WHITEPAPER

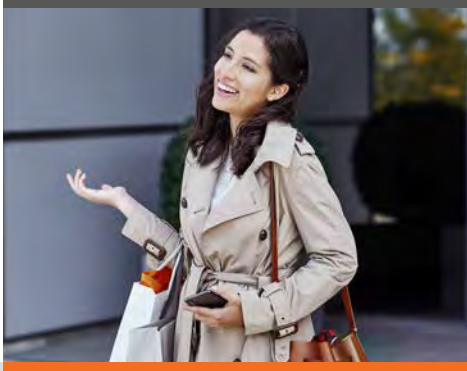
Oticon Medical **connectivity solution** for cochlear implant users

ABSTRACT

A few years ago, the first users switched on their Neuro sound processors and opened up a world of sound. The Neuro System is the result of an ambitious focus on continuous improvement and lifelong patient outcomes – using advanced technologies from the hearing healthcare industry to meet users' daily hearing needs. The Neuro 2 sound processing is designed to keep the signal as clean as possible, based on Voice Guard, especially developed to improve listening comfort and speech understanding.

However, in many daily life situations, even the best signal processing strategies will be challenged. Over the ten-year period, communicating long distance is perhaps just as important as communicating face-to-face. Whether it's taking a phone call, video chatting or watching TV, connecting to today's digital world is an important part of living and enjoying life. The signal of interest may now be coming from electronic devices with questionable sound quality or it may be masked by surrounding noise making it hard for the sound processing to clean the signal and make it sufficiently understandable to the user. Technologies that can help in such situations have therefore been introduced, matured and optimised.

The Oticon Medical connectivity solutions are a direct result of the close link with Oticon. We draw on their technological expertise and combine it with our in-depth understanding of the challenges patients encounter in their day-to-day lives. This is what enables us to develop implantable hearing solutions that improve quality of life, now and in the future.



Regin Kopp Pedersen, *Senior Product Manager, CI Product Management, Oticon Medical*
Catherine Soulet, *Scientific Communication Specialist, CI Clinical Evidence, Oticon Medical*

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Introduction to connectivity and cochlear implants

We live in a complex world full of dynamic inputs from many sources around us. Many of these inputs come from devices such as mobile phones or tablets. For people with hearing impairment, including cochlear implant (CI) users, a connection to these devices via hearing assistive technology is key to improving hearing in many daily life situations. CI users are especially challenged in noisy listening situations. Literature studies indicate that they need a better signal to noise ratio (SNR) compared to normal hearing listeners to reach the same level of speech perception, (Zaltz et al. (1)). Assistive technology enables CI users to regain control of their listening environment with several technologies designed to increase the SNR and thereby improve their listening-in-noise experience.

Hearing Assistive Technology Systems (HATS) can help people hear better where hearing devices are of limited benefit. All HATS are based on the principle of bridging the distance between the sound source and the listener. This solves two issues at the same time: sound attenuation with distance and noise interference. HATS are therefore capable of considerably enhancing speech perception. They can provide improved auditory access in many challenging acoustic situations for people with hearing loss and they are compatible with hearing devices, including CI sound processors.

HATS are connected to the CI system via different wireless communication protocols (including inductive loops, FM and Bluetooth). They are intended to improve sound perception in difficult environments (noisy or reverberant environments, such as meeting rooms or classrooms), to individualize the access to a sound source (telephone, TV, cinema, theatres or other public places), or to closely interact with the CI system to modify its function (remote control or external environment analyzers).

Traditionally, only induction loop systems based on telecoil inputs have been provided. Over the past few years, other wireless solutions with a higher sound quality have been introduced, adapted from hearing aids (HA) to CIs. Now a wide range of HATS is available, and they are often associated to applications providing many options for the patient as they allow a self-adjustment of the parameters of the CI system.

Access to connectivity is definitely an asset for patients. There is a current trend towards dedicated wireless solutions with a higher sound quality and gradually towards direct 2.4 GHz Bluetooth Low Energy technology, while being adapted for unilateral, bilateral and bimodal configurations.

Connectivity benefits for CI users

Clinical studies have demonstrated the benefit of HATS for improving SNRs, speech perception and patient comfort.

The literature falls within four main categories of contexts of use:

Telecoil

By providing direct and individualized access to sound sources, T-coils can improve sound quality and speech intelligibility either when using sound emitting devices, such as phones, or in public places where T-coils can improve access to social or cultural events for CI users. In their studies, Julström et al. (2) and Marcrum et al. (3) showed improved access to sounds delivered via phones equipped with an induction loop and Meyer et al. (4) demonstrated improved self-reported experience in museums for CI users receiving an audio-guide through their T-Coil.

