ACTA Otorhinolaryngologica Italica 2025;45:47-57; doi: 10.14639/0392-100X-N3081

Cochlear implant procedure. Italian Clinical Practice Guidelines of the Italian Society of Otorhinolaryngology (SIOeChCF) and Italian Society of Audiology and Phoniatrics (SIAF). Part 1: cochlear implants in adults

Cover figure. Cochlear implant is a well-established treatment for adults with sensorineural hearing loss without benefit from hearing aids.

Stefano Berrettini[1], Domenico Cuda[2,3], Silvia Minozzi[4], Franca Artioli[5], Umberto Barbieri[6], Cristian Borghi[7-9], Eliana Cristofari[10], Giorgio Conte[11,12], Davide Cornolti[13,14], Diego di Lisi[15], Anna Rita Fetoni[16], Simona Fiori[17,18], Elisabetta Genovese[19], Giorgia Girotto[20,21], Marinella Majorano[22], Pasquale Marsella[23], Emanuele Marzetti[24,25], Maria Nicastri[26], Gaetano Paludetti[27], Nicola Quaranta[28], Patrizia Trevisi[29], Diego Zanetti[30], Michela Cinquini[4], Francesca Forli[1,31], Sara Ghiselli[2]

[1] Otolaryngology Audiology and Phoniatrics Unit, Pisa University Hospital, Pisa, Italy; [2] Department of Otolaryngology, AUSL Piacenza, Italy;

Received: May 20, 2024
Accepted: July 22, 2024

Correspondence
Francesca Forli
E-mail: francesca.forli@gmail.com

How to cite this article: Berrettini S, Cuda D, Minozzi S, et al. Cochlear implant procedure. Italian Clinical Practice Guidelines of the Italian Society of Otorhinolaryngology (SIOeChCF) and Italian Society of Audiology and Phoniatrics (SIAF). Part 1: cochlear implants in adults. Acta Otorhinolaryngol Ital 2025;45:47-57. https://doi.org/10.14639/0392-100X-N3081

Summary

Objective. Cochlear implant (CI) is a well-established treatment for adults with sensorineural hearing loss and without benefit from hearing aids. The Italian guidelines date back 15 years; given the expansion of indications for CI, including single side deafness and asymmetrical hearing loss, it became necessary to establish updated guidelines.
Methods. Thirteen experts and 2 patient representatives selected the key questions and drew up recommendations. The document was developed following GRADE methodology. The methodological team of the Mario Negri Pharmacological Research Institute performed systematic reviews for each question and supported the overall process.
Results. Five key questions were identified and recommendations formulated, with subgroups and considerations on implementation.
Conclusions. Though the systematic research of scientific literature found a scarcity of randomised trials and an overall poor conduct and reporting quality of primary studies and systematic reviews, strong or conditional recommendations in favour of CI have been formulated for different subgroups of patients. Further studies should enrol a larger number of participants and use consistent instruments to evaluate hearing outcomes, in order to increase the comparability of results and data pooling with meta-analysis.

Key words: cochlear implant, hearing loss, adult patients, guidelines, clinical practice recommendation

[3] Department of Medicine and Surgery, University of Parma, Italy; [4] Laboratory of Systematic Review Methodology and Guideline Development. Mario Negri Institute for Pharmacological Research IRCCS, Milan, Italy; [5] Otolaryngology Unit, Modena University Hospital, Modena, Italy; [6] Patient representative; [7] Amplifon Italy SpA; [8] University of Padua, Padua, Italy; [9] University of Parma, Parma, Italy; [10] Audiovestibology Cochlear Implant Center, Department of Neurosciences - ASST Settelaghi, Varese, Italy; [11] Neuroradiology Unit, Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico, Milan, Italy; [12] Department of Pathophysiology and Transplantation, University of Milan, Milan, Italy; [13] Association for Deafness and Cochlear Implants - ODV (A.S.I.C.-ODV), Lucca, Italy; [14] Institute of Clinical Phisiology (IFC), CNR Pisa, Italy; [15] Section of Audiology and Cochlear Implant, Section of Otolaryngology 3, Martini Hospital,Torino, Italy; [16] Department of Neurosciences, Reproductive Sciences, and Odontostomatology; Unity of Audiology and Vestibology, University Hospital Federico II, University of Naples Federico II, Naples, Italy; [17] Neuroscience Department, Meyer Children's Hospital, Florence, Italy; [18] University of Florence, Florence, Italy; [19] Department of Maternal, Infant, and Adult Medical and Surgical Sciences, University of Modena and Reggio Emilia; [20] Department of Medical, Surgical, and Health Sciences, University of Trieste, Trieste, Italy; [21] IRCCS Burlo Garofolo, Trieste, Italy; [22] Department of Human Sciences, University of Verona, Verona, Italy; [23] UOC of Audiology and Otosurgery, Cochlear Implant and Implantable Prosthesis Center, Pediatric Hospital "Bambino Gesù" - IRCCS Rome, Italy; [24] University Hospital Foundation "A. Gemelli" IRCCS, Rome, Italy; [25] Department of Geriatrics, Orthopedics and Rheumatology, Università Cattolica del Sacro Cuore, Rome, Italy; [26] UOC Otolaryngology-Cochlear Implant Centre; Policlinico Umberto I, Rome, Italy; [27] Otolaryngology Unit, University Hospital Foundation A. Gemelli, IRCCS, Università Cattolica del Sacro Cuore, Rome, Italy; [28] Department of Translational Biomedicine and Neurosciences, University of Bari "Aldo Moro", Bari, Italy; [29] Otolaryngology Unit, Department of Neurosciences, University Hospital of Padua, Padua, Italy; [30] Section of Audiology; Foundation IRCCS Cà Granda Ospedale Maggiore Policlinico di Milano, Milan, Italy; [31] Hearing Implant Section Karolinska Institutet, Stockholm, Sweden

Introduction

This report summarises the recommendations of Clinical Practice Guidelines regarding cochlear implant (CI) procedure in adults [1], drawn up according to the GRADE methodology [2] and promoted by the Italian Society of Otorhinolaryngology (SIOeChCF) and Italian Society of Audiology and Phoniatrics (SIAF). Current knowledge on CI procedures is translated into relevant practical recommendations following the rules and the methodology indicated by the Centro Nazionale per l'Eccellenza delle Cure (CNEC) and the Istituto Superiore di Sanità (ISS).

