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Update on surgical and nonsurgical treatment options for age-related hearing loss

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In this article

Abstract

Background: Age-related hearing loss (ARHL) is one of the most common chronic conditions that impacts on everyday life far beyonds speech understanding. Chronic hearing loss has been associated with social isolation, depression, and cognitive decline. Early diagnosis and appropriate treatment are recommended.
Objective: To give an overview of surgical and non-surgical treatment options for ARHL and the gap between the high prevalence of ARHL and its inadequate treatment to date.
Material and methods: A selective literature search was carried out in PubMed.
Results: In case of mild to moderate hearing loss, provision of air conduction hearing aids is still the method of choice as it leads to a large benefit in speech understanding and hearing-specific quality of life, and to a slight improvement in overall quality of life. Implantable middle ear systems are used for the treatment of special types of hearing impairment. In case of severe to profound hearing loss, cochlear implantation should be considered; however, only a small number of older people with hearing loss are supplied with hearing aids or cochlear implants despite the well-known benefits of both. This also applies to high-income countries where the costs are covered by health insurance funds.
Conclusion: Considering the low rate of properly treated people with hearing loss, large-scale screening programs, including better counselling of older people, should be developed.

Keywords
Presbyacusis · Hearing aid · Cochlear implant · Benefit · Speech perception

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Hearing loss is one of the major global health problems, affecting 1.57 billion people worldwide to various degrees. Of the people with hearing loss 62% are older than 50 years and mainly suffer from age-related hearing loss (ARHL) [1]. Prevalence data on ARHL vary considerably because of the different methods used to assess hearing loss, e.g., audiometric measurement versus subjective self-assessment. Based on pure tone audiometric data, a hearing loss of > 25 dB was observed in a German population-based study in 20.3% of adults aged 60–69 years, in 42.3% of those aged 70–79 years and in 71.5% of those aged 80 years and older [2].

Besides the negative impact on speech perception and communication, ARHL has also been associated with social isolation, depression, and cognitive decline. Due to the multifactorial causes of ARHL, including individual genetic predisposition, environmental factors, cochlear aging, changes in the central auditory pathways, and other health comorbidities, a specific approach to prevent or delay ARHL is not yet available. Pharmacological approaches, particularly the application of antioxidants, have mainly been per-

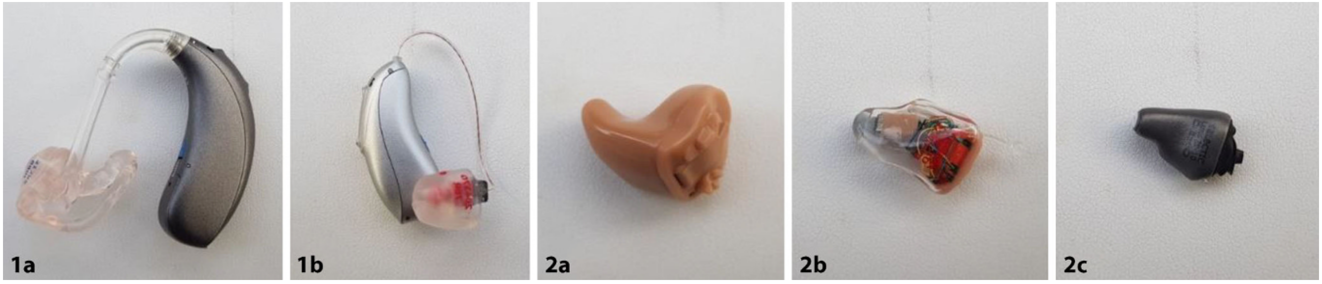

Fig. 1 ▲ Different designs of hearing aids. *1a* behind the ear (*BTE*), *1b* BTE with receiver in the canal (*RIC*), *2a* in the canal (*ITE*), *2b* completely in the canal (*CIC*), *2c* invisible in the canal (*IIC*)

formed in experimental animal studies and might only partially slow down the progression of ARHL. Even if some studies claim that polyunsaturated fatty acids and antioxidants may prevent hearing loss in humans, no causal treatment of ARHL will be available or implemented in the clinical routine in the near future. Therefore, technical solutions in terms of hearing devices are still the method of choice in the treatment of ARHL.

