Choosing which ear to implant in adult candidates with functional residual hearing

Claire A. Fielden,[1,2,4] Rajnikant L. Mehta[1,3] and Pádraig T. Kitterick[1,3]

[1] NIHR Nottingham Hearing Biomedical Research Unit, Ropewalk House, Nottingham NG1 5DU, United Kingdom

[2] Nottingham University Hospitals NHS Trust, Queen's Medical Centre, Nottingham NG7 2UH

[3] Otology and Hearing group, Division of Clinical Neuroscience, School of Medicine, University of Nottingham, Nottingham NG7 2UH, United Kingdom

[4] Midlands Hearing Implant Programme, University Hospital Birmingham, Birmingham B15 2TH

Contact author: Claire Fielden, claire.fielden@nottingham.ac.uk

Keywords: cochlear implants; bimodal aiding; cochlear implant candidacy; contralateral hearing aid; residual hearing, choice of ear.

Word count (including references and abstract): 2234

Total number of figures and tables: 2

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 in the non-implanted ear where possible. Future approaches to determining candidacy should therefore consider that a sub-set of patients may obtain additional benefit from this residual hearing following implantation.

Introduction

Unilateral cochlear implantation remains the standard of care for severe-to-profoundly deaf adults in the United Kingdom (UK). The expansion of candidacy criteria to include adults with severe-to-profound hearing loss rather than only those with profound deafness (NICE 2009) increased the likelihood that cochlear implant (CI) candidates may now have a level of useable residual hearing that may be aided by an acoustic hearing aid (HA). Previous research has indicated that implanting a 'functionally-better' ear, either in terms of a shorter duration of profound deafness (UKCISG 2004) or measurable pre-operative speech discrimination ability (Dowell et al, 2004), is likely to give better results post-implantation than implanting a functionally-poorer ear. While providers of unilateral implant services have always faced with a challenge in choosing which ear to implant, the expansion of candidacy criteria has created the possibility that candidates may now have some usable residual hearing. As a result, clinical teams now have to balance: (a) the desire to maximise benefit from the implant alone by implanting the functionally-better ear with the greatest capacity to support speech perception, and (b) the possibility that patients may benefit from a contralateral acoustic HA if any useful residual hearing is preserved by implanting the functionally-poorer ear (Illg et al., 2014).

Self-report data from existing unilateral implant users in the UK suggests that the proportion of candidates who persist with using a HA following implantation has increased substantially since the publication of NICE guidance (Fielden et al., 2016). That study also observed that the proportion of HA users was highest among those who were implanted in what they considered to be their poorer ear. If clinicians are willing to recommend that a functionally-poorer ear is implanted when other relevant factors are similar for both ears, it would suggest that their decision making process considers the potential benefits of preserving access to

residual hearing. A decision-choice experiment was conducted to examine factors that may influence the preference of professionals to preserve residual hearing.

Methods

Audiologists working with adult CI patients were invited to complete an anonymous online decision-choice questionnaire created using SurveyMonkey and distributed via the British Cochlear Implant Group (BCIG). Programme coordinators were also invited to forward the questionnaire to any audiologist who may not be a member of the BCIG.

The questionnaire contained eight hypothetical listening scenarios describing post-lingually deafened adults. Respondents were asked to select the ear they would recommend for implantation in each given scenario.

Listening scenarios

The description of the right ear in the questionnaire was kept constant in all scenarios. It was described as an ear that was likely to provide a favourable outcome if implanted (UKCISG 2004, Dowell et al, 2004): it had a short duration of deafness (3 years), had been stimulated continually (aided), and had measurable open-set speech perception (45% correct) on the BKB sentence test that was close to, but did not exceed, the maximum permitted performance level (<50% correct) of eligible implantation candidates in the UK (NICE 2009). The right ear was therefore likely to result in a favourable outcome based on using the CI alone, and is referred to as the 'scoring ear'.

