Precision medicine: Sensorineural hearing loss treatment

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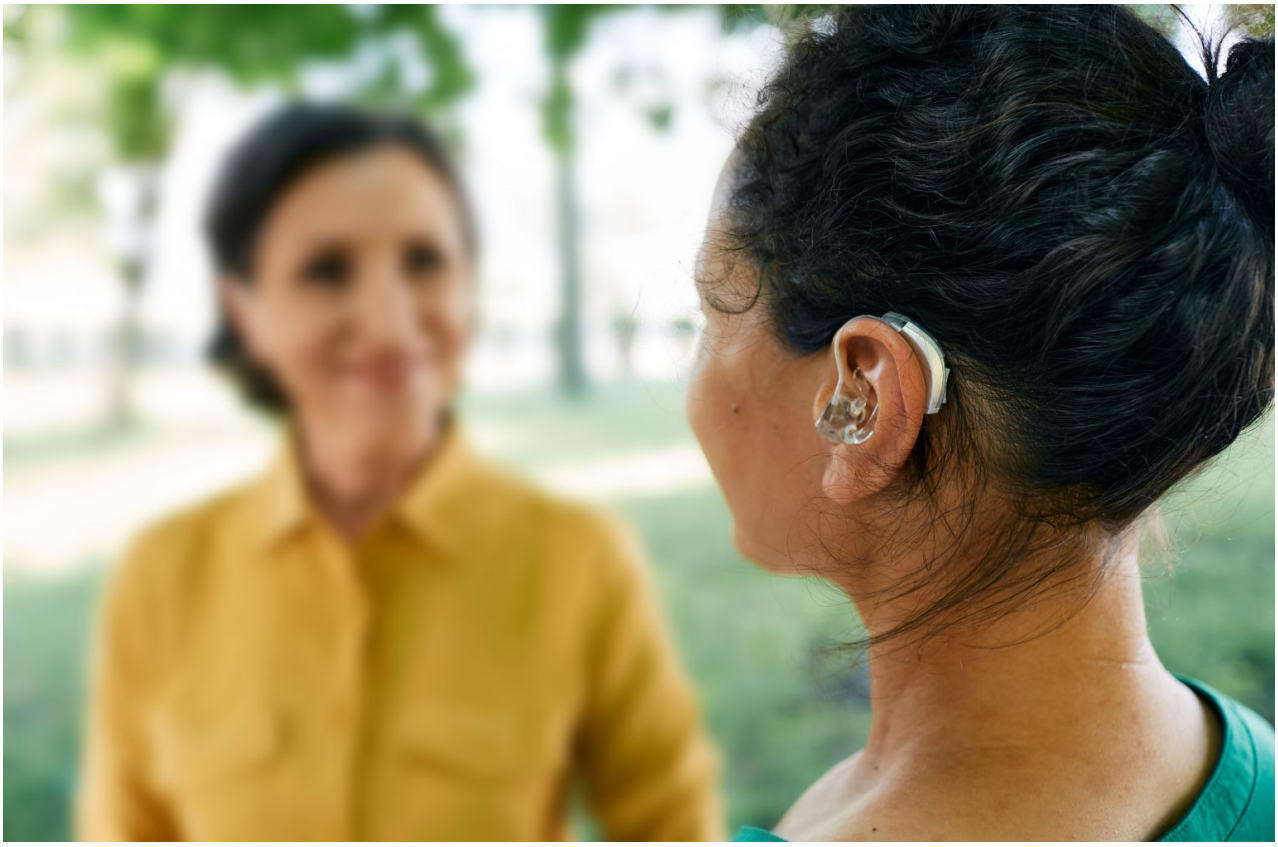

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Aarno Dietz, Professor of Otorhinolaryngology at Kuopio University Hospital, turns the spotlight on hospital precision medicine, focusing on the treatment of sensorineural hearing loss

Today, most medical treatments are designed for the average patient. This “one-size-fits-all-approach” may be effective for some patients but not others. Precision medicine refers to tailoring medical treatment to the individual characteristics of each patient, aiming to target the right treatments to the right patients at the right time. In general, a precision medicine approach does not mean unique treatments (e.g., drugs or medical devices) designed for each patient but rather the ability to classify individuals into subpopulations based on specific characteristics of the underlying disease or its response to a particular treatment. Advances in precision medicine have already led to new treatment strategies, e.g., in oncology, where tumour profiling is used to optimize adjuvant treatments, improving survival rates.

Hearing loss is the most common sensory disorder in humans, with globally over 480 million people suffering from disabling hearing loss. In infants and children, hearing loss impedes access to spoken language. In adolescents and young adults, it is often associated with poorer literacy, lower education and reduced employment opportunities compared to their normal-hearing peers. In adults and elderlies, it is associated with social isolation, depression, loss of independence and a two to threefold increased risk for cognitive decline and dementia development. Age-related hearing loss is already the leading cause of global years lived with disability in people over 70. Therefore, effective prevention and management of hearing loss would have a significant medical, social and societal impact.