Hearing aids

Air conduction hearing aids (HA) are still the most frequently applied treatment option for addressing ARHL. These HAs amplify the acoustic energy picked up by the microphone and modified by the processor based on the user's specific needs. The minimum legal requirements for HAs vary between different countries. Currently, in Germany the statutory health insurance fund only supports the provision of digital HAs which have at least 4-channel signal processing, 3 hearing programs, background noise and feedback suppression, and an amplification capacity of up to 75 decibels (dB). Depending on the degree of hearing loss and the user's individual preference, behind the ear (BTE) and in the ear (ITE) HAs (such as in the canal (ITC), completely in canal (CIC), and invisible in canal (IIC) HAs) can be used (◘ **Fig. 1**).

Legal requirements for the care pathways vary between countries: in Europe there are legally regulated procedures for the provision of HAs in general. In Germany, for example, the indications are evaluated, and the prescription made by an otorhinolaryngologist and the reimbursement are specified in the statutory guidelines on remedies and aids issued by the Joint Federal Committee. In case of a bilateral hearing loss, which is the most common situation in presbycusis, bilateral HA provision is considered the standard treatment [3]; however, studies analyzing bilateral HA provision compared to unilateral HA provision with respect to audiometric and subjective benefits are insufficient [4]. The initial fitting of HAs by the hearing aid acoustician based on prescription rules usually leads to satisfactory clinical outcomes. For further adjustments several consultations of the acoustician and speech intelligibility tests are required. To simplify and optimize this fine tuning stage, further developments, such as automatic speech recognition, may be used in the near future [5].

In the USA a new category of over the counter (OTC) HAs without the need for prescription or professional fitting was introduced by the Food and Drug Administration for adults with mild to moderate hearing loss in addition to the aforementioned professional regulation and adjustment paths to increase accessibility and affordability of HAs. At present, the efficiency of this policy is not yet proven.

Evidence of HA benefit

As there is an acclimatization effect, especially in subjects with a long duration of hearing loss, with an improvement of about 2 dB signal to noise ratio in speech perception in background noise within the first 4 weeks after fitting [6], fitting of HAs should be performed in an adaptive manner to obtain the best benefit.

Although the benefits from HAs are well known, large prospective controlled studies on the benefits are missing. A Cochrane review involving 825 adults with mild to moderate ARHL showed a beneficial effect of HAs in two categories:

1. Increased ability to listen as assessed by the profile of hearing aid performance (PHAP) or by the abbreviated profile of hearing aid benefit (APHAB) questionnaires (standardized mean difference, SMD: −1.88)
2. Increased hearing-specific health-related quality of life (QoL) as assessed by the hearing handicap inventory for the elderly (HHIE, SMD: −26.47)

In contrast, only a small effect on general health-related QoL was found (SMD: −0.38); however, there was a huge variability in outcome measures used and studies using audiometry to verify the benefit of HAs were not included in the review [7].

Audiometric evaluation of the benefits of HAs was rarely reported in the past. Besides acoustic gain measurements, speech audiometry in quiet and noise assessed by the Freiburg monosyllabic test is the mostly used assessment for HA evaluation in Germany [3]. Meister et al., who studied the objective benefit of HAs in 30 persons with sensorineural hearing loss wearing modern HAs, found that the participants obtained a significant benefit from the HAs, with speech in quiet improving by about 20–25% and speech reception thresholds in fluctuating noise increasing by about 2.5 dB in the aided versus the unaided conditions [8]; however, the monosyllabic speech recognition score with HAs is often below the maximum word recognition score with headphones, especially in subjects with a severe hearing loss of more than 60 dB HL. This was described by Kronlacher et al. in a study with 40 HA users aged 66–88 years. Although an improvement was observed in 82% of the users,