CI is a well-established, safe and effective treatment for adults with sensorineural hearing loss who do not benefit from traditional hearing aids. In the adult patient, deaf-

ness, if untreated, causes difficulties in communication and social interactions, hindering the development of potential in all spheres, including work and social relationships [3,4].

The US Food and Drug Administration (FDA) [5] approved the use of CIs in adults in 1984. Initially, CI was only dedicated to patients with profound bilateral hearing loss. Subsequently, the indications for this procedure were broadened, mainly on the basis of extremely positive clinical evidence and technological advances, which allowed for faster, safer and less invasive surgery as well as better outcomes. Consequently, the procedure was also considered for subjects with greater residual hearing, asymmetrical hearing loss, or even unilateral deafness (so-called single sided deafness, SSD). In addition, simultaneous or sequential bilateral procedures are currently available for certain types of patients. However, some of the more recent areas of application of the procedure are still debated, since the evidence on clinical benefits and cost effectiveness is limited.

Although several guidelines have been published that define the indications for the procedure in the adult patient, there is no uniformity on the criteria that are considered by various groups to define its appropriateness. Moreover, the currently available guidelines are mostly national and their structure is not defined and universally shared.

In Italy, in 2009, guidelines for the CI procedure were published by a working group coordinated by the SIOeChCF [6]. These guidelines date to 15 years ago and, given the enormous expansion of indications for CI, in some aspects should considered outdated, since they do not consider some areas in which CI is currently indicated (e.g., SSD, asymmetrical hearing loss, etc.). Furthermore, in 2011 a Health Technology Assessment (HTA) project, promoted by the Italian Ministry of Health, was concluded by a working group of experts coordinated by Berrettini [7] to outline the appropriateness criteria of the CI procedure in adults and children. This document does not consider certain aspects, such as CI in asymmetrical hearing loss and SSD, and does not reflect criteria for a proper guideline.

For these reasons, it became necessary to establish new and updated guidelines on the criteria for selection and appropriateness of the CI procedure in adult patients. In particular, attention was paid to unilateral or bilateral implantation and to CI in asymmetrical hearing loss and SSD.

Materials and methods

The panel was composed by 3 otolaryngologists, 2 audiologists/phoniatricians, one audiometrist, one hearing aid specialist, one speech pathologist, one pediatric neuropsychiatrist, one geneticist, one geriatrician, one neuroradiologist, one psychologist and 2 patient representatives. The experts, indicated by the above-mentioned scientific societies, and the patient representatives identified, by collegial discussion, the key questions that healthcare providers are frequently faced with, discussed the evidence provided by the methodological team and drew up guidelines.

This document was developed according to the rules of the Centro Nazionale per l'Eccelenza delle Cure (CNEC) of the Italian Ministry of Health with the support of the methodological team of the Laboratory of Methodology of Systematic Reviews and Guidelines production of the Mario Negri Pharmacological Research Institute. The key questions were developed according to the Population, Intervention, Comparison, Outcomes (PICO) acronym. For each PICO question, the literature on MEDLINE/PubMed, Embase and Cochrane Library databases was systematically searched with both thesaurus terms and free text up to June 2023 and included systematic reviews, randomised and non-randomised controlled trials and non-controlled studies. A further hand search was performed on the bibliography of retrieved articles.

Recommendations were formulated applying the GRADE approach[2] according to the CNEC manual [8]. All aspects concerning questions, assessment of evidence and conclusions were discussed among panel members and voted upon. Before voting, members declared their potential conflict of interests (COI) relevant to the PICO question, and only those without COI voted. The online GRADEpro GDT tool was used to develop questions, assess evidence, and make decisions [9]. The certainty of evidence was assessed applying the tool for Risk of Bias (RoB) in randomised trials as suggested by Cochrane [10]. The methodological quality of systematic reviews was evaluated by the AMSTAR 2 checklist [11].

Results

Table I summarises the PICO questions about Treatment, Recommendations, Certainty of evidence, and Strength of recommendation of CI procedures in adult recipients.

Key Question 1. In an adult patient (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA 0.5-1-2-4 kHz ≥ 75 dB) and poor performance/unsatisfactory outcomes with hearing aids, is cochlear implantation indicated?

Hearing loss in adults is a frequent disorder representing the third leading cause of disability worldwide [12]. The num-

Table I. PICO questions about cochlear implant (CI) procedure in adult recipients.

	PICO	Recommendation	Certainty of evidence	Strength of recommendation
1	In an adult patient (age ≥ 18 years) with bilateral severe-deep hearing loss (THA 0.5-1-2-4 KHz ≥ 75 dB) and poor performance/ unsatisfactory outcomes with hearing aids, is cochlear implantation indicated?	For adult patients (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA* 0.5-1-2-4 KHz ≥ 75 dB) and poor performance/ unsatisfactory outcomes with hearing aids, panel recommends cochlear implantation (unilateral, bilateral simultaneous, bilateral sequential) over hearing aids/no intervention	Moderate for desirable outcome quality of life, judged by the panel to be of critical importance, very low for desirable outcomes perception of language/communication, low for undesirable outcomes	Strong in favour of cochlear implant
2	In an adult patient (age ≥ 18 years) with bilateral severe-deep hearing loss (THA 0.5-1-2-4 KHz ≥ 75 dB) and poor performance/ unsatisfactory outcomes with hearing aids, is bilateral cochlear implantation indicated?	For adult patients (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA 0.5-1-2-4 KHz ≥ 75 dB) and poor performance/ unsatisfactory outcomes with hearing aids, panel suggests using simultaneous bilateral implantation over unilateral implantation considering the patient's age and social and working conditions	Very low	Conditional in favour of simultaneous bilateral implantation
3	In an adult patient (age ≥ 18 years) with bilateral severe-deep hearing loss (THA 0.5-1-2-4 KHz ≥ 75 dB), unilateral cochlear implant wearer, and poor performance/ unsatisfactory results with hearing aids, is cochlear implantation in the second ear (sequential implantation) indicated?	For adult patients (age ≥ 18 years) single-lateral cochlear implant recipients with contralateral severe-profound hearing loss (PTA 0.5-1-2-4 KHz ≥ 75 dB) and poor performance/unsatisfactory outcomes with hearing aids, panel suggests using cochlear implantation in the contralateral ear (sequential implantation) versus no intervention or use of hearing aids	Very low	Conditional in favour of sequential implantation in the second ear
4	In an adult patient (age ≥ 18 years) with asymmetrical hearing loss (worst ear with severe-deep hearing loss i.e., PTA 0.5-1-2-4 KHz ≥ 75 dB, best ear with PTA > 30 dB and < 75 dB and interaural difference PTA ≥ 30 dB) and poor performance/unsatisfactory results with hearing aids, is cochlear implantation in the worst ear indicated?	For adult patients (age ≥ 18 years) with asymmetrical hearing loss (worst ear with severe-profound hearing loss i.e., PTA 0.5-1-2-4 KHz ≥ 75 dB, best ear with PTA > 30 dB and < 75 dB and interaural difference PTA ≥ 30 dB) and poor performance/unsatisfactory outcome with hearing aids, panel suggests cochlear implantation in the worst ear	Very low	Conditional in favour of cochlear implantation in the worst ear
5	In an adult patient (age ≥ 18 years) with severe-profound hearing loss in the worst ear (so-called Single Sided Deafness: SSD) and hearing threshold in the best ear PTA ≤ 30 dB, is cochlear implantation in the worst ear indicated?	For adult patients (age ≥ 18 years) with severe-profound hearing loss in the worst ear (so-called Single Sided Deafness: SSD) and hearing threshold in the best ear PTA ≤ 30 dB, panel suggests cochlear implantation in the worst ear	Very low	Conditional in favour of cochlear implantation in the worst ear

