

# Effectiveness of Cochlear Implants in Adults with Sensorineural Hearing Loss

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# Disclosure of conflict of interest

The technical consultant, Marilyn W. Neault, PhD, CCC-A discloses her affiliation as an Audiology Advisor on the Advisory Panel of Cochlear™ Americas. Her role in this report was limited to educating the Tufts-EPC on cochlear implantation and speech perception tests.

**All other investigators do not have any affiliation or financial involvement related to the material presented in this report.**

# Objective

- Evaluate the clinical effectiveness of unilateral cochlear implants and bilateral cochlear implants in adult patients ( $\geq 18$  years of age) with sensorineural hearing loss.

# Key questions

1. What current cochlear implantation devices are approved by the FDA **for individuals  $\geq 18$  years of age**? What are the indications for their use?
2. What are the **communication-related health outcomes** as well as the **quality of life outcomes** that are achieved in the population of adults ( $\geq 18$  years old) who undergo **unilateral cochlear implantation**? How is a “successful” implantation defined?

# Key questions - continued

2a. For those individuals  $\geq 18$  years of age with sensorineural hearing loss, what are the **preoperative patient characteristics associated with the successful attainment** of the aforementioned improved communication-related health outcomes as well as quality of life outcomes in those who undergo **unilateral cochlear implantation**?

# Key questions - continued

**2b. Of studies of unilateral cochlear implants (KQ2), are there data available separately for those individuals with sensorineural hearing loss as demonstrated by preimplantation test scores of  $> 40$  percent and  $\leq 50$  percent, as well as those with test scores  $> 50$  percent and  $\leq 60$  percent (best aided listening on tape or otherwise recorded tests of open-set sentence recognition)?**



# Key questions - continued

3. For those individuals  $\geq 18$  years of age, what are the additional communication-related health outcomes as well as quality of life outcomes (as compared with those achieved in question 2) that **are gained from the use of bilateral cochlear implants over a unilateral cochlear implant**? How is a “successful” bilateral cochlear implant defined?

# Key questions - continued

What are the **preoperative patient characteristics associated with the successful attainment** of the communication-related health outcomes as well as quality of life outcomes in questions 2 or 3 in individuals  $\geq 18$  years of age who undergo....

**3a. ...simultaneous bilateral cochlear implantation?**

**3b. ...sequential bilateral cochlear implantation?**

# Key questions - continued

**3c. Of studies of bilateral cochlear implants (KQ3, 3a&3b), are there data available separately for those individuals with sensorineural hearing loss as demonstrated by preimplantation test scores of  $> 40$  percent and  $\leq 50$  percent, as well as those with test scores  $> 50$  percent and  $\leq 60$  percent (best aided listening on tape or otherwise recorded tests of open-set sentence recognition)?**

# Predictors of interest (KQ2a, KQ3a, KQ3b)

## including but not limited to

- Speech recognition/word understanding
- Auditory sensitivity/audibility
- Duration of impaired hearing
- Associated ear or bone disease
- Pre vs. postlinguistic deafness
- Presence of other disabilities (e.g., visual impairment, impending or current)
- Age at implantation (or older vs. younger age at baseline)
- Degree of pre implant residual hearing (i.e., pure tone thresholds)
- Choice of implanted ear
- Site or center (expertise) of cochlear implant team
- Implanted device



# Methods

# Search strategy

- **Approval status of implant devices (KQ1)**
  - Devices@FDA (term *cochlear*); FDA Premarket Approvals database (product code *MCM* “implant, cochlear”)
  - ClinicalTrials.gov (term *cochlear*)
- **Systematic review of literature (KQ2, KQ3)**
  - MEDLINE®, the Cochrane Central Register of Controlled Trials, and Scopus (January, 2004 through February, 2011)
    - Scopus includes articles indexed in Embase since 1997
    - Combined terms for *unilateral and bilateral cochlear implantation* and *sensorineural hearing loss*, and limited to adult humans

