Editorial

Implantable Hearing Aids: Expanding the Therapeutic Horizon of Auditory Rehabilitation

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Highlights

- Implantable hearing aids (IHA) gaining popularity among patients with HL
- IHA are not considered a replacement method for conventional hearing aids (HA)
- IHA are a bridge between HA and cochlear implants across different types of HL

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Hearing impairment is the most common form of sensory deficit in humans. Hearing loss is currently the third most common burden among diseases. Aging populations around the world and high rates of consanguineous marriage in developing regions contribute further to the issue. This disability can greatly disrupt patients' psychological well-being, ability to communicate, and economic outlook.

Currently, conventional hearing aids serve as the primary treatment for this condition. Due to the current limitations of hearing aids, only 1 out of every 8 patients uses hearing aids. Even though these limitations are decreasing, they still exist. In light of technological progress, especially in the biomedical field, the necessity to develop additional treatment options is clear. A notable limitation with current hearing aids is the restricted gain and sound quality issues, especially at high frequencies. Particularly while using CIC hearing aids, popular due to their convenient size, the close placement of the microphone to the speaker results in feedback that can cause significant discomfort to the user.

Another issue is the cosmetic appearance of the hearing aids. The occlusion of the ear canal can lead to a feeling of pressure, a higher likelihood of ear canal infections, and a prevention of natural ear canal resonance, among other things.

All these factors have led to implantable hearing aids gaining popularity among patients with various types of hearing loss.

Implantable hearing aids can be categorized by the degree of implantation ("semi" and "total"), the international certifications they have obtained, or according to their capability to cover a range of hearing impairments. Perhaps the

more effective classification is into two groups, which highlight their attributes, strengths, and weaknesses more effectively. The first group is middle ear active implants, such as Vibrant Soundbridge. The second group is bone-anchored hearing aids, like BAHA and Bonebridge.

Over the past four decades, there has been impressive progress in the size and efficiency of the devices and the simplicity of surgical techniques. Modern surgical techniques are much simpler than those used in the past. Implantable hearing aids are more compact and better tolerated by patients. Implantable hearing aids now provide better and wider coverage according to the audiogram. In the case of the Vibrant Soundbridge, by adding different couplings, the device can be attached to various locations on the ossicular chain. Even in the absence of the ossicular chain, as in situations where the patient is without an ossicular chain due to recurrent infections or tumors, we can use round window vibroplasty or Floating Mass Transducer (FMT) implantation on the round window to transmit motion in the inner ear fluids and produce a "travelling wave". Due to this, the Vibrant Soundbridge is suitable for various types of hearing loss, such as conductive, mixed, or sensorineural, depending on the audiogram.

Osia, a bone-anchored type device, reduces the size of the internal receiver, has a shape designed to fit the cranial curvature, and is compatible with mobile phones using Bluetooth communication. This has increased the effectiveness and user acceptance of the device among both surgeons and patients. Digital signal processing has also helped extend battery lifespan and reduce the size of the devices.

In certain models, magnetic transducers are utilized as in Vibrant Soundbridge, while other models use a piezoelectric transducer, such as Osia.

There is increasing evidence of the role implantable hearing aids can play in the reduction of tinnitus. There is also a hypothesis that, alongside visual, vestibular, and proprioceptive input, auditory data can be beneficial to a patient's balance and posture control. While these are currently subjective reports, further empirical data may validate this hypothesis.

Despite the improvement of implantable hearing aids in curing various types of hearing loss, cross-functional teamwork among otologists, audiologists, neuroscientists, and biomedical engineers is needed to help develop strategies to address challenging cases. This team is vital for several key steps of the process. Proper selection of the patient and a suitable type of hearing loss to form a candidacy is needed. Patient expectations must be kept rational and attainable. Precise surgical skill is crucial for ensuring long term stability of the device and preventing damage to the facial nerve or inner ear.

There are still many areas in which implantable hearing aids can be improved.

Across many countries, especially in areas without proper insurance, the cost of these devices can be a significant barrier. Devices that are fully implantable will continue to increase social and physical acceptance. This is often the limiting factor in the use of these devices. Implementation of AI to optimize acoustic processing can be beneficial to assist users in more easily utilizing the prothesis especially in diverse environments. Wireless connection with smartphones will facilitate integration into personal technology.

In conclusion, implantable hearing aids are considered a standard and effective method for certain patient populations. They are not considered a replacement method for conventional hearing aids, but rather a bridge between hearing aids and cochlear implants across different types of hearing loss. Given the growing prevalence of hearing impairments, the biomedical industry must focus on standardizing protocols, reducing costs, and leveraging AI for individualized processing to improve global accessibility and patient outcomes.