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Original Article

Factors related to the satisfaction level of elderly hearing-impaired individuals with cochlear implants

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ABSTRACT

Objective: This study investigated factors related to the satisfaction level of cochlear implants for the elderly.

Methods: A survey was conducted by sending an anonymous self-reported questionnaire to medical facilities specializing in cochlear implantation throughout Japan and members of cochlear implant self-help groups aged 65 years and older. The subjects were divided into two age-based groups (under 75 and 75 years and older) to analyze the usage of cochlear implants. Binary logistic regression was performed to analyze factors related to the satisfaction level of the recipients with hearing improvements provided by cochlear implants ($p<0.05$).

Results: Responses were received from 60 cochlear implant users. The mean age of the respondents was 74.9±6.87 (mean ± 1SD) years. The mean cochlear implant use was 12.4 ± 4.0 (mean ± 1SD) hours per day. Regarding satisfaction with the cochlear implants, 93.3% responded "somewhat satisfactory" or better, indicating at least moderate satisfaction. However, fewer respondents in the 75-years and older group reported feeling "satisfactory" or better (chi-square test, $p<0.05$). Concerning device operation and management, difficulties including volume adjustment, switching between program, and exchanging cables, were reported. Among the patient-reported indices of postoperative hearing improvements studied, their ability to hear and comprehend conversations with family members and information provided at reception desks were most associated with user satisfaction with cochlear implants.

Conclusion: Many elderly patients were satisfied with their cochlear implants; however, respondents in the 75-years and older group had lower levels of satisfaction compared to those in respondents in the under-75-years group. Elderly patients had problems with more complex operations and management of their cochlear implants. Moreover, they were satisfied with their ability to comprehend familiar, everyday conversations. These factors related to satisfaction level may be useful in providing valuable rehabilitation for elderly patients with cochlear implants.

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1. Introduction

In recent years, there have been reports of increasing numbers of elderly individuals in countries such as Japan, Germany, and Italy, and predictions of similar trends in other countries in Asia such as China and South Korea [1]. These

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increases are expected to be accompanied by concurrent increases in the number of hearing-impaired elderly individuals. According to an epidemiological report by Yueh et al. (2003), hearing impairments occurred in 25% to 40% of individuals aged 65 years and older, 40% to 66% of those aged 75 years and older, and at least 80% of those aged 85 years and older [2].

A variety of psychological and social impacts related to hearing impairment among the elderly have been investigated and correlations between hearing impairment among the elderly and both depression and dementia have been reported [3,4]. In their longitudinal study of aging in the United States (Baltimore Longitudinal Study of Aging), Lin et al. focused on the risk of dementia among the hearing-impaired. They reported that dementia was 1.89- 3.00-, and 4.94-fold more likely among those with slight, moderate, and severe hearing impairments, respectively, than among those with normal hearing. The same study also recommended the early use of hearing aids among elderly individuals as hearing aid users had higher cognitive skill function scores and lower risk of dementia onset than those in individuals who did not use hearing aids [3].

Cochlear implants are indicated for hearing-impaired elderly individuals for whom hearing aids are not expected to improve their hearing function. One reason for this is the fact that it is difficult for elderly individuals to learn new methods of conversation such as sign language and lip-reading after sudden hearing loss. Studies on the use of cochlear implants by the elderly have reported lower speech discrimination and self-assessed hearing ability compared to those in young people [5,6]. However, other reports on the same issues have reported comparable speech discrimination under conditions of silence as reported in young people [7–10].

Nevertheless, there are problems associated with cochlear implants for elderly individuals such as higher risks during surgery due to general anesthesia compared to that in younger individuals [11] as well as reduced voluntary movement of the fingers when wearing the devices. Thus, there is a need to investigate problems associated with the operation, management, and use of cochlear implants. In addition, there are major individual differences in lifestyles as well as the physical and cognitive abilities of people who are retired from full-time work, resulting in challenges unique to elderly individuals that increase with age.

Thus, the objective of this study was to elucidate the usefulness of cochlear implants in elderly cochlear implant users. We investigated 1) the patient profiles of elderly hearing-impaired individuals with cochlear implants and their satisfaction level with cochlear implants via self-assessment, 2) factors related to the satisfaction level, 3) problems associated with the subjects' ability to operate and manage their cochlear implants, and 4) the effects of aging through analysis of two subject age subgroups (<75 and ≥75-years).

