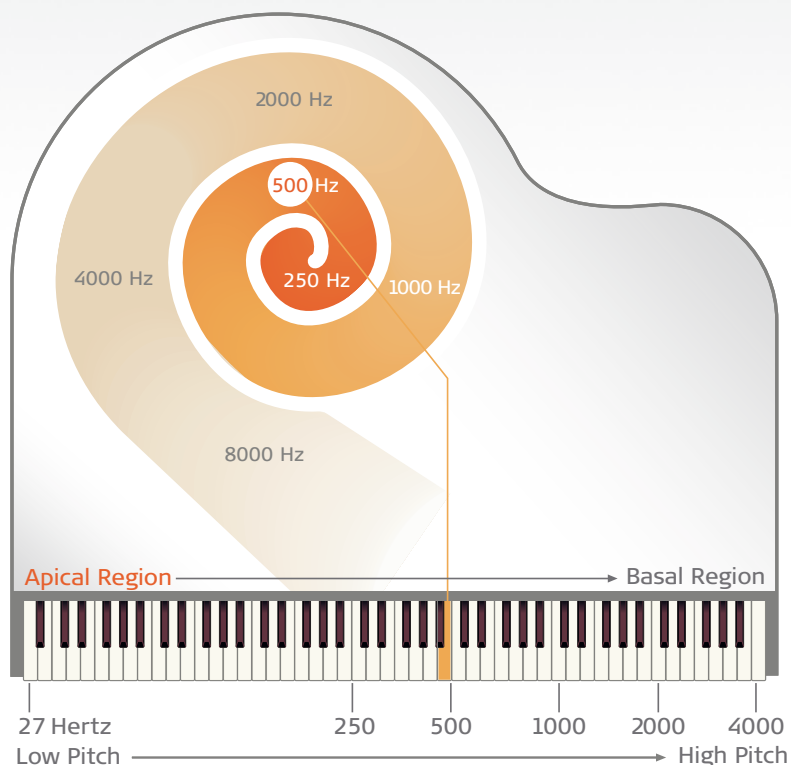
Since the auditory nerve fibers located all along the cochlear spiral are each specialized for processing specific pitches, the ability to stimulate all of them provides the implant user a richer, more natural sound quality.³

MED-EL is the only cochlear implant manufacturer to design electrode arrays that are specifically intended to stimulate the entire cochlea instead of just the lower 2/3 of the organ.

Complete cochlear coverage may provide the best opportunity for the development and maturation of the auditory system in young children⁴



Hair cells in the cochlea are arranged according to pitches or tones. This arrangement is referred to as **tonotopicity**.




The Cochlea in the Normal Hearing Process

To appreciate the importance of full cochlear coverage, it is helpful to understand how the cochlea works in the normal hearing process. The cochlea is a small (pea-sized), spiral-shaped structure located in the inner ear. It is responsible for converting sounds from mechanical vibrations into signals that are passed on to the brain via the cochlear nerve. This process is performed by specialized sensory cells (hair cells) within the cochlea.

Like the keys of a piano, the cochlea is arranged in order of pitch (frequency). One end of the cochlea sends high-pitched information to the brain, while the other end sends low pitched information. In other words, a high-pitched sound causes the sensory cells in the bottom (base) of the cochlea to vibrate. A low-pitched sound causes the sensory cells in the uppermost part of the cochlea (apex) to vibrate. Speech, music, noise and all other sounds contain many different pitches. As a result, the stimulation of the entire cochlea, from base to apex is needed to provide the rich sound experience that characterizes normal hearing.

The cochlea is approximately 35 mm in length. The length of the longest MED-EL electrode is 31.5 mm.



The Cochlea in the Cochlear Implant Hearing Process

Cochlear implants work by imitating the natural hearing process. They convert sounds into electrical signals that are used to stimulate the cochlea. The electrode array, which is placed into the cochlea during implantation, contains small metallic surfaces (electrode contacts) that electrically stimulate various areas of the cochlea. As in the natural hearing process, the pitch of the incoming sound determines the area of stimulation in the cochlea. For high-pitched sounds, the electrode array should ideally stimulate the bottom area (base) of the cochlea. Similarly, for low-pitched sounds, the electrode should ideally stimulate the upper area (apex).