The description of the left ear in the questionnaire always had no measurable open-set speech perception (0% correct) and is therefore referred to as the 'non-scoring ear'. Two

characteristics of this ear were varied systematically across scenarios: (i) duration of deafness, which was varied so that the odds of it providing a favourable outcome if implanted were either the same as the scoring ear (3 years) or less favourable (15, 25 and 50 years) (UKCISG 2004); and (ii) whether it had been continually stimulated by a HA as continual stimulation may have maintained the health of the ear to some extent.

Participants were informed that all other factors that may influence their choice of ear, such as medical status, patient choice and radiological findings, were identical in all scenarios.

Analyses

To analyse the effects of varying the duration of deafness and aiding status of the non-scoring ear, respondents' choices were subjected to binary logistic regression using Generalized Estimating Equations, a form of general linear modelling that accounts for correlation between variables when multiple measurements are obtained from the same participants; e.g. repeated measures designs (Liang and Zeger, 1986). An independence correlation structure was used and a sensitivity analysis confirmed that the model fit was not adversely affected by this choice. Wald tests assessed the overall effect of each factor.

In accordance with an actuarial model of outcomes in profoundly deaf UK candidates (UKCISG, 2004), the ear that would be most likely to result in benefit from the use of the CI alone (the 'unilateral' choice) corresponded to the non-scoring ear in the 3-year scenario and the scoring ear in the 15-, 25-, and 50-year scenarios (Figure 1). Respondents' choices were analysed to evaluate in which scenarios (if any) they might seek to preserve contralateral residual hearing by selecting the poorer performing ear for implantation rather than any of

these ‘unilateral’ choices. Differences in the level of agreement between choices were assessed using McNemar’s test for correlated proportions.

Figure 1 here

Results

Thirty-four audiologists participated with at least one response received from all 20 UK adult CI centres. Sixty-six audiologists were registered on the BCIG mailing list as working with adult patients at the time the questionnaire was distributed. The sample therefore represented an estimated response rate of 52% based on the number of audiologists working with adults who are current BCIG members.

Figure 2 shows respondents’ choices expressed as the proportion of those who recommended implanting the ear that would be likely to maximise benefit from use of the implant alone (‘unilateral’ choice) in both the aided and unaided conditions. Respondents’ choices were influenced by whether the non-scoring ear was described as aided or not ($\chi^2(1)=5.5$, $p<.05$) and by its duration of deafness ($\chi^2(3)=31.0$, $p<.001$). Respondents were more than twice as likely to recommended the non-scoring ear for implantation if it had been aided continuously rather than unaided (Odds Ratio (OR) 2.4, 95% confidence interval 1.1 to 5.0). The odds of choosing the non-scoring ear reduced significantly when the duration increased from 3 to 15 years (OR 0.1, 95% confidence interval 0.04 to 0.3) and from 15 to 25 years (OR 0.4, 95% confidence interval 0.2 to 0.96), but not from 25 to 50 years (OR 0.3, 95% confidence interval 0.06 to 1.6).

Figure 2 here

In the unaided scenarios, the proportion who made the 'unilateral' choice was generally high and increased at longer durations of deafness (3 years vs 50 years, $p<.05$). In the aided scenarios, the proportion who made the 'unilateral' choice was also high in the 3-year and 50-year scenarios but was significantly lower than in the unaided scenarios in both the 15-year and 25-year scenarios ($p<.001$ and $p<.05$, respectively). The largest effect of aiding on the proportion of 'unilateral' choices was observed in the 15-year scenario (29.4% difference), in which half of all respondents still chose the non-scoring ear despite it having both no measurable speech perception and a longer duration of deafness, and hence less favourable odds of improving performance if implanted compared to the scoring ear.

