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Bilateral cochlear implantation is regarded as very beneficial: results from a worldwide survey by online questionnaire

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Abstract

Purpose Bilateral cochlear implant (CI) provision is now widely regarded as the most beneficial hearing intervention for acceptable candidates. This study sought to determine if a number of well-regarded hearing professionals at highly reputable clinics shared similar practices and beliefs regarding bilateral CI provision, use, and rehabilitation in children and adults.

Methods An 11-question online questionnaire was created and distributed to all 27 clinics in the HEARRING group. Questions 1–5 asked for facts; questions 6–11 asked for opinions.

Results 20 completed questionnaires were returned. All 20 respondents reported that their clinics perform bilateral cochlear implantation in children; 18 do so in adults. Regarding the fact-based questions, bilateral CI provision is more commonly performed and more likely to be reimbursed in children than in adults. Children are also much more likely to be implanted simultaneously than are adults. Regarding the opinion-based questions, respondents gave broadly similar answers. Communication between the CIs and speech coding strategies specifically developed for bilateral CI users were regarded as the two future technologies that would most enhance the benefit of bilateral CI use.

Conclusions Most clinics in the HEARRING group are very familiar with bilateral CI provision and hold similar opinions on its results and benefits. Hopefully the results described herein will lead to a greater acceptance and regular reimbursement of bilateral CI provision, especially in adults.

Keywords Bilateral cochlear implant · Paediatric cochlear implant · Sequential cochlear implant · Simultaneous cochlear implant

Introduction

Bilateral cochlear implant (CI) use, compared to unilateral CI use, can provide appropriate adult and paediatric candidates with a host of benefits, most notably significantly better speech understanding in noise [1–6] and sound localization ability [1, 3–5, 7]. As such, bilateral CI implantation is now widely seen the gold standard, as evidenced by the numerous consensus/position statements advocating bilateral CI provision in adults [8–10] and in children [8–13]. Further, Papsin and Gordon [11], Ramsden et al. [12], and the British Cochlear Implant Group [13] all advocate simultaneous—as opposed to sequential—bilateral CI provision in appropriate paediatric candidates. Indeed, in the UK, Cullington et al. [14] had to use data of sequentially implanted children as a comparator for those of simultaneously implanted children because unilateral CI provision in paediatric bilateral candidates is unethical under UK guidelines [15]. The primary focus of much recent research into bilateral CI use now compares groups of bilateral CI users with each other (e.g. sequential vs. simultaneous implantation or cost-benefit analyses), not with unilateral CI users, e.g., [5, 16, 17].

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But are the findings of this research reflected in the beliefs and practices of hearing implant centres? One such group of centres is the HEARRING group. Modelled after comprehensive cancer centre networks, the HEARRING group is an international collaborative of comprehensive hearing centres and is committed to creating and maintaining the highest standards of quality [18]. The aim of this study was to obtain an overview about the opinions and practices of HEARRING member clinics regarding bilateral cochlear implantation in children and adults.

Materials and methods

The online questionnaire was created by the team of the Comprehensive Hearing Center, Würzburg (member of the HEARRING group) in May 2015. The final version consisted of 11 questions, all in English, (see Online Appendix 1) and was emailed to all 27 HEARRING clinics (as of Nov. 2016). Questions 1–5 asked for facts; questions 6–11 asked for opinions. Completed questionnaires were returned digitally. Respondents could choose to be anonymous. Results are presented descriptively. Missing data were treated as missing.

Results

20 completed questionnaires were returned within the deadline. 7/20 questionnaires were answered anonymously. Although we had intended only one response per clinic, in at least two occasions we received responses from two surgeons per clinic. Anonymization prevented further investigation into if other clinics also responded more than once.

In Questions 1−5 (the factual questions) when a clinic had variant answers to the same question, we followed up via email with the two respondents at both clinics to receive a consistent answer. Both clinics returned updated consistent answers. This necessitated changing/updating seven data points. One answer, in Question 5 as noted below, was not consistent with the answer provided in Question 1, but since the respondent was anonymous, this could not be resolved. The answers to Questions 6−11 were not scrutinized per clinic or followed up because they queried the respondents' opinions.

Question 1: "Do you perform bilateral cochlear implantation in your departments?" For children, all 20 respondents answered 'Yes'; for adults, 18 answered 'yes' and 2 answered 'no'.

Question 2: "Is bilateral cochlear implantation reimbursed in your country?" For children, 17 respondents answered "yes", 0 answered "sometimes", and 3 answered "no"; for adults, 11 answered "yes", 6 answered "no", and 3 answered "sometimes".

Question 3: "In which year was the first bilateral patient (2nd ear) implanted in your department?" Answers varied widely but showed that bilateral implantation in children started earlier than in adults (Table 1).