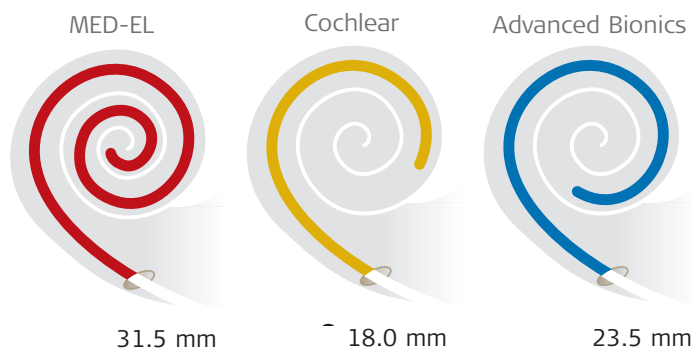
To best mimic natural hearing, it is important for a cochlear implant to be able to stimulate the entire length of the cochlea. Special electrodes designed for deep insertion into the cochlea ensure that a wide range of pitches (frequencies) stimulate their corresponding neural structures, much like they would in the normal hearing ear.

Benefits of MED-EL electrode arrays

MED-EL's cochlear implants feature the **longest electrode array** available, which extends 31.5 mm into the cochlea. This is only possible through MED-EL's unique and extremely flexible electrode design. The advantage of this design is that the electrode covers all areas of the cochlea, including the deepest areas that are responsible for hearing low pitch sounds.

Other commercially available electrode arrays are shorter and are only able to stimulate approximately two-thirds of the cochlea. As a result, short electrode arrays ignore the parts of the cochlea responsible for low pitch hearing. MED-EL electrode arrays allow the cochlea to be stimulated along its entire length, much like the normal hearing ear. The electrode array covers the widest pitch range while ensuring the best possible pitch discrimination among the various electrode contacts.⁵

MED-EL's Standard electrode array covers the widest pitch range while ensuring the **best possible pitch discrimination** among the various electrode contacts



Numerous studies have shown that MED-EL cochlear implant users experience improved speech understanding and more natural sound quality when the entire length of the cochlea is stimulated.^{3,5} There is also evidence of better speech discrimination in a shorter period of time following initial activation of the implant. By stimulating the low pitch region, the implanted cochlea responds more like the normal cochlea, enabling the user to hear a broad spectrum of pitches. This improved hearing experience is thought to contribute to a faster learning curve when beginning to interpret speech and other sounds with a new cochlear implant.



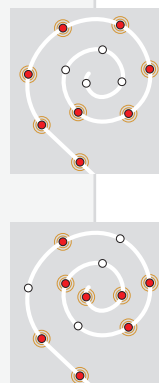
Complete cochlear stimulation provides a richness and fullness of sound that partial cochlear coverage cannot achieve.

In one study,³

users of the MED-EL standard electrode array featuring 12 pairs of electrode contacts were researched. Participants were divided into two groups:

The **first group** listened to speech with only 8 electrodes pairs active: the 4 electrode pairs in the low frequency portion of the cochlea were turned off (see right). The sounds were described as "tinny" and "unnatural."

The **second group** listened with 8 electrode pairs that were spread out along the electrode array, from the base to the apex. The sounds were described as a "much richer, more natural sound quality."



● Electrode Active
○ Electrode Inactive

Take it all in.

Automatic Sound Management


Because your day takes place in a peaceful park or at a loud carnival, in a music hall or on a relaxing beach, MAESTRO's unique technologies are designed to provide outstanding performance for real life – automatically.



Den Anordnungen des Personals
ist Folge zu leisten!

Wellenflug

Circus Welt



Make seamless transitions
between listening environments
without adjusting settings

Other processors require users to make frequent program or setting changes in order to enjoy the best possible listening experience. Superior front-end processing featuring Automatic Sound Management detects changing listening situations on-the-go, adapting automatically so you (or your child) don't have to.

How Automatic Sound Management Works

For cochlear implant sound processing to be effective, it is critical to compress the large (120 dB) acoustical dynamic range of normal hearing into an acceptable range for electrical stimulation (30 dB). To meet this challenge, all MED-EL audio processors make use of the front-end processing strategy known as Automatic Sound Management (ASM). ASM consists of a dual stage Automatic Gain Control (AGC) providing a wide Input Dynamic Range (IDR) and automatic volume control.

Input Dynamic Range is one of the most important features in audio processor technology. Studies show that only a wide IDR allows for adequate speech perception in noise.^{6,7} All MED-EL behind-the-ear (BTE) processors feature an Input Dynamic Range of 75 dB. Therefore, all signals within the range of 25 dB and 100 dB SPL are processed. This allows for detailed processing of a very wide range of sound inputs.

