

Prevalence of Contralateral Hearing Aid Use in Adults with Cochlear Implants

Cintia Tizue Yamaguchi¹ Maria Valéria Schmidt Goffi-Gomez¹

¹Division of Cochlear Implants, Department of Audiology, Clinic Hospital of the Medicine High School of the University of São Paulo (HCFMUSP), São Paulo/SP, Brazil

Address for correspondence Cintia Tizue Yamaguchi, Audiologist, 255 Dr. Enéas de Carvalho Aguiar, 6th floor, Cerqueira César, São Paulo/SP 05403-000, Brazil (e-mail: ct.yamaguchi@uol.com.br).

Int Arch Otorhinolaryngol 2013;17:370–374.

Abstract

Introduction The exclusive use of a cochlear implant (CI) in one ear allows patients to effectively hear speech in a quiet environment. However, in environments with competing noise, the processing of multiple sounds becomes complex. In an attempt to promote binaural hearing in a noninvasive manner, the use of a hearing aid in the nonimplanted ear is suggested for patients with a unilateral CI.

Aims To identify the prevalence of hearing aid use in the contralateral ear in adults who already have a CI; to determine the reasons why some patients do not use contralateral hearing aids (CHAs); and to analyze the effects of residual hearing in CHA users.

Materials and Methods This is a clinical study in 82 adult patients with CI implants who responded to a questionnaire designed to determine current use of CHA.

Results In our patient sample, 70 CHA nonusers were identified. The prevalence of CHA users was determined to be 12% with a 95% confidence interval of 11 to 13%. About 58.2% of the CHA nonusers reported a lack of noticeable benefit even after wearing hearing aids, and 23.6% reported not having received the option to use a CHA. CHA users had a pure tone average of 107-dB hearing level, whereas CHA nonusers had a pure tone average of 117-dB hearing level.

Conclusion The prevalence of the use of a CHA is low in our study. We attribute the low use of a CHA to either a lack of residual hearing or to a lack of benefit from the amplification.

Keywords

- ▶ cochlear implantation
- ▶ deafness
- ▶ hearing aids
- ▶ speech perception

Introduction

Deafness is a disability that affects individuals on variety of levels: social, emotional, and familial. As a result, deafness leads to significant lifestyle modifications.

Individual sound amplification devices (hearing aids) can mitigate hearing loss by amplifying sound input according to the needs of a patient. However, some patients with severe to profound hearing loss do not benefit from the use of hearing aids (due to a lack of sensory input) and cannot appropriately discriminate words and sentences.

The most efficient and widely used solution for this type of deficit is the placement of a cochlear implant (CI). A CI is an electronic device that is implanted into the cochlea. CIs are

indicated for the treatment of individuals with hearing loss who have severe to profound hearing loss and have not benefitted from the use of traditional hearing aids. The CI is an effective adjunct during the (re)habilitation of prelingual hearing-impaired children and postlingual hearing impaired adults.^{1,2}

The CI is usually implanted unilaterally. However, questions have been raised concerning issues related to unilateral hearing. For instance, unilateral hearing impairs the performance of speech perception in environments with a high level of ambient noise and negatively affects the performance of schoolchildren.^{3,4}

The exclusive use of a CI in one ear (without the use of a contralateral hearing aid) allows patients to effectively hear

received
September 4, 2012
accepted
June 6, 2013

Copyright © 2013 by Thieme Publicações Ltda, Rio de Janeiro, Brazil
DOI <http://dx.doi.org/10.1055/s-0033-1352501>.
ISSN 1809-9777.

speech in a quiet environment. However, in environments with competing noise, the processing of multiple sounds becomes difficult. In an attempt to promote binaural hearing in a noninvasive manner, the use of a hearing aid on the nonimplanted ear has been suggested for patients with a CI. This approach has been referred to as *bimodal stimulation*.⁵

The International Consensus on Bilateral Cochlear Implants and Bimodal Stimulation recommends the application of bimodal stimulation in patients with residual hearing.⁶ It also proposes that bimodal stimulation may offer advantages with respect to speech perception in quiet and noisy environments and may contribute to sound localization.

The use of both CIs and hearing aids, rather than each of these alone, has shown an improvement in speech perception in noisy environments.⁷

Potts et al performed a study evaluating the concomitant use of CIs and hearing aids and the combined effect on speech recognition and localization.⁸ They suggested that the hearing aid must be designed using digital technology. They concluded that the combined benefits of a CI and a contralateral digital hearing aid are greater than the benefits of using these alone.

Fitzpatrick and Leblanc conducted a study exploring the factors influencing the discontinuation contralateral hearing aid use in patients with a CI.⁹ They proposed that an “enhanced understanding of the factors influencing patients’ decisions may help clinicians to modify their recommendations and counseling and thereby increase patient exposure to the potential benefits of combining acoustic and electrical stimulation.”