Discussion

In recommending a poorer-performing ear with a longer duration of deafness for implantation, many clinicians would appear to be seeking to preserve functional residual acoustic hearing where possible. The fact that this preference was contingent on whether the poorer-performing ear had been aided is compatible with the fact that the potential deleterious effects of auditory deprivation on CI outcome remains an important factor in decision making around the ear to implant. The willingness of up to half of all respondents to consider recommending implantation of an ear that existing data would suggest is less likely to maximise outcome using the CI alone suggests that many clinicians believe that some

patients may derive additional benefit from access to residual hearing in the contralateral ear following implantation.

Recommendations to implant a poorer-functioning ear are presumably motivated by a desire to minimise loss of existing hearing function and to facilitate HA use in the non-implanted ear following implantation. In more traditional candidates with no useful residual hearing, the choice of ear for implantation can be informed by factors know to reliably predict outcomes following implantation such as duration of deafness and pre-operative speech perception scores (Dowell et al, 2004; UKCISG 2004). Emerging evidence suggests that outcomes resulting from the combined use of a CI and a contralateral HA may also be predicted by the level of residual hearing in the non-implanted ear (Zhang et al., 2013). Compatibly, recent data from UK patients suggests that the largest reported increase in HA use since the publication of NICE guidance in 2009 has occurred among those implanted in their poorer ear (Fielden et al 2016). Further research is required to identify the audiological factors that have the greatest capacity to predict 'bimodal' outcomes and thus should be considered when recommending which ear to implant in candidates with aidable residual hearing.

Conclusion

The results of a decision-choice experiment suggest that clinicians seek to preserve aidable residual hearing where possible, presumably to enable patients to benefit from contralateral hearing aid use following implantation. Future approaches to determining candidacy should therefore consider that a sub-set of patients may obtain additional benefit from the simultaneous use of an implant and a hearing aid and that the size of that benefit may not necessarily be predicted by the same factors that predict implant-only outcome.

Acknowledgements

This study was supported by infrastructure funding from the National Institute for Health Research (NIHR), Nottingham University Hospitals NHS Trust, and the University of Nottingham. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health. The authors wish to acknowledge the support of the British Cochlear Implant Group and all the clinicians who completed the survey. The authors declare no conflicts of interest.

193 **References**

194 Dowell, R. C., Hollow, R., Winton, E. (2004). Outcomes for cochlear implant users with
195 significant residual hearing: implications for selection criteria in children. Archives
196 of Otolaryngology: Head and Neck Surgery, 130, 575-581.
197 Fielden, C. A., Hampton, R., Smith, S., Kitterick, P. T. (2016). Access to aidable residual
198 hearing in adult candidates for cochlear implantation. Cochlear Implants
199 International Supplement on Candidacy.
200 Illg, A., Bojanowicz, M., Lesinski-Schiedat, A. et al. (2014). Evaluation of the bimodal
201 benefit in a large cohort of cochlear implant subjects using a contralateral hearing
202 aid. Otology and Neurotology, 35, 240-244.
203 Liang, K.-Y., Zeger, S. (1986). Longitudinal data analysis using generalized linear models.
204 Biometrika, 73, 13-22.
205 NICE. (2009). Cochlear Implants for children and adults with severe to profound deafness.
206 National Institute for Clinical Excellence Technology Appraisal Guidance 166. UK.
207 UKCISG (2004). Criteria of candidacy for unilateral cochlear implantation in postlingually
208 deafened adults III: prospective evaluation of an actuarial approach to defining a
209 criterion. Ear and Hearing, 25, 361-374.
210 Zhang, T., Spahr, A. J., Dorman, M. F. et al. (2013). Relationship between auditory function
211 of nonimplanted ears and bimodal benefit. Ear and Hearing, 34, 133-141.
212
213
214

215 **Figure Legends**

216 **Figure 1:** Schematic representation of the eight scenarios that described hypothetical
217 candidates with one 'scoring' ear and one 'non-scoring' ear. The duration of deafness of the
218 non-scoring ear was varied across the scenarios and was described as either having been
219 aided continuously or unaided. The shaded ear in each scenario represents the 'unilateral'
220 choice; that is, the choice that was likely to maximise benefit from use of the implant alone
221 based an actuarial model of outcomes in profoundly-deaf UK candidates (UKCISG 2004).