GRADE Working Group grades of evidence:
High certainty: *we are very confident that the true effect lies close to that of the estimate of the effect.*
Moderate certainty*: we are moderately confident in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.*
Low certainty*: our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect.*
Very low certainty*: we have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of effect.*

ber of adults with hearing loss globally is also expected to increase over the next 30 years [12].

Untreated hearing impairment can compromise access to oral communication resulting in emotional effects, isolation, social problems, reduced employment opportunities, and worsened quality of life [13-15].

There is well-established evidence in the literature that cochlear implantation is the gold standard to restore hearing ability for adults with severe hearing loss [16]. However, there are few and not universally agreed upon guidelines regarding candidacy criteria for CI [4,17]. Sixteen systematic reviews were analysed [3,18-32] published between 2010 and 2022 that included a total of 228 primary studies, mostly case series or case reports with evaluations performed before and after cochlear implantation. The majority of studies included patients with postverbal hearing loss receiving unilateral implantation.

Most of the reviews were of low methodological quality and did not conduct meta-analyses because of the heterogeneity of the instruments used to assess outcomes, length of follow-up, and poor quality of reporting of primary studies. All the reviews that evaluated quality of life reported an improvement after CI, assessed both by generic (SSQ questionnaire, APHAB) and symptom-specific instruments (NCIQ, HHI-E and HHIA questionnaires) [18,20,23,25]. In addition, all studies that assessed subjective benefits reported an improvement in the SSQ questionnaire score. All systematic reviews that evaluated audiometric outcomes reported improved hearing threshold and speech perception with cochlear implantation [3,20-23,25,31,32].

The undesirable effects observed were facial nerve stimulation and incomplete array insertion reported in 10-12% of participants, all of whom with otosclerosis [19,28], tinnitus, reported in 5.6% and 47% of cases [19,23,30], dizziness, reported in 2.2% and 30.9% of patients with percentages increasing with age [23,26,27], skin complications reported in about 6% of participants [22,24], and surgery failures reported in 5.5% [29].

Cost-effectiveness

Economic evaluations conducted in the United Kingdom indicate that unilateral cochlear implantation in adults with severe/profound deafness is likely to be cost-effective compared with non-implantation or prosthetic hearing aids (willingness to pay range £30,000 to €50,000 per QALY gained) [20,33]. An economic analysis conducted in Sweden [34] indicated that unilateral CI is a cost-effective option to improve hearing in Swedish adults with severe to profound deafness and who had previously gained some benefit from hearing aids (willingness to pay SEK 250,000 per QALY gained).

Recommendation: **in adult patients (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA 0.5-1-2-4 kHz ≥ 75 dB) and poor performance/unsatisfactory outcomes with hearing aids, the panel recommends cochlear implantation (unilateral, bilateral simultaneous, bilateral sequential) over hearing aids/no intervention.**

Certainty of evidence: moderate for quality of life, judged by the panel to be of critical importance, very low for perception of language/communication, low for undesirable outcomes.

Strength of recommendation: strong in favour of CI.

Considerations in subgroups: for patients with auditory neuropathy, elderly patients, patients with preverbal deafness or with major middle and inner ear malformations and/or associated otologic pathologies, cochlear implantation is still recommended, although the benefits achieved may be less and the indications deserve to be evaluated on a case-by-case basis.

Considerations for implementation: in the pre-implant audiological evaluation of patients who are candidates for the intervention, the following exams should be performed: tonal audiometric examination, speech audiometric examination, speech perception test in silence and noise both with hearing aids and without devices. It is recommended that patient management during selection for cochlear implantation be multidisciplinary (audiologist, otolaryngologist, otosurgeon, audiometrist, speech pathologist, radiologist, hearing aid specialist). It is also recommended that postoperative management and follow-up of the patient should be handled by an appropriate team at the CI centre.

Key Question 2. In an adult patient (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA 0.5-1-2-4 kHz ≥ 75 dB) and poor performance/unsatisfactory outcomes with hearing aids, is simultaneous bilateral cochlear implantation indicated?

In an adult subject with bilateral profound deafness who does not sufficiently benefit from the use of prosthetic hearing aids, it is still debated whether the use of a CI in only one ear is sufficient to ensure "socially" useful hearing, or whether bilateral cochlear implantation, especially when performed simultaneously in both ears, makes a significant contribution to the ability to understand verbal communication and, therefore, to the quality of life. There is also evidence that restoration of binaural hearing provides the

ability to identify a sound source and improves speech comprehension in environments with background noise. One randomised trial [35] and 10 observational studies [36-45] were reviewed, involving a total of 273 patients.
Seven studies evaluated speech perception in silence: in the randomised study [35] there was no significant difference between unilateral and bilateral simultaneous implants; in contrast, in 6 observational studies the evidence was in favour of bilateral implants [36,37,39,41-44]. The randomised study [35] and 7 observational studies [36,37,39-41,44] evaluated speech perception in noise: the randomised study found no significant differences, while the evidence was in favour of simultaneous bilateral implantation in 5 of 7 observational studies.
Sound localisation ability was assessed in the randomised trial[35] and in 6 observational studies [38,40-43,45]; in all studies sound localisation ability was better with simultaneous bilateral CI.
Only one study assessed quality of life benefits [35] with the speech, spatial and qualities (SSQ) questionnaire; the study reported postoperative improvement in 2 of the 3 subscales of the SSQ.
Only the randomised trial [35] reported adverse events; simultaneous performance of bilateral rather than unilateral implants does not appear to result in increased frequency of tinnitus; no other major complications were reported. The expected frequency of intervention-related adverse events does not differ from that observed with unilateral implantation.