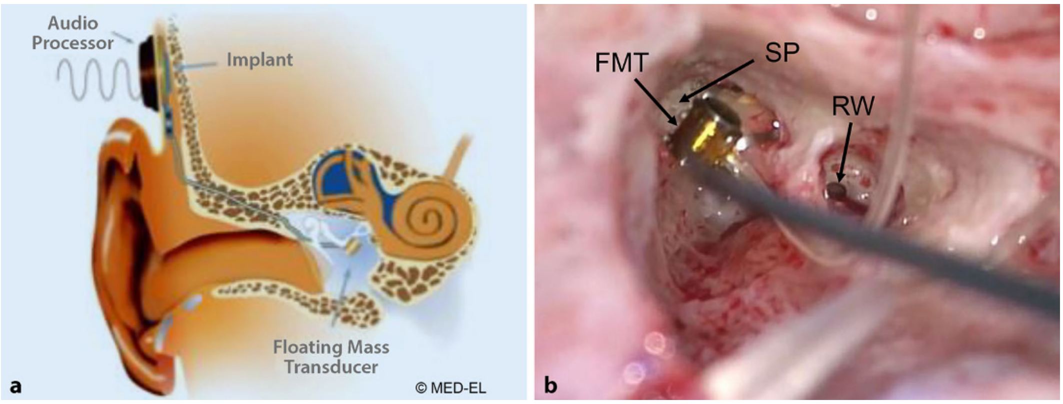

Fig. 2 ◀ Diagram in sagittal section of the position of an active middle ear implant (AMEI) Vibrant Soundbridge® which can be coupled either to the long (**a**) or to the short process (**b**) of the incus (photograph of the in vivo position). *FMT* floating mass transducer, *SP* short process of the incus, *RW* round window niche

56% failed to achieve an improvement of at least 20% as suggested by the Federal Joint Committee for the evaluation of HAs [9]. Besides suboptimal fitting, this might be due to a lack of acceptance of the required acoustic amplification or a diminished adaptation to the HA in long-lasting hearing loss.

Furthermore, HA fitting has a positive effect far beyond speech perception as reported in a couple of studies. Marques et al. conducted a randomized controlled study in subjects with moderate ARHL and showed a significant reduction of depressive symptoms 4 weeks after fitting, probably caused by a decrease of social isolation [10]. Studies evaluating the impact of hearing aids on cognitive abilities vary in outcome. Whereas Choi et al. showed an improvement in short-term memory and learning ability in 18 HA users 6 months after fitting compared to a non-fitted control group of 11 subjects [11], Nkyekyer et al. did not demonstrate a significant improvement in cognition in 40 subjects with mild to moderate hearing loss 3 and 6 months after auditory training and HA fitting [12]. Sanders et al. conducted a systematic review on the literature from 1990 to 2020 including 17 studies on 3526 participants and concluded that it is too premature to make conclusions on the effect of HAs on cognition due to the poor quality of most studies, with a short follow-up period and many different cognitive test batteries applied which are difficult to compare [13].

Active middle ear implants

Active middle ear implants (AMEI) are used only in rare cases of a stable sensorineural ARHL hampered by a treatment-resistant chronic external otitis due to conventional HAs plugging the external auditory canal [14].

In AMEI, deflection of the stapes is directly amplified by the activated implant which is coupled to the intact ossicular chain instead of transmitting the amplified sound energy to the tympanic membrane like in hearing aids. Currently, there are two AMEI devices approved for clinical use: 1) the partially implantable Vibrant Soundbridge® (MED-EL, Innsbruck, Austria), usually used with the vibrating floating mass transducer coupled to the long or short process of the incus when the ossicular chain is intact (◘ **Fig. 2**) and 2) the fully implantable AMEI Esteem® (Envoy Medical, White Bear Lake, MN, USA). Surgical implantation of the latter AMEI requires interruption of the ossicular chain. As this leads to an additional conductive hearing loss of 50–60 dB, and thus making residual hearing without the use of the activated implant impossible, the use of this AMEI in ARHL should be considered with caution.

Cochlear implants

Whereas in the case of mild to moderate hearing loss amplification of the residual cochlear function by HAs is mostly sufficient to achieve satisfactory speech perception, cochlear implantation followed by postoperative auditory rehabilitation is the treatment of choice in the case of severe to profound hearing loss.

