Research on Candidacy for Cochlear Implants

Brief Summary of Evidence. (does not cover all the studies detailed in the Bibliography)

Context

The audiological criterion for cochlear implantation set by NICE is the ability to hear only sounds that are louder than 90 dB HL at frequencies of 2 and 4 kHz without acoustic hearing aids (i.e. the 90 dB HL criterion level). An additional criterion is the absence of adequate benefit from acoustic hearing aids which is defined as:

• for adults, a score of 50% or greater on Bamford–Kowal–Bench (BKB) sentence testing at a sound intensity of 70 dB SPL;
• for children, speech, language, and listening skills appropriate to age, developmental stage, and cognitive ability.

International Comparisons on Candidacy arrangements

There is considerable variation at the International level (Vickers et al., 2016) with many countries with audiometric guidelines which are much less restrictive. In Australia they use 70 dB HL criteria, Germany, Italy and the USA are also less restrictive than the UK with the majority of clinics using a 75–80 dB HL cut off at frequencies greater than 1 kHz (Raine, 2013; Vickers et al., 2016b). Further in Germany, Italy and Australia implant teams have a greater level of clinical discretion to determine appropriate candidacy using a number of criteria that clinicians find useful (Raine, 2013; Vickers et al., 2016). In the UK however there are only limited examples of obtaining funding for special cases. The requirement for higher audiometric testing levels in CI candidacy in the UK than many other countries means that a lower proportion of adults are being provided with CIs.

Adults

Audiometric tests have also come under scrutiny as pre-implant residual hearing is one of the important attributes contributing to the post-operative outcomes (Chundu and Flynn, 2014) and therefore criteria which favour a lower threshold would also indicate the prospect of greater post-operative benefit. Adults who are deafened early have also been seen to have substantial gains from cochlear implantation and those who are also late implanted as well as early deafened are now showing significant levels of improvement across speech recognition and quality of life measures. Capretta (2016) also found that “speech recognition measures in quiet do not correlate broadly with QOL.” Further Leal et al. (2016) showed that by using the speech intelligibility index (SII) that children, and by implication adults, could benefit from a lower threshold candidacy level (80 dB HL at 2 and 4 kHz) and that the SII could be used as an additional resource to determine candidacy, especially for borderline candidates with atypical hearing loss configurations. It has also been proposed (Chundu and Flynn, 2014) that in areas such as ANSD, the average of the whole frequency range of pure-tone hearing threshold levels at 250, 500, 1000, 2000, and 4000 Hz ≥90 dB HL (British Society of Audiology, 2011), and that BKB scores <50% need to be considered. Individuals who are not deriving benefit from their hearing aids should also be considered for cochlear implantation regardless of their scores on the assessments because there is currently no established measure to quantify the damage to the cochlea.
The ability to preserve residual hearing at low frequency thanks to improved implantation techniques and the ability to use EAS stimulation also indicates that we might need to reassess our views on candidacy as it is clear that more patients could benefit. Further as Verschuur et al. (2016) has shown more patients could be referred under current candidacy requirements if the impact of EAS was better understood. Fielden et al., has also suggested that “It may therefore be appropriate to consider a patient’s capacity to exploit their residual hearing following implantation when assessing candidacy for implantation.”

The use of sentence tests, rather than monosyllabic words, has become increasing questioned as it enables deafened adults to use their previous linguistic knowledge and cognitive ability to predict words and give a false impression of audibility. A number of alternative measures or combination of measures has been proposed as an alternative. Raine (2013) has proposed that assessment of performance with monosyllabic words would be more appropriate which has also been supported by Sladen et al., (2017). The use of monosyllables in testing for qualification purposes has been used in Germany for a number of years where patients achieve <30% correct for Freiberg monosyllables at 70 dB SPL in the best aided condition (Aschendorff et al., 2007; Gifford et al., 2010). As people with greater residual hearing are being assessed they may score greater than 50% on BKB in quiet and should therefore be tested in noise as well to fully understand the difficulties that the individual faces.

In Germany where people with greater levels of hearing are being assessed there has been a move towards testing in noise (Haumann et al., 2012). Further Doran and Jenkinson (2016) has suggested that the Arthur Boothroyd (AB) word test would be a suitable supplement to BKB testing to detect candidates who have some residual hearing but would benefit and Vickers and Bradley (2016) and Vickers (2016) also challenge the current guidelines arguing for a combination of tests which do not rely on a person’s pre-existing linguistic knowledge including monosyllabic word tests and for use of AB test alongside BKB tests. Gifford et al. (2010) in a retrospective review of post-operative speech perception performance found that non-traditional implant recipients, with higher levels of preoperative speech understanding than traditional patients, demonstrated significant benefit from cochlear implantation.

These considerations suggest that the BKB provides useful information and together with the AB words this would be a good combination of measures. However there is more work needed on the candidacy cut off point.

**Advances in Technology which impact on candidacy.**

The performance of CI’s has also improved over this period and therefore so has selection criteria for different types and degrees hearing impairment Arnoldner et al., (2013, Briggs 2011). Dowell (2012) concluded that “average open sentence set identification averaged less than 40% for sound processors in the 1990s compared to an average 80% correct score with modern technology, even without visual cues.” While Büchner et al., (2017) concluded that “successive advances in CI technology and the consequent substantial hearing improvements over time have since then resulted in continuous relaxation of indication criteria toward residual hearing. While achievements in implant and processor electronics have been one key factor for the ever-improving hearing performance, development of electro-acoustic CI systems-together with atraumatic implantation concepts-has led to enormous
improvements in patients with low-frequency residual hearing.”

**Children**
There is evidence that the current criteria for children may also be too restrictive. Paediatric implant recipients that have not met the current criteria have been seen to derive significant benefit from cochlear implantation. Research by Carlson et al. (2015) concluded, after a retrospective case study of implanted children who had less severe hearing loss than specified in the current indications and had open-set word and/or sentence recognition scores greater than 30% for children who are able to participate in speech perception testing; that a large-scale reassessment of paediatric cochlear implant candidacy, including less severe hearing losses and higher preoperative speech recognition, should be undertaken. This work supports other calls for a reduction of the audiometric criteria (Lovett et al., 2015) who concluded that “Children with an unaided four-frequency PTA of 80 dB HL or poorer in both ears should be considered candidates for bilateral cochlear implantation. In cases where a four-frequency PTA cannot be measured, the criterion of candidacy should be a two-frequency PTA of 85 dB HL or poorer in both ears.” Further Vickers (2015) who looked at the criteria for bilateral fitting and concluded that; “The candidacy criteria in the United Kingdom for bilateral CIs in children should be based on either a four-frequency (0.5, 1, 2, and 4 kHz) pure tone average poorer than or equal to 80 dBHL or a two frequency (2 and 4 kHz) pure tone average poorer than or equal to 85 dBHL.”

In looking at post-operative benefit Sampath Kumar et al., (2016) also found that audiometric tests were not good at capturing benefits for pre-lingually deaf young people arguing that improvements in speech discrimination scores may not be apparent in this group after implantation but more subtle benefits such as improved interpersonal skills, emotional wellbeing, greater satisfaction at work and greater personal satisfaction were reported. It has also been suggested that CIs provide better results compared with hearing aids in children with residual hearing (Gratacap et al., 2015). Further Greaver et al., (2017) found that “Children with single-sided deafness or asymmetric hearing loss who have traditionally not been considered candidates for cochlear implantation should be evaluated on a case-by-case basis.”