Cost effectiveness

Three studies comparing simultaneous versus sequential bilateral implantation extracted from a systematic review [46] conducted in the UK and the Netherlands reported that simultaneous bilateral implantation is not cost effective.

Recommendation: **for adult patients (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA 0.5-1-2-4 kHz ≥ 75 dB) and poor performance/unsatisfactory outcomes with hearing aids, the panel suggests using simultaneous bilateral implantation over unilateral implantation while considering the patient's age and social and working conditions.**

Certainty of evidence: very low.

Strength of recommendation: conditional in favour of simultaneous bilateral implantation.
Considerations in subgroups: simultaneous bilateral CI is especially indicated in the following patients:

- associated disabilities (e.g., deaf-blind, progressive neurodegenerative disease);
- risk of cochlear ossification (meningitis, cochlear otosclerosis, previous otological surgery, Cogan syndrome), although in this subgroup the benefits achieved are often lower than the average in adult patients with normal anatomy;
- young patients (working or studying).

Considerations for implementation: the considerations suggested for PICO 1 are also valid for PICO 2.

Key Question 3. In an adult patient (age ≥ 18 years) with bilateral severe-profound hearing loss (PTA 0.5-1-2-4 kHz ≥ 75 dB), unilateral cochlear implant user, and poor performance/unsatisfactory results with hearing aids, is cochlear implantation in the second ear (sequential implantation) indicated?

A unilateral implant provides adequate perceptual abilities in silent environments, but does not allow the patient to benefit from the advantages provided by binaural hearing in competitive environments. The mechanisms of binaurality, in fact, through the integration of signals from both sides, improve perception in noisy environment [47] and optimise the ability to localise the sound source and control environment [48], resulting in improved quality of life and reduced listening fatigue[49]. The use of a hearing aid in the ear contralateral to the implant, encouraged for the purpose of keeping it actively stimulated, is unable to restore the mechanisms of binaurality and provide an advantage for perceptual purposes, and is often rejected by patients. Sequential implantation in the second ear may allow the possibility of restoring the benefits of binaural hearing.
One randomised trial [50] and 9 observational studies reported in 10 publications [51-60] with a total of 344 patients included were identified.
Most of the observational studies evaluated intrasubject benefit assessments, comparing outcomes related to the first implant with outcomes at a varying distance of time after activation of the second implant.
Speech perception in quiet was examined in 6 studies [51,52,54,57,58,60]; all studies showed a positive trend, but only 2 studies [52,61] found statistically significant improvements in all conditions tested. This discordance can be attributed to several factors, including high performance with the first implant and low sample size.
Speech perception in noise has been investigated in 7 studies [52-55,57,58,60], 4 of which reported in 5 publications [53,55,56,58,60], finding statistically significant results in favour of bilateral implantation; however, in some studies, the benefit from second implantation varied according to the location of the signal and noise in the tests.

Localisation ability was examined in 3 studies reported in 4 articles with intrasubject analysis [53,55,56,59]. Although the investigations differed in methodology, number of speakers, and stimuli used, all studies demonstrated significant improvements in localisation accuracy with bilateral implantation.
Subjective benefits, as measured by the SSQ, were evaluated in the randomised trial [50] and 2 observational studies [53,54]. All studies showed improvement related to binaural stimulation, with particular relevance to spatial hearing dimension [50]. The other parameters measured showed improvement, demonstrating an incremental trend, but not reaching statistical significance.
Specific adverse events compared with sequential implantation have been evaluated in only 2 studies [50,57] and were infrequent overall; the randomised trial [50] reported marked worsening of tinnitus in 8% of cases, while the observational study [57] reported the case of a patient who discontinued use of the processor one week after the second implant was activated, having been unable to integrate the separate signals from the two sides. The expected frequency of intervention-related adverse events does not differ from that observed with unilateral implantation.

Cost effectiveness
Two studies comparing sequential bilateral implantation versus no intervention extracted from a systematic review [46] identified an incremental cost-effectiveness ratio (ICER) for sequential bilateral implantation of $48,798/QALY (57% for the willingness to pay 100,000 reference value). The minimum and maximum values were $16,047/QALY and $55,020/QALY, respectively, and showed a wide variability, which depended on the values used in the definition of quality of life by the different studies, the study methodology, and the reference time horizon.

Recommendation: **for adult patients (age ≥ 18 years) single-lateral cochlear implant recipients with contralateral severe-profound hearing loss (PTA 0.5-1-2-4 kHz ≥ 75 dB) and poor performance/unsatisfactory outcomes with hearing aids, the panel suggests using cochlear implantation in the contralateral ear (sequential implantation) *versus* no intervention or use of hearing aids.**
Certainty of evidence: very low.
Strength of recommendation: conditional in favour of sequential implantation in the second ear.

Considerations in subgroups: the recommendation is particularly indicated for individuals with severe visual impairment, in whom control environmental and interpersonal communication are primarily dependent on auditory input, and in patients with autoimmune or infectious diseases (e.g., meningitis) with possible evolution toward ossification of the cochlea. Furthermore, it is particularly indicated for individuals of working age to promote greater adequacy in work environments or in students, in whom restoration of binaural hearing is able to reduce strain in listening and thus promote learning.

Considerations for implementation: it is recommended that the pre-implant audiological evaluation of patients candidate to the cochlear implantation in the second ear (sequential implantation) include evaluation by free-field tonal and vocal audiometry with implant and with possible prosthetic contralateral, individually and in combination, and tests of speech perception in quiet and with competing noise. Time elapsed from the first implant should also be considered, especially for patients who are not wearing the contralateral prosthesis, possible anaesthesiologic risks, and, in the case of malformations, any surgical risks associated with the procedure.
Pre- and postoperative patient management and follow-up require a dedicated multidisciplinary team including audiologist, otosurgeon, otolaryngologist, audiometrist, speech pathologist, radiologist, and hearing aid specialist.