Exploring sensorineural hearing loss

Current management of sensorineural hearing loss is non-specific and limited to amplification devices and implanted neuroprosthetics, which may provide functional improvements but do not cure the specific underlying disease. In mild-moderate to moderate-severe hearing loss, hearing aids can compensate through acoustic amplification for loss in audibility and impaired loudness perception. In clinical practice, diagnosis often relies exclusively on pure-tone audiometry results, which only measure the loss of cochlear sensitivity; however, it fails to characterize complex individual suprathreshold deficits. Therefore, standard audiometry correlates poorly with the patient's hearing performance in everyday listening environments.

Suprathreshold distortions may also limit the benefits of hearing aids, contributing to low compliance with hearing aid rehabilitation. In patients with severe to profound sensorineural hearing loss, cochlear implants have become a standard therapy, though it is still underutilized due to the required surgery and relatively high costs compared to conventional hearing devices. The considerable variation of the hearing outcomes with cochlear implants calls for clinical prediction models to counsel eligible candidates adequately.

Precision medicine models in the treatment of hearing loss

There are two parallel approaches for implementing precision medicine models for treating hearing loss: i) Data-driven auditory profiling for improving the rehabilitation results with hearing devices; ii) systematic genetic testing and the development of targeted gene- and molecular treatments.

Clinical big data in sensorineural hearing loss

For data-driven profiling, deep-learning algorithms can unveil complex characteristics and connections hidden in the data. Hence, there is a need for a comprehensive collection of hearing and hearing-related data, including the foundation of a hearing loss registry from which this big data can be retrieved. This approach has been applied in various medical fields and recently also for classifying hearing aids. Recent advances in hearing research have demonstrated that hearing loss is not limited to the inner ear but rather a

multifaceted neuro-degenerative entity. This fact becomes very apparent in patients with cochlear implants in whom the integrity of the central auditory pathways and central information processing capabilities are essential for favourable hearing outcomes.

Successful CI surgery also requires the avoidance of cochlear trauma and optimal coverage of the inner ear nerve cells for a good performance outcome. Since the size and configuration of the inner ear anatomy vary significantly between individuals, a “one-size-fits-all” electrode array will often not provide the best possible results. Again, a personalized approach to selecting electrode length according to individual needs could offer better outcomes. However, more comprehensive precision medicine cochlear implantation models must be developed.

Genetics of hearing loss & targeted inner ear therapy prospects

Big data resources in the form of clinical genetic data repositories and databases have revolutionized the diagnostic paradigm of hereditary diseases including genetic hearing loss. The complexity of the genetics of hearing loss has made the development of targeted treatment challenging. However, with the introduction of next-generation sequencing technology, the clinical implementation of genetic workup to evaluate hearing loss has become possible. In the future, molecular genetic testing will become increasingly important in the clinical diagnostic workup of pediatric patients and age-related hearing loss and adult CI candidates. The information on etiology and prognosis could help in patient selection, prognosis, and appropriate operation timing.

With more precise knowledge about the etiology and mechanisms of sensorineural hearing loss, inner ear molecular and gene therapy become possible. The cochlea is a promising target for individualized gene therapy as it is surgically easily accessible. It is also anatomically isolated, allowing targeted drug injections and vectors for gene therapy with minimal unwanted effects on genes in other tissues. The labyrinth contains two basic access points for injection or infusion: through the round window membrane and a drilled access through the bone of the labyrinth. Cochlear implant arrays as a drug-eluting array or as a catheter can be utilized to deliver drugs, genes or stem cells into the inner ear.

The heterogeneity of hearing loss still represents a significant challenge

However, the genetic heterogeneity of sensorineural hearing loss still represents a significant challenge in targeted intracochlear treatment, as a manifold of factors affects treatment efficacy. Additionally, the high cost and risks of investigational new drugs may discourage investigators from clinical trials. When considering the medical, social and societal impact of hearing loss, more prevention and targeted treatment research would be justified. It is encouraging that a few medical companies are engaged in animal models and preclinical trials for targeted treatment of hearing loss.

For the time being, treatment of hearing loss will rely on hearing aids and cochlear implants. Therefore, sufficient resources should be addressed for research to optimize current treatment modalities with hearing aids and cochlear implants until clinically

applicable targeted inner ear therapies are available to prevent and treat hearing loss.

The association of inadequately addressed hearing loss with numerous medical, social and societal consequences calls for increased awareness of healthcare providers to allocate sufficient resources for early detection and effective treatment of hearing loss.

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