Question 4: "What is the % of bilateral cochlear implantation in your department?" The majority of bilateral cochlear implantations are in children. Both clinics that answered (in Question 1) that they do not perform bilateral implantation in adults answered 0−20%, we assume they meant 0% (Table 2).

Question 5a: "When bilateral cochlea-implantation is performed, what is the percentage of bilateral simultaneous procedures?" Simultaneous bilateral implantation is more commonly performed in children than in adults. Both clinics that answered (in Question 1) that they do not perform bilateral implantation in adults answered 0−20%, we assume they mean 0% (Table 3).

Question 5b: "When bilateral cochlear implantation is performed, what is the percentage of bilateral sequential procedures?" Sequential bilateral implantation is commonly performed in both children and in adults. 1 of the 2 clinics that answered (in Question 1) that they do not

Table 1 The years when the respondents' departments first bilaterally implanted children and adults. 5 answers were missing for both children and adults

	Year																
	19				20												
	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12
Children	0	2	1	1	0	2	0	0	3	1	0	1	1	0	2	0	1
Adults	1	0	0	0	3	0	0	0	1	1	2	1	1	2	0	2	1

Table 2 What is the percentage of bilateral cochlear implantation in your department?

	81–100%	61–80%	41–60%	21–40%	0–20%	No answer
Children	11	2	1	2	4	0
Adults	0	0	3	2	14	1

Table 3 When bilateral cochlear implantation is performed, what is the percentage of bilateral simultaneous procedures?

	81–100%	61–80%	41–60%	21–40%	0–20%	No answer
Children	10	0	1	0	9	0
Adults	2	0	1	0	17	0

Table 4 When bilateral cochlear implantation is performed, what is the percentage of bilateral sequential procedures?

	81–100%	61–80%	41–60%	21–40%	0–20%	No answer
Children	8	0	1	2	9	0
Adults	11	1	2	0	4	2

Table 5 When you compare bilateral CI with monaural CI, what is, in your opinion, the largest benefit for the patient?

	Benefit ($n=19$)		
	Largest	Medium	Smallest
Speech comprehension in noise	13	4	2
Directionality	10	8	1
Persistent hearing capability when 1 CI is not available (e.g. broken, damaged, lost)	3	3	13

Table 6 What is the most probable reason for improved speech comprehension of bilateral CI users?

	Probability				
	1	2	3	4	Missing
Detection of interaural level differences	5	6	4	1	4
Detection of interaural time differences	2	3	7	3	5
Head shadow effect	10	4	1	2	3
I am not sure	1	1	1	1	16

1 = most probable; 4 less probable

perform bilateral implantation in adults answered 0−20% (we assume they mean 0%), however the other answered 81−100 (Table 4).

Question 6: "Is the rehabilitation progress of the second ear faster or slower after implantation?" 13 answered "faster", 6 answered "slower", and 1 did not answer.

Question 7: "In what % is the 2nd implanted ear better in speech comprehension ability compared to the 1st ear?" 9 answered 0–20%, 5 answered 21–40%, 2 answered 41–60%, 0 answered 61–80%, 3 answered 81–100%, and 1 did not answer.

Question 8: "When you compare bilateral CI with monaural CI, what is, in your opinion, the largest benefit for the patient?" Improved speech comprehension and localization/directionality ability are viewed as the biggest benefits of bilateral CI use (Table 5).

Question 9: "What is the most probable reason for improved speech comprehension of bilateral CI users?" The elimination of the head shadow effect is viewed as the most probable reason for the improved speech comprehension of bilateral CI users. Regarding the detection of interaural differences, the detection level differences is regarded as more beneficial than the detection of time differences (Table 6).

Question 10: "Which audiological tests are the best to test the benefit of bilateral cochlea implantation?" Localization testing is regarded as the best way to assess the benefit of bilateral CI use (Table 7).

Question 11: "How would you rank the following in terms of propagating the application of bilateral CI?" Communication between the CIs and special speech coding strategies are regarded as the future technologies most likely to enhance the benefit of bilateral CI use (Table 8).

Table 7 Which audiological tests are the best to test the benefit of bilateral cochlea implantation?

	1	2	3	Missing
Monosyllabic words in noise	4	2	1	13
Sentences in noise	2	4	1	13
Localization	9	5	1	5

1 = best; 3 = worst

Table 8 How would you rank the following in terms of propagating the application of bilateral CI?

	1	2	3	Missing
Communication between the 2 CIs	6	8	2	4
Power reduction	2	7	6	5
Special speech coding strategies for bilateral CI	7	3	5	5

1 = important; 3 = less important

Discussion

The questionnaire results allowed a provisional insight into the practices and beliefs of leading clinicians regarding bilateral cochlear implantation in children and in adults.