**Next Steps**
This has led to a number of calls for a review of the criteria with the BCIG consensus process (2017) calling for; “Expanding candidacy to include some groups of adults and children with less profound forms of hearing loss would be appropriate because the benefits would outweigh the risks. The current assessment used to determine whether someone receives sufficient benefit from their hearing aids (the BKB sentence test) does not adequately assess the difficulties with listening that adults and children experience in everyday life.” Further that “Assessment procedures should be chosen based on evidence that they are reliable and valid for determining candidacy for cochlear implantation” While Vickers et al., (2016b,) in reviewing the evidence has stated “those working in the cochlear implant (CI) field in the UK believe that the guidelines for candidacy no longer reflect the entire population of patients that the BCIG and the UK implant field consider to be potential CI candidates. There is a clear need to review these guidelines in light of new evidence,”
### Research

| Arnoldner, C., Lin, V.  
Expanded selection criteria in adult cochlear Implantation. Cochlear implants international, November 2013. | The past decade of CI has shown a remarkable improvement of performance of the average cochlear implant recipient. This has led to an expansion of selection criteria for different types and degrees hearing impairment. With these new expanded selection criteria, the breadth and reach of the positive impact of cochlear implants on individuals with hearing loss grows and clinicians and surgeons should target remaining contraindications for cochlear implant surgery and critically ask whether those individuals may benefit as well. |
|---|---|
| Amoodi HA, Mick PT, Shipp DB, Friesen LM, Nedzelski JM, Chen JM, Lin VY  
Results with cochlear implantation in adults with speech recognition scores exceeding current criteria. Otol Neurotol. 2012 Jan;33(1):6-12. | OBJECTIVES:  
The primary purpose of this study was to evaluate a group of postlingually deafened adults, whose aided speech recognition exceeded commonly accepted candidacy criteria for implantation. The study aimed to define performance and qualitative outcomes of cochlear implants in these individuals compared with their optimally fitted hearing aid(s).  
STUDY DESIGN:  
Retrospective case series.  
SETTING:  
Tertiary referral center.  
PATIENTS:  
All postlingually deafened subjects (N = 27), who were unsuccessful hearing aid users implanted between 2000 and 2010 with a preimplantation Hearing in Noise Test (HINT) score of 60% or more were included.  
INTERVENTION:  
We compared patients' preoperative performance (HINT score) with hearing aids to postoperative performance with the cochlear implant after 12 months of device use. In addition, the Hearing Handicap Inventory questionnaire was used to quantify the hearing-related handicap change perceived after the implantation.  
RESULTS:  
The study group demonstrated significant postoperative improvement on all outcome measures; most notably, the mean HINT score improved from 68.4% (standard deviation, 8.3) to 91.9% (standard deviation, 9.7). Additionally, there was a significant improvement in hearing-related handicap perceived by all patients.  
CONCLUSION:  
The envelope of implantation candidacy criteria continues to expand as shown by this study's cohort. Patient satisfaction and speech recognition results are very encouraging in support of treating those who currently perform at a level above the conventional candidacy threshold but struggle with optimally fitted hearing aids. |
To date, improved hearing outcomes have been achieved by improvements in: speech processing strategies; microphone technology; pre-processing strategies; electrode placement; bilateral implantation; use of a hearing aid in the opposite ear (bimodal stimulation); and the combination of electric and acoustic stimulation in the same ear. The resulting expansion of CI candidacy, with more residual hearing, further improves the outcomes achieved. Largely facilitated by advances in electronic capability and computerization, it can be expected that these improvements will continue.

Consensus statement at [https://www.cicandidacy.co.uk/](https://www.cicandidacy.co.uk/); Expanding candidacy to include some groups of adults and children with less profound forms of hearing loss would be appropriate because the benefits would outweigh the risks. The current assessment used to determine whether someone receives sufficient benefit from their hearing aids (the BKB sentence test) does not adequately assess the difficulties with listening that adults and children experience in everyday life. The process to determine whether someone receives sufficient benefit from their hearing aids should be revised to better assess real-world listening difficulties.

Assessment procedures should be chosen based on evidence that they are reliable and valid for determining candidacy for cochlear implantation. Different procedures may therefore need to be adopted for different subgroups of patients who are potential candidates.

Twenty years ago, cochlear implants (CI) were indicated only in cases of profound hearing loss or complete deafness. While from today's perspective the technology was clumsy and provided patients with only limited speech comprehension in quiet scenarios, successive advances in CI technology and the consequent substantial hearing improvements over time have since then resulted in continuous relaxation of indication criteria toward residual hearing. While achievements in implant and processor electronics have been one key factor for the ever-improving hearing performance, development of electro-acoustic CI systems-together with atraumatic implantation concepts-has led to enormous improvements in patients with low-frequency residual hearing. Manufacturers have designed special processors with integrated hearing aid components for this patient group, which are capable of conveying acoustic and electric stimulation. A further milestone in improvement of hearing in challenging listening environments was the adoption of signal enhancement algorithms and assistive listening devices from the hearing aid industry. This article gives an overview of the current state of the art in the abovementioned areas of CI technology.

Traditionally, children are cochlear implant (CI) candidates if bilateral severe to profound hearing loss is present and amplification benefit is limited. The current study investigated abilities of adolescents with asymmetric...

hearing loss (one ear with severe to profound hearing loss and better hearing contralaterally), where the poorer ear received a CI and the better ear maintained amplification.

STUDY DESIGN:
Within-subject case study.

SETTING:
Pediatric hospital, outpatient clinic.

PATIENTS:
Participants were 5 adolescents who had not met traditional CI candidacy because of one better hearing ear but did have 1 ear that met criteria and was implanted. All maintained hearing aid (HA) use in the contralateral ear. In the poorer ear, before implant, 3 participants had used amplification, and the other 2 had no HA experience.

MAIN OUTCOME MEASURE:
Participants were assessed in 3 listening conditions: HA alone, CI alone, and both devices together (bimodal) for speech recognition in quiet and noise and sound localization.

RESULTS:
Three participants had CI open-set speech recognition and significant bimodal improvement for speech recognition and localization compared with the HA or CI alone. Two participants had no CI speech recognition and limited bimodal improvement.

CONCLUSION:
Some adolescents with asymmetric hearing loss who are not typical CI candidates can benefit from a CI in the poorer ear, compared with a HA in the better ear alone. Additional study is needed to determine outcomes for this population, especially those who have early onset profound hearing loss in one ear and limited HA experience.


Objectives/Hypothesis

Current postoperative clinical outcome measures for adults receiving cochlear implants (CIs) consist of testing speech recognition, primarily under quiet conditions. However, it is strongly suspected that results on these measures may not adequately reflect patients' quality of life (QOL) using their implants. This study aimed to evaluate whether QOL for CI users depends on speech recognition performance.

Study Design

Twenty-three postlingually deafened adults with CIs were assessed.

Methods
Participants were tested for speech recognition (Central Institute for the Deaf word and AzBio sentence recognition in quiet) and completed three QOL measures—the Nijmegen Cochlear Implant Questionnaire; either the Hearing Handicap Inventory for Adults or the Hearing Handicap Inventory for the Elderly; and the Speech, Spatial and Qualities of Hearing Scale questionnaires—to assess a variety of QOL factors. Correlations were sought between speech recognition and QOL scores. Demographics, audiologic history, language, and cognitive skills were also examined as potential predictors of QOL.

Results

Only a few QOL scores significantly correlated with postoperative sentence or word recognition in quiet, and correlations were primarily isolated to speech-related subscales on QOL measures. Poorer pre- and postoperative unaided hearing predicted better QOL. Socioeconomic status, duration of deafness, age at implantation, duration of CI use, reading ability, vocabulary size, and cognitive status did not consistently predict QOL scores.

Conclusion

For adult, postlingually deafened CI users, clinical speech recognition measures in quiet do not correlate broadly with QOL. Results suggest the need for additional outcome measures of the benefits and limitations of cochlear implantation.


STUDY DESIGN:
Retrospective case series.

SETTING:
Two tertiary academic cochlear implant centers.

PATIENTS:
All pediatric patients that underwent cochlear implantation were reviewed. Only those meeting one or both of the following criteria were included: (1) less severe hearing loss than specified in the current indications and (2) open-set word and/or sentence recognition scores greater than 30% for children who are able to participate in speech perception testing. Patients with auditory neuropathy were excluded.

INTERVENTION(S):
Cochlear implantation.

MAIN OUTCOME MEASURES:
Pre- and postoperative results of age appropriate speech recognition tests, auditory questionnaires, and standardized norm-referenced estimates of speech and language development.

RESULTS:
A total of 51 patients met study criteria. The mean age at time of surgery was 8.3 years and 24% underwent bilateral sequential implantation. Overall, the mean speech recognition improvement was 63 percentage points in the implanted ear (p < 0.001) and 40 percentage points in the bimodal condition (p < 0.001). Results of auditory and language development measures revealed significant improvement after implantation (p < 0.05).

CONCLUSION: Non-traditional paediatric implant recipients derive significant benefit from cochlear implantation. A large-scale reassessment of paediatric cochlear implant candidacy, including less severe hearing losses and higher preoperative speech recognition, is warranted to allow more children access to the benefits of cochlear implantation.


OBJECTIVE: Currently, there is a paucity of literature evaluating hearing preservation outcomes in children following cochlear implantation. The objective of the current study is to report pediatric hearing preservation results following cochlear implantation with conventional full-length electrodes.

STUDY DESIGN: Retrospective review (2000-2016).