# Study selection

- **Population and condition of interest**

- Adult ( $\geq 18$  years) subjects with sensorineural hearing loss
  - Subset of Medicare elderly population: subjects  $\geq 60$  years with a cochlear implant

- **Interventions of interest**

- Both unilateral and bilateral implants
  - One or two multichannel implants using whole-speech processing coding strategies
  - Both sequential and simultaneous bilateral implants
  - Combined use of cochlear implant and hearing aid (bimodal)
- Exclusion: brain stem implants, middle ear implants, bone-anchored hearing aids

# Study selection - continued

- **Comparators of interest**

- Unilateral implant vs. hearing aids in one ear or both ears
- Postoperative vs. preoperative implant
- Bilateral vs. unilateral implant with or without hearing aids
  - Comparison of two cohorts
  - Cross-over design: Bilateral patients who have one ear disconnected at a time are considered as unilateral implantation comparison group.



# Study selection - continued

- **Study design and sample size**
  - KQ 2:  $N \geq 30$  with unilateral implant of any study design with a comparator of interest
  - KQ 3:  $N \geq 10$  with bilateral implant of any study design with a comparator of interest  
(small number of studies evaluating bilateral cochlear implantation )

# Data extraction

- **Study characteristics**

- year, study design, country/setting, recruitment dates, funding source, inclusion and exclusion criteria, interventions, comparators, concurrent treatment, outcome assessor, and duration of follow-up

- **Population characteristics**

- number of patients enrolled and completed, age, percentage of male patients, degree and duration of deafness, device coding strategy, and time between deafness and cochlear implantation

- **Predictor-outcome associations**

- **Outcomes**

- Speech perception: Open-set sentence tests; two syllable/multi-syllable tests
- Sound localization
- Health-related quality-of-life (HRQoL) measures
- Additional binaural processing outcomes
- Communication-related adverse events

# Quality assessment of individual study

- Three-grade classification (A, B, or C) using the AHRQ methods guide. Applicable to any study design.
  - **Quality-A:** good quality studies that have the least bias and their conclusions are considered valid.
  - **Quality-B:** fair or moderate quality studies that are susceptible to some bias, but it is not sufficient to invalidate the results.
  - **Quality-C:** poor quality studies have significant flaws that imply biases of various types that may invalidate the study results.

# Quality assessment examples

- **Quality-B:** fair or moderate quality studies
  - Example – Studies of any design with clear reporting of majority items:  
selection criteria, recruitment method, adjusted analyses for potential confounders, and reasons for attrition
- **Quality-C:** poor quality studies
  - Example - Retrospective cohort study did not adjust for potential confounders in the analyses

# Grading a body of evidence

- **Based on individual studies rated quality-A or -B, we rated the strength of evidence with one of the following four strengths:**
  - **High**
    - There is a high level of assurance that the findings of the literature are valid with respect to the relevant comparison. No important scientific disagreement exists across studies. **At least two quality A studies are required for this rating.** In addition, there must be evidence regarding important clinical outcomes. Further research is very unlikely to change our confidence in the estimate of effect.
  - **Moderate**
    - Little disagreement exists across studies. Further research may change our confidence in the estimates of effect and may change the estimate.
  - **Low**
    - Underlying studies may report conflicting results. Further research is likely to change our confidence in the estimate of effect and may change the estimate for this outcome.
  - **Insufficient**
    - Evidence is either unavailable or does not permit estimation of an effect due to a lack of or sparse data. **In general, when only one study has been published, the evidence was considered insufficient,** unless the study was particularly large, robust, and of good quality.