2. Subjects and methods

The subjects were elderly cochlear implant users aged 65 years and older who were receiving outpatient care at 112 registered cochlear implant medical facilities throughout Japan. The subjects included members of a patients' association who met the inclusion criteria. Survey responses were received from 62 individuals and 31 institutions, of which valid responses from 60 individuals were included in the analyses. The study was conducted from June 1 to July 31, 2016 (2 months). A description of the overall study design is shown in Supplementary File 1.

The survey was conducted as an anonymous self-administered questionnaire. Questionnaire forms were distributed to the subjects by audiologists in charge of rehabilitation at the medical institutions and by the secretariat at the patients' association.

The 18 question items were divided into the following four categories: 1) personal attributes (sex, age, history of hearing loss), 2) usage of the cochlear implant, 3) level of satisfaction with the cochlear implant, and 4) ability to operate and manage the cochlear implant. The subjects were asked to choose one response from 2–7 options for each question. The questionnaire is shown in Supplementary File 2-1 and 2-2.

The level of satisfaction with the cochlear implant was evaluated through self-assessment of satisfaction and comparison of the actual experience with the participants' expectations before surgery. The subjects chose one response each from among five options. The options for the former item were "satisfied, somewhat satisfied, cannot say if satisfied or not, not fully satisfied, and should not have done." The choices for the latter item were "as expected, nearly as expected, cannot say whether expectation was met, and somewhat different from expectations." The response was scored on a 5-point scale; the highest score (5) was assigned for the first-listed option and the lowest score (1) for the last option.

The responses were analyzed after dividing the subjects into two groups; namely those under 75 years of age (<75-years group; in other words, 65–74 years of age) and those aged 75 years and older (≥75 years group). T- and chi-square tests were used for comparisons between the two age groups, while analysis of variance and multiple comparisons were used for comparisons between items.

Pearson's product-moment-coefficients were determined for correlation analysis between the subjects' ability to operate and manage their cochlear implants. Questionnaire of "activity ability" in Q19 (Supplementary file 2-3, Q19, 13 items) was an Index of competence method previously used by the Tokyo Metropolitan Institute of Gerontology [12]. The value of "activity ability" calculates the average of the total "yes" scores in Q19. The value of "speech performance" was calculated using the total number of "yes" scores in Q17, then representing this score as an average. The value of "age at implant", "age (current age)", and "duration of CI use" were defined mean value as continuous variables. The value of "satisfaction levels", "cochlear implant operation", and "cochlear implant management" were calculated by the average sum of the ordered scale values.

Binary logistic regression analysis was performed using the satisfaction level with the cochlear implant as the dependent variable and the personal attributes and factors related to hearing improvement [13] as independent variables. Hearing

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Table 1
The history of cochlear implant and use

	All			65~74 Years			≧75 Years			(65~74/≧75)
Answering branch	n	AVE	1SD	n	AVE	1SD	n	AVE	1SD	t test p<.05
Duration of deafness[a]	58	6.5	8.6	28	8.6	10.7	30	4.6	5.6	n.s
Duration of CI use[a]	59	6.0	5.6	28	6.2	6.6	31	5.8	4.5	n.s
CI use per day[b]	59	12.4	4.0	29	12.2	4.2	30	12.6	4.0	n.s
Duration of HA use (Pre operation)	50	13.7	12.8	24	10.7	8.3	26	16.5	15.6	n.s

[a] Duration(year)
[b] Duration(hour)
CI: cochlear implant

improvement factors were subjected to univariate analysis and those with $p<0.05$ were included in the multivariate regression analysis. The univariate and multivariate analyses were performed using the forced entry and stepwise procedures, respectively. Data were analyzed using IBM SPSS Statistics for Windows, version 24.0.

This study was conducted with the approval of the Institutional Review Board for Human Research at the University of Tsukuba (approval number: Higashi 28-14) and the Institutional Review Boards of The Jikei University School of Medicine and the Jikei University Hospital (approval number: 28-086). Subjects' consent to participate in this study was established by means of submitting consent documents to the Director of the institution where the implantation surgery was performed and returning the completed questionnaire to the study authors.

3. Results

3.1. Study subjects

Survey responses were received from 35 women and 25 men. The mean age of the respondents was 74.9 ± 6.87 (mean ± 1SD) years. The <75-years and ≥75-years groups included 29 and 31 individuals, respectively. No significant differences between men and women or between the two age-based groups were observed.

More subjects were living with one or more family members (78.3%) compared to those who were living alone. Most subjects were not employed (90.0%); the <75-years group included more employed subjects compared to the ≥75-years group ($p<0.01$). Subjects with up to 12 years of education accounted for a greater proportion (78.3%) than those with 13–19 years of education (18.3%; $p<0.01$). Fifty-two subjects had used hearing aids before the surgery for a mean of 13.7 ± 12.8 (mean ± 1SD) years. No significant differences in the number of years of hearing aid use were observed between the two age groups.