A cochlear implant (CI) as shown in ◘ **Fig. 3** consists of an implanted part with an electrode array carrying 12–22 electrodes, depending on the manufacturer, and an externally worn speech processor (◘ **Fig. 4**). In contrast to the physiological peripheral auditory process, usually mediated by about 15,000 hair cells, the CI provides direct electric stimulation of the auditory nerve. Although hearing with a CI differs from normal hearing or from hearing with a hearing aid, a pre- to postoperative improvement of 44–65% in monosyllabic words can be achieved in most CI recipients [15]; 96% of the CI recipients obtain a better score on monosyllabic speech tests in quiet with the CI than with best fitted HAs at maximum acoustic amplification [16].

Hearing-impaired individuals with substantial residual hearing in the lower frequencies and a severe to profound hearing loss in the middle and higher frequencies may benefit from a combination of acoustic hearing in the lower frequencies (amplified by a HA) and electric stimulation of the auditory nerve in the higher frequencies (by a CI). This is referred to as electric acoustic stimulation (EAS) and can lead to a greater increase in speech perception by 15.6–25%, especially in noise, and to a more natural sound perception due to the residual acoustic components [17]; however, the reported results differ in the degree of postoperative residual hearing achieved. These differences in outcome are presumably related to the differences in the degree of preoperative residual hearing, in the criteria for defining residual hearing, in the selection of electrode arrays, which differ in design and length, and in the duration of follow-up.

Although satisfactory speech perception can be achieved by the electric inner ear prosthesis in the majority of cases the quality of artificial hearing and the precision of sound encoding are still limited.

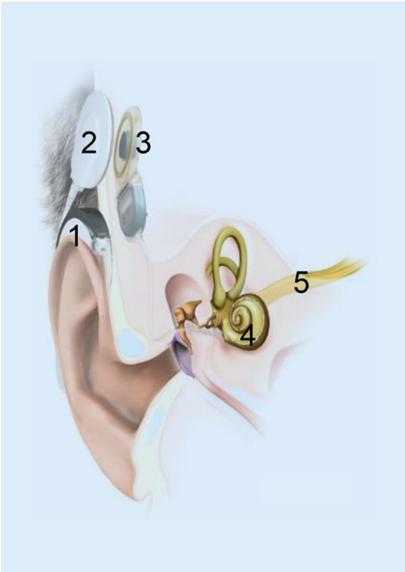

Fig. 3 ▲ Diagram of the principles of a cochlear implant. Sound waves are picked up by a microphone situated in the audio processor (*1*), converted into electrical signals, and transmitted via the transmitter coil (*2*) to the receiver implant, (*3*) located beneath the skin. The electrical signals then stimulate the auditory nerve fibers (*5*) in a frequency-specific manner via the electrodes arranged on the electrode carrier (*4*) (by kind permission by MED-EL, Innsbruck, Austria)

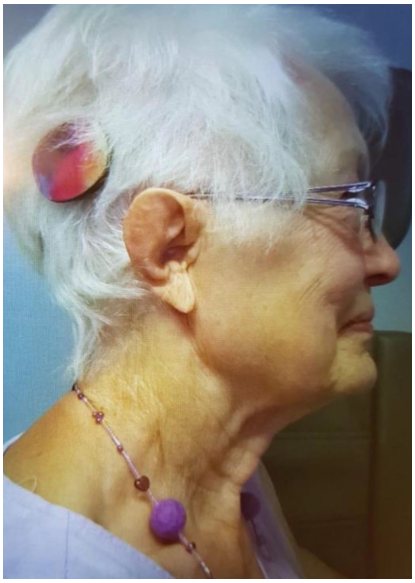

Fig. 4 ▲ Photograph of a patient wearing an externally worn single unit speech processor

The spread of the electrical field throughout the cochlea upon electrode stimulation is regarded as one of the limitations of electrical stimulation. Recently, optogenetic stimulation has been proposed as a method of providing more precise stimulation of the auditory nerve, thereby invoking clearer perceptions in the user. The first experimental results are promising [18], and this may become the auditory restoration technology of the future.