SETTING: Tertiary referral center.

PATIENTS: All pediatric patients with a ≤75 dB preoperative low-frequency pure tone average (LFPTA; 250-500 Hz average), who underwent cochlear implantation with a conventional length electrode.

INTERVENTION(S): Cochlear implantation.

MAIN OUTCOME MEASURE(S): Complete, partial, minimal, or no hearing preservation following cochlear implantation (Skarzynski et al., 2013); maintenance of functional low frequency hearing (≤85 dB LFPTA).

RESULTS: A total of 43 ears, in 35 pediatric patients, met inclusion criteria. The mean age at time of implantation was 8.6 years (range, 1.4-17.8 yr), 20 (57.1%) patients were female, and 25 (58.1%) cases were left-sided. The mean preoperative ipsilateral low frequency PTA and conventional four-frequency PTA (500, 1000, 2000, 3000 Hz average) were 54.2 dB (range, 15-75 dB) and 82.2 dB (range, 25-102.5 dB), respectively. The mean low frequency PTA and conventional four-frequency PTA shifts comparing the pre- and first postoperative audiogram were Δ25.2 dB (range, -5 to 92.5 dB) and Δ18.3 dB (range, -8.8 to 100 dB), respectively. Overall, 17 (39.5%) ears demonstrated complete hearing preservation, 19 (44.2%) ears partial hearing preservation, 0 minimal hearing...
preservation, and 7 (16.3%) exhibited no measurable acoustic hearing after surgery. In total, 28 (65.1%) ears maintained functional low-frequency hearing (i.e., ≤85 dB LFPTA) based on the initial postoperative audiogram. There was no statistically significant difference in the initial low frequency PTA shift comparing lateral wall and perimodiolar electrodes (Δ22.2 versus Δ28.1 respectively; p = 0.44), cochleostomy and round window insertions (Δ25.2 vs. Δ24.7 respectively; p = 0.95), or statistically significant association between age at implantation and low frequency PTA shift (r = 0.174; p = 0.26). In total, 22 ears in 19 patients had serial audiometric data available for review. Over a mean duration of 43.8 months (range, 2.6-108.3 mo) following surgery, the mean low frequency PTA and conventional four-frequency PTA shift comparing the initial postoperative and most recent postoperative audiogram was Δ9.7 dB (range, -27.5 to 57.5 dB) and Δ8.1 dB (range, -18.8 to 31.9 dB), respectively.

**CONCLUSIONS:**
Varying levels of hearing preservation with conventional length electrodes can be achieved in most pediatric subjects. In the current study, 82% of patients maintained detectable hearing thresholds and 65% maintained functional low-frequency acoustic hearing. These data may be used to guide preoperative counseling in pediatric patients with residual acoustic hearing. Additionally, the favorable rates of hearing preservation achieved in children provide further evidence for the expansion of pediatric cochlear implant candidacy to include patients with greater degrees of residual hearing.

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<td>Chundu, S., Flynn, S.L. 2014. Audiogram and cochlear implant candidacy – UK perspective. Cochlear Implants International, 15(4): 241–244.</td>
<td>Cochlear implant candidacy should be individually based and needs to take into account other factors such as work, quality of life, and social impact rather than just adhering to the pure-tone audiometry guidelines. These guidelines should not be considered as strict criteria nor used to deny the benefit of a cochlear implant at the earliest possible opportunity.</td>
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<td>Doran, M. &amp; Jenkinson, L. Mono-syllabic word test score as a pre-operative assessment criterion for cochlear implant candidacy in adults with acquired hearing loss Cochlear Implants International Vol. 17, Iss. sup1,2016</td>
<td>The review of data for the North Wales CI programme identified a pre-operative score of 15% in AB word test as a suitable and conservative cut-off criterion for CI candidacy. The new AB word criterion was adopted in addition to the existing BKB criterion and was used for counselling on potential outcome benefits for candidates with a profound hearing loss at 2 and 4 kHz who gain &gt; 50% on BKB sentence testing.</td>
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<td>Dowell R, C. (2012) Evidence about the effectiveness of Cochlear implants in adults. In: Wong L, Hickson L, editors. Evidence- Based Practice in Audiology.</td>
<td>Reviewed of the evidence supporting the growing effectiveness of cochlear implants over the past several decades found that average open sentence set identification averaged less than 40% for sound processors in the 1990s compared to an average 80% correct score with modern technology, even without visual cues.</td>
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**Objectives:**
To propose categories for the various types of residual hearing in children and to review the outcomes of cochlear implantation (CI) in children with these different hearing conditions.

**Methods:**
We identified 53 children with residual hearing who had received a cochlear implant. Five groups were arbitrarily defined based on auditory features: G1, characterized by low-frequency residual hearing (n = 5); G2, characterized by severe sensorineural hearing loss (SNHL) and low speech discrimination (n = 12); G3, characterized by asymmetric SNHL (n = 9); G4, characterized by progressive SNHL (n = 15); and G5, characterized by fluctuating SNHL (n = 12). The main audiometric features and outcomes of the groups were analyzed.

**Results:**
The mean age at implantation was 10.15 years (range, 2.5-21 years). The mean preoperative score for the discrimination of open-set words was 48%; this score increased to 74% at 12 months and 81% at 24 months after the CI procedure (G1 to G5, respectively: 79/62/77%, 50/81/88%, 59/75/86%, 35/74/67%, and 39/69/80%). Children who were implanted after 10 years of age did not improve as much as those who were implanted at a younger age (open-set word list speech perception [OSW] score at 12 months: 62% vs 83%; P = .0009). Shorter delays before surgery were predictive of better performance (P = .003). Inner ear malformation and SLC26A4 mutations were not predictive of the outcome.

**Conclusions:**
CIs provide better results compared with hearing aids in children with residual hearing. Factors that may impact the benefits of CIs in patients with residual hearing are age, delay in performing the CI procedure, which ear is implanted, and initial underestimation of the patient’s hearing difficulties.

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**Abstract**
This study examined whether audiologists consider the potential benefits of contralateral hearing aid use following cochlear implantation when recommending which ear to implant in UK adult candidates with residual hearing. Thirty-four audiologists from providers of adult implantation services completed a decision-choice experiment. Clinicians were willing to consider recommending that the poorer ear be implanted, provided it had been aided continuously, suggesting that their decision making seeks to preserve access to residual hearing.
Future approaches to determining candidacy should therefore consider that a sub-set of patients may obtain additional benefit from this residual hearing following implantation.

Since the publication of the NICE guidance in 2009, there has been a significant increase in reported contralateral HA use among adult unilateral CI users. As a result, there may now be many more CI users who benefit from simultaneous access to electric and acoustic information. It may therefore be appropriate to consider a patient’s capacity to exploit their residual hearing following implantation when assessing candidacy for implantation.

OBJECTIVES: Cochlear implantation as a treatment for UHL is on the rise yet little is known about factors that could impact performance or whether there is a group at risk for poor cochlear implant outcomes when hearing is near-normal in one ear. The overall goal of our research is to investigate the range and source of variability in speech recognition in noise and localization among individuals with severe to profound UHL and thereby help determine factors relevant to decisions regarding cochlear implantation in this population.

DESIGN: The present study evaluated adults with severe to profound UHL and adults with bilateral normal hearing. Measures included adaptive sentence understanding in diffuse restaurant noise, localization, roving-source speech recognition (words from 1 of 15 speakers in a 140° arc), and an adaptive speech-reception threshold psychoacoustic task with varied noise types and noise-source locations. There were three age-sex-matched groups: UHL (severe to profound hearing loss in one ear and normal hearing in the contralateral ear), normal hearing listening bilaterally, and normal hearing listening unilaterally.

RESULTS: Although the normal-hearing-bilateral group scored significantly better and had less performance variability than UHLs on all measures, some UHL participants scored within the range of the normal-hearing-bilateral group on all measures. The normal-hearing participants listening unilaterally had better monosyllabic word understanding than UHLs for words presented on the blocked/deaf side but not the open/hearing side. In contrast, UHLs localized better than the normal-hearing unilateral listeners for stimuli on the open/hearing side but not the blocked/deaf side. This suggests that UHLs had learned strategies for improved localization on the side of the intact ear. The UHL and unilateral normal-hearing participant groups were not significantly different for speech in noise measures. UHL participants with childhood rather than recent hearing loss onset localized significantly better; however, these two groups did not differ for speech recognition in noise. Age at onset in
UHL adults appear to affect localization ability differently than understanding speech in noise. Hearing thresholds were significantly correlated with speech recognition for UHL participants but not the other two groups.