Streaming devices and Bluetooth

Using streaming devices allows direct and individualized access to sound from a Bluetooth or other wirelessly transmitting device. Directly transmitted television sound to a sound processor via a proprietary digital radio frequency transmission system substantially improved CI recipients' ability to understand speech over the television in a noisy listening situation. Many participants also showed substantial gains in speech recognition in quiet with the use of a wireless television HATS (Duke et al. (5)). Direct streaming of the same sound source to both ears in bilateral CI and bimodal CI/HA

users seems associated with increased speech perception scores. For example, Wolfe et al. (6) showed that the use of a wireless digital HATS telephone device resulted in a significant improvement in the recognition of recorded monosyllabic words over the telephone when compared to use of the implant sound processor alone. Warren et al. (7) measured an improvement of speech understanding when comparing direct streaming via a smartphone to the acoustic condition. In this situation, bilateral and bimodal CI users gained greater benefit when streaming to both ears.

FM systems and microphones

FM systems are available as a complementary technology for use in combination with CIs to improve the perception of speech in noisy environments (multi-speaker situations, concurrent sounds, speech reverberations) or when speech must be perceived from a distance. FM systems are frequently used in educational settings such as classrooms or lecture theatres. Bertachini et al. (8) performed an analysis of the literature to evaluate the benefits regarding speech perception in noise shown by children who wear hearing aid devices and/or cochlear implants with an FM System at school. The results showed an improvement of speech perception and speech threshold in noise, addressing the fact that HATS are especially interesting for children who are developing auditory and cognitive functions and who are therefore even more affected by sub-optimal listening situations.

Remote controls and assistants

The main benefit of remote controls is to ease adjustment of programs and volume in CI sound processors, compared to using volume buttons placed on the sound processor itself. This could be particularly useful for people with limited arm and/or finger dexterity or other motor problems. Remote assistants offer a range of extended functionalities compared to remote controls by also providing diagnostic capabilities, such as detailed information about the status of the sound processor (current program, battery charge level, current volume setting, etc.). In their study, Lorens et al. (9) used questionnaires to test the satisfaction and usability of a remote control provided with a sound processor: 96% of patients rated the handling of the remote control as ‘easy’, confirming its usability.

This white paper describes Oticon Medical’s CI wireless connectivity solution and expected user benefits. The Oticon Medical Streamer XM (Streamer) offers multiple connectivity options in one system and can be used with the Neuro CI system, especially with the Neuro 2 sound processor.

The Oticon Medical connectivity solution for CI users

Description and features

The Oticon Medical connectivity solution is centered around a single carry on device named Oticon Medical Streamer XM (Streamer). It works as a personal gateway between the user’s hearing devices and a wide range of communication and audio devices.

The Streamer works in unilateral and bilateral configurations of Neuro 2, as well as in bimodal configurations with selected Oticon hearing instruments, such as the Dynamo and Sensei SP Super Power hearing aids.
The Streamer offers an extensive range of wireless audio input options including Bluetooth, FM and telecoil (Fig.1).

The audio signal can be streamed directly from Bluetooth devices such as smartphones, tablets and PCs using the standard Bluetooth protocol. In addition to wireless inputs, the Streamer supports wired direct audio inputs via a Euro-pin connector and via a mini-jack connector.

The Streamer also has a built-in microphone for picking up the voice of the user. The user's voice is sent via Bluetooth to the user's phone enabling fully hands-free phone conversations.

The Streamer supports the use of the ConnectLine Bluetooth transmitters providing wireless access to TV, a landline phone and a personal microphone.

It also has dedicated user controls to manage phone calls via a smartphone or landline phone, as well as individual controls for selecting audio from the ConnectLine TV adaptor and the ConnectLine microphone.

The Streamer also works as a remote control for the Neuro 2 and compatible hearing devices allowing bilateral program selection, volume adjustments and muting.

Figure 1: Neuro 2 Sound processor and Streamer XM

Streamer XM integrated functions (Fig.2):

Headset for mobile phones: The Streamer can be paired with most mobile phones, in effect turning the hearing devices into a high-quality headset, thanks to the built-in microphone at the top of the Streamer.

Headphone for music: Audio can be transmitted directly and securely by using either a cable or wirelessly using Bluetooth.