222

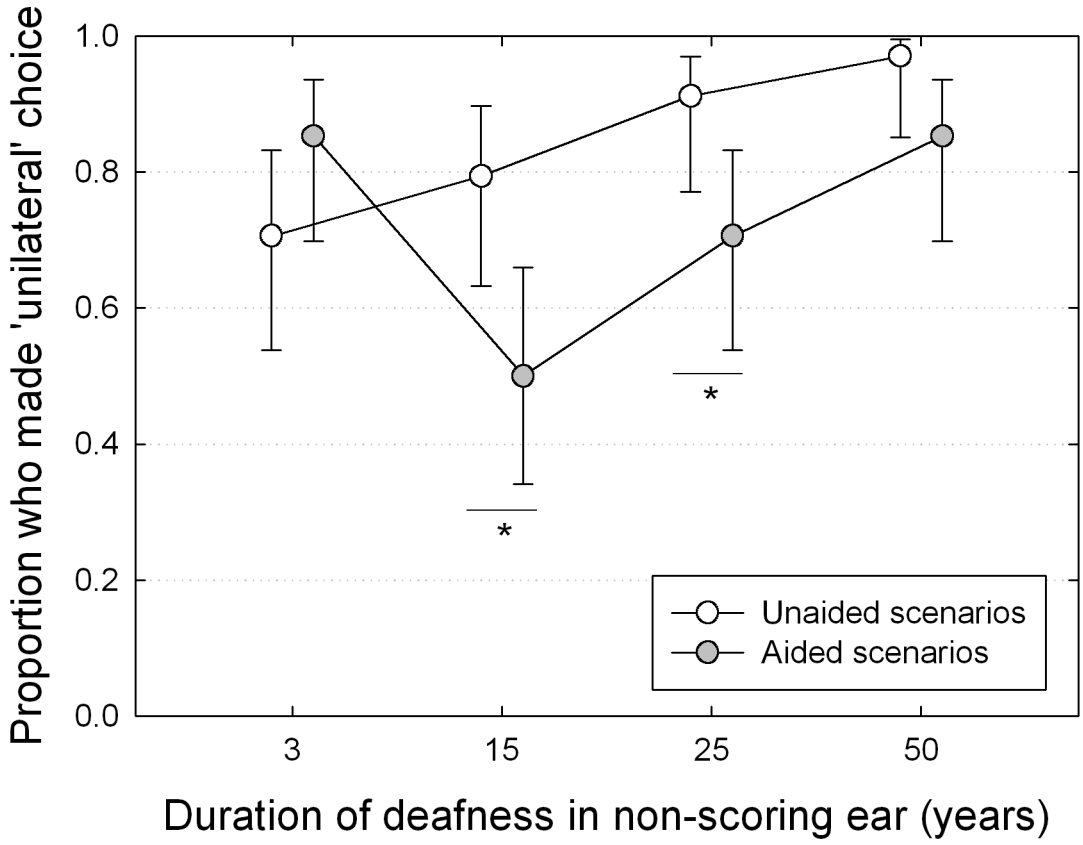
223 **Figure 2:** The proportion of respondents who chose the ear that was likely to maximise
224 benefit from the implant alone ('unilateral' choice) based an actuarial model of outcomes in
225 profoundly-deaf UK candidates (UKCISG 2004). Proportions are shown separately for the
226 four unaided scenarios (open symbols) and the four aided scenarios (shaded symbols). Error
227 bars plot 95% confidence intervals for the proportions.

228

229

	Non-scoring (left) ear		Scoring (right) ear	
Scenario	Aided?	Duration	Aided?	Duration
1	Y	3	Y	3
2	N	3	Y	3
3	Y	15	Y	3
4	N	15	Y	3
5	Y	25	Y	3
6	N	25	Y	3
7	Y	50	Y	3
8	N	50	Y	3

Figure 1



233

234 Figure 2