CONCLUSIONS:
Auditory abilities of UHLs varied widely and could be explained only in part by hearing threshold levels. Age at onset and length of hearing loss influenced performance on some, but not all measures. Results support the need for a revised and diverse set of clinical measures, including sound localization, understanding speech in varied environments, and careful consideration of functional abilities as individuals with severe to profound UHL are being considered potential cochlear implant candidates.


OBJECTIVE:
To evaluate the communication-related outcomes and health-related QOL outcomes after unilateral or bilateral cochlear implantation in adults with sensorineural hearing loss.

DATA SOURCES:
MEDLINE, Cochrane Central Register of Controlled Trials, Scopus, and previous reports from January 1, 2004, through May 31, 2012.

STUDY SELECTION:
Published studies of adult patients undergoing unilateral or bilateral procedures with multichannel cochlear implants and assessments using open-set sentence tests, multisyllable word tests, or QOL measures.

DATA EXTRACTION:
Five researchers extracted information on population characteristics, outcomes of interest, and study design and assessed the studies for risk of bias. Discrepancies were resolved by consensus.

RESULTS:
A total of 42 studies met the inclusion criteria. Most unilateral implant studies showed a statistically significant improvement in mean speech scores as measured by open-set sentence or multisyllable word tests; meta-analysis revealed a significant improvement in QOL after unilateral implantation. Results from studies assessing bilateral implantation showed improvement in communication-related outcomes compared with unilateral implantation and additional improvements in sound localization compared with unilateral device use or implantation only. Based on a few studies, the QOL outcomes varied across tests after bilateral implantation.

CONCLUSIONS AND RELEVANCE:
Unilateral cochlear implants provide improved hearing and significantly improve QOL, and improvements in sound localization are noted for bilateral implantation. Future studies of longer duration, higher-quality reporting, and large databases or registries of patients with long-term follow-up data are needed to yield stronger evidence.

**OBJECTIVES:**
The primary objective of this study was to determine whether a revision and/or expansion of current audiologic cochlear implant candidacy criteria is warranted.

**DESIGN:**
The study design was a retrospective review of postoperative speech perception performance for 22 adult cochlear implant recipients who demonstrated preoperative Consonant Nucleus Consonant word recognition scores of 30% or higher in the best-aided condition. This criterion was chosen to exceed that specified by the North American clinical trial of the Nucleus Freedom cochlear implant system.

**RESULTS:**
The mean preoperative best-aided monosyllabic word score for the 22 patients was 41% correct. The degree of postoperative benefit for the best postoperative condition (electric only or bimodal) ranged from 10 to 68 percentage points with a mean benefit of 27 percentage points for the electric-only condition and 40 percentage points for the bimodal condition. Statistical analyses revealed highly significant differences between preoperative-aided, implant-only, and bimodal performance on Consonant Nucleus Consonant monosyllabic word recognition performance. That is, both postoperative scores -- electric only and bimodal -- were significantly different from one another and from the preoperative best-aided performance.

**CONCLUSIONS:**
The current results suggest that a large-scale reassessment of manufacturer and Medicare preoperative audiologic candidacy criteria for adults is warranted to allow more hearing-impaired individuals to take advantage of the benefits offered by cochlear implantation.


The purpose of the current study was to provide information on the pre-operative psychophysical characteristics of low-frequency hearing and speech recognition abilities, and on the resultant postoperative speech recognition and associated benefit from cochlear implantation. The current preoperative data for the 16 listeners receiving cochlear implants demonstrate: 1) reduced or absent nonlinear cochlear processing at 500 Hz, 2) impaired frequency selectivity at 500 Hz, 3) normal temporal resolution at low modulation rates for a 500-Hz carrier, 4) poor speech recognition in a modulated background, and 5) highly variable speech recognition (from 0 to over 60% correct) for monosyllables in the bilaterally aided condition. As reported previously, measures of auditory function were not significantly correlated with pre- or post-operative speech recognition - with the exception of nonlinear cochlear processing and preoperative sentence recognition in quiet (p=0.008) and at +10 dB SNR (p=0.007). These correlations, however, were driven by the data obtained from two listeners who had the highest degree of nonlinearity and preoperative sentence recognition. All estimates of postoperative speech recognition performance were significantly higher than preoperative estimates for both the ear that was implanted (p<0.001) as well as for the best-aided condition (p<0.001). It can
be concluded that older individuals with mild sloping to profound sensory hearing loss have very little to no residual nonlinear cochlear function, resulting in impaired frequency selectivity as well as poor speech recognition in modulated noise. These same individuals exhibit highly significant improvement in speech recognition in both quiet and noise following cochlear implantation. For older individuals with mild to profound sensorineural hearing loss who have difficulty in speech recognition with appropriately fitted hearing aids, there is little to lose in terms of psychoacoustic processing in the low-frequency region and much to gain with respect to speech recognition and overall communication benefit. These data further support the need to consider factors beyond the audiogram in determining cochlear implant candidacy, as older individuals with relatively good low-frequency hearing may exhibit vastly different speech perception abilities - illustrating the point that signal audibility is not a reliable predictor of performance on supra-threshold tasks such as speech recognition.


OBJECTIVES/HYPOTHESIS:
Determining cochlear implant candidacy requires a specific sentence-level testing paradigm in best-aided conditions. Our objective was to determine if findings on routine audiometry could predict the results of a formal cochlear implant candidacy evaluation. We hypothesize that findings on routine audiometry will accurately predict cochlear implant evaluation results in the majority of candidates.

STUDY DESIGN:
Retrospective, observational, diagnostic study.

METHODS:
The charts of all adult patients who were evaluated for implant candidacy at a tertiary care center from June 2008 through June 2013 were included. Routine, unaided audioligic measures (pure-tone hearing thresholds and recorded monosyllabic word recognition testing) were then correlated with best-aided sentence-level discrimination testing (using either the Hearing in Noise Test or AzBio sentences test).

RESULTS:
The degree of hearing loss at 250 to 4,000 Hz and monosyllabic word recognition scores significantly correlated with sentence-level word discrimination test results. Extrapolating from this association, we found that 86% of patients with monosyllabic word recognition scores at or below 32% (or 44% for patients with private insurance) would meet candidacy requirements for cochlear implantation.

CONCLUSIONS:
Routine audiometric findings can be used to identify patients who are likely to meet cochlear implant candidacy upon formal testing. For example, patients with pure-tone thresholds (250, 500, 1,000 Hz) of ≥75 dB and/or a monosyllabic word recognition test score of ≤40% have a high likelihood of meeting candidacy criteria. Utilization of these predictive patterns during routine audiometric evaluation may assist hearing health professionals in deciding when to refer patients for a formal cochlear implant evaluation.
The purpose of this clinical report is to present case studies of children who are non-traditional candidates for cochlear implantation because they have significant residual hearing in one ear and to describe outcomes and considerations for their audiological management and habilitation.

**METHOD:**

Case information is presented for 5 children with profound hearing loss in one ear and normal or mild-to-moderate hearing loss in the opposite ear and who have undergone unilateral cochlear implantation. Pre- and postoperative assessments were performed per typical clinic routines with modifications described. Post-implant habilitation was customized for each recipient using a combination of traditional methods, newer technologies, and commercial materials.

**RESULTS:**

The 5 children included in this report are consistent users of their cochlear implants and demonstrate speech recognition in the implanted ear when isolated from the better hearing ear.

**CONCLUSIONS:**

Candidacy criteria for cochlear implantation are evolving. Children with single-sided deafness or asymmetric hearing loss who have traditionally not been considered candidates for cochlear implantation should be evaluated on a case-by-case basis. Audiological management of these recipients is not vastly different compared with children who are traditional cochlear implant recipients. Assessment and habilitation techniques must be modified.

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Hanvey, K. Ambler, M. Maggs, J. & Wilson, K. Criteria versus guidelines: Are we doing the best for our paediatric patients? Cochlear Implants International Vol. 17, Iss. sup1,2016

**Method**

Cases were selected through a database search of patients who have pre-implant data reflective of most recent clinical practice. However, some cases are rare (e.g. reverse-slope hearing loss) and therefore the database search spanned patients assessed and implanted between 2010 and 2015. Information provided by the whole multi-disciplinary team, including the child (where appropriate), family, and local support team, was collected and collated for this review. For the purposes of this paper, children who have audiometric thresholds at 90 dB HL or greater at 2 and 4 kHz were categorised as being ‘in criteria’. Children whose audiometric thresholds are better than 90 dB HL at 2 and 4 kHz were categorised as being ‘out of criteria’.

