

Long Term Effects of Cochlear Implantation on Quality of Life and Perception of Handicap

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Cochlear implants (CIs) have provided remarkable hearing benefits to people with severe to profound sensorineural hearing loss. However, it is important to measure quality of life and handicap perception in CI users to assess how implantation affects their lifestyles. Eight adult CI users were administered 2 questionnaires, the Quality of Life and the Performance Inventory for Profound and Severe Loss, from pre-implantation to post-implant-activation 0 to 2 years, 2 to 3 years, and 3 plus years. The findings reflect improvement in numerous factors and a reduction in participation limitation following intervention. Additionally, responses from 1 elderly CI user were examined in depth revealing increased benefits over time.

Cochlear implants (CIs) have been proven to provide remarkable hearing benefits to people with severe-to-profound sensorineural hearing loss who receive little or no benefit from hearing aids (e.g., Shin et al., 2000). The majority of research in CIs has focused on the successes of speech perception and communication in implant users. Despite the great strides obtained in speech perception per-

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formance, it is still important to assess the impact of CIs on users' quality of life (QOL) and perception of handicap to determine the overall satisfaction of cochlear implantation.

World Health Organization (WHO; 1980, 2001) clearly defined disability and handicap and classified them as activity limitation and participation limitation, respectively. QOL simply refers to personal feelings of life (Bradley et al., 1999), which may be affected by different issues such as environmental or personal factors. Limitation of activity and/or social participation may cause negative feelings or dissatisfaction of a person's life. Mulrow, Aguilar, Endicott, Velez, and Tuley in 1990 demonstrated that the reduction of disability and handicap limitation led to improvement of QOL.

Previously, a limited number of studies have investigated the impact of CIs on QOL, and the results indicated that cochlear implantation is a successful treatment not only for improving speech perception, but also QOL in CI users (e.g., Hinderink, Krabbe, & Van Den Broek, 2000). For the most part, these studies have examined the short term impact of implantation. There is also evidence of significant reduction in the degree of depression and anxiety in implant users, which was linked to a more positive QOL (Birger, Morten, & Sten, 2005).

Other studies have focused on the perception of handicap in CI users. Shipp, Nedzelski, and Chen (2000) used the Performance Inventory for Profound and Severe Loss (PIPSL) questionnaire in their study to investigate handicap perception in CI users. Results from 100 adult CI users indicated significant changes in handicap perception between pre-implantation and 12-month post-stimulation time periods, and this perception was maintained afterwards. However, no systematic evaluation of QOL was conducted in their study.

To our knowledge, Spitzer, Kessler, and Bromberg (1992) have conducted the only study to systematically investigate both QOL and handicap perception aspects with cochlear implantation. Eighty-two veteran CI users were recruited to complete the QOL and PIPSL during pre-implantation, post-implant-stimulation, and post-stimulation 3 months, 1 year, and 2 years. Results indicated significant changes in perceptions of QOL and handicap through the 3-month time period and perceptions were maintained throughout the 2 year assessment.

To improve QOL, more and more elderly people are pursuing CI(s). However, little is known about the outcomes of CIs in elderly patients (especially "the old old," 80 years of age and above) since most data have not addressed the elderly group. Current studies have indicated that CIs appear to be safe in the elderly population, with minimal risks of complications (e.g., Pasanisi et al., 2003). Also, it has been shown that CIs can improve speech perception in the elderly. According to Sterkers et al. (2004) patients over the age of 70 years and those who were younger had similar performance, except under the circumstance when sentences were presented in noise or at a faster rate.

A small number of studies have examined the impact of cochlear implantation

on the QOL in the elderly. When comparing the QOL of older adults implanted over the age of 60 years to younger CI users, the benefits experienced by older adults was not significantly different from the benefits received by younger adults (Shin et al., 2000). According to Connell and Balkany (2006), age at implantation for adults should not be considered a major factor in CI candidacy.

It is important to examine QOL and perception of handicap across time to determine if there are significant changes when comparing pre-implantation perceptions and QOL to those immediately after implantation and at successive intervals thereafter. Understanding how the impact of cochlear implantation affects QOL and perceived handicap will serve as a tool for professionals to effectively counsel their CI patients. In addition, by looking at the impact of cochlear implantation over time, CI users can be counseled on realistic expectations. The purpose of the present study was to investigate the effects of cochlear implantation on both QOL and handicap perception over a 3 year time period. It was also of interest to observe the effects of one elderly CI user in greater detail to determine if there were any age-related effects on these measures.

METHODS

Subjects

This is a retrospective study. Eight post-lingually deafened adults were selected from the CI patient pool of Columbia University Medical Center in New York. The subjects were implanted between the ages of 44 to 83 years ($M = 60.46$ years). All subjects had baseline data (pre-implantation) plus subsequent measurements and responses (post-implantation). Demographic information for each subject including age, gender, CI device, speech processor, age at implantation, hearing aid experience, etiology, and onset of hearing loss is shown in Table 1.

Materials and Procedure

Three speech tests, the Northwestern University (NU)-6 Word Test (Tillman & Carhart, 1966), the Consonant Nucleus Consonant (CNC; Peterson & Lahiste, 1962), and the Hearing In Noise Test (HINT; Nilsson, Soli, & Sullivan, 1994), and two questionnaires, the QOL (Spitzer et al., 1992) and the PIPSL (Owens & Raggio, 1998), were used in this study to investigate the impact of cochlear implantation on perceptions of QOL and handicap.