# No quantitative synthesis (meta-analysis) due to heterogeneity

- Considerable differences across studies including but not limited to:
  - Duration of deafness
  - Implanted devices
  - Speech coding strategies
  - Open-set sentence tests
  - HRQoL measures

# Results

# Results – KQ 1 *What current cochlear implantation devices*

*are approved by the FDA for individuals  $\geq 18$  years of age? What are the indications for their use?*

Device	Indications for adult patients with bilateral sensorineural hearing loss
Cochlear™ Nucleus® cochlear implants	<ul style="list-style-type: none"><li>• Pre, peri, or postlinguistic onset</li><li>• Moderate to profound loss in low speech frequencies and profound (<math>\geq 90</math>dB) in mid to high frequencies</li><li>• <math>\leq 60\%</math> correct on open set sentence recognition tests with hearing aid</li></ul>
Advanced Bionics® HiRes 90K® Implant	<ul style="list-style-type: none"><li>• Postlinguistic onset</li><li>• Severe to profound (<math>\geq 70</math>dB) loss</li><li>• <math>\leq 50\%</math> correct HINT sentences with hearing aid</li></ul>
MED-EL MAESTRO™ Cochlear Implant System	<ul style="list-style-type: none"><li>• Severe to profound loss (<math>\geq 70</math>dB) in mid to high speech frequencies</li><li>• <math>\leq 40\%</math> correct HINT sentences with hearing aid</li></ul>



# Results – KQ 2 *Communication-related health outcomes and the HRQoL in adult unilateral implant patients*

- 22 studies (N= 2,609) with unilateral implants
  - 7 were prospective cohort, 10 retrospective cohort, and 5 cross-sectional studies
  - Number of subjects: 30 to 864
  - Mean baseline age: 37 to 74 years
- 9 quality-B studies (n= 724 or 28%) ; 13 quality-C studies (n=1,885 or 72%)
- U.S. (6 studies), The Netherlands (3 studies), and UK (3 studies), Australia (2 studies), and others.

# Summary Results – KQ 2

## effectiveness of unilateral cochlear implants

Outcome category	No. Quality A; B Studies	Study findings	Grading of body of evidence
Speech perception using open-set sentences tests; multi-syllable tests	A: 0 B: 5	• Consistent clinical and statistical benefit	<b>Moderate</b>
Generic HRQoL measures	A: 0 B: 6	• Consistent benefit for overall and social domains	<b>Moderate</b>
Disease-specific HRQoL measures	A: 0 B: 4	• Consistent beneficial results across the domains	<b>Moderate</b>

Note: All studies reported a mean/median speech test score at baseline <40% correct

# Results – KQ 2a

*Associations between preoperative patient characteristics and communication-related health outcomes as well as HRQoL outcomes in unilateral implant patients*

- 21 studies (N=2,202) with unilateral implants
  - 4 were prospective cohort, 13 retrospective cohort, 1 case-control, and 3 cross-sectional studies
  - Number of subjects: 22 to 316; Mean baseline age: 37 to 74 years
- 4 quality B studies (n= 424, 19%) ; 17 quality C studies (n=1,778, 81%)
- U.S. (7 studies), U.K. (5 studies), Australia and N.Z. (3 studies), and others

# Summary Results – KQ 2a preoperative predictors of speech outcomes after unilateral implant

Potential modifying factor	No. Quality A; B Studies	Speech perception outcomes (quality B studies)	Grading of body of evidence
Longer duration of impaired hearing	A: 0 B: 3	<ul style="list-style-type: none"> <li>Longer duration significantly correlated with poorer speech outcomes</li> </ul>	<b>Moderate</b>
Age at implantation (continuous variable)	A: 0 B: 2	<ul style="list-style-type: none"> <li>Consistently no significant association</li> </ul>	<b>Low</b>
Type of implanted device	A: 0 B: 2	<ul style="list-style-type: none"> <li>Advance Bionics CII better AzBio scores vs. Nucleus 3G, but not HINT or BKB</li> <li>No significant associations for other devices comparison</li> </ul>	<b>Low</b>
Older age ( $\geq 65$ yr) vs. younger age	A: 0; B: 0 C: 7	-	<b>Insufficient</b>