Impact of age on benefits of auditory restoration by cochlear implantation

Several studies have evaluated to what degree older individuals with hearing loss benefit from cochlear implantation with respect to speech perception in quiet and noise and to QoL. In general, cochlear implantation leads to a significant improvement in speech understanding in these individuals. Although age has a small negative impact on auditory performance in monosyllabic understanding [19], postoperative speech performance in quiet tested by sentence recognition was similar between younger and older subjects, even in subjects up to 75 years old [19–21]; however, some studies have observed that older users need more time to obtain the maximum speech outcome. This was also confirmed by Chan et al. who showed that although younger CI users achieved better speech understanding than older users 6 months after cochlear implantation, this difference was no longer evident at 12 months [22].

In contrast, speech perception in noise after cochlear implantation shows less consistent results. Whereas some studies could not detect any difference between age groups [21, 23], others showed significantly lower speech understanding in noisy surroundings in older compared to younger users [20]. This may be due to central presbycusis, reduced cognitive abilities, or a longer duration of hearing loss in older subjects.

With respect to QoL benefits, these are observed in older users as early as 6 months after cochlear implantation, and QoL gains are greater than those observed in younger users [24]. Better self-confidence, self-esteem, participation in social activities, and a decrease in depressive moods have also been described in individuals with ARHL after cochlear implantation [25]. Furthermore, cochlear implantation may also have a positive impact on neurocognitive functions, regardless of the age when implantation took place [26].

Impact of age on surgical risks of cochlear implantation

Surgical risks, such as wound healing, duration of surgery, facial nerve paresis, taste disturbances and anesthesiologic risks in the context of cochlear implantation are not more frequent in older than in younger subjects [25]; however, there is an age-related increase in postoperative vertigo with new onset of vertigo observed in 17.4% of the patients as shown in a meta-analysis covering 116 studies by Hänsel et al. [27]. It should be kept in mind that unspecific vestibular dysfunction is quite common in older patients and 15% of CI candidates already present with a unilateral vestibulopathy before surgery [28]. In cases where vestibular function is lost unilaterally, cochlear implantation on the contralateral side should be carefully evaluated with respect to the risk of bilateral postoperative vestibulopathy.

Adherence to HA or CI usage

In general, utilization of hearing devices among individuals with ARHL is quite low. Von Gablenz et al. observed that only 5.8% of individuals with AHRL aged 60–69 years, 18.3% aged between 70 and 79 years, and 32.6% of subjects aged 80 years and older used either unilateral or bilateral hearing devices [2]. The same was shown in the USA by Sharma et al. who found that only 15.5% of people aged 80–85 years wear HAs despite a prevalence of ARHL of 77.2%, and less than one third of people at the age of 95 years despite a prevalence of 93.8% [29].

Several studies have analyzed the underlying causes of the low utilization of HAs. Besides financial reasons which were reported in about half of the studies, lack of comfort or handling problems were reported in a scoping study done by McCormack et al. [30]. Several different individual problems were identified in a qualitative study, such as issues related to maintenance requirements, difficulties in handling, and poor sound quality. Therefore, questionnaires covering these device-related problems and appropriate counselling by professionals have been proposed to be applied in the clinical routine [31]; however, one major issue seems to be the discrepancy between the perceived difficulties and the expectations of people with hearing loss. The most influential factors on HA utilization and use are the self-reported hearing disability, reduced sensitivity and the difficulty in understanding speech in noise. This has been recently confirmed by Humes et al. who compared first time HA users and found that the adherent group differed from the nonadherent group mainly in the perceived difficulties and the expectations which stresses the necessity of appropriate counselling by professionals. Furthermore, a poorer aided outcome was observed in those who returned the devices in the long-term follow-up [32].

Another way to improve adherence is the involvement of the significant others. Nixon et al. clearly showed that an increased family interaction was associated with significantly more frequent use of HAs. In this context, strategies of a family-centered audiology care should be discussed [33].