For this perspective, the study was successful. The results of the study will hopefully lead to a greater acceptance of bilateral cochlear implantation and therefore more candidates will be able to benefit from this type of hearing rehabilitation.

It was confirmed that children and, especially since the early 2000s, adults both receive bilateral cochlear implantation. Most bilateral cochlear implantations are performed in children. Adults are more likely to be implanted sequentially than simultaneously, whereas children are roughly equally likely to be sequentially or simultaneously implanted. One factor in these discrepancies may be that bilateral implantation in children is more likely to be reimbursed. A further influence on the findings likely is that bilateral CI use is thought to be more beneficial in children than in adults because binaural hearing better enables children to develop critical communication skills; skills that most adult CI recipients, since their deafness is usually postlingual, have already developed. Ideally, all willing and eligible candidates would receive bilateral CIs; realistically, health care budgets are finite and children tend to be prioritized. This is, however, out of the scope of the present study.

Regarding beliefs, most respondents had similar answers to questions 6−11, e.g. 13/19 respondents thought that the rehabilitation process is faster in the second implanted ear than in the first implanted ear and 14/19 thought the first implanted ear is better than the second implanted ear in speech comprehension. In the first example above, rehabilitation performed in the first implanted ear might facilitate rehabilitation in the second implanted ear. In the second example above, the answer is in contrast with the results of Radeloff et al. [19], who found no difference between the first and second implanted ear. Nonetheless, respondents may regard the first implanted ear as better because, at the time of rehabilitation of the second ear, the first is the better ear. Removing the CI on the first side for reasons of training the second ear may be uncomfortable for the user. In any case, the answer here is an example of a disagreement between clinical experience and study results. There was general agreement that improved speech comprehension in noise and improved directionality are the biggest benefits of bilateral CI use and that the improved speech comprehension is probably primarily due to the elimination of the head shadow effect, although the ability to detect interaural level differences is also important. Curiously, although improved speech comprehension in noise and localization ability were regarded as the best benefits, it was localization testing that was regarded as the best way to test the benefit of bilateral CI use; although, the results of this question should be approached with caution since missing answers outnumbered answers 31 to 29, particularly regarding the speech testing in noise. This incongruity is probably because localization testing is the easiest and most reliable way to assess the benefit of bilateral rather than unilateral CI use. CI users without bilateral hearing score significantly lower on localization tests than do bilateral CI users [14, 20, 21].

The final question of the questionnaire asked for opinions on which future developments for bilateral cochlear implantation would be most beneficial. Communication between both CIs and speech coding strategies developed especially for bilateral CIs were rated as the most important potential developments for the propagation of bilateral cochlear implantation. Reduction in battery consumption was regarded as being of secondary importance. As this study queried experts in the field of CIs, the results hopefully will inspire CI companies to work on these developments.

However, the present study has some limitations. First, in questionnaire design, a differentiation between 0% and 1−20% in the possible answers to questions 4, 5, and 7 would have been better. This was pertinent to the subquestions regarding implantation in adults: two clinics reported that they do not perform this procedure. For Question 4b, both these clinics answered 0−20% wherein their answers were combined with 12 other respondents whose departments do perform bilateral cochlear implantation in adults. In Question 5bii, one of these two clinics left the answer blank instead of answering 0−20%, thereby making their answer look like missing data rather 0%. Second, since the questionnaires were mailed out to HEARRING members at HEARRING clinics, not 1 questionnaire per clinic, sometimes two members of the same clinic responded. While this does still provide valuable information for the opinion questions (questions 1−5), it may have had an amplifying and distorting effect on the results of the factual questions (questions 6−11) since some clinics (and countries) are represented more than once whereas others are, since they did not respond, not represented at all. Third, due to the selection bias inherent in the questionnaire distribution (only to professionals at HEARRING clinics), it should be stressed that these results are not necessarily reflective of hearing health care professionals in general.

Conclusions

In HEARRING clinics bilateral cochlear implantation is performed with great post-operative benefit for the recipients. Bilateral cochlear implantation is more commonly performed in children than in adults because children's are thought to benefit most from bilateral cochlear implantation. While there was no consensus in the opinion of the needed postoperative tests, there was a broad agreement on most aspects surrounding bilateral CI use in adults and in children.