**Grading of body of evidence was based on all studies rated quality–B studies.**

# Summary Results – KQ 2a speech perception outcome continued

Potential modifying factor	Number of studies (quality)	Speech perception outcomes (quality B studies)	Grading of body of evidence
Preoperative speech perception scores	A: 0 B: 1	•better preoperative HINT → better postoperative HINT	<b>Insufficient</b>
Degree of pre-implant residual hearing	A: 0 B: 1	•No significant association	<b>Insufficient</b>
Associated ear or bone diseases, post vs. prelinguistic deafness, age of hearing loss onset	A: 0; B: 0 C: 2 each predictor	-	<b>Insufficient</b>
Choice of implanted ear	A: 0 B: 1	•No significant association	<b>Insufficient</b>

Note: No study examining implant site/expertise of cochlear implant teams or other patient-related disabilities.

# Summary Results – KQ 2a preoperative predictors of HRQoL after unilateral implant

- Grading of body of evidence: **Insufficient**
- Only 3 studies (2 B and 1 C) examined HRQoL outcomes
  - Duration of impaired hearing (2 quality B studies with inconsistent results)
  - Age at implantation (1 quality-B study)
  - Older vs. younger age (1 quality-B study)
  - Preoperative speech recognition (1 quality-B study)
  - Degree of pre-implant residual hearing (1 quality-B study)

**KQ2b** *Are there data available separately for those individuals with sensorineural hearing loss as demonstrated by preimplantation test scores of > 40 percent and ≤ 50 percent, as well as those with test scores > 50 percent and ≤ 60 percent?*

- **No study was identified (out of 22 studies included in KQ2)**

- Speech perception outcomes (16 studies)
  - 10 studies reported mean/median pre-implant score <40%
    - **Some individuals had a test score of >40 percent but were not analyzed separately**
  - 6 studies did not report pre-implant scores
- HRQoL outcomes (10 studies)
  - 2 studies reported mean/median pre-implant score <40%
  - 8 studies did not report pre-implant scores

# Results - KQ2b

*Are there data available separately for those individuals with sensorineural hearing loss as demonstrated by test scores of > 40 percent and ≤ 50 percent, as well as those with test scores > 50 percent and ≤ 60 percent?*

- **Two out of 21 studies included in KQ2a (one quality-B and one quality-C)**
  - Friedland et al. 2010 (quality-B) analyzed elderly (≥65 yr, n=28) and their matched younger adults (<65 yr, n=28),
  - Retrospective cohort study design
  - Matching was based on pre-implant HINT-Q score and duration of deafness
  - Higher pre-implant HINT-Q score (≤20%, 21-40%, ≥40%) → higher post-implant HINT-Q and HINT-N score (P=0.02 and P=0.04, respectively)



# Results - KQ2b Continued

For studies included in KQ2a

- Chatelin et al. 2004 (quality-C) analyzed adults implanted with either the Clarion or Nucleus device between 1991 and 2002
  - Retrospective cohort study design
  - Criteria for cochlear implantation: severe to profound hearing loss in both ears and a score of  $\leq 50$  percent on an open-set sentence test
  - Both elderly ( $\geq 70$  yr,  $n=65$ ) and younger ( $<70$  yr;  $n=101$ ) adults had significant improvement in HINT and CID scores after implantation. Between groups  $P=0.07$ .
  - **Rated quality-C due to no adjustment for confounders.**

# Summary Results – KQ2b

*Effectiveness of unilateral implant by their preimplantation test scores of > 40 percent and  $\leq$  50 percent, as well as those with test scores > 50 percent and  $\leq$  60 percent?*

- Grading of body of evidence: **Insufficient**
- Of the 22 studies that evaluated KQ 2, **no studies** provided data.
- Of the 21 studies that evaluated KQ 2a, only **one quality-B study** provided data by their preimplant test scores.
- The proportion of patients between the scores of > 40 percent and  $\leq$  50 percent in this study was unclear.