Telecoil: The Streamer has a built-in telecoil for users with hearing instruments without a telecoil, or for users who find it more convenient to use the Streamer's telecoil.

Telecoils provide wireless access to hearing-aid-compatible telephones and induction-loop systems. Telecoils capture electromagnetic fields in the environment and deliver these signals to the sound processor, directly or through a streaming device.

Computer/VoIP – plug and play: The Streamer can be connected directly to a computer for headset functionality.

Remote Control: This is used to adjust hearing device volume and change programs.

Apps, FM and ConnectLine accessories:

ConnectLine App: for iPhone®, iPad®, iPod touch® and Android™ devices. The App offers a discreet way to control the hearing instruments and the ConnectLine system, as well as the possibility to customize the features of the ConnectLine system.

FM input: The Streamer has a socket to support the use of FM receivers. The system can be used with Phonak's Roger system.

ConnectLine TV adaptor: This dedicated solution streams sound directly from the TV to the hearing instruments to enable high sound quality when watching TV.

ConnectLine Phone adaptor: This dedicated solution for home phone use effectively turns the Streamer and the hearing instruments into a wireless headset.

ConnectLine Microphone: A small discreet clip-on microphone substantially improves the SNR for the hearing instrument user when used in difficult and noisy situations.

Neck Loop: The neck loop is integrated in the Streamer's electronic system. It is used as an antenna to transmit sound to the hearing devices. The Streamer comes with two neck loops, a long and a medium.

Audio inputs and controls are digitally transmitted via low power Near Field Magnetic Induction (NFMI) radio technology through the neck loop to the Neuro 2 sound processor and other compatible devices within range.

Neuro 2 integrates low power radio technology making it compatible with the Oticon Medical Streamer XM and thereby the ConnectLine App available for both iOS and Android smartphones. These accessories provide remote control of the Neuro 2 processor and allow easy access and control of audio from a wide range of consumer devices, such as smartphones, tablets, computers, TV and personal microphones. A digital communication technology (NEARlink) operating at 3.83 MHz provides an audio streaming bandwidth up to 10 kHz with error correction.

Figure 2: Many connectivity options in one device

Technical investigations

Oticon Medical performed laboratory tests to calculate the SNR improvement and evaluate the benefit provided by the Streamer in conjunction with the Neuro 2 Cochlear Implant system.

As described above, the Streamer can receive wireless transmission from various inputs. The inputs investigated were wireless Bluetooth audio from the ConnectLine Microphone and from a smartphone (mobile phone call).

Test 1: Listening over distance in noise

The test examines the benefit of placing a microphone close to the source (target speaker) and transmitting it directly to the listener's sound processor via Streamer compared to the input from the microphone integrated into the listener's BTE sound processor.

Test conditions

Signal input: HINT sentences presented at 65dB SPL in quiet or in noise (65dB). A simulator used in place of the listener is wearing the Streamer which receives the signal from the ConnectLine Microphone of the speaker. The signal is transmitted from the ConnectLine Microphone to the Streamer via Bluetooth, and from the Streamer to the sound processor(s) via Near Field Magnetic Induction (NFMI). The Streamer also transmits the signal to a second CI - or compatible Oticon hearing aid – on the contralateral ear. Measurements are made with the listener positioned at 2, 4 and 7 metres from the speaker, with and without the Streamer. Signal level, Noise level, SNR and improvement are reported for each condition.

Results

This test reproduces the listening over the distance conditions that users can regularly encounter in a meeting room or in a classroom if they are children. It emphasizes the most important parameter that affects the ability to hear and understand speech in the presence of background noise is the speech-to-noise ratio (SNR) – the level of the speech relative to the level of the background.

Without the Streamer, the CI users face a decrease up to -6dB (at 7m from the talker) corresponding to an extremely challenging situation. When using the Streamer and the ConnectLine Microphone, the experiment clearly demonstrated that the conditions for listening to a target speaker over distance in background noise are greatly improved by up to 44 dB (38dB SNR measured at 7m with the Streamer). Results showed that the Streamer removes the detrimental impact of distance and noise when used with the ConnectLine Microphone. (Fig. 3)