Key Question 4. In an adult patient (age ≥ 18 years) with asymmetrical hearing loss (worse ear with severe-profound hearing loss i.e., PTA 0.5-1-2-4 kHz ≥ 75 dB, better ear with PTA > 30 dB and < 75 dB and interaural difference PTA ≥ 30 dB) and poor performance/unsatisfactory results with hearing aids, is cochlear implantation in the worse ear indicated?
In asymmetrical hearing loss, the PTA hearing threshold for the worse ear is ≥ 75 dB hearing loss and the PTA for the better ear is > 30 dB and < 75 dB hearing loss. The airway gap between the two ears is ≥ 30 dB hearing loss [61]. Though the hearing of the side with the lesser degree of loss can be rehabilitated with a traditional hearing aid, the same aid, however, does not fully rehabilitate the side with greater loss, especially if the loss of the worse side is even greater with a PTA > 75 dB. Traditionally, an asymmetric hearing loss was treated with a single hearing aid fitted to the ear with the better hearing as it was sufficient for listening in favourable environmental situations (e.g., listening in a quiet environment). However, such listening is limiting as there is a loss of binaurality (listening from both sides). Binaural listening is, in fact, necessary for sound localisa-

tion skills [48], understanding in noise [47] and consequently for optimising non-audiological parameters such as quality of life [49].
Only one systematic review was identified [62] that included 2 studies with 10 participants each with asymmetric hearing loss [6,64]. Both studies demonstrated significant improvements in speech perception in silence between pre- and post-implantation assessed after 6 and 12 months of follow-up. One study also reported improvement in speech perception in noise. The other study found improvement in localisation skills. One study showed improved subjective benefits assessed with the SSQ questionnaire, especially in scales related to listening speech, spatiality, and sound quality.
The expected frequency of intervention-related adverse events does not differ from that observed in patients who receive unilateral implantation in case of symmetrical hearing loss.

Cost effectiveness
No study evaluating cost effectiveness of cochlear implantation in adult patients (age ≥ 18 years) with asymmetrical hearing loss was identified.

Recommendation: **for adult patients (age ≥ 18 years) with asymmetrical hearing loss (worse ear with severe-profound hearing loss i.e., PTA 0.5-1-2-4 kHz ≥ 75 dB, better ear with PTA > 30 dB and < 75 dB and interaural difference PTA ≥ 30 dB) and poor performance/unsatisfactory outcome with hearing aids, the panel suggests cochlear implantation in the worse ear.**

Certainty of evidence: very low.

Strength of recommendation: conditional in favour of cochlear implantation in the worse ear.

Considerations in subgroups: the recommendation is particularly intended for patients with autoimmune or post-meningitis disease due to possible cochlear ossification and progressiveness of hearing impairment which may lead to bilateral hearing loss that is not restorable with traditional hearing aids. It is particularly indicated for individuals who are also visually impaired to give them the opportunity to have the best possible sensory input and consequently improve autonomy. Finally, it is particularly indicated for younger working individuals and for students.

Considerations for implementation: the implementation considerations suggested for PICO 1 are also valid for PICO 4.

Key Question 5. In an adult patient (age ≥ 18 years) with severe-profound hearing loss in the worse ear (so-called single-sided deafness) and hearing threshold in the better ear PTA ≤ 30 dB, is cochlear implantation in the worse ear indicated?

Single-sided deafness (SSD, profound-severe hearing loss in the worse ear and a hearing threshold in the better ear with PTA ≤ 30 dB) prevents binaural acoustic stimulation, resulting in reduced spatial localisation abilities of the sound source and reduced speech perception abilities in the presence of background noise. At present, cochlear implantation surgery in the affected ear is the only solution that can stimulate the ear with deafness in this type of patient and thus restore binaural stimulation. The FDA approved the use of one brand of CI in patients with SSD in 2019 and another brand in 2022 [5].
Eight systematic reviews were identified that included studies with patients with unilateral deafness; 4 reviews included patients with profound unilateral deafness of any origin [65-68], 2 reviews included only patients with Meniere's disease [23,69]; one review included only patients with sporadic vestibular schwannoma [70]; and one review included only patients in whom the onset of deep unilateral deafness was acute and rapidly progressive[71].
Reviews have reported improvement in speech perception in general [70] and more specifically in silence [23,66,69] and noise [65,66] in most studies. In one review [68], no significant changes after implantation in speech perception ability in noise were reported.
The expected frequency of intervention-related adverse events did not differ from that in patients who received unilateral implantation in case of symmetrical hearing loss.

Cost effectiveness
Two studies have been identified: an HTA report conducted in Canada [72] and a cost effectiveness study conducted with the perspective of the Austrian and German Health Service [73], which reported, respectively, an ICER of $18,148 (willingness to pay $100,000/QALY) and an ICER of 34,845.20 euros (willingness to pay Austria for 2019 euros 40,458; Germany for 2019 euros 38,814). These studies have shown that in settings other than Italy, CI is cost effective with improvement in QALY indices compared with no intervention in adults with SDD in whom all other forms of amplification were unsuccessful.

Recommendation: for adult patients (age ≥ 18 years) with severe-profound hearing loss in the worse ear (so-called single-sided deafness) and hearing threshold in the better ear PTA ≤ 30 dB, the panel suggests cochlear implantation in the worse ear.

Certainty of evidence: very low.

Strength of recommendation: conditional in favour of cochlear implantation in the worse ear.

Considerations in subgroups: the recommendation is particularly intended for patients with disabling tinnitus, patients with a risk of cochlear ossification, such as those with autoimmune disease or post-meningitis deafness, or forms of sudden hearing loss with a tendency to cochlear obstruction/ossification, as well as for patients with progressive forms of hearing loss (e.g., wide vestibular aqueduct, cytomegalovirus-related forms) that can lead to hearing loss over time in the better ear and thus to bilateral hearing loss that cannot be restored with traditional hearing aids. Preimplant audiological evaluation should consider the time of deprivation of deaf ear and the dominance of the hearing ear, which can have a major influence on clinical outcomes and the patient's expectations (e.g. high risk of non-user). It is particularly indicated for all individuals who are also visually impaired to give them the opportunity to have the best sensory input and consequently improve autonomies. Finally, it is particularly indented for younger working subjects or students.

Considerations for implementation: the implementation considerations suggested for PICO 1 are also valid for PICO 5.

Equity, feasibility and acceptability of cochlear implantation

The panel judged that cochlear implantation probably has no impact on equity as adequate care is impartially guaranteed throughout Italy, and that overall it is well accepted, even if cosmetic appearance may be a concern for patients and that there are no issues of feasibility.