# Bilateral vs. unilateral implant

# Results – KQ 3 *Communication-related health outcomes and the HRQoL in adult bilateral vs. unilateral implants*

- 16 studies (N=443) with bilateral implants
  - 1 RCT (3 publications analyzed as prospective cohort)
  - 6 prospective cohort; 1 retrospective cohort; 6 cross-sectional studies
  - Duration of follow-up: 3 to 12 months
  - Number of subjects: 13 to 40
  - Mean baseline age: 46 to 64 years
  - 6 studies were multicenter
- Eight studies were conducted in the U.S.; 7 studies in Europe; 1 study both U.S. and Europe

## Results – KQ 3 *Continued*

- Bilateral simultaneous 9 studies; sequential 5 studies; 2 both
- Most often subjects crossed-over (bilateral vs. right ear alone or left ear alone)
- In some studies bilateral implants were compared with 136 external unilateral implants
- B quality 9 studies (N = 257 bilateral implants);
- C quality 7 studies (N = 186 implants)

# Summary Results - KQ 3 effectiveness of bilateral implants

Outcome category	N studies	Study findings	Grading of body of evidence*
Speech perception (open-set sentences; multi-syllable)	A: 0 B: 9	Consistent statistically significant clinical benefit	<b>Moderate</b>
Sound localization	A: 0 B: 7	Consistent statistically significant clinical benefit	<b>Moderate</b>
Disease-specific HRQoL measures	A: 0 B: 1	Significant benefit in two domains but inconsistent results in one domain	<b>Low</b>
Generic HRQoL measures	A: 0 B: 1	Significant benefit in one domain but worsening in two domains	

*Grading of body of evidence was based on all studies rated quality–B studies.*

# Summary Results - KQ 3a & 3b

- **Evidence was rated low** based on two quality-B rated studies reporting (inconsistent) data on age at implantation as a predictor of postoperative outcomes.
- Duration of hearing loss before implant (two quality-B studies) and implant device characteristics (one quality-B study) did not predict postoperative outcomes in bilateral implants.

# Results - KQ3c

*Data among bilateral implants by their preimplant test scores of > 40 percent and ≤ 50 percent, as well as those with test scores > 50 percent and ≤ 60 percent?*

Outcome category	Specific outcome	Study [N subjects]	Comparison groups	Results	Study quality
<i>Speech perception test</i>					
<i>Pre-implant open-set sentence score of ≤ 50 percent</i>					
BKB-SIN	SNR-50 mean scores	Litovsky 2006 [37]	Bilateral CI vs. either ear unilaterally (within subject comparisons)	↑	B (prospective; some patients not accounted)
HINT	Subjects with higher scores			↑*	
HINT-Q	Subjects with higher scores	Koch 2009 [15]	Bilateral CI vs. either ear unilaterally (within subject comparisons)	↑	B (prospective; unclear selection process)
CUNY in noise	SNR	Buss 2008 [29]	Bilateral CI vs. either ear unilaterally (within subject comparisons)	↓ (3, 6 mo)	B (prospective; unclear selection process, 10% excluded from analysis)
	Derived measures of binaural processing			↑ (6, 12 mo) ↑	



# KQ3c – simultaneous bilateral implants *continued*

- Overall, **evidence was rated low** for the effectiveness of simultaneous bilateral implantation by their preimplantation open-set sentence test scores of  $\leq 40$  percent
- This was evaluated in three quality-B studies that showed improved speech perception, and sound localization, but inconsistent gains in terms of hearing-specific quality-of-life in one study.

# Summary Results KQ3c – sequential bilateral implants *continued*

- **Evidence was rated insufficient** for the effectiveness of sequential bilateral implantation by the preimplantation test scores of  $\leq 40$  percent
- This was evaluated in one quality-B study that showed improved speech perception in noise, and sound localization.
- No difference in speech perception in quiet
- Negative results or non-significant changes in health-related quality-of-life after the second ear implant vs. first ear implant.