Automatic volume control deals with the wide range of input levels occurring in everyday life, including soft speech and loud speech. Automatic volume control assures that speech perception in background noise is largely immune to variations in speech level, meaning that users of MED-EL audio processors can understand soft and loud speech equally well as normal speech. Varying-level speech can be understood equally well as constant-level speech.⁸

MED-EL audio processors also feature a **dual stage Automatic Gain Control**.⁹ This technology allows users to experience a **very quiet sound** (like a whisper) to a **very loud sound** (such as an airplane) without uncomfortable overstimulation or the need to adjust processor settings. It puts the variations in sound levels within the patient's hearing range so that sounds are perfectly matched to their ear's tolerable levels, while still maintaining the subtle loudness differences in sounds that are so critical for speech understanding. Dual stage front-end processing also ensures that a sudden increase in loudness does not result in an uncomfortable change in volume for the user, and it prevents overly muffled sounds following a sudden loud signal. Therefore, sounds that users hear are always presented to maximize speech comprehension and to preserve the subtle differences in loudness from one sound to the next.

Other processors require users to frequently remove the processor from the ear or switch programs in order to make adjustments based on the environment and level of background noise. Users of processors featuring Automatic Sound Management can rest assured these changes are being made automatically. This is particularly important for infants or small children who may not be able to recognize changes in their surroundings.

Automatic Sound Management

| takeoff



Going stereo.

Bilateral Cochlear Implantation

In 1996, a MED-EL patient at the University of Würzburg in Germany was the first person implanted with a goal of restoring binaural hearing. In 1998, the same clinic accomplished the first bilateral implantation to restore binaural hearing in a child. Since then, bilateral implantation has gained momentum, resulting in thousands of bilateral MED-EL users worldwide, more than two-thirds of them children.

As the research data grows, we can begin to reach some conclusions about the effect of hearing with one implant versus two. In addition, we can draw conclusions from the vast amount of research that evaluates binaural hearing in people with normal hearing, with single-sided hearing loss, and those using binaural hearing aids.

A study of 39 bilaterally implanted children showed that communication behavior improved with the second implant, especially in difficult listening situations.³⁶





Binaural hearing is extremely important for everyday life: to localize sound and hear better in noisy environments.

Why is binaural hearing important?

The term “binaural hearing” refers to specific listening skills that can only be achieved with two ears. When we hear with two ears, we are able to orient ourselves in space and can choose to pay attention to certain sounds or voices selectively. We can also distinguish important sound information even in difficult listening environments, such as a noisy room with voices in the background. Binaural hearing is extremely important for everyday life and helps us with:

1. The ability to determine the direction of a sound (**localization**). Localization helps us identify the direction of a sound, so we can react accordingly. Just as the brain needs two eyes to determine the distance of an object, it needs input from two ears to hear where a sound comes from.
2. The ability to perceive speech in noisy situations (**speech understanding in noise**). When we hear with two ears, we are also better able to separate the important information in a noisy environment.

The position of our ears on the sides of our head makes these binaural abilities unique, and helps us perceive a sound slightly differently with each of our ears. Our brains then analyze these small differences between the right and the left ear. The brain processes the rapid and intricate comparison of differences between ears, giving us the ability to localize sounds, and to distinguish speech from background noise. When we hear with only one ear, we cannot perceive these differences easily, which leads to more difficulty with localization and speech understanding in noisy environments.

Hearing with two ears

It is well-accepted that listening with two ears provides an advantage in noisy environments^{10,11,12,13,14,15} that is necessary for finding the direction of a sound.¹⁶ For people with hearing loss, there is overwhelming evidence that, in most instances, using two hearing aids for amplification helps achieve better performance than only one across a wide variety of conditions.^{17,18} It is also well-accepted today that binaural hearing aid fitting can restore sound localization,¹⁹ at least in listeners who are moderately to severely impaired.²⁰

Hearing with only one ear

People with hearing loss in one ear generally report difficulties with hearing conversations on the impaired side, finding the direction a sound is coming from, and understanding speech in noisy situations. However, their speech understanding in quiet environments is generally as good as that of people with “normal” hearing. As listening conditions worsen (i.e. become more noisy), the difficulty experienced by a person with **unilateral hearing loss** increases.²¹

A relatively large number of children experience unilateral hearing loss.^{22,23} Children are especially negatively affected by unilateral hearing loss during the years of language learning and academic development. Up to 35 percent of children with unilateral hearing loss fail one or more grades in school, and demonstrate significantly poorer speech understanding in the presence of noise than their normally-hearing counterparts.²⁴ As expected, localization ability is significantly poorer in children with unilateral hearing loss than for children with “normal” hearing.²⁵ Research clearly demonstrates that the benefits of bilateral hearing are lost when only one normally-hearing ear is available. When these statistics are considered along with the real-world challenges of ever-changing noise levels in most school classrooms, the importance of achieving the best possible hearing to support language growth and academic development becomes very obvious. These findings in people with unilateral deafness could lead us to assume that listening with two cochlear implants, rather than one, has important advantages.