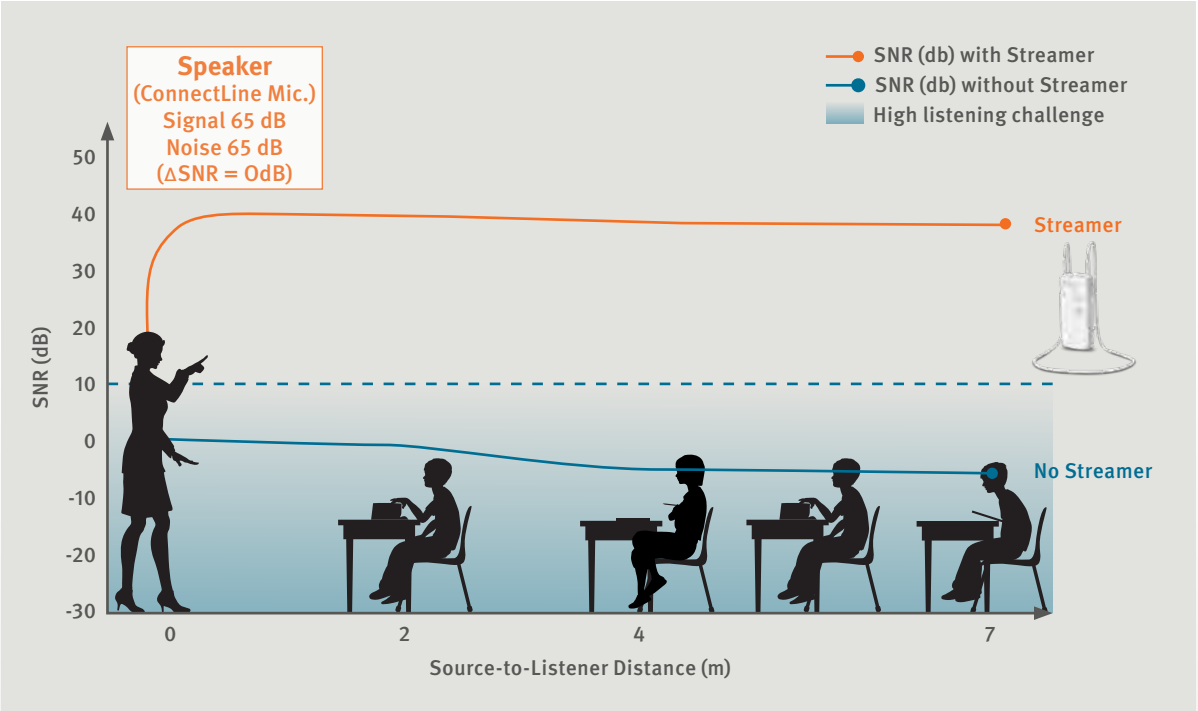

Figure 3: Listening over distance in noise, SNR improvement

Test 2: Mobile phone call in quiet and in noise
This test evaluates listening to a phone call in a quiet and in a challenging (noisy) acoustic environment with the Streamer directly streaming the signal to the CI system. The test also evaluates the benefit of providing binaural listening by transmitting the phone call to both sound processors (CI & CI or Hearing Aid) when the listener is aided on both sides.

Test conditions
A simulator is used in place of the listener wearing a CI and a second CI or a hearing aid on the other side. The Streamer is placed around the neck, receives the signal from a mobile phone via Bluetooth and transmits it to the sound processor or hearing aid by NFMI (HA, Oticon Dynamo).

Three handset positions (ideal, toward the back and at the ear canal), and two acoustic environments (quiet and 65dB noise) are evaluated with an input of 90dB or 80dB SPL speech level. The SNR improvement is evaluated by generating speech and noise and recording the "phone side" (CI) and "non-phone side" (HA or CI) recordings independently. Three input mixing configurations and three phone handset positions are evaluated. Signal level, noise level and SNR are reported for each condition.

Results
Results show a notable SNR benefit on the phone ear and non-phone ear (35 dB and 76dB respectively) in a noisy phone call situation, when the CI user uses the Streamer. By streaming the signal directly to the CI, the Streamer can provide listening benefit, it reduces the level of the background sound and the attenuation caused by incorrect positioning of the phone handset loudspeaker relative to the microphone located on the BTE. Moreover, when receiving a phone call either in a quiet or a noisy listening environment, the speech is heard in both ears when using the Streamer with 2 CIs or with a CI and a compatible hearing aid. The test performed clearly shows the benefit of providing binaural listening by transmitting the phone call to both sound processors (CI & CI or HA) when the listener is aided on both sides. (Fig. 4)