**Discussion**

An approach of establishing candidacy criteria solely on the basis of audiometric thresholds does not account for the limited test–retest reliability of audiological measurements or a child’s functional performance. This would appear to contradict NICE guidance. Section 4.3.2 states ‘The Committee concluded that decisions about the appropriateness of CI should take into consideration a person's functional hearing and the benefit they gain...’
from acoustic hearing aids.’ Additionally, section 4.3.3 states ‘[...] The Committee heard that tests for children should assess whether speech, language and listening skills are appropriate to the age, development stage and cognitive ability of the child.’ One could therefore argue that NICE guidelines allow for a certain level of flexibility which permit other relevant clinical findings to be considered, such as those described in the four case studies in this paper.

Public health funding bodies in the UK have an extremely difficult task when making decisions about how to interpret NICE guidance to form criteria. Further clinical evidence is required to give funding bodies confidence to recognise more flexible criteria which remain within the guidance. For children, this evidence could be provided through the use of: (a) clinical tools that provide information about a child’s ability to discriminate between sounds rather than just detect the presence of sound (e.g. ASSE); (b) clinical tools that provide an indication of the audibility of sound (e.g. aided SII); and (c) age-appropriate language assessments. Increased confidence in clinical decision making would allow children who are currently out of audiological criteria to be fitted with CIs where a multi-disciplinary assessment has concluded that a child’s progress is being limited through inadequate amplification.

Conclusion

Clinical recommendations should be based on thorough, appropriately experienced, multi-disciplinary assessment, where the best interests of the child are at the centre of decision making. Further research is recommended to explore the advantages of CI for children who are unable to reach their potential with hearing aids.


OBJECTIVE:
This study examined whether cochlear implant (CI) recipients with substantial preoperative residual hearing obtained more benefit from a CI than from a hearing aid (HA).

STUDY DESIGN:
Retrospective records review.

SETTING:
Tertiary referral center.

PATIENTS:
Thirty-seven CI recipients (11 children/teens, 26 adults) were identified that met the following inclusion criteria: preimplant sentence recognition scores greater than 50% correct in the implanted ear or greater than 60% in the best-aided/binaural condition (Group 1, n = 18); audiometric thresholds less than 70 dB HL at 2 or more
frequencies (i.e., better than a severe-profound hearing loss; Group 2, \( n = 13 \) ears in 12 recipients), or those that met both the audiometric and sentence-recognition criteria (Group 3, \( n = 7 \)).

**MAIN OUTCOME MEASURE:**
Postimplant speech-perception scores.

**RESULTS:**
Postimplant speech perception was substantially better than the preimplant performance for 12 of 18 recipients in Group 1, 10 of 12 recipients (11/13 ears) in Group 2, and 5 of 7 recipients in Group 3 (total, 73.7%). Five recipients (13.1%) showed no change from preimplant performance levels. Results were inconclusive for 2 recipients (5.3%) because preimplant versus postimplant testing was conducted in different conditions. Three recipients (7.9%) exhibited decreased performance postimplant.

**CONCLUSION:**
For most recipients whose hearing was better than that defined by traditional candidacy criteria, performance improved with the CI. These results may help clinicians guide candidates in the decision-making process by providing information on the range of outcomes for recipients with similar preimplant performance levels, identify the need for additional preimplant counseling regarding expectations, and recognize the importance of systematizing preimplant and postimplant testing for longitudinal assessment of performance.