Practical benefits

Later in this booklet, you'll find the latest research findings with bilateral implants. Research studies test subjects in a clinic or lab, and the findings from these studies could help you and your implant center decide whether bilateral implantation is a good decision for you. However, a lab environment isn't the real world. Aside from clinical test results, patients report practical considerations.

- Many patients suggest that one of the best things about having two implants is that they are **never "off the air."** If you need to replace batteries on one side, for example, the other side is still on while you're putting in new batteries. The small size of the MED-EL audio processor, and our wide variety of wearing options, means you can wear two audio processors without feeling weighed down.
- Special bilateral listening accessories provide a stereo listening experience, which is very exciting for some users. Some patients report that having a second device helps them feel somehow **"balanced" and more connected to their environment** because they have sound input from both sides. Others tell us that they don't have to think so much about how they manage difficult environments – for example, positioning their "good" ear closer to the sound source. Driving might be easier if you are trying to talk with a passenger, especially if your only hearing ear is facing away from the passenger on your other side. Listening effort may also be reduced, as some listeners report feeling less fatigued at the end of the day when wearing two versus one.
- Finally, bilateral implantation **ensures that the "best" ear has been implanted.** Based on your history, your implant center may be able to tell you that one ear has a better chance of success than the other. But, more often than not, especially when the hearing loss and history is essentially the same between the two ears, "best ear" is impossible to determine. Some bilateral implant users have reported that the ear they thought would hear best with an implant actually doesn't contribute the most. Other patients start by implanting their "worst" ear, but when it quickly begins to outperform the "better" ear that is still using a hearing aid, they begin considering the potential benefit from a second implant.

Bilateral impact on rehabilitation

Listening practice under the guidance of a professional can be very beneficial whether you have one implant or two. We recommend that all children receive auditory therapy in addition to any other types of habilitation for speech and language they might get after implantation. Although fewer adults seek rehabilitation, those who do generally report that it helped them adjust quickly when using either a first or second cochlear implant. The therapy environment is the best place to work on listening in difficult situations, which can translate into communicating with more ease in the real world.

The addition of a second implant may or may not change what your therapist recommends. In the case of simultaneous bilateral implantation, most professionals recommend starting off with both implants on all the time. There might be times where it is important to isolate one ear or the other during therapy or for testing, but in general, both implants are in use simultaneously.

However, in the case of sequential bilateral implantation, therapy recommendations vary from center to center, especially if a significant amount of time has passed between the two surgeries. Some therapists recommend using only the new implant for a period of time, so that the “new ear” works harder to catch up quickly²⁷. Others recommend using both right away, while some may recommend a compromise. For example, a student might initially wear both implants at school to get academic information, but might only use the new implant in therapy situations, or at home where the demand to understand is not as critical. Talk with your therapist about his or her philosophy, and know that there is no one correct way. If one method doesn't seem to work for you, try another!

Simultaneous - both cochlear implants are received at or nearly at the same time.

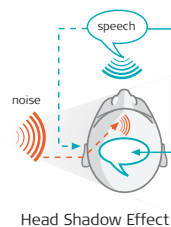
Sequential - time has passed between receiving the first and second cochlear implant.

In the years 2000-2008, over 200 research studies were published or presented that investigated bilateral implantation. Across these studies, results support the possibility of improved outcomes for both adults and children with bilateral implants.

Some of the key findings are summarized here.

A review of the research

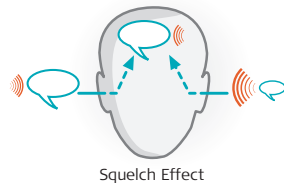
It is possible to test whether a person is able to use sound coming from both ears to make these difficult judgments. If having two ears improves the test score, we call that a “binaural advantage.” Generally, four listening skills are tested to determine whether a binaural advantage is present:



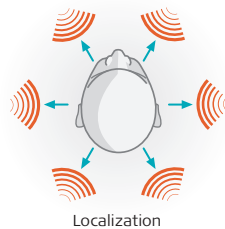
Head shadow effect. The head helps block noise for the ear that is farthest away from the noise. If the head shadow effect is present, the ear farther away from the noise helps the brain more than the ear on the same side as the noise.