Cullington and Zeng compared music perception, affective prosody discrimination, speaker identification, and speech recognition in presence of a competing talker in bimodal and bilateral CI users.¹⁰ The aim of their study was to identify whether bilateral CI users or those with bimodal stimulation had the best aural performance. The authors found no difference between the groups.

However, this approach is not always followed in clinical practice. As a result, the potential stimulation of residual hearing of the opposite ear, which would allow the patients to benefit from binaural hearing, is often not attempted.

In the present study, we focus on the reasons why adults with CIs who have residual hearing do not use a hearing aid on the contralateral ear.

Aims

To identify the prevalence of the use of hearing aids in adults who received a CI at the Clinic Hospital of Medicine High School of the University of São Paulo (HCFMUSP); to determine the reasons why patients with CIs reported the nonuse of hearing aids and to elucidate the effects that residual hearing has on the decision to use a hearing aid in the contralateral ear.

Materials and Methods

The studied cohort included all of the patients who were implanted with a Cochlear Nucleus 22, Cochlear Nucleus 24, or Medel Combi 40 multichannel CIs from April 12, 1999 to July 18, 2007. Patients who met the following inclusion criteria were enrolled in the study: users of unilateral, multichannel CIs that met the HCFMUSP criteria¹¹; prelingual or postlingual hearing-impaired adults (aged 18 years or older).

Three types of methods were used for data collection: in-person interviews (patients who were scheduled for programming of their CI within the period of data collection); telephone interviews; and questionnaires sent via e-mail. In some cases, it was necessary to use more than method of contact.

A questionnaire (► **Table 1**) was prepared and presented to all contacted patients. The questions were designed to encompass the following information: the use or nonuse of hearing aids in the contralateral ear, the reasons for use or nonuse, and whether the patients experienced any

Table 1 Hearing aid and cochlear implant (CI) use questionnaire

Name:
Age:
Gender:
Education:
CI side: date of CI placement:
Pure tone average implanted side: not required Pure tone average opposite side: not required
1. Did you use hearing aids before receiving the CI? If yes, in which ear?
Yes () No ()
Right ear () Left ear ()
2. Do you use a hearing aid on the ear other than the one with the CI?
Yes (). Why?
I was oriented to ()
I have benefited from the hearing aid ()
It contributes to the CI ()
Others: ()
No (). Why?
Lack of orientation ()
Lack of benefit ()
Lack of financial resources ()
Others: ()
3. Do you miss or have difficulty in localizing sounds?
Yes () No ()
Sometimes () _____

Table 2 Demographic data

	Group 1	Group 2
<i>n</i>	72	10
Age (y)		
Median	42	37
Minimum	18	22
Maximum	70	63
Hearing aid users (<i>n</i>)	72	10
PTA contralateral (dB)		
Median	117.8	107.2
Minimum	93	95
Maximum	125	125

Abbreviation: PTA, pure tone average.

difficulties in sound localization. The questionnaire included a section about consent for the use of the data in our study.

After completion of the questionnaire, data relating to the pure tone average (PTA) threshold of 500, 1,000, and 2,000 Hz were collected from medical records.¹² A value of 125 dB was determined as the frequency threshold absent in audiometry for the calculation of the PTA threshold of the ear contralateral to the CI.

In total, 137 adults met the initial criteria for entry into our study. Of these, we were unable to contact 32, and 23 patients were excluded on the basis of the exclusion criteria. Therefore, the final total sample size was 82 patients (36 women and 46 men). The cohort was divided into two groups: group 1 comprised CI patients who were nonusers of a contralateral hearing aid; group 2 comprised CI patients who were users of a contralateral hearing aid (► **Table 2**).

The data were analyzed through descriptive statistics. Shapiro–Wilk test was used to assess the normality of the data. When normality was observed, a *t* test was used; otherwise, parametric Mann–Whitney test was applied. Data were considered statistically significant if *p* values were < 0.05.

Results

The prevalence of individuals with CIs who were using hearing aids in the contralateral ear was 12% (95% confidence interval, 11 to 13%; ► **Tables 2 and 3**).