3.2. Cochlear implant history

Table 1 shows the history of cochlear implant usage. The mean age at which the subjects lost their hearing was 62.4 ± 13.4(mean ± 1SD) years and the mean duration of hearing loss was 6.5 ± 8.6(mean ± 1SD) years. The mean length of cochlear implant usage was 6.0 ± 5.6(mean ± 1SD) years.

3.3. Assessment of level of satisfaction and comparison with preoperative expectations of cochlear implants

Table 2 shows the postoperative assessments of the level of satisfaction and comparisons to preoperative expectations of the cochlear implants. Positive responses; namely, those at level 5 (68.3%) and 4 (25.0%) comprised 93.3% of responses. Only one individual (1.7%) responded "Not fully satisfied" (level 2).

Evaluation of responses regarding the potential gap with preoperative expectations showed that over half of the respondents (overall, 68.3%; level 5, 43.3%, level 4, 25.0%) reported postoperative assessments indicating that their preoperative expectations were generally met. However, the satisfaction level based on the difference between pre- and postoperative expectations was not as high as that for satisfaction with the surgery itself.

Subjects in the ≥75-years group had lower levels of satisfaction with surgery than the levels among those in the <75-years group (χ^2 test, $p<0.05$). However, no difference between the age groups was observed regarding the gap with preoperative expectations.

3.4. Ability to operate and manage cochlear implants

Table 3 summarizes the results of the analysis of the participants' reported ability to operate and manage cochlear implants. Most subjects (96.6%) could independently use (1, attaching; 2, turning on and off) and operate (3, volume adjustment, 76.3%; 4, switching between programs, 59.3%) their cochlear implants. The results of the multiple comparison analysis indicated a higher level of independence for the first group of tasks (numbers 1 and 2 above) than for the second group (numbers 3 and 4).

Regarding management tasks, most subjects could independently 1) charging batteries (89.8%), 2) exchanging batteries, 3) storing the device (86.7%), and 4) noticing malfunctions (76.7%). In contrast, a smaller proportion of subjects could independently 5) requesting repairs (63.3%) or 6) exchanging cables (46.7%) (multiple comparison, $p<0.01$).

Table 4 shows the correlations among independence in cochlear implant operation and management and various factors such as individual attributes indicating correlations between cochlear implant operation and age, speech performance, activity ability, and age at implant and between

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Table 2
Assessment of level of satisfaction and comparison with preoperative expectations of CI.

		All		65~74 Years		≧75 Years		(65~74/≧75)
Categories	Answering branch	n	%	n	%	n	%	χ^2test p<.05
Satisfaction with the CI	5. Satisfied	41	68.3	24	82.8	17	54.8	p<.05*
	4. Somewhat satisfied	15	25.0	4	13.8	11	35.5	
	3. Cannot say	2	3.3	0	0.0	2	6.5	
	2. Not fully satisfied	1	1.7	0	0.0	1	3.2	
	1. Should not have done	0	0.0	0	0.0	0	0.0	
	Blanks	1	1.7	1	3.4	0	0.0	
	AVE± 1 SD	1.37±0.64	1.14±0.36	1.58±0.77				
Comparison with preoperative expectations	5. As expected	26	43.3	14	48.3	12	38.7	n.s*
	4. Nearly expected	15	25.0	8	27.6	7	22.6	
	3. Cannot say	7	11.7	2	6.9	5	16.1	
	2. Somewhat different	10	16.7	4	13.8	6	19.4	
	1. Different from expectations	2	3.3	1	3.4	1	3.2	
	AVE± 1 SD	2.12±1.24		1.97±1.21		2.26±1.26		

* Analyzed with 5 vs 1-4.
CI: cochlear implant.

Table 3
Ability to operate and manage cochlear implants.