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<th>Reference</th>
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<tr>
<td>Haumann, S., Hohmann, V., Meis, M., Herzke, T., Lenarz, T., Büchner, A. 2012. Indication criteria for cochlear implants and hearing aids: impact of audiological and non-audiological findings. Audiology Research, 2: e12.</td>
<td>Owing to technological progress and a growing body of clinical experience, indication criteria for cochlear implants (CI) are being extended to less severe hearing impairments. It is, therefore, worth reconsidering these indication criteria by introducing novel testing procedures. The diagnostic evidence collected will be evaluated. The investigation includes postlingually deafened adults seeking a CI. Prior to surgery, speech perception tests [Freiburg Speech Test and Oldenburg sentence (OLSA) test] were performed unaided and aided using the Oldenburg Master Hearing Aid (MHA) system. Linguistic skills were assessed with the visual Text Reception Threshold (TRT) test, and general state of health, socio-economic status (SES) and subjective hearing were evaluated through questionnaires. After surgery, the speech tests were repeated aided with a CI. To date, 97 complete data sets are available for evaluation. Statistical analyses showed significant correlations between postsurgical speech reception threshold (SRT) measured with the adaptive OLSA test and pre-surgical data such as the TRT test ( (r=0.29) ), SES ( (r=0.22) ) and (if available) aided SRT ( (r=0.53) ). The results suggest that new measures and setups such as the TRT test, SES and speech perception with the MHA provide valuable extra information regarding indication for CI.</td>
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Advances in hearing technology offer patients with hearing loss even better ways to improve communication and quality of life. Hearing devices are more convenient and compatible than ever, with wireless connectivity to smartphones and lithium-ion rechargeable batteries, while improved surgical techniques widen the candidacy... |
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<th><strong>Pádraig T. K. &amp; Lucas, L.</strong></th>
<th><strong>Objective:</strong> Unilateral deafness and highly asymmetric hearing loss can impair listening abilities in everyday situations, create substantial audiological handicap, and reduce overall quality of life. Preliminary evidence suggests that cochlear implantation may be effective in reversing some of these detrimental effects. Patient-level data from existing studies were re-analysed to explore potential factors that may be predictive of improved speech perception scores following implantation.</th>
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<td><strong>Predicting speech perception outcomes following cochlear implantation in adults with unilateral deafness or highly asymmetric hearing loss</strong></td>
<td><strong>Methods:</strong> Logistic regression modelling examined whether improved speech perception following implantation under various listening conditions was related to the duration of deafness of the severe-to-profoundly deaf ear and/or the level of hearing in the better ear.</td>
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<td><strong>Cochlear Implants International Vol. 17, Iss. sup1,2016</strong></td>
<td><strong>Results:</strong> Patients with a shorter duration of deafness were more likely to improve in listening conditions that created a less favourable SNR at the implanted ear than the non-implanted ear. Those with more residual hearing in the better ear were more likely to improve in the listening condition that created a less favourable SNR at that ear.</td>
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<td><strong>Discussion:</strong> The analysis suggests that characteristics of both ears may be relevant when seeking to identify those candidates who are likely to obtain benefit to speech perception following cochlear implantation.</td>
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<th><strong>Lamb, B.</strong></th>
<th><strong>Expert opinion: Can different assessments be used to overcome current candidacy issues?</strong> Cochlear Implants International Vol. 17, Iss. sup1,2016</th>
<th>**The recommendation for a CI should be always based on functional hearing, taking into account the difficulties faced by the patients and their families in real-life situations rather than strictly adhering to the audiological criteria. Further, the current testing needs review and supplementing with more refined measures, including PROMS, and a lower threshold for testing where 80 dB HL has also been suggested given the evidence of gains outside of the current criteria and for specific groups of patients. Taken together this suggests that NICE needs to urgently review its current guidelines so that more people can benefit from this technology. A more sophisticated analysis would show that increased candidacy would save the NHS money if the wider costs of disability and illness are taken into account.</th>
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<td><strong>Leal, C., Marriage, J., Vickers, D. 2016.</strong></td>
<td><strong>Evaluating recommended audiometric changes to candidacy using the Speech Intelligibility Index.</strong> Cochlear Implants International, 17(S1).</td>
<td><strong>In this study, we analysed aided SII scores derived for different hearing loss profiles falling within the current 90 dB HL criteria and equivalent profiles falling within the new 80 dB HL criteria.</strong></td>
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<td><strong>In this study, we analysed aided SII scores derived for different hearing loss profiles falling within the current 90 dB HL criteria and equivalent profiles falling within the new 80 dB HL criteria.</strong></td>
<td><strong>Results:</strong> The aided SII scores demonstrated that the majority of potential hearing configurations falling within the new proposed 80 dB HL criteria have aided SII values of less than 0.65 (a recommended cut-off point below which there is not sufficient audibility to receive adequate benefit through hearing aids).</td>
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<td><strong>Leigh JR, Moran M, Hollow R, Dowell RC. (2016) Evidence-based guidelines for recommending cochlear implantation for postlingually deafened adults. Int J Audiol. 2016;55 Suppl 2:S3-8.</strong></td>
<td><strong>Objective:</strong> Adult selection criteria for cochlear implantation have been developed based on analysis of the post-operative performance of a large group of postlingually deafened adults. Original criteria published in 2004 were reviewed and amended to reflect outcomes currently being achieved by implant recipients. <strong>Design:</strong> Retrospective review of 12-month post-operative speech perception performance of adults implanted at the Eye and Ear Hospital, Melbourne, Australia. <strong>Study sample:</strong> A total of 382 postlingually deafened adults, using a Freedom, Nucleus 5, or CI422 Slim Straight cochlear implant were used to create a comparative set of data. <strong>Results:</strong> Revised guidelines suggest that adults with postlingual hearing loss can now be considered cochlear implant candidates if they obtain scores of up to 55% for open-set phonemes in quiet in the ear to be implanted. <strong>Functional benefit may vary depending on the recipients’ contralateral hearing. Conclusions:</strong> This study supports the provision of cochlear implants to candidates with significant residual hearing when at least one ear meets the criterion outlined above. Patient-specific counseling is required to ensure the potential to benefit predicted by the current model is acceptable to the individual patient and their family. Counseling regarding functional benefit must take into consideration hearing in the contralateral ear.</td>
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<td><strong>Lenarz M, Joseph G, Sönmez H, Büchner A, Lenarz T. Effect of technological advances on cochlear implant performance in adults. Laryngoscope. 2011 Dec;121(12):2634-40. doi: 10.1002/lary.22377.</strong></td>
<td><strong>OBJECTIVES/HYPOTHESIS:</strong> To evaluate the effect of technological advances in the past 20 years on the hearing performance of a large cohort of adult cochlear implant (CI) patients. <strong>STUDY DESIGN:</strong> Individual, retrospective, cohort study. <strong>METHODS:</strong> According to technological developments in electrode design and speech-processing strategies, we defined five virtual intervals on the time scale between 1984 and 2008. A cohort of 1,005 postlingually deafened adults was selected for this study, and their hearing performance with a CI was evaluated retrospectively according to these five technological intervals. The test battery was composed of four standard German speech tests:**</td>
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<td><strong>RESULTS:</strong> The direct comparison of the speech perception in postlingually deafened adults, who were implanted during different technological periods, reveals an obvious improvement in the speech perception in patients who benefited from the recent electrode designs and speech-processing strategies. The major influence of technological advances on CI performance seems to be on speech perception in noise. <strong>CONCLUSIONS:</strong> Better speech perception in noisy surroundings is strong proof for demonstrating the success rate of new electrode designs and speech-processing strategies. Standard (internationally comparable) speech tests in noise should become an obligatory part of the postoperative test battery for adult CI patients.</td>
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<th>Looi, V. Bluett, C &amp; Boisvert, I. Referral rates of postlingually deafened adult hearing aid users for a cochlear implant candidacy assessment. International Journal of Audiology published online 5th July</th>
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<tr>
<td><strong>Objective:</strong> The aims of this study were: to investigate the referral rates of postlingually deafened adult cochlear implant (CI) candidates from a hearing aid (HA) clinic for a CI candidacy assessment and to gain insight about factors influencing the referral pathways to CI assessments. <strong>Design:</strong> Two methodologies were used: a retrospective cohort study reviewing clinical files and a questionnaire to clinicians. <strong>Study sample:</strong> The files of 1249 adult clients from the HA clinic who had average puretone hearing thresholds greater or equal to 65 dB HL in the better hearing ear and unaided phoneme recognition scores of less than 50% in both ears were reviewed. All of the clinicians completed the online questionnaire. <strong>Results:</strong> Eighteen adults met the CI candidacy criteria, of whom 16 (89%) had a CI discussion with their audiologist, with 11 (61%) being referred for a CI evaluation. Of these 11, four proceeded to implantation. Questionnaire responses revealed the need for better information on candidacy and referral guidelines for HA and CI clinics. <strong>Conclusions:</strong> Overall the results indicate that the referral pathway to obtain a CI assessment is a barrier contributing to the low CI penetration rate in adults. (Not clear what country but given threshold info thought it was useful?)</td>
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<th>McRackan, T. R., Bauschard, M., Hatch, J. L., Franko-Tobin, E., Droghini, H. R.,</th>
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<td><strong>Objectives</strong> Determine the impact of cochlear implantation on quality of life (QOL) and determine the correlation between</td>
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<td>Nguyen, S. A. and Dubno, J. R. (2017), Meta-analysis of quality-of-life improvement after cochlear implantation and associations with speech recognition abilities. The Laryngoscope. July 2017.</td>
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<tr>
<td>Ng, Z, Y. Lamb, B. Harrigan, S. Archbold, S. Athalye S Allen, S. Perspectives of adults with cochlear implants on current CI services and daily life. Cochlear Implants International Vol. 17, Iss. sup1, 2016</td>
</tr>
<tr>
<td>O’Neill, C., Lamb, B., Archbold, S. (2016) Cost implications for changing candidacy or access to service within a publicly funded healthcare system? Cochlear</td>
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</table>
INTRODUCTION:
Every child and adult in the United Kingdom who fulfils the criteria for cochlear implantation is entitled to receive treatment under the National Health Service (NHS); children since 2009 are eligible for bilateral simultaneous implants and adults single implants unless they have additional sensory needs.

HISTORY:
During a period between 1982 and 1990, when a number of individual teams ran programmes using charitable funding, the British Cochlear Implant Group approached the UK Department of Health, who agreed to set up a 4-year pilot study of 10 programmes, including one children's programme. The outcomes were collected and analysed by the Medical Research Council's Institute of Hearing Research. The results, showing positive outcomes for adults and children, were published in 1995 and subsequently funding was provided directly by the NHS.

ACCESS:
Between 2001 and 2006 the Universal Newborn Hearing Screen (UNHS) was implemented in England and Wales and also in Scotland and Northern Ireland. Data from UNHS and also data from the three main cochlear implant manufacturers have allowed estimates of access to cochlear implants for children and adults within the criteria for implantation.

CHILDREN:
Between 2006 and 2011 the figures show that 74% of estimated eligible children aged 0-3 years have received implants and 94% by the age of 17.

ADULTS:
For adults the figures are considerably lower, with only about 5% of those eligible for an implant actually receiving one. The reasons for this include, to a lesser degree, the fact that guidelines by the National Institute of Clinical Excellence (NICE) are stricter than in some other European countries, but chiefly because of lack of awareness among candidates and professionals, both of criteria for eligibility and of the potential advantages from cochlear implantation.

Cochlear implant (CI) intervention is expensive and accessed mainly by developed countries. The introduction of Universal Newborn Hearing Screening and funding via a public health service give children better access to CIs. However for adults large disparities exist between utilization and estimated prevalence. In the UK CI selection criteria are restrictive compared with many other countries. Improved audiological awareness and screening programmes for adults would improve access to hearing technologies that would improve health and quality of life. Hearing loss itself has significant medical and financial burdens on society and by investing in early
intervention and using best technology this would mitigate some of the rising associated medical costs.

| **Sadadcharam, M. Warner, L. Henderson, L. Brown N. & Bruce, I. A.**
| **Unilateral cochlear implantation in children with a potentially useable contralateral ear.**
| **Cochlear Implants International Vol. 17, Iss. sup1, 2016**
| Increasingly, children are considered for a unilateral CI, even if the contralateral ear falls outside current audiological guidelines, especially if they are not considered to be reaching their educational potential. **The primary aim was to investigate the benefit of unilateral CI in children currently outside UK** [National Institute for Health and Care Excellence Technology Appraisal Guidance. 2009. Cochlear implants for children and adults with severe to profound deafness. NICE technology appraisal guidance [TAG166]. Available January 29, 2016 from http://www.nice.org.uk/ta166] audiological guidelines in the contralateral ear. The secondary aim was to measure compliance. A retrospective case review with standard demographic data was performed. Forty-seven children were identified as having received a unilateral CI with the contralateral ear falling outside of current UK audiological criteria. These children were allocated to two groups; with hearing between 50 and 70 dB, and 70 and 90 dB at 2 and 4 kHz in the contralateral ear, respectively. Categories of auditory performance (CAP) were assessed. Pre- and post-operative CAP scores demonstrated a statistically significant improvement in auditory perception. **We would suggest that assessing candidacy in individual ears and subsequent unilateral CI, has given these children a benefit they may not otherwise have acquired if they only had bilateral hearing aid.**