# Discontinuation of implant use

- In total, 20 subjects across all groups were reported to have adverse events
- In summary, where adverse event data were available, 20 out of 495 subjects (4.0 percent) discontinued use of their cochlear implant(s) after hearing-related complications.
- Reasons: exacerbation of existing illness, tinnitus, disappointed with outcomes, cerebrovascular events, etc..



# Conclusions

# Effectiveness of unilateral implantation

- An effective method of hearing assistance.
- Results in significant gains in speech perception in adults with unilateral implants.
- Results in significant gains in health-related quality of life in adults with unilateral implants.

# Effectiveness of unilateral implantation *continued*

- **Insufficient evidence** among unilateral implants by preimplantation open-set sentence test scores of  $> 40$  percent and  $\leq 50$  percent, as well as those with test scores  $> 50$  percent and  $\leq 60$  percent.
- **No study was identified under KQ2**
- **One quality-B study was identified under KQ2a**
  - Some individuals had a test score of  $>40$  percent but were not analyzed separately

# Effectiveness of unilateral implantation *continued*

- **Moderate evidence** for pre-operative duration of hearing loss as a predictor of post-operative outcomes.
- Additional predictors: **Low evidence** for age at implant and implanted device.
- **Insufficient evidence** to draw a conclusion about the relationships between remaining preoperative patient characteristics and postoperative HRQoL outcomes. (**either 1 study or no study**)

# Effectiveness of bilateral vs. unilateral implants

- Show significantly greater benefit in speech perception outcomes (open-set sentence test in noise and multisyllable tests) among adults with bilateral implants compared with unilateral implantation.
- Offer better sound localization compared with unilateral cochlear implantation.
- Benefits in binaural processing measures
- Inconsistent results for HRQol reported in few studies.



# Effectiveness of simultaneous bilateral implants by their preimplant scores

**Overall low evidence** - Effectiveness by their preimplantation open-set sentence test scores of  $\leq 40$  percent.

- **Moderate evidence** based on three quality-B studies that showed improved postimplant scores of open-set sentence tests in noise and quiet.
- **Insufficient evidence** for the outcome of hearing-specific quality-of-life from only one study.

# Effectiveness of sequential bilateral implants by their preimplant scores

**Overall insufficient** - Effectiveness by their preimplantation open-set sentence test scores of  $\leq 40$  percent

- **Insufficient evidence** based on one quality-B study that showed improved postimplant open-set sentence test scores in noise, and sound localization.
- In this study, the second ear implant resulted in negative results or non-significant changes in health-related quality-of-life after the first ear implant.

# Effectiveness of Bilateral implants by their preimplant scores *continued*

- **Insufficient evidence** among bilateral implants by preimplantation open-set sentence test scores of  $> 40$  percent and  $\leq 50$  percent, as well as those with test scores  $> 50$  percent and  $\leq 60$  percent.
- **No study was identified**

# Limitations

- Short duration of follow-up (< 6 month follow-up)
- Few studies evaluated quality-of-life outcomes (often quoted in literature as 'subjective' outcomes)
- Incomplete reporting of baseline characteristics, center characteristics, adjustment for potential confounders, and often missing recruitment site and year
- Duplicate publications and overlapping patients in multiple studies

# Future research recommendations

- Need good methodological quality studies in terms of clear reporting of selection criteria, center characteristics, recruitment dates, and with reasons for loss to follow-up.
- Research should be conducted to address health policy needs.
- Large database or registry of patients who received cochlear implants with long-term follow-up data on patient outcomes is needed.
- Need to develop better measures of disease-specific HRQol instruments.



Thank you!