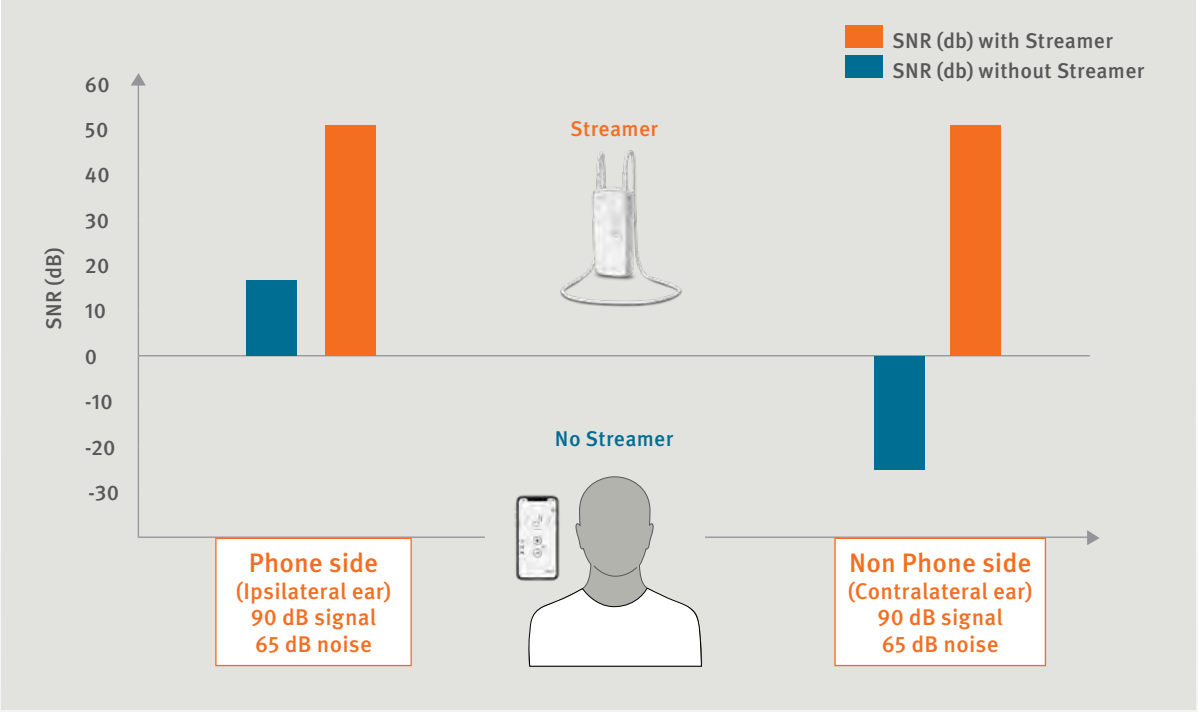

Figure 4: Benefit of the Streamer with the Neuro 2 CI system: mobile phone use in a 65dB SPL noise listening environment with an input of 90dB SPL speech level (specified level used in telephony testing)

Expected benefits

Summary and conclusions

It is well known that cochlear implant users are especially challenged in noisy listening situations. Access to technologies supporting these needs are especially important for them as they are highly dependent on clear speech cues in everyday listening situations. They are also especially dependent on hearing assistive technology that can improve their ability to cope with everyday life situations such as having a phone conversation or hearing a distant talker in a noisy environment.

Laboratory tests have been conducted in noisy environments and many different situations, demonstrating large SNR improvements. The Oticon Medical connectivity solution not only significantly improves CI users' ability to understand speech and participate in conversations in noisy environment conditions, but also gives them many ways to connect in one device.

Whether it's answering a phone call, video chatting or watching TV, staying connected to today's digital world is an important part of living and enjoying life. Oticon Medical's Streamer XM is designed to support these needs.

References

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Notes

Notes

Because sound matters

Oticon Medical is a global company in implantable hearing solutions, dedicated to bringing the magical world of sound to people at every stage of life. As part of the Demant group, a global leader in hearing healthcare with 15,000 people in over 130 countries, we have access to one of the world's strongest research and development teams, the latest technological advances and insights into hearing care.

Our competencies span more than a century of innovations in sound processing and decades of pioneering experience in hearing implant technology. We work collaboratively with patients, physicians and hearing care professionals to ensure that every solution we create is designed with users' needs in mind. We share an unwavering commitment to provide innovative solutions and support that enhance quality of life for people wherever life may take them. Because we know how much sound matters.

Oticon Medical

NEURELEC
2720 Chemin Saint-Bernard
06220 Vallauris
France
Tel. +33 (0) 4 93 95 18 18 – Fax + 33 (0) 4 93 95 38 01
info@oticonmedical.com

223881UK / 2020.07

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