| **To date, the most consistent finding is that patients with greater degrees of residual hearing preoperatively perform at higher levels with cochlear implants. In children, this situation is even more complex because of greater difficulty and reduced reliability of audiologic testing in very young children. Slowly though, the data that have accumulated support the implantation of patients at increasingly younger ages and in those patients with higher degrees of residual hearing. The indications for cochlear implantation have expanded, as many unilaterally implanted individuals are able to achieve open-set word recognition.**

| **Seth R Schwartz, Stacey D Watson & Douglas D Backous**
| **Assessing candidacy for bilateral cochlear implants: A survey of practices in the United States and Canada**
| **Cochlear Implants International Vol. 13, Iss. 2, 2012.**
| **Objectives**
| **There are currently no agreed-upon criteria to establish candidacy for bilateral cochlear implants (CIs). This study categorized practice patterns for establishing bilateral CI candidacy.**

| **Methods**
| **A postal survey was sent to all practices performing CIs in the United States and Canada. The survey queried centers regarding candidacy criteria for bilateral implantation, testing parameters, definition of ‘best aided condition’, use of testing in noise, localization, and quality-of-life questionnaires. The survey was resent to non-responding centers 4 weeks after the initial mailing.**

| **Results**
The overall response rate was 40%. ‘Best aided condition’ (70%) and hearing in noise (52%) were used to establish bilateral candidacy, while 45% of centers offered bilateral implants to all candidates. The majority of respondents defined ‘best aided’ as hearing aids only (57% non-exclusive) or CI and hearing aid together (57%). Only 25% considered a CI alone as best aided. Nearly 5% considered no aiding to be the best aided. Sound localization was used by 8% of respondents for candidacy assessment. Reimbursement affected candidacy decision for 45%. There was variability in stimulus levels (60, 50, 45, and 55 dB), signal-to-noise ratios, and speaker orientations used.

Discussion

There are no consistent criteria to assess patients for bilateral CIs. This practice variation makes comparing outcomes across centers challenging and leaves open the possibility of having external standards imposed by regulators or payors. Standardization of candidacy assessment is necessary to develop best practices for bilateral cochlear implantation both to optimize patient outcomes and to ensure the continuity of coverage for these services.


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<th>Objective</th>
<th>To evaluate the use of monosyllabic word recognition versus sentence recognition to determine candidacy and long-term benefit for cochlear implantation.</th>
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<td>Study Design</td>
<td>Prospective multi-center single-subject design.</td>
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<td>Methods</td>
<td>A total of 21 adults aged 18 years and older with bilateral moderate to profound sensorineural hearing loss and low monosyllabic word scores received unilateral cochlear implantation. The consonant-nucleus-consonant (CNC) word test was the central measure of pre- and postoperative performance. Additional speech understanding tests included the Hearing in Noise Test sentences in quiet and AzBio sentences in +5 dB signal-to-noise ratio (SNR). Quality of life (QoL) was measured using the Abbreviated Profile of Hearing Aid Benefit and Health Utilities Index.</td>
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<td>Results</td>
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Performance on sentence recognition reached the ceiling of the test after only 3 months of implant use. In contrast, none of the participants in this study reached a score of 80% on CNC word recognition, even at the 12-month postoperative test interval. Measures of QoL related to hearing were also significantly improved following implantation.

**Conclusion**

Results of this study demonstrate that monosyllabic words are appropriate for determining preoperative candidate and measuring long-term postoperative speech recognition performance.

|---|
| **BACKGROUND:** Some adolescents have hearing impairments characterized by normal or slightly elevated thresholds in the low and mid-frequency bands (below 1500 Hz) and nearly total deafness in the high frequency range. These patients often remain beyond the scope of effective hearing aid treatment.  
**CASE REPORT:** This study presents the case of a 16-year-old adolescent with good hearing in the range 125-1500 Hz and deafness at other frequencies. An implant was used to restore hearing at high frequencies, while preserving low and mid frequency acoustic hearing in the implanted ear. This is described as electro-natural stimulation (ENS) of the inner ear.  
**CONCLUSIONS:** The results demonstrate that low and mid frequency hearing (up to 1500 Hz) can be preserved using the round window surgical technique. A substantial improvement in speech discrimination was also observed when electrical stimulation on one side was combined with acoustic stimulation on both sides. There is scope to extend qualifying criteria for cochlear implantation to include adolescents who are suited to ENS. |

|---|
| **Abstract**  
**OBJECTIVES:** The objective of this study was to determine the validity and clinical applicability of intelligibility of the patient’s own speech, measured via a Vowel Identification Test (VOW), as a predictor of speech perception for prelingually deafened adults after 1 year of cochlear implant use. Specifically, the objective was to investigate the probability that a prelingually deaf patient, given a VOW score above (or below) a chosen cutoff point, reaches a postimplant speech perception score above (or below) a critical value. High predictive values for VOW could support preimplant counseling and implant candidacy decisions in individual patients.  
**DESIGN:** One hundred and fifty-two adult cochlear implant candidates with prelingual hearing impairment or deafness took part as speakers in a VOW; 149 speakers completed the test successfully. Recordings of the speech stimuli, |
consisting of nonsense words of the form [h]-V-[t], where V represents one of 15 vowels/diphthongs ([Equation is included in full-text article.]), were presented to two normal-hearing listeners. VOW score was expressed as the percentage of vowels identified correctly (averaged over the 2 listeners). Subsequently, the 149 participants enrolled in the cochlear implant selection procedure. Extremely poor speakers were excluded from implantation, as well as patients who did not meet regular selection criteria as developed for postlingually deafened patients. From the 149 participants, 92 were selected for implantation. For the implanted group, speech perception data were collected at 1-year postimplantation.

RESULTS:
Speech perception score at 1-year postimplantation (available for 77 of the 92 implanted participants) correlated positively with preimplant intelligibility of the patient's speech, as represented by VOW ($r = 0.79, p < 0.00001$): the more intelligible the patient's speech, the higher the predicted postimplant speech perception score. This correlation is explained by the hypothesis that the two variables have a common driving force, i.e., (in)adequacy of auditory speech input in the earliest years of life. With a 60% cutoff point, VOW can discriminate between individuals with "above-chance" postimplant speech perception and those with "chance level" postimplant speech perception with sensitivity and specificity of 0.84 and 0.86, respectively. The probability that a patient with a VOW score ≥ 60% achieves "above-chance" speech perception after implantation is 0.91. Conversely, the probability that a patient with VOW < 60% reaches "above-chance" speech perception is 0.25.

CONCLUSIONS:
For prelingually deaf adults, intelligibility of the patient's speech-as represented by VOW-is a valid predictor of postimplant speech perception. A patient with a VOW score above a preset cutoff is much more likely to develop acceptable speech perception after implantation than a patient with a VOW score below that cutoff. The binary classification based on VOW and the associated probabilities of cochlear implant success in terms of speech perception can be used in addition to existing criteria to support the clinician in guiding patient expectations and in considering implant candidacy for individual patients.


A retrospective evaluation of pre- and post-operative audiometric data at a single large UK cochlear implant centre over 25 years was undertaken.

METHODS:
Analysis of pre-operative hearing levels showed that there was a modest but significant reduction in average pre-operative hearing thresholds among patients referred between 1990 and 2015, particularly in the low frequencies.

OUTCOMES:
The proportion of those referred who would meet widely-accepted candidacy criteria for electro-acoustic...
Action Group on Adult Cochlear Implants - key references for Candidacy and CI’s. Version 1.

stimulation (EAS) grew significantly over time but in the period 2011-2015 just 9% of those referred had sufficient residual hearing for EAS. On average, implant recipients lost 20 dB hearing at frequencies ≤1000 Hz as a result of the surgery.

CONCLUSIONS: The findings suggest that hearing preservation is now widely achievable, and that both candidacy criteria and referrer education should take into account potential EAS benefit.