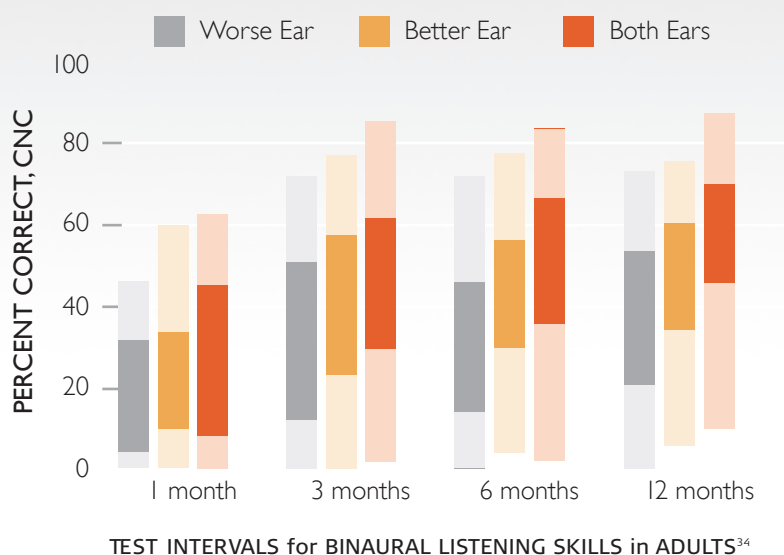
Summation effect. Information presented to both ears increases ease of hearing, because the information is presented twice to the brain – once from each ear. Two presentations give the brain a better chance of understanding the information.



Squelch effect. The squelch effect is the most difficult to describe. It is the ability of the brain to analyze the difference in the mix of speech and noise at each ear. In essence, the squelch effect is the result of the brain using both ears to help minimize background noise.



Localization. Localization is the ability to know which direction a sound is coming from, and helps us orient ourselves in our environment.



Studies in adult users

- Adult bilateral CI users demonstrated all of the binaural effects (head shadow, summation and squelch) that normal hearing individuals enjoy.^{26,27,28,39}
- Several studies have reported restored ability to localize sounds.^{30,31,32,33} Two of these studies showed that subjects went from *guessing* where a sound came from while using one implant, to *knowing* the direction when the second implant was added. Another study found that localization was nearly as good with implant users as it was with individuals with normal hearing. One study noted that localization abilities developed over time and were stable after five months of bilateral implant use.
- Binaural listening skills seem to develop over the first year of use. Simultaneously implanted adult bilateral CI users demonstrated improved speech understanding in quiet when using both ears compared to only one³⁴ (summation effect). This result was found to be present over the first year of bilateral implant use. The head shadow effect was found to be present by six months, and although the squelch effect was not measurable at six months, it was present by one year of bilateral implant use. (See chart above.)
- Even when researchers created a more difficult listening situation by using multiple sound sources, a significant bilateral advantage was found, and the largest effect was found in the most difficult conditions.³⁵