The situation is quite similar with CIs. Although among CI users, those aged 65 years or older accounted for 20.2% of users in 2017, an increase from 6.4% in 1990 [19], the number of CI recipients in this age group is still low and only 8.5% of those who would benefit from a CI actually received one [34]. This might be caused by the fact that some healthcare professionals are not sufficiently familiar with CIs and the benefits obtained with cochlear implantation in older people [35]. Furthermore, changes in the decision-making process in older age might not have been perfectly addressed so far. A study done by Illg et al. revealed that in 22% of older people with severe hearing loss who were CI candidates there was a gap of more than 1 year between counselling and the final decision to get an implant. Furthermore, 28% waited 6 months or longer between candidacy and decision making. Thus, patient associations and hearing care professionals should play a more prominent role in the decision-making process before cochlear implantation [36].

Assistive listening devices

In challenging acoustic situations, such as listening in large groups, assistive listening devices which wirelessly broadcast the audiological signal directly to the receiver and which can be used in combination with a hearing aid or a CI or as stand-alone devices might be helpful. Although an audiologic benefit in the signal to noise of 15–20 dB was evaluated, the use of these devices is still rare. This might be due to insufficient training, costs, and the size of the devices which makes the hearing impairment more visible [37]. Furthermore, the supplementary use of visual-enabled or vibrotactile-enabled alarm systems, such as alarm clocks or smoke detectors, should be considered, especially for people with severe to profound hearing loss.

Conclusion

As neither prevention nor treatment of the ultimate causes of ARHL will become clinically available in the near future, the care for people affected by ARHL focuses on hearing devices, such as HAs or CIs, supplemented by assistive listening devices. A large body of evidence-based data on the benefits of such devices, not only in terms of improved speech understanding and the prevention of social isolation, but also in terms of improved QoL, reduced depressive symptoms, and presumably also improved cognitive abilities has been reported in recent years. Despite the available options, only a small proportion of people affected by ARHL currently use these devices. To successfully treat as many people as possible at an early stage, screening procedures for the early identification of ARHL, and intensive counselling by hearing professionals should be routinely included in the care of older people.

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Declarations

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For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case. For images or other information within the manuscript which identify patients, consent was obtained from them and/or their legal guardians.

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Zusammenfassung

Update über chirurgische und nichtchirurgische Behandlungsmöglichkeiten bei altersbedingtem Hörverlust

Hintergrund: Presbyakusis (ARHL) ist eine der häufigsten chronischen Erkrankungen, die weit über eine Einschränkung des Sprachverstehens hinausgehen. Auch soziale Isolation, Depression und kognitiver Abbau werden hiermit in Verbindung gebracht. Daher sind eine frühzeitige Diagnose und eine angemessene Therapie notwendig.
Zielsetzung: Darstellung (nicht) chirurgischer Behandlungsmöglichkeiten einer Presbyakusis und der Diskrepanz zwischen ihrer hohen Prävalenz sowie der bislang noch unzureichenden Versorgung.
Material und Methoden: Selektive Literatursuche in PubMed.
Ergebnisse: Da bislang keine kausale Behandlung einer Presbyakusis existiert, stellt die Rehabilitation in Form einer technisch-apparativen Versorgung immer noch die Standardtherapie dar, wobei es in den letzten Jahren enorme technische Entwicklungen gegeben hat. Bei einem gering- bis mittelgradigen Hörverlust ist die Versorgung mit Hörgeräten nach wie vor die Methode der Wahl, die zu einer deutlichen Verbesserung des Sprachverstehens und der hörspezifischen Lebensqualität sowie zu einer geringen Verbesserung der allgemeinen Lebensqualität führt. Implantierbare Mittelohrsysteme sind Sonderfällen vorbehalten. Bei einem hochgradigen Hörverlust sollte ein Cochlea-Implantat in Betracht gezogen werden. Trotz der bekannten Vorteile wird bislang nur eine geringe Anzahl hörgeschädigter älterer Menschen mit Hörgeräten oder Cochlea-Implantaten versorgt, auch in Ländern mit hohem Einkommen, in denen die Kosten hierfür von den Krankenkassen übernommen werden.
Schlussfolgerung: Im Hinblick auf die niedrige Rate an adäquat versorgten Menschen mit Presbyakusis sind Screening-Programme notwendig, die auch eine bessere Beratung der älteren Menschen beinhalten sollten.

Schlüsselwörter
Presbyakusis · Hörgerät · Cochlea-Implantat · Benefit · Sprachverstehen

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