Abstract
The aim of the present paper is to critically review the current evidence on the efficacy of cochlear implantation as a treatment modality for single-sided deafness (SSD), and/or unilateral tinnitus. Systematic literature review in Medline and other database sources was conducted along with critical analysis of pooled data. The study selection includes prospective and retrospective comparative studies, case series and case reports. The total number of analyzed studies was 17. A total of 108 patients with SSD have been implanted; 66 patients due to problems associated with SSD, and 42 primarily because of debilitating tinnitus. Cochlear implantation in SSD leads to improved sound localization performance and speech perception in noise from the ipsilateral side with an angle of coverage up to (but not including) 90(°) to the front, when noise is present in the contralateral quartile (Strength of recommendation B). Speech and spatial hearing also subjectively improve following the insertion of a cochlear implant (Strength of recommendation B); this was not the case regarding the quality of hearing. Tinnitus improvement was also reported following implant placement (Strength of recommendation B); however, patients need to be advised that the suppression is mainly successful when the implant is activated. The overall quality of the available evidence supports a wider use of cochlear implantation in SSD following appropriate selection and counseling (overall strength of recommendation B). It remains to be seen if the long-term follow-up of large number of patients in well conducted high quality studies will confirm the above mentioned results.


Abstract
OBJECTIVE: Recommendation for cochlear implant (CI) treatment for individuals with severe to profound single-sided deafness (SSD) and asymmetrical hearing loss (AHL) is on the rise. This raises the need for greater consistency in the definition of CI candidacy for these cases and in the assessment methods of patient-related benefits to permit effective comparison and interpretation of the outcomes with both conventional and implantable options across studies.

METHOD: During a dedicated seminar on implant treatment in AHL patients, the panellists of the closing round table reviewed the clinical experience presented with the aim to define clear audiometric characteristics for both AHL
and SSD cases, as well as a common data set enabling consistent evaluation of hearing benefits in this population.

CONCLUSIONS:
The panellists agreed on a clear differentiation between AHL and SSD CI candidates, defining average pure-tone thresholds up to 4 kHz for better and poorer ears. Agreement was reached on a minimum set of assessment procedures, and included the necessity of trials with conventional CROS/BICROS hearing aids and bone conduction devices before considering CI treatment. Objective assessment of sound localisation abilities was identified as the most relevant criterion to quantify performance before and after treatment. In parallel, subjective assessment of overall hearing ability was recommended via the Speech, Spatial and Qualities of hearing questionnaire. Longitudinal follow-up of these parameters and the hours of daily use were considered essential to reflect the potential treatment benefits for this population. The consistency in the data collection and its report will further support health authorities in their decision on acceptable gains from available hearing loss treatment options.

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<td>Results showed differences in the funding model between countries. Unilateral implants for both adults and children and bilateral implants for children were covered by national funding in approximately 60% of countries (30% used medical insurance and 10% self-funding). Fewer countries provided bilateral implants routinely for adults: national funding was available in only 22% (37% used medical insurance and 41% self-funding). Main evolving candidacy areas are asymmetric losses, auditory neuropathy spectrum disorders and electro-acoustic stimulation. For countries using speech-based adult candidacy assessments, the majority (40%) used word tests, 24% used sentence tests, and 36% used a mixture of both. For countries using audiometry for candidacy (70-80% of countries), the majority used levels of 75-85 dB HL at frequencies above 1 kHz. The United Kingdom and Belgium had the most conservative audiometric criteria, and countries such as Australia, Germany, and Italy were the most lenient. Countries with a purely self-funding model had greater flexibility in candidacy requirements.</td>
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<td>Results Odds of 4:1 of a better outcome with CIs were associated with a four frequency pure tone average between 76 and 86 dBHL or a two-frequency pure tone average between 80 and 92 dBHL depending on the word test and condition used.</td>
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<td>Conclusion The candidacy criteria in the United Kingdom for bilateral CIs in children should be based on either a four-frequency (0.5, 1, 2, and 4 kHz) pure tone average poorer than or equal to 80 dBHL or a twofrequency (2 and 4 kHz) pure tone average poorer than or equal to 85 dBHL.</td>
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<td>Vickers, D. Kitterick, P. Verschuur, C. Leal, C. Jenkinson, L. Vickers, F. &amp; Graham, J. (2016a) Issues in Cochlear Implant Candidacy. Cochlear Implants International, 17: S1, 1-2.</td>
<td>In a recent survey by the British Cochlear Implant Group (BCIG) council, members were asked what the priority working areas for the BCIG council should be. The topic of candidacy was the emphatic winner. This is because those working in the cochlear implant (CI) field in the UK believe that the guidelines for candidacy no longer reflect the entire population of patients that the BCIG and the UK implant field consider to be potential CI candidates. There is a clear need to review these guidelines in light of new evidence, some of which is collated in this supplement. The population of CI candidates who could potentially benefit from implantation appears to be far wider than current guidelines permit.</td>
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<td>Vickers, D, A. (2016b) Et al., Preliminary assessment of the feasibility of using AB words to assess candidacy in adults. Cochlear Implants International Vol. 17, Iss. sup1,2016</td>
<td>Background: Adult cochlear implant (CI) candidacy is assessed in part by the use of speech perception measures. In the United Kingdom the current cut-off point to fall within the CI candidacy range is a score of less than 50% on the BKB sentences presented in quiet (presented at 70 dBSPL). Goal: The specific goal of this article was to review the benefit of adding the AB word test to the assessment test battery for candidacy. Results: The AB word test scores showed good sensitivity and specificity when calculated based on both word and phoneme scores. The word score equivalent for 50% correct on the BKB sentences was 18.5% and it was 34.5% when the phoneme score was calculated; these scores are in line with those used in centres in Wales (15% AB word score). Conclusion: The goal of the British Cochlear Implant Group (BCIG) service evaluation was to determine if the pre-implant assessment measures are appropriate and set at the correct level for determining candidacy, the future analyses will determine whether the speech perception cut-off point for candidacy should be adjusted and whether other more challenging measures should be used in the candidacy evaluation. This analysis has demonstrated that the AB words may have potential as a measure in the candidacy test battery. There is no evidence at this stage to suggest that it should replace the BKB sentences, but the exploration did identify cases (EAL, older adults, BSL users and individuals with high levels of cognitive processing) where it could be beneficial as an additional tool for assessment. The absolute values that are appropriate for candidacy and the actuarial equation will re-evaluated in the future analysis.</td>
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<td>Vickers, F. &amp; Bradley, J. Outcomes in implanted teenagers who Severe to profoundly deaf adults who score 50% or over on the Bamford-Kowal-Bench (BKB) sentence test currently cannot obtain NHS funding for a cochlear implant according to the NICE guidelines (NICE Technical</td>
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**Key References for Candidacy and CI’s. Version 1.**

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<th>Article</th>
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<td><strong>Appraisal Guidance (TAG166), 2009.</strong></td>
<td>Cochlear implants for children and adults with severe to profound deafness. NICE technology appraisal guidance [TAG166]. <a href="http://www.nice.org.uk/ta166">http://www.nice.org.uk/ta166</a> accessed 08/02/2016. There is no cut-off restriction from the BKB score for children. This study challenges this restrictive criteria for adults, by presenting the outcomes of cochlear implantation in older children who scored over 50% on BKB sentence testing pre-implantation and therefore would not have been implanted under the adult NICE guidelines. Outcomes are presented using the Speech, Spatial and Qualities of Hearing Scale Version C (SSQ-C) (Gatehouse, S., Noble, W. 2004. The Speech, Spatial and Qualities of Hearing Scale (SSQ). International Journal of Audiology, 43: 85–99.). This study suggests a greater proportion of adults who are currently being restricted from having a cochlear implant would benefit from implantation.</td>
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<td><strong>Wilson, K. Ambler, M. Hanvey, K. Jenkins, M. Jiang, D. Maggs, J &amp; Tzifam, K. Cochlear implant assessment and candidacy for children with partial hearing</strong></td>
<td>A retrospective review was carried out of 28 children (35 ears) with low frequency PH, who were implanted at Birmingham Children’s and St Thomas’ Hearing Implant Centres between 2008 and 2015. The age range was 13 months to 12 years, with a mean age of 6.0 years. PH was considered to be &lt;65 dB HL at one or more frequencies between 250 and 1000 Hz. All children had hearing thresholds of &gt;90 dB HL at 2 and 4 kHz. All children in our group have preserved hearing and perform better with their CI than with their hearing aids, regardless of the level of preservation. All but one post-implant CAP2 outcome demonstrates improvements. SIR scores also show improvements for younger children, however our older children’s speech intelligibility do not consistently improve post-implant. Our clinical observations suggest the benefits of early implantation apply to partial deafness in the same way as traditional candidates.</td>
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Complied by Brian Lamb for the Action Group. For additions or comments please contact brian.actiongroupci@gmail.com also for the latest information see our website at https://actiongrouponadultcochlearimplants.wordpress.com/