Extra slides



# Results – KQ2

## Effectiveness of unilateral cochlear implants on speech perception & multi-syllable tests

**Table 3. Summary results of speech perception measures in unilateral cochlear implants (quality B studies)**

Outcome category	Specific outcome	Study [subjects]	Comparison groups	Results	Study quality
BKB	% correct	Bai 2005 <sup>8</sup> [47]	Post vs. pre CI	⬆ 5.5 mo	B (prospective; no adj.)
BKB	% correct	UK CI Study Group 2004 <sup>25</sup> [316]	Post vs. pre CI	⬆ 9 mo (ES=1.5)	B (prospective; mostly qualitative interpretations)
CID	% correct	Rama-Lopez 2006 <sup>22</sup> [30]	Post vs. pre CI	⬆ 1, 2, 3yr	B (prospective; poor reporting)
CUNY-Q	% correct	Morris 2007 <sup>19</sup> [101]	Post vs. pre CI	⬆ 1yr	B (retrospective; good analyses)
CUNY-N	% correct		Post vs. pre CI	⬆ 1yr	
HINT-Q	% correct	Morris 2007 <sup>19</sup> [101]	Post vs. pre CI	⬆ 1yr	B (retrospective; good analyses)
HINT-Q	% correct	Roditi 2009 <sup>23</sup> [55]	Post vs. pre CI	⬆ 28mo	B (retrospective; some information could not be used because of eligibility criteria)
HINT-N	% correct		Post vs. pre CI	⬆ 28mo	
2-syllable words	% correct	Rama-Lopez 2006 <sup>22</sup> [30]	Post vs. pre CI	⬆ 1, 2, 3yr	B (prospective; unclear description of sampling method)

Adj = adjustment, BKB = Bamford-Kowal-Bench, CI = cochlear implant, CID = Central Institute for the Deaf, CUNY = City University of New York, HINT = Hearing in Noise test, Q = quiet, N = Noise, ES = effect size, mo = month, yr = year.

⬆ = benefit with statistical significance, ⬆ = benefit but no statistical significance.

# Example study: speech perception in unilateral implant

Study: Roditi 2009 U.S.	Pre-operative score	Post-operative score at 28 months
	% correct (95%CI) N=55	% correct (95%CI) N=55
HINT in quiet	21.3 (15.2, 27.4)	85.9 (80.9, 90.9)
HINT in noise (+10 dB)	8.93 (5.2, 12.7)	65.54 (57.6, 73.5)

Note: Results were judged statistically significant based on non-overlapping confidence intervals

# Results – KQ2 Effectiveness of unilateral cochlear implants on disease-specific HRQoL measures

**Table 5. Summary results of health related quality-of-life (disease-specific) in unilateral cochlear implants**

Outcome category	Specific outcome	Study [subjects]	Comparison groups	Results	Study quality
Adapted Deaf Identity Developmental Scale	Mean score	Most 2009{Most, 2010 90070 /id} [38]	Post vs. pre CI	↑ (communication, social skills, academic and work performance, general satisfaction) ⇔ (family climate)	B (retrospective; no adjusted analysis)
HPS	Mean score	Hawthorne 2004 <sup>14</sup> [34]	Post vs. pre CI	↑ (total)	B (prospective; missing data)
NCIQ	Mean score	Damen 2007 <sup>10</sup> [59]	Post vs. pre CI	↑ (sound perception, sound perception advanced, speech production, self-esteem, activity, social interactions)	B (prospective; not representative sample)
NCIQ	Mean score	Klop 2008 <sup>15</sup> [44]	Post vs. pre CI	↑ (sound perception, basic & advanced; speech production; self-esteem; activity; social interactions)	B (prospective; no adjusted analysis)
HHIA	Mean score	Vermeire 2005 <sup>28</sup> [89]	Post vs. preCI	↑ (total, emotional, situational)	C (cross-sectional; poor reporting)
HHIA	Mean score	Vermeire 2006 <sup>27</sup> [50]	Post vs. pre CI	↑ (total)	C (cross-sectional; huge drop out)

HPS = Hearing Participation Scale, NCIQ = Nijmegen Cochlear Implant Questionnaire, HHIA = Hearing Handicap Inventory for Adults, CI = cochlear implant.

↑ = benefit with statistical significance, ⇔ = no difference between comparison groups