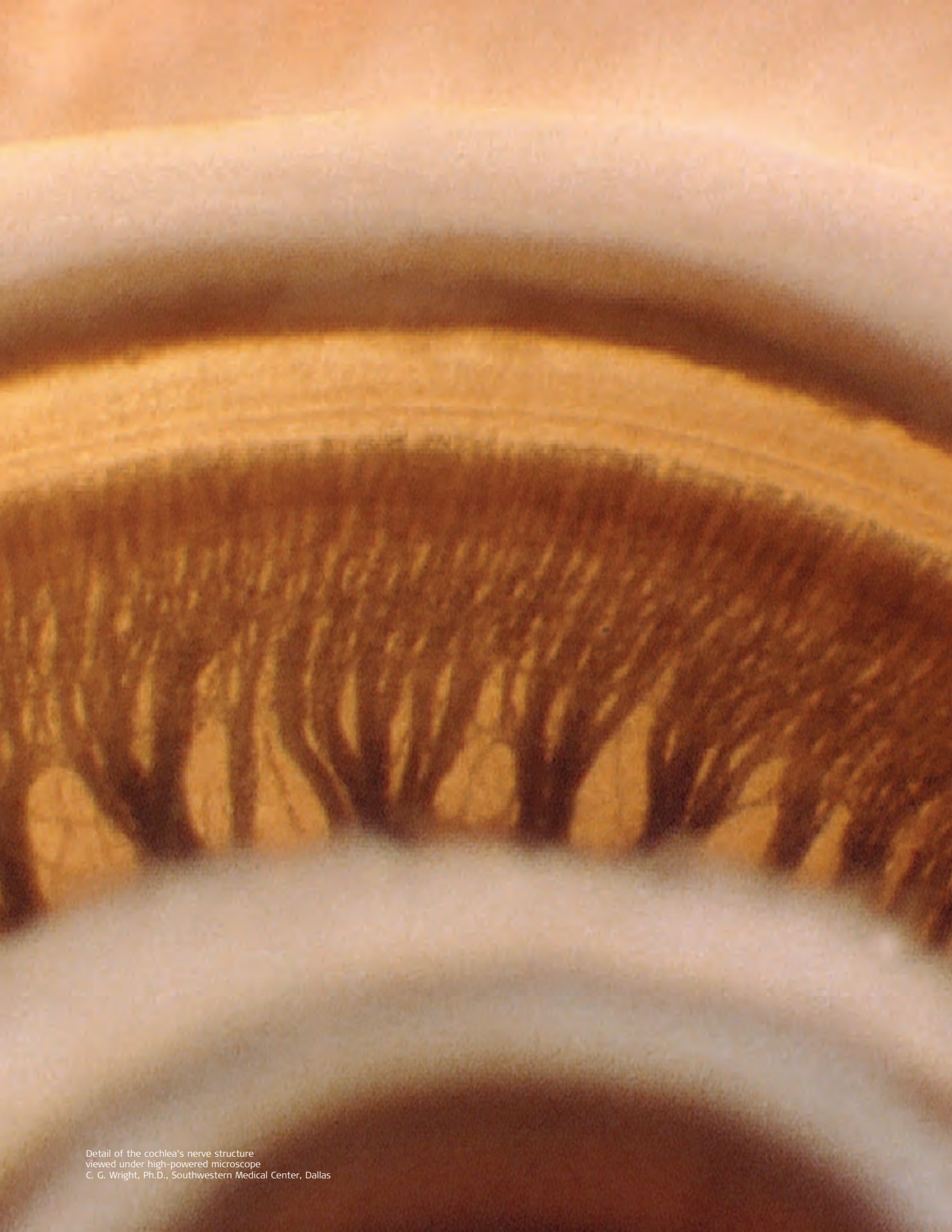
Studies in children

- A study of 39 bilaterally implanted children showed that communication behavior improved with the second implant, especially in difficult listening situations. The children demonstrated better understanding of spoken words, and significantly better understanding of speech in noise when using both implants.³⁶
- Although localization skills are difficult to measure in children, one study showed that 2/3 of a group of bilaterally implanted children were able to tell the difference between two separate but close sound locations, and the implanted children in the study even outperformed children who listened with two hearing aids.³⁷ Another study on young children found that localization skills were starting to develop in toddlers with bilateral CIs, but were not seen in toddlers with only one cochlear implant.³⁸

Ensuring a hearing future.

Hearing Preservation

At MED-EL, we think your future and your present well-being are equally important. This philosophy has driven us to design the softest and most flexible electrodes available to help preserve the delicate structures of the cochlea.



Detail of the cochlea's nerve structure
viewed under high-powered microscope
C. G. Wright, Ph.D., Southwestern Medical Center, Dallas

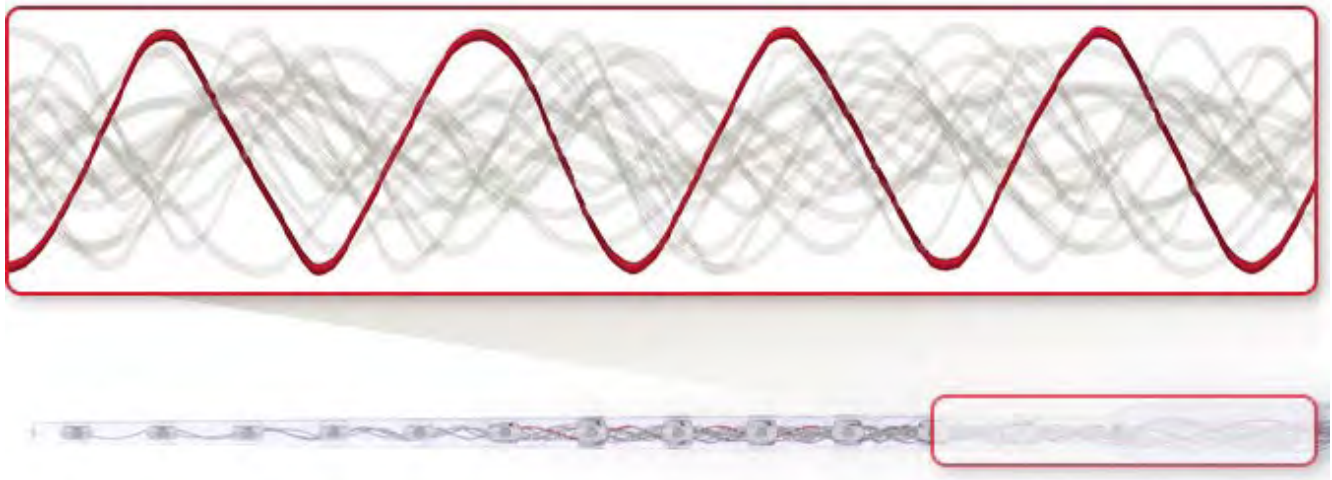
Hearing Preservation for Cochlear Implant Users

Many individuals with severe to profound hearing loss may still have some measurable hearing especially in the low frequencies. This measurable hearing is referred to as **residual hearing**.