Table 3 Difficulty of sound localization of studied groups referred during interview

Difficulty in the sound localization	Group 1		Group 2		<i>p</i>
	<i>n</i>	%	<i>n</i>	%	
No	14	19.4	2	20	0.9693
Only in environments	34	47.2	2	20	0.0851
Yes	17	23.6	3	30	0.6988
Data not available	7	9.7	3	30	0.2249
Total	72	100	10	100	

Table 4 Reasons for using hearing aids contralateral to the CI and PTA threshold (in decibels hearing level) of patients who reported the reasons

	<i>n</i>	%	PTA (dB)	
			Mean	SD
Helps to listen better	7	70	103.14	6.36
Instructed to use	1	10	100	–
Binaural advantage and instructed	2	20	125	–
Total	10	100	–	–

Abbreviations: CI, cochlear implant; PTA, pure tone average; SD, standard deviation.

Table 5 Between-group statistical analysis of pure-tone average threshold (in decibels hearing level)

	Group 1	Group 2	<i>p</i>
<i>n</i>	72	10	0.0051
Mean	117.76	107.2	
Standard deviation	9.46	10.77	
Median	125	103	

During the interview, the participants were asked about their difficulties with sound localization. In Group 1, a majority of the participants noted difficulty with sound localization in environments with background noise. The difference between groups 1 and 2 was not statistically significant (► **Table 4**).

We observed that 70% of the patients reported improvement in their hearing ability with the combined use of CI and a contralateral hearing aid; 20% of the patients benefited from bimodal stimulation with 125 dB of residual hearing (► **Table 5**).

The Mann–Whitney test showed a significant difference in the PTA thresholds of the two groups (*p* = 0.0051; ► **Table 6**).

Discussion

Currently, bimodality (CI combined with a contralateral hearing aid) is fundamental with regard to the possibility of achieving binaural hearing in patients with bilateral, severe to

Table 6 Distribution of the pure tone average threshold (in decibels hearing level) by intervals in both studied groups

dB	Group 1				Group 2				p value
	n	%	Main	SD	n	%	Main	SD	
90–100	6	8.50	96	2.76	4	40.00	98.75	2.5	0.184
101–110	8	11.30	106,13	3.6	3	30.00	104	2.65	0.3337
111–120	20	28.20	115,7	2.68	1	10.00	115	–	–
> 120	37	52.10	124,89	0.66	2	20.00	125	0	0.9075
Total	71				10				

Abbreviation: SD, standard deviation.

profound, hearing loss. This combination is generally used in patients who have residual hearing and/or who have a good response with a hearing aid in the nonimplanted ear. Several studies have been conducted on the subject with the aim to expand upon the knowledge already known about bimodality.^{1,2,5–7}

Several researchers have concluded that sound localization can be improved through the use of a CI combined with a contralateral hearing aid.^{5,8,13} **Table 2** displays the responses of the participants when questioned about the difficulty of sound localization. The responses relating to sound localization were similar in both groups. Moreover, in our study there were participants who did not describe difficulties in sound localization; despite being unilateral CI users without a contralateral hearing aid. Dunn et al¹⁴ published a study in which only 2 of the 12 patients evaluated for sound localization were able to localize sound with a CI combined with a contralateral hearing aid. The authors also reported that patient effort is a factor when it comes to improving the integration of sensory information (and improved sound localization) provided by the combined use of a CI and a hearing aid. Their conclusion concerning the importance of patient effort is supported by the following factors: (1) sound localization is a central auditory nervous system process, and (2) some people are able to integrate information from two ears (improving speech perception and sound localization) and others (with similar, two-ear capabilities) are not.

The patient responses concerning the reasons for the use of a CI in conjunction with a hearing aid are presented in **Table 3**. These data show that most patients (70%) reported that sound quality was better with the combined use of a CI and a hearing aid. The data also show that these patients have PTA contralateral to a CI capable of offering acoustic information that contributes to sound quality. Some authors have suggested a theory for how the bimodal condition provides superior information: acoustic amplification through a contralateral hearing aid provides necessary, low-frequency information, which is not provided by the CI alone.^{5,15,16}

We believe that the level of residual hearing plays an important role in bimodal adaptation. PTA comparison between group 1 and group 2 was statistically significant ($p = 0.0051$; **Table 4**). The group of patients with better

residual hearing was the group that reported the combined use of a CI with a contralateral hearing aid.

Several other authors have suggested that residual hearing contributes to the effectiveness of bimodality.^{5,6,8,13} However, Ching et al found no statistical significance when comparing the PTA in children on the basis of tests for sound localization and speech perception and questionnaires given to parents of the children.¹⁷ The authors mentioned that the contributions from residual hearing were found to be associated with the individual. Therefore, the following questions remain: (1) Is the success of bimodal hearing directly dependent upon the residual hearing of patients? (2) Is the success of bimodal hearing more dependent upon the integration of the central, auditory, nervous system? (3) Is the success of bimodal hearing associated with both of these factors? Potts et al stated that it “is recommended that unilateral CI recipients, with measurable unaided hearing thresholds, be fit with a hearing aid.”⁸

Continuing with the topic of residual hearing, **Table 5** shows the distribution of residual hearing according to groups. It was observed that the percentage of subjects with residual hearing up to 110 dB was higher in group 2, and the percentage of individuals with residual hearing up to 110 dB was lower in group 1. Interestingly, all of the patients in group 2 used hearing aids in both ears prior to their CI placement. In addition, most of the patients in group 1 did not use hearing aids in both ears prior to their CI placement. This leads us to conclude that the use of hearing aids prior to the placement of a CI may have some influence on the central auditory nervous system integration, such that, when adapted to bimodality, integration and plasticity of the auditory pathways already exist.