		All		χ^2test/	65~74 Years		≧75 Years		(65~74/≧75)
	Answering branch	YES	%	multiple	YES	%	YES	%	χ^2test p<.05
Operate	1.Attaching	57	96.6	p<.01/1,2>3,4	28	96.6	29	96.7	n.s
	2.Turning and off	57	96.6		28	96.6	29	96.7	n.s
	3.Volume adjustment	45	76.3		25	86.2	20	66.7	n.s
	4.Switching between program	35	59.3		22	75.9	13	43.3	p<.05
Manage	1.Charging batteries	53	89.8	p<.01/ 1,2,3>5,64>6	27	96.4	26	83.9	n.s
	2.Exchanging batteries	52	86.7		25	86.2	27	87.1	n.s
	3.Storing the device	52	86.7		25	86.2	27	87.1	n.s
	4.Noticing malfunction	46	76.7		25	86.2	21	67.7	n.s
	5.Requesting repairs	38	63.3		19	65.5	19	61.3	n.s
	6.Exchanging cables	28	46.7		17	58.6	11	35.5	n.s

Table 4
Correlations among independence in cochlear implant operation and management

	Independence in operation	Independence in management
Activity ability	0.360**	0.418**
Speech performance	0.260*	0.423**
Age at implant	-0.281*	-0.311*
Age	-0.300*	-0.224
Satisfaction levels	0.264*	0.218
Duration of CI use	0.170	0.013

* p<0.05
** p<0.01

cochlear implant management and activity ability, speech performance, and age at implant. Cochlear implant operation and management showed negative correlations with age at implant. Cochlear implant operation was also correlated with current age. Activity ability and speech performance were correlated with cochlear implant operation and management.

3.5. Factors related to the level of satisfaction with hearing improvement for cochlear implants

Table 5 shows the factors related to the satisfaction level of the hearing improvement for cochlear implants. The hearing improvement-related items with significant (p<0.05) regression coefficients for dependent variables in the univariate analysis included "family conversations" and "conversations at reception desks." Others (conversations with audiologists, telephone, conversations in noisy conditions, watching television, and conversations with multiple people) did not have significant regression coefficients. The factors significant in the logistic analysis were improvement in family conversations (odds ratio [OR], 11.64; 95% confidence interval [CI], 1.13–20.2; p<0.05) and improvement in conversations at reception desks (OR, 4.79; 95% CI, 1.13–20.2; p<0.05).

The results showed a high level of satisfaction with their cochlear implants among elderly users owing to improvements in their ability to understand everyday conversations with family members and to have conversations at reception desks such as those in banks and shops.

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Table 5
Factors related to the level of satisfaction for cochlear implants (Multivariate analysis)

Dependent variable:patient satisfaction					
Explanatory variable	B	1SD	d f	P value	Odds ratio (Confidence Interval)
Family conversations	2.454	0.960	1	0.011	11.64 (1.77-76.42)
Conversations at reception desks	1.565	0.735	1	0.033	4.79 (1.13-20.22)

*Control variable:Age (under 75/75 and older), Sex, Duration of deafness

4. Discussion

The objective of this study was to elucidate the usefulness of cochlear implants in elderly cochlear implant users. Our survey design allowed respondents to honestly answer the questionnaire anonymously as it did not disclose the names of the medical facilities and patients. We investigated as many facilities as possible to avoid a bias in facilities. We used a self-administered questionnaire to survey the respondents regarding their use of cochlear implants and how they rated their satisfaction level and identified factors related to hearing improvement and problems related to the operation and management of cochlear implants. We divided the respondents into two age-based groups; namely, those under 75 years and those at or above 75 years of age, to analyze the effect of aging. Our analyses revealed the following.

4.1. Level of satisfaction with cochlear implants

The results of this study indicated that the users had positive responses to attaching/wearing cochlear implants (93.3%). However, the number of positive responses was lower in the ≥75-years group than that in the <75-years group (χ^2 test, $p<0.05$), indicating decreased satisfaction with increasing age. Akamatsu et al. reported that 88% of adults responded positively (“somewhat satisfied” or “better”) to cochlear implants and 46% felt at least nearly as good as expected [14]. These results indicated a higher level of satisfaction with cochlear implants among the elderly users in the present study. Ramos et al. investigated quality of life (QOL) improvements and hearing ability for cochlear implants in elderly users aged 60 years and older, reporting higher levels of satisfaction in elderly users compared those in younger users (40–60 years of age), although their scores on hearing ability were not higher [15]. The plausible explanations for the higher levels of satisfaction in elderly users include the fact that, compared to younger adults, elderly individuals have a lower standard related to hearing in the workplace and they received cochlear implants to improve their ability to live in their communities.

The present study observed lower levels of satisfaction with cochlear implants in the ≥75-years group than that in the <75-years group. However, Rafferty et al. compared QOL assessments by elderly cochlear implant users in their 50s, 60s, and 70s and above and reported no differences in assessments among age groups [16]. This difference may be attributable to the fact that the present study included subjects in a higher age range (65–89 years). Since individual differences in daily living circumstances increase with age, further studies with larger numbers of subjects may be required.