Discussion and conclusions

The systematic research of the available scientific literature found a scarcity of randomised trials and an overall poor quality of conduct and reporting of both primary studies and systematic reviews. Notwithstanding, in this field, uncontrolled case series with evaluation of outcomes before and after implantation may provide acceptable evidence. Given the stable and chronic nature of the condition, further studies should enroll a larger number of participants and use consistent instrument and scales to evaluate hearing outcomes, in order to increase comparability of results across studies and pooling of data in meta-analysis.

Acknowledgements

The authors thank Marta Monteforte, Veronica Andrea Fittipaldo, Marien Gonzalez Lorenzo (Oncology Department, Istituto di Ricerche Farmacologiche Mario Negri) for the methodological support.

Conflict of interest statement

Marinella Majorano: research grants (to Institution) from Cochlear srl. Diego Zanetti: registration fees for scientific conferences and reimbursement of travel or living expenses. Co-funding to Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico di Milano for scholarship for the purpose of supporting research. Medel Italia, Cochlear Italia, Amplifon, Audionova, Audiomedica, Fonema. The other authors declare no conflict of interest.

Funding

Funding for this study was provided by the AOOI (Associazione Otorinolaringoiatri Ospedalieri Italiani) Foundation.

Author contributions

SG, PM, DZ, PT, FA, CB, MN, SF, GG, EM, GC, MM, DC, UB, FF: formed the Panel Group. The Authors equally contributed to the critical appraisal of the evidence and the formulation of recommendations. SG, FF, DZ, FA: wrote the draft of the manuscript, all the authors critically revised and gave important intellectual content and final approval of the version to be published; SM, MC: chaired the method group: they performed the systematic review of literature and guided the panel to develop the statements.

Ethical consideration

Not applicable.

References

1 https://www.iss.it/web/guest/-/impianto-cocleare-adulto-bambino, Accessed April 17, 2024.

2 Guyatt GH, Oxman AD, Vist GE, et al. GRADE Working Group. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336:924-926. https://doi.org/10.1136/bmj.39489.470347.AD

3 Berrettini S, Baggiani A, Bruschini L, et al. Systematic review of the literature on the clinical effectiveness of the cochlear implant procedure in adult patients. Acta Otorhinolaryngol Ital 2011;31:299-310.

4 Hermann R, Lescanne E, Loundon N, et al. French Society of ENT (SFORL) guidelines. Indications for cochlear implantation in adults. Eur Ann Otorhinolaryngol Head Neck Dis 2019;136:193-197. https://doi.org/10.1016/j.anorl.2019.04.006

5 FDA, US Food and Drug Administration (2022). Cochlear implants. https://www.fda.gov/medical-devices/implants-and-prosthetics/cochlear-implants. Accessed April 17, 2024.

[6] Quaranta A, Arslan E, Burdo S, et al. Documento del Gruppo S.I.O. Impianti Cocleari: linee guida per l'applicazione dell'impianto cocleare e la gestione del centro impianti cocleari. Acta Otorhinolaryngol Ital 2009;3:1-5.

[7] Berrettini S, Arslan E, Baggiani A, et al. Analysis of the impact of professional involvement in evidence generation for the HTA Process, subproject "cochlear implants": methodology, results and recommendations. Acta Otorhinolaryngol Ital 2011;31:273-280.

[8] CNEC - Centro Nazionale per l'Eccellenza delle Cure Manuale metodologico per la produzione di linee guida di pratica clinica, Roma: ISS - Istituto Superiore di Sanità; 2023. Available at https://www.iss.it/documents/20126/7949265/Manuale+Metodologico+-+marzo+2023.pdf/01f4bc8e-f3e6-66ec-bbe1-e80186908c6c?t=1679921943422 Accessed April 17, 2024.

[9] GRADEpro GDT [Computer program] mcmaster university (developed by evidence prime) GRADEpro GDT, Hamilton (ON): McMaster University; 2021. Version accessed 25 March 2024 developed by Evidence Prime.

[10] Higgins JPT, Green S (eds). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from www.handbook.cochrane.org. Accessed April 17, 2024.

[11] Shea BJ, Reeves BC, Wells G, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomized or non-randomized studies of healthcare interventions, or both. BMJ 2017;358:j4008. https://doi.org/10.1136/bmj. j4008

[12] GBD 2019 Hearing Loss Collaborators. Hearing loss prevalence and years lived with disability, 1990-2019: findings from the Global Burden of Disease Study 2019. Lancet 2021;397:996-1009. https://doi.org/10.1016/S0140-6736(21)00516-X

[13] Mick P, Kawachi I, Lin FR. The association between hearing loss and social isolation in older adults. Otolaryngol Head Neck Surg 2014;150:378-384. https://doi.org/10.1177/0194599813518021

[14] Shukla A, Harper M, Pedersen E, et al. Hearing loss, loneliness, and social isolation: a systematic review. Otolaryngol Head Neck Surg 2020;162:622-633. https://doi.org/10.1177/0194599820910377

[15] World Health Organization WHO. World report on hearing. 3 March 2021. https://www.who.int/teams/noncommunicable-diseases/sensory-functions-disability-andrehabilitation/highlighting-priorities-for-ear-and-hearing-care. Accessed April 17, 2024.

[16] Zeitler DM, Prentiss SM, Sydlowski SA, et al. American Cochlear Implant Alliance Task Force: recommendations for determining cochlear implant candidacy in adults. Laryngoscope 2024;134(Suppl 3):S1-S14. https://doi.org/10.1002/lary.30879

[17] NICE, National institute for care and health excellence (2019). Cochlear implants for children and adults with severe to profound deafness. Technology appraisal guidance. 26 ottobre 2023. https://www.nice.org.uk/guidance/ta566

[18] Andries E, Gilles A, Topsakal V, et al. Systematic review of quality of life assessments after cochlear implantation in older adults. Audiol Neurootol 2021;26:61-75. https://doi.org/10.1159/000508433

[19] Assiri M, Khurayzi T, Alshalan A, et al. Cochlear implantation among patients with otosclerosis: a systematic review of clinical characteristics and outcomes. Eur Arch Otorhinolaryngol 2022;279:3327-3339. https://doi.org/10.1007/s00405-021-07036-5

[20] Bond M, Elston J, Mealing S, et al. Systematic reviews of the effectiveness and cost-effectiveness of multi-channel unilateral cochlear implants for adults. Clin Otolaryngol 2010;35:87-96. https://doi.org/10.1111/j.1749-4486.2010.02098.x

[21] Buchman CA, Gifford RH, Haynes DS, et al. Unilateral cochlear implants for severe, profound, or moderate sloping to profound bilateral sensorineural hearing loss: a systematic review and consensus statements. JAMA Otolaryngol Head Neck Surg 2020;146:942-953. https://doi.org/10.1001/jamaoto.2020.0998