In many cases, cochlear implant candidates have some degree of residual hearing, even though it may be minimal. Preserving residual hearing is still essential for cochlear implant candidates because it illustrates that the neural structures have not been damaged.

Ensuring that the neural tissues are left undamaged is critical for all cochlear implant patients, but **especially for young children who may face multiple implantations in their lifetime**. It is likely that any future interventions, be they device, biological, or pharmaceutical in nature, will be more successful in a cochlea that has received minimal trauma through reduced insertion force.

Reduced insertion force is facilitated through the design of an electrode array which is inserted gently into the cochlea. MED-EL electrodes have been specifically engineered to preserve residual hearing through their soft and flexible design featuring wave-shaped wires. This design gently follows the natural shape of the cochlea when being inserted. Therefore, a surgeon is able to use minimal insertion force when placing the electrode into the cochlea. Greater insertion force increases the risk of damage to the sensitive neural tissues and structures that enable hearing.



MED-EL electrode arrays feature wave-shaped wires for gentle insertion into the cochlea. The wave-shaped wire design makes MED-EL electrode arrays the world's softest and most flexible.

When it all comes together.

Performance studies

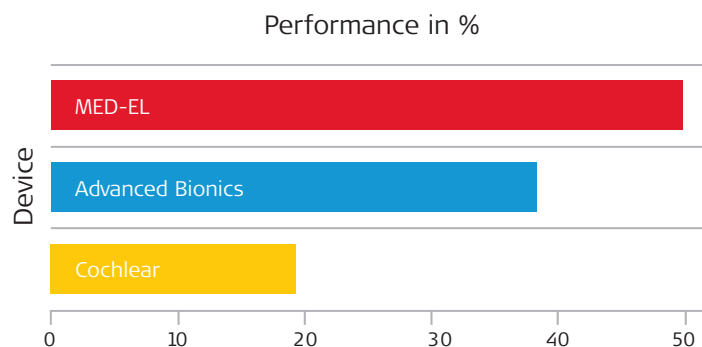
Numerous studies have demonstrated that MED-EL Cochlear Implants deliver exceptional sound quality and performance, not only when compared to previous generations of MED-EL products, but also in comparison to other cochlear implant systems.^{39,40,41,42,43,44}

Better results. Faster.

Users of the MAESTRO CI System featuring FineHearing not only outperform other CI systems, they achieve better hearing performance faster. The authors noted that "data indicate that the OPUS 2 group 'take off' more quickly than patients in other groups."⁴⁵



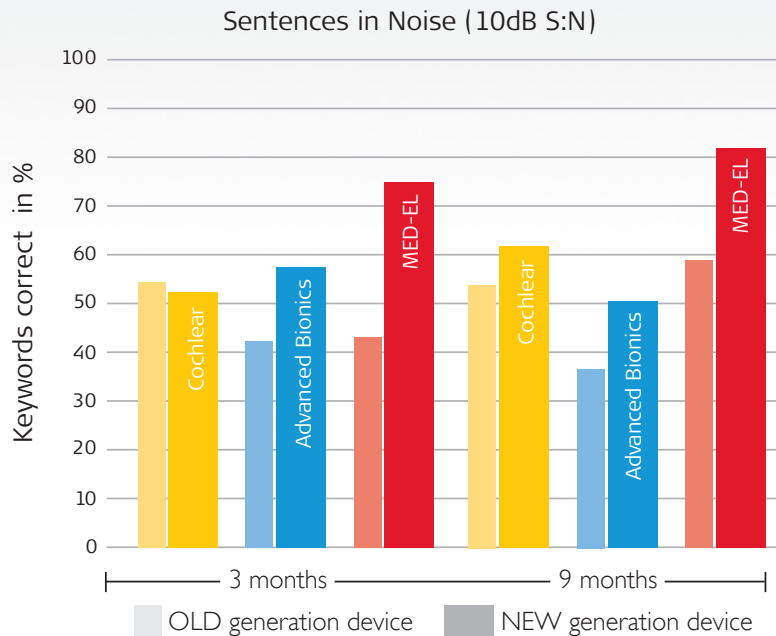
The successful combination of FineHearing technology, Automatic Sound Management and Complete Cochlear Coverage has been proven by the most comprehensive independent clinical study available.