4.2. Circumstances in which cochlear implants are used

The subjects lost their hearing at a mean of 62.4 ± 13.4 years of age and the period between hearing loss and cochlear implantation surgery was 6.5 ± 8.6 years. The average duration of hearing aid use by those who used hearing aids before cochlear implantation was 13.7 ± 12.8 years, a relatively long time. The average period of cochlear implant use was 6.0 ± 5.6 years and the implants were worn for an average of 12.4 ± 4.0 hours per day, indicating that they normally used the implants all day. Hinderink et al. reported that half of cochlear implant users wore the implants for 12–16 hours per day [17], a finding roughly corresponding to the data for elderly cochlear implant users in our study.

4.3. Independence in cochlear implant use, operation, and management

Elderly cochlear implant users were highly independent in basic operations such as attaching, turning on and off, charging batteries, exchanging batteries, and storing of the device. However, they were less independent in somewhat complex operations such as adjusting the volume, switching between programs, and exchanging cables. In particular, the number of users reporting difficulties in switching between programs increased with age. Our previous survey of speech-language-hearing therapists demonstrated that the characteristics and problems of rehabilitation included difficulties in device operation and management among elderly patients, particularly those aged 75 years or over [18]. These results indicated the need for repetitive practice and assistance in elderly patients and for therapists to provide better guidance and training on device operation and management of cochlear implants.

Cochlear implant operation and management both showed negative correlations with age at implant, suggesting that, even among the same advanced age group, the younger the age at surgery, the higher the level of independence in cochlear implant operation and management. Cochlear implant operation was also correlated with current age, further indicating that the operation was strongly affected by age. Moreover, both activity ability and speech performance were correlated with cochlear implant operation and management, indicating that the higher the active speech performance, the better the cochlear implant use.

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Problems related to transportation arise in the communities in which elderly people live; in some cases, elderly individuals living alone do not receive assistance from family members. Thus, creating assistance systems in local communities and creating remote medical care systems may assist in ensuring that elderly individuals continue to use cochlear implants.

4.4. Factors related to satisfaction with cochlear implants

In this study, the results of logistic regression analysis using the cochlear implant satisfaction level as the dependent variable indicated that users were more likely to feel "good" about cochlear implantation surgery if they were able to understand daily conversations with family members and conversations at reception desks.

Hearing-impaired elderly individuals likely expected improvements in their ability to hear and comprehend conversations with multiple people before having surgery. Meanwhile, they were satisfied with their ability to comprehend familiar, everyday conversations such as those with family members and at reception and information desks at banks and shops, indicating the need to provide support for these situations.

A multivariate analysis of cochlear implant use among young adults (20–60 years of age) reported that overall hearing ability was related to the level of satisfaction with the device [6].

In the present study, while personal attributes were not contributing factors, individuals with long periods of hearing loss have been reported to have lower postoperative levels of satisfaction and lower assessments of their QOL [16,19]. This finding suggests the need for careful consideration regarding whether the surgery is indicated and individualized support for those who do undergo the surgery.

In conclusion, the present study examined the satisfaction levels with cochlear implants themselves and factors related to these satisfaction levels to make better use of cochlear implants for elderly patients. Many elderly patients were satisfied with cochlear implants; however, respondents in the 75-years and older group had lower levels of satisfaction than those in respondents in the under-75-years group. Elderly patients had problems with more complex operations and management of their cochlear implants. Moreover, they were satisfied with their ability to comprehend familiar, everyday conversations such as those with family members and at reception and information desks at banks and shops. These factors related to satisfaction level may be useful for providing valuable rehabilitation for elderly patients with cochlear implants.

4.5. Study limitations

The present study included very few individuals who stopped hospital visits and discontinued use of the device; thus, the lack of opinions from individuals who had experienced considerable issues was a limitation. Moreover, the results from a survey of young cochlear implant users were not used for comparison; thus, there is a limitation in the generalization of these results.

A future study will conduct a survey of young adult cochlear implant users using a structurally identical questionnaire and delineate the characteristics of elderly cochlear implant users compared to those of young adult users.

5. Conclusion

We observed a high degree of satisfaction with the use of cochlear implants among elderly hearing-impaired individuals. However, respondents in the 75-years and older group had lower levels of satisfaction than those in the under-75-years group and had problems with more complex operations. We conclude that support designed to ensure the continued use of cochlear implants requires an understanding of the specific circumstances of individual users as well as extremely detailed support tailored to those circumstances.

Declaration of Competing Interest

The authors declare no conflicts of interest associated with this manuscript.

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Supplementary materials

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