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Compliance with ethical standards

Conflict of interest The study is conducted by members of HEARRING, which is logistically supported by MED-EL. The authors have received research grants from MEDEL. The authors declare no conflicts of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Johnston JC, Durieux-Smith A, Angus D, O'Connor A, Fitzpatrick E (2009) Bilateral paediatric cochlear implants: a critical review. Int J Audiol 48:601–617. https://doi.org/10.1080/14992020802665967
2. Eapen RJ, Buchman CA (2009) Bilateral cochlear implantation: current concepts. Curr Opin Otolaryngol Head Neck Surg 17:351–355. https://doi.org/10.1097/MOO.0b013e3283301702
3. von Schoonhoven J, Sparreboom M, van Zanten BG, Scholten RJ, Mylanus EA, Dreschler WA, Grolman W (2013) The effectiveness of bilateral cochlear implants for severe-to-profound deafness in adults: a systematic review. Otol Neurotol 34:190–198
4. von Zon A, Smulders YE, Stegeman I et al (2016) Stable benefits of bilateral over unilateral cochlear implantation after two years: a randomized controlled trial. Laryngoscope 127:1161–1168. https://doi.org/10.1002/lary.26239
5. Kraaijenga VJC, Ramakers GGJ, Smulders YE et al (2017) Objective and subjective measures of simultaneous vs sequential bilateral cochlear implants in adults a randomized clinical trial. JAMA Otolaryngol Head Neck Surg 143:881–890. https://doi.org/10.1001/jamaoto.2017.0745
6. Bianchin G, Tribi L, Formigoni P, Russo C, Polizzi V (2017) Sequential pediatric bilateral cochlear implantation: The effect of time interval between implants. Int J Pediatr Otorhinol 102:10–14. https://doi.org/10.1016/j.ijporl.2017.08.025
7. Lammers MJ, van der Heijden GJ, Pourier VE, Grolman W (2014) Bilateral cochlear implantation in children: a systematic review and best-evidence synthesis. Laryngoscope 124:1694–1699. https://doi.org/10.1002/lary.24582
8. Balkany T, Hodges A, Telischi F et al (2008) William House Cochlear Implant Study Group: position statement on bilateral cochlear implantation. Otol Neurotol 29:107–108. https://doi.org/10.1097/mao.0b013e318163d2ea
9. Craddock L, Brinton J, Saeed SR, Balkany TJ (2008) Editorial. Bilateral cochlear implantation: the British Cochlear Implant Group position. Cochlear Implants Int 9:65–69. https://doi.org/10.1179/cim.2008.9.2.65
10. Schramm D (2010) Canadian position statement on bilateral cochlear implantation. J Otolaryngol Head Neck Surg 39:479–485
11. Papsin BC, Gordon KA (2008) Bilateral cochlear implants should be the standard for children with bilateral sensorineural deafness. Curr Opin Otolaryngol Head Neck Surg 16:69–74. https://doi.org/10.1097/MOO.0b013e3282f5e97c
12. Ramsden J, Gordon K, Aschendorff A et al (2012) European bilateral pediatric cochlear implant forum consensus statement. Otol Neurotol 33:561–565. https://doi.org/10.1097/MAO.0b013e3182536ae2
13. British Cochlear Implant Group (2016) Quality standards. Cochlear implant services for children and adults. https://www.bcig.org.uk/wp-content/uploads/2016/05/BCIG-Quality-Standard-2016.pdf
14. Cullington HE, Bele D, Brinton JC et al (2016) United Kingdom national paediatric bilateral project: Demographics and results of localization and speech perception testing. Cochlear Implants Int 18:2–22. https://doi.org/10.1080/14670100.2016.1265055
15. NICE (2009) NICE technology appraisal guidance 166. Cochlear implants for children and adults with severe to profound deafness: National Health Service National Institute for Health and Care Excellence
16. Park HJ, Lee JY, Yang CJ et al (2018) What is the sensitive period to initiate auditory stimulation for the second ear in sequential cochlear implantation? Otol Neurotol 39:177–183. https://doi.org/10.1097/MAO.0000000000001640
17. Dhondt CMC, Swinnen FKR, Dhooge IJM (2018) Bilateral cochlear implantation or bimodal listening in the paediatric population: retrospective analysis of decisive criteria. Int J Pediatr Otorhinolaryngol 104:170–177. https://doi.org/10.1016/j.ijporl.2017.10.043
18. HEARRING (2014) The HEARRING Mission Statement. http://www.hearring.com/wp-hearring/about/. Accessed: 29-Jan-2018
19. Radeloff A, Neckel M, Shehata-Dieler W et al (2017) 20 years of bilateral cochlear implantation—an analysis of the implanted patients. Laryngorhinootologie 96:35–39. https://doi.org/10.1055/s-0042-109615. (Article in German)
20. Asp F, Mäki-Torkko E, Karltop E et al (2012) Bilateral versus unilateral cochlear implants in children: speech recognition, sound localization, and parental reports. Int J Audiol 51:817–832. https://doi.org/10.3109/14992027.2012.705898
21. Grossmann W, Brill S, Moeltner A, Mlynski R, Hagen R, Radeloff A (2016) Cochlear implantation improves spatial release from masking and restores localization abilities in single-sided deaf patients. Otol Neurotol 37:658–664. https://doi.org/10.1097/MAO.0000000000001043