Up to 30% Better Performance in Noise than Any Other Tested System

The strengths and weaknesses of a cochlear implant system become apparent when tested under conditions aimed at assessing speech perception in real-life circumstances. An independent study performed by the Department of Otolaryngology at the Medical University of Hannover, the world's largest cochlear implant center, aimed to do just that. **The results of this study show that the MAESTRO CI System outperforms all other cochlear implant systems.**⁴⁶

Participants in this study listened to sentences with varying levels of speech in order to simulate real-life listening situations. All major cochlear implant brands were represented in this study. Statistical analysis revealed significant differences in performance between cochlear implant systems. As the listening situation became progressively more challenging, only MED-EL users continued to improve. Additionally, only MED-EL users were able to still understand 50% of speech, even when the noise level was louder than the presented speech.



20% Higher Speech Perception Scores for Users of MAESTRO

Best hearing performance for the MAESTRO CI System is further supported by an ongoing comparison study conducted by the Manchester Cochlear Implant Program at the Central Manchester University Hospital – one of the leading cochlear implant centers in Great Britain.⁴⁵ **Once again, the MED-EL MAESTRO CI System performs better than any other tested system.**⁴⁵

This study not only measured performance among CI systems, it also compared older generation processors to current generation systems. All major cochlear implant systems were represented. **Results indicate that users upgrading to a MED-EL audio processor experience the most benefit from upgrading to a current generation processor.**

Whether in quiet or in noise, in changing and challenging listening situations, the MAESTRO System's unique technologies make the difference:

- **Complete Cochlear Coverage** maximizes the potential of the entire cochlea
- **FineHearing Technology** makes the fine details of sound come alive
- **Automatic Sound Management** adapts to changing listening environments

Why smart people chose MED-EL

After a lifetime of using hearing aids, and two decades managing a hearing assistance technology business, I knew precisely what I wanted in CI: universality with third-party assistive devices, ease of use, maintenance and customer support. My MED-EL processors have delivered on all counts without fail, consistently excelling in easing everyday listening situations. I greatly value the T-coil capability, as well as readily accessible cables that enable connection of battery-powered devices, such as MP3s, iPods and, in difficult listening situations, FM systems. Thanks to MED-EL, I'm connected to today's world in a way I never thought possible.

JOAN B., Owner/Consultant
Assistive Technology Company

My requirements for a cochlear implant included a 'cutting-edge,' yet upgradeable processor and impeccable quality. A comprehensive review of the literature and discussions with multiple CI professionals convinced me that MED-EL met my high standards. For a more detailed comparison of features unfettered by 'marketing hype,' I downloaded the FDA-approved user manuals. I was further impressed by MED-EL's efficient design, user-interface including the simplicity of the FineTuner and its smooth connectivity with assistive listening devices. I remain extremely happy with my choice.

ROY K., MD, MBA
Owner/Principal Consultant

As someone who teaches pre-kindergarten students with hearing loss, I was particularly intrigued by user studies filled with accolades for MED-EL processors in phone usage. I've found FineHearing gives me added clarity, so I am more adept at encouraging correct pronunciation of speech sounds among my students. It's quite amazing.

VIRGI M., MEd
Auditory-Oral Educator

Instead of relying on a cursory reading of web sites and marketing materials, I evaluated CI options from the perspective of a clinical researcher. I used numerous research citations to gather input, then formulated my own conclusions. As indicated in literature provided by MED-EL, the performance data from the Haumann study was very convincing. Such documented evidence is extremely valuable to anyone taking the CI journey.

JEFF C., Director/Consultant
Medical Manufacturing Company

I was quite impressed with MED-EL's straightforward and informative marketing materials. But I was more interested in the information I read in cited references, peer-review journals, and white papers. A host of professional communications presented data that confirmed MED-EL's technology was indeed superior. Ultimately, the opinions of experts are what swayed my decision to choose MED-EL.

EDDIE H., Electrical Engineer

I was particularly interested in understanding each CI brand's electrode design and coding strategies. I informally conducted some very thorough investigation to better grasp each company's philosophy regarding stimulation rate, electrode spacing, and the coding processes. I was very impressed with MED-EL's electrode arrays, as well the company's approach to minimizing channel interaction. MED-EL's technology development has always been at the forefront of the industry, and my incredible success is a testament to that.

KERI R., Vice-President
Nationwide Banking Institution

Extensive personal data analysis guided my CI choice. I was impressed by the ENT researcher presentations at a conference in Sydney, Australia that documented superior performance and reliability reviews for MED-EL devices. I was also swayed by technical information gleaned at the Hearing Loss Association of America's Convention, as well as my admiration for MED-EL's long experience with CI technology. From a practical standpoint, I liked the compact design, ease of use and conservative color scheme of the external profile. But at the end of the day, my most important consideration was that MED-EL's internal device was the only CI approved by the FDA to withstand an MRI without having to remove the magnet.

PETER U., President/CEO
Scientific & Educational Organization

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