[22] Chaudhry D, Chaudhry A, Muzaffar J, et al. Cochlear implantation outcomes in post synaptic auditory neuropathies: a systematic review and narrative synthesis. J Int Adv Otol 2020;16:411-431. https://doi.org/10.5152/iao.2020.9035

[23] Di Berardino FD, Conte G, Turati F, et al. Cochlear implantation in Ménière's disease: a systematic review of literature and pooled analysis. Int J Audiol 2020;59:406-415. https://doi.org/10.1080/14992027.2020.1720922

[24] Ekman B, Laureano J, Balasuriya B, et al. Comparison of adult and pediatric cochlear implant wound complications: a meta-analysis. Laryngoscope 2023;133:218-226. https://doi.org/10.1002/lary.30168

[25] Gaylor JM, Raman G, Chung M, et al. Cochlear implantation in adults: a systematic review and meta-analysis. JAMA Otolaryngol Head Neck Surg 2013;139:265-272. https://doi.org/10.1001/jamaoto.2013.1744

[26] Hänsel T, Gauger U, Bernhard N, et al. Meta-analysis of subjective complaints of vertigo and vestibular tests after cochlear implantation. Laryngoscope 2018;128:2110-2123. https://doi.org/10.1002/lary.27071

[27] Ibrahim I, da Silva SD, Segal B, et al. Effect of cochlear implant surgery on vestibular function: meta-analysis study. J Otolaryngol Head Neck Surg 2017;46:44. https://doi.org/10.1186/s40463-017-0224-0

[28] Kondo M, Vasan K, Jufas NE, et al. Cochlear implantation in far advanced otosclerosis: a systematic review and meta-analysis. Laryngoscope 2023;133:1288-1296. https://doi.org/10.1002/lary.30386

[29] Layfield E, Hwa TP, Naples J, et al. Failure and revision surgery after cochlear implantation in the adult population: a 10-year single-institution retrospective and systematic review of the literature. Otol Neurotol 2021;42:408-413. https://doi.org/10.1097/MAO.0000000000002940

[30] Ramakers GG, van Zon A, Stegeman I, et al. The effect of cochlear implantation on tinnitus in patients with bilateral hearing loss: a systematic review. Laryngoscope 2015;125:2584-2592. https://doi.org/10.1002/lary.25370

[31] Tyler GK, Martin TP, Baguley DM. Systematic review of outcome of cochlear implantation in superficial siderosis. Otol Neurotol 2012;33:976-982. https://doi.org/10.1097/MAO.0b013e3182565a46

[32] Zia N, Nikookam Y, Muzaffar J, et al. Cochlear implantation outcomes in patients with mitochondrial hearing loss: a systematic review and narrative synthesis. J Int Adv Otol 2021;17:72-80. https://doi.org/10.5152/iao.2020.9226

[33] Cutler H, Gumbie M, Olin E, et al. The cost-effectiveness of unilateral cochlear implants in UK adults. Eur J Health Econ 2022;23:763-779. https://doi.org/10.1007/s10198-021-01393-y

[34] Gumbie M, Olin E, Parkinson B, et al. The cost-effectiveness of cochlear implants in Swedish adults. BMC Health Serv Res 2021;21:319. https://doi.org/10.1186/s12913-021-06271-0

[35] Smulders YE, van Zon A, Stegeman I, et al. Comparison of bilateral and unilateral cochlear implantation in adults: a randomized clinical trial. JAMA Otolaryngol Head Neck Surg 2016;142:249-256. https://doi.org/10.1001/jamaoto.2015.3305

[36] Buss E, Pillsbury HC, Buchman CA, et al. Multicenter U.S. bilateral MED-EL cochlear implantation study: speech perception over the first year of use. Ear Hear 2008;29:20-32. https://doi.org/10.1097/AUD.0b013e31815d7467

[37] Dunn CC, Noble W, Tyler RS, et al. Bilateral and unilateral cochlear implant users compared on speech perception in noise. Ear Hear 2010;31:296-298. https://doi.org/10.1097/AUD.0b013e3181c12383

[38] Dunn CC, Tyler RS, Oakley S, et al. Comparison of speech recognition and localization performance in bilateral and unilateral cochlear implant

users matched on duration of deafness and age at implantation. Ear Hear 2008;29:352-359. https://doi.org/10.1097/AUD.0b013e318167b870

[39] Eapen RJ, Buss E, Adunka MC, et al. Hearing-in-noise benefits after bilateral simultaneous cochlear implantation continue to improve 4 years after implantation. Otol Neurotol 2009;30:153-159. https://doi.org/10.1097/mao.0b013e3181925025

[40] Koch DB, Soli SD, Downing M, et al. Simultaneous bilateral cochlear implantation: prospective study in adults. Cochlear Implants Int 2010;11:84-99. https://doi.org/10.1002/cii.413

[41] Litovsky RY, Parkinson A, Arcaroli J, et al. Bilateral cochlear implants in adults and children. Arch Otolaryngol Head Neck Surg 2004;130:648-655. https://doi.org/10.1001/archotol.130.5.648

[42] Litovsky R, Parkinson A, Arcaroli J, et al. Simultaneous bilateral cochlear implantation in adults: a multicenter clinical study. Ear Hear 2006;27:714-731. https://doi.org/10.1097/01.aud.0000246816.50820.42

[43] Litovsky RY, Parkinson A, Arcaroli J. Spatial hearing and speech intelligibility in bilateral cochlear implant users. Ear Hear 2009;30:419-431. https://doi.org/10.1097/AUD.0b013e3181a165be

[44] Mosnier I, Sterkers O, Bebear JP, et al. Speech performance and sound localization in a complex noisy environment in bilaterally implanted adult patients. Audiol Neurootol 2009;14:106-114. https://doi.org/10.1159/000159121

[45] Neuman AC, Haravon A, Sislian N, et al. Sound-direction identification with bilateral cochlear implants. Ear Hear 2007;28:73-82. https://doi.org/10.1097/01.aud.0000249910. 80803.b9

[46] Health Quality Ontario. Bilateral cochlear implantation: a health technology assessment. Ont Health Technol Assess Ser 2018;18:1-139.