Conclusions

In our clinic, we were able to identify that the prevalence of the use of a contralateral hearing aid in adults with CI was 12%. One of the reported reasons for not using a contralateral hearing aid in conjunction with a CI was a lack of perceived benefit from the hearing aid. The residual hearing of the CI patients who use a contralateral hearing aid was higher (107-dB hearing level) than that of the CI patients who do not use a contralateral hearing aid (117-dB hearing level).

References

- 1 Bento FR, Neto RB, Castilho AM, Gómez VG, Giorgi SB, Guedes MC. Resultados auditivos com implante coclear multicanal em pacientes submetidos à cirurgia no Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo. *Braz J Otorhinolaryngol* 2004;70:632–637
- 2 Bevilacqua MC, Filho OC, Nascimento LT, Banhara MR. Evaluation of the combined use of hearing aid and cochlear implants in adults. *Disturb Comun* 2004;16:27–33
- 3 Feuerstein JF. Monaural versus binaural hearing: ease of listening, word recognition, and attentional effort. *Ear Hear* 1992;13:80–86
- 4 Lieu JE. Speech-language and educational consequences of unilateral hearing loss in children. *Arch Otolaryngol Head Neck Surg* 2004;130:524–530
- 5 Ching TY, Incerti P, Hill M, van Wanrooy E. An overview of binaural advantages for children and adults who use binaural/bimodal hearing devices. *Audiol Neurootol* 2006;11(Suppl 1):6–11
- 6 Offeciers E, Morera C, Müller J, Huarte A, Shallop J, Cavallé L. International consensus on bilateral cochlear implants and bimodal stimulation. *Acta Otolaryngol* 2005;125:918–919
- 7 Hamzavi J, Pok SM, Gstoettner W, Baumgartner WD. Speech perception with a cochlear implant used in conjunction with a hearing aid in the opposite ear. *Int J Audiol* 2004;43:61–65
- 8 Potts LG, Skinner MW, Litovsky RA, Strube MJ, Kuk F. Recognition and localization of speech by adult cochlear implant recipients wearing a digital hearing aid in the nonimplanted ear (bimodal hearing). *J Am Acad Audiol* 2009;20:353–373
- 9 Fitzpatrick EM, Leblanc S. Exploring the factors influencing discontinued hearing aid use in patients with unilateral cochlear implants. *Trends Amplif* 2010;14:199–210
- 10 Cullington HE, Zeng FG. Comparison of bimodal and bilateral cochlear implant users on speech recognition with competing talker, music perception, affective prosody discrimination, and talker identification. *Ear Hear* 2011;32:16–30
- 11 Gomez MVSG, Guedes MC, Sant'Anna SBG, et al. Medical and audiological selection criteria and evaluation for cochlear implants candidates: HC-FMUSP protocol. *Int Arch Otorhinolaryngol* 2004;8:295–303
- 12 Davis H, Silverman RS. *Hearing and Deafness*. 3rd ed. New York: Holt, Rinehart & Wilson; 1970
- 13 Seeber UB, Baumann U, Fastl H. Localization ability with bimodal hearing aids and bilateral cochlear implants. *J Acoust Soc Am* 2004;116:1699–1709
- 14 Dunn CC, Tyler RS, Witt SA. Benefit of wearing a hearing aid on the unimplanted ear in adult users of a cochlear implant. *J Speech Lang Hear Res* 2005;48:668–680
- 15 Kong YY, Stickney GS, Zeng FG. Speech and melody recognition in binaurally combined acoustic and electric hearing. *J Acoust Soc Am* 2005;117(3 Pt 1):1351–1361
- 16 Vandali AE, Sucher C, Tsang DJ, McKay CM, Chew JW, McDermott HJ. Pitch ranking ability of cochlear implant recipients: a comparison of sound-processing strategies. *J Acoust Soc Am* 2005;117:3126–3138
- 17 Ching TY, Psarros C, Hill M, Dillon H, Incerti P. Should children who use cochlear implants wear hearing aids in the opposite ear? *Ear Hear* 2001;22:365–380