[47] Avan P, Giraudet F, Büki B. Importance of binaural hearing. Audiol Neurootol 2015;20(Suppl 1):3-6. https://doi.org/10.1159/000380741

[48] Moore DR. Anatomy and physiology of binaural hearing. Audiology 1991;30:125-134. https://doi.org/10.3109/00206099109072878

[49] Ketterer MC, Häussler SM, Hildenbrand T, et al. Binaural hearing rehabilitation improves speech perception, quality of life, tinnitus distress, and psychological comorbidities. Otol Neurotol 2020;41:E563-E574. https://doi.org/10.1097/MAO.0000000000002590

[50] Quentin Summerfield A, Barton GR, Toner J, et al. Self-reported benefits from successive bilateral cochlear implantation in post-lingually deafened adults: randomised controlled trial. Int J Audiol 2006;45(Suppl 1):S99-S107. https://doi.org/10.1080/14992020600783079

[51] Budenz CL, Roland JT Jr, Babb J, et al. Effect of cochlear implant technology in sequentially bilaterally implanted adults. Otol Neurotol 2009;30:731-735. https://doi.org/10.1097/MAO.0b013e3181b1227e

[52] Gifford RH, Shallop JK, Peterson AM. Speech recognition materials and ceiling effects: considerations for cochlear implant programs. Audiol Neurootol 2008;13:193-205. https://doi.org/10.1159/000113510

[53] Härkönen K, Kivekäs I, Rautiainen M, et al. Sequential bilateral cochlear implantation improves working performance, quality of life, and quality of hearing. Acta Otolaryngol 2015;135:440-446. https://doi.org/10.3109/00016489.2014.990056

[54] Laske RD, Veraguth D, Dillier N, et al. Subjective and objective results after bilateral cochlear implantation in adults. Otol Neurotol 2009;30:313-318. https://doi.org/10.1097/MAO.0b013e31819bd7e6

[55] Nopp P, Schleich P, D'Haese P. Sound localization in bilateral users of MED-EL COMBI 40/40+ cochlear implants. Ear Hear 2004;25:205-214. https://doi.org/10.1097/01.aud.0000130793.20444.50

[56] Schleich P, Nopp P, D'Haese P. Head shadow, squelch, and summation effects in bilateral users of the MED-EL COMBI 40/40+ cochlear implant. Ear Hear 2004;25:197-204. https://doi.org/10.1097/01.ud.0000130792.43315.97

[57] Ramsden R, Greenham P, O'Driscoll M, et al. Evaluation of bilaterally implanted adult subjects with the nucleus 24 cochlear implant system. Otol Neurotol 2005;26:988-98. https://doi.org/10.1097/01-mao.0000185075.58199.22

[58] Tyler RS, Dunn CC, Witt SA, et al. Speech perception and localization with adults with bilateral sequential cochlear implants. Ear Hear 2007;28(2 Suppl):86S-90S. https://doi.org/10.1097/AUD.0b013e31803153e2

[59] Verschuur CA, Lutman ME, Ramsden R, et al. Auditory localization abilities in bilateral cochlear implant recipients. Otol Neurotol 2005;26:965-971. https://doi.org/10.1097/01.mao.0000185073.81070.07

[60] Zeitler DM, Kessler MA, Terushkin V, et al. Speech perception benefits of sequential bilateral cochlear implantation in children and adults: a retrospective analysis. Otol Neurotol 2008;29:314-325. https://doi.org/10.1097/mao.0b013e3181662cb5

[61] Van de Heyning P, Távora-Vieira D, Mertens G, et al. Towards a unified testing framework for single-sided deafness studies: a consensus paper. Audiol Neurootol 2016;21:391-398. https://doi.org/10.1159/000455058

[62] Sampathkumar R, Kaehne A, Kumar N, et al. Systematic review of cochlear implantation in adults with asymmetrical hearing loss. Cochlear Implants Int 2021;22:311-329. https://doi.org/10.1080/14670100.2021.1936363

[63] Firszt JB, Holden LK, Reeder RM, et al. Cochlear implantation in adults with asymmetric hearing loss. Ear Hear 2012;33:521-533. https://doi.org/10.1097/AUD.0b013e31824b9dfc

[64] Franko-Tobin E, Camilon PR, Camposeo E, et al. Outcomes of cochlear implantation in adults with asymmetric hearing loss. Otol Neurotol 2015;36:409-415. https://doi.org/10.1097/MAO.0000000000000700

[65] Cabral Junior F, Pinna MH, Alves RD, et al. Cochlear implantation and single-sided deafness: a systematic review of the literature. Int Arch Otorhinolaryngol 2016;20:69-75. https://doi.org/10.1055/s-0035-1559586

[66] Kitterick PT, Smith SN, Lucas L. Hearing instruments for unilateral severe-to-profound sensorineural hearing loss in adults: a systematic review and meta-analysis. Ear Hear 2016;37:495-507. https://doi.org/10.1097/AUD.0000000000000313

[67] Oh SJ, Mavrommatis MA, Fan CJ, et al. Cochlear implantation in adults with single-sided deafness: a systematic review and meta-analysis. Otolaryngol Head Neck Surg 2023;168:131-142. https://doi.org/10.1177/01945998221083283

[68] van Zon A, Peters JP, Stegeman I, et al. Cochlear implantation for patients with single-sided deafness or asymmetrical hearing loss: a systematic review of the evidence. Otol Neurotol 2015;36:209-219. https://doi.org/10.1097/MAO.0000000000000681

[69] Selleck AM, Dillon M, Perkins E, et al. Cochlear implantation in the setting of Menière's disease after labyrinthectomy: a meta-analysis. Otol Neurotol 2021;42:E973-E979. https://doi.org/10.1097/MAO.0000000000003200

[70] Bartindale MR, Tadokoro KS, Kircher ML. Cochlear implantation in sporadic vestibular schwannoma: a systematic literature review. J Neurol Surg B Skull Base 2019;80:632-639. https://doi.org/10.1055/s-0038-1676768

[71] Blasco MA, Redleaf MI. Cochlear implantation in unilateral sudden deafness improves tinnitus and speech comprehension: meta-analysis and systematic review. Otol Neurotol 2014;35:1426-1432. https://doi.org/10.1097/MAO.0000000000000431

[72] Ontario Health (Quality). Implantable devices for single-sided deafness and conductive or mixed hearing loss: a health technology assessment. Ont Health Technol Assess Ser 2020;20:1-165.

[73] Seebacher J, Muigg F, Kühn H, et al. Cost-utility analysis of cochlear implantation in adults with single-sided deafness: Austrian and German perspective. Otol Neurotol 2021;42:799-805. https://doi.org/10.1097/MAO.0000000000003103