All tests were administered at 50 dB HL in sound-field using recorded speech materials to assess speech recognition. The NU-6 word test consisted of 25 words that were scored for words correct. The CNC test consisted of 50 words that were scored for both words and phonemes correct. Two lists of the HINT, which consisted of 10 sentences per list (4 to 5 words per sentence), were administered to each subject in quiet and the average words correct was calculated as the final score. Percentage correct ($\% = \text{correct words}/\text{total words}$; $\% = \text{cor-$

Table 1

Background Data for 8 Cochlear Implant (CI) Users

Patient/ gender/ age (years)	Hearing aid experience in years	Etiology	Age at implantation (years)	CI device	CI processor
1-M-88	>10	Presbycusis	82/83	CI 24 RE(CA)	Freedom
2-F-50	>10	Sudden	44	CI 24 R(CS)	Freedom
3-F-70	10	Unknown	65	CI 24 RE(CA)	Freedom
4-M-56	2	Meniere's	51/52	CI 24 RE(CA)	Freedom
5-F-69	30	Ear infections	58	CII bionic ear	Auria
6-F-61	<1	Rheumatic fever	50/53	CI 24 R(CS)/ CI 24 RE(CA)	Freedom
7-F-69	>5	Autoimmune disease	62	CI 24 RE(CA)	Freedom
8-M-72	>5	Sudden	64	CI 24 R(CS)	Freedom

rect phonemes/total phonemes) was calculated for each speech test. For the assessment, the subjects wore their hearing aids (pre-implantation) or CI (post-implantation) as they were routinely used. During the tests, the subjects were seated in a quiet, sound-treated room, 1 m away from a speaker.

The QOL questionnaire was administered to measure the effects of hearing loss on a person's lifestyle. This questionnaire consisted of 41 questions assessing how hearing loss impacted hobbies, social relationships and events, and occupation. Subjects responded to each question using a 5-point scale from 1 (e.g., *poor/very difficult*) to 5 (e.g., *excellent/not difficult*), with 1 implying a negative impact of deafness and 5 indicating a more satisfactory QOL. Examples of items used in this questionnaire included "How frustrating is communication for you?" and "How would you evaluate your performance at work?"

The PIPSL questionnaire was used to assess subjects' perception of activity and participation limitation. This questionnaire consisted of 74 hypothetical communication situations such as response to auditory failure and understanding speech with or without cues. Subjects responded to each question using a 7-point scale from 0 (*Never*) to 6 (*Always*). A response of NA, not applicable, was used if that situation did not apply to them. Examples of items in this test included "Can you understand speech on the radio?" and "You are with two or three friends or family members sitting around a table talking. Sometimes people interrupt each other. When you are aware of the general topic, can you follow what is being said?"

Some questions were asked in a reversed phrase (QOL, question 1, 2, 4, 12, 14, 17-20, 22-24, 26-28, 31, 32, 34, 38, and 40; PIPSL, question 6, 12, 18, 24, 30,

36, 42, 48, 56, and 64). In order to compensate for the reversed questions, scoring adjustments were made so that the high numerical value indicated improved QOL and reduction in the perception of the handicap. Also in the QOL, questions 33, 37, and 39 were open-ended questions and were not reflected in the total scores.

Speech tests and questionnaires were administered to all subjects at the time of their CI evaluation and follow-up appointments. Questionnaires were completed through paper-pencil method. Responses were obtained in four different time periods: pre-implantation and post-implant-activation from 0 to 2 years, 2 to 3 years, and 3 or more years.

Data Analysis

A percentage score was calculated for each speech test. For each questionnaire, numerical responses were summed together to get a total value for each subject per time period. This total value was divided by the number of questions answered. To standardize the results, the scores for each questionnaire were divided by the maximum possible score and multiplied by 100 to get a percentage score. Mean scores and standard deviations (*SD*) were then calculated for both measures within each time period. Also, repeated measures of analysis of variance (RANOVA) and Post Hoc Tukey Honestly Significant Difference (HSD; $\alpha = 0.05$) were used to compare pre-implantation and post-implantation responses.

RESULTS

Speech Recognition

Table 2 lists the average speech recognition scores obtained pre-implantation and post-implantation 0 to 2 years, 2 to 3 years, and 3 or more years. Speech

Table 2
Average Speech Recognition Scores for Pre-Implant and Post-Implant Epochs.
Data Represent the Average Responses of All 8 Cochlear Implant Users.

Condition	Pre-implant			Post-implant		
	(% correct) aided			(% correct)		
	Binaural	Right	Left	0-2 years	2-3 years	3+ years
NU-6	12.43	6.88	26.29	34.00	34.67	57
CNC words	9.00	6.00	17.67	35.50	30.00	36
CNC phonemes	38.00	22.67	37.67	57.50	54.00	56
HINT	30.20	19.60	39.75	69.88	62.00	79

Note. NU-6 = Northwestern University-6 Word Test. CNC = Consonant Nucleus Consonant. HINT = Hearing in Noise Test.

recognition scores revealed significant improvements from pre-implantation to post-implantation and continued to improve with time (RANOVA: $p = .0001$; Post Hoc Tukey HSD, $\alpha = 0.05$). The greatest improvements in speech recognition were seen at the 3 or more years time period with scores of 57% correct for NU-6 words, 36% for CNC word score, 56% for CNC phoneme score, and 79% for HINT sentences.

QOL and PIPSL

Figure 1 plots the average QOL and PIPSL responses over time from pre-implantation to post-implantation 3 or more years. A significant improvement in post-implantation scores was indicated (RANOVA: QOL, $p = .0253$; PIPSL, $p < .0001$). For QOL, there was an increase from the pre-implantation score ($M = 56.59$, $SD = 4.99$) to the post-implantation 0 to 2 year score ($M = 65.87$, $SD = 7.48$). However, significant improvement (Post Hoc Tukey HSD, $\alpha = 0.05$) occurred post-implantation 2 to 3 years ($M = 74.33$, $SD = 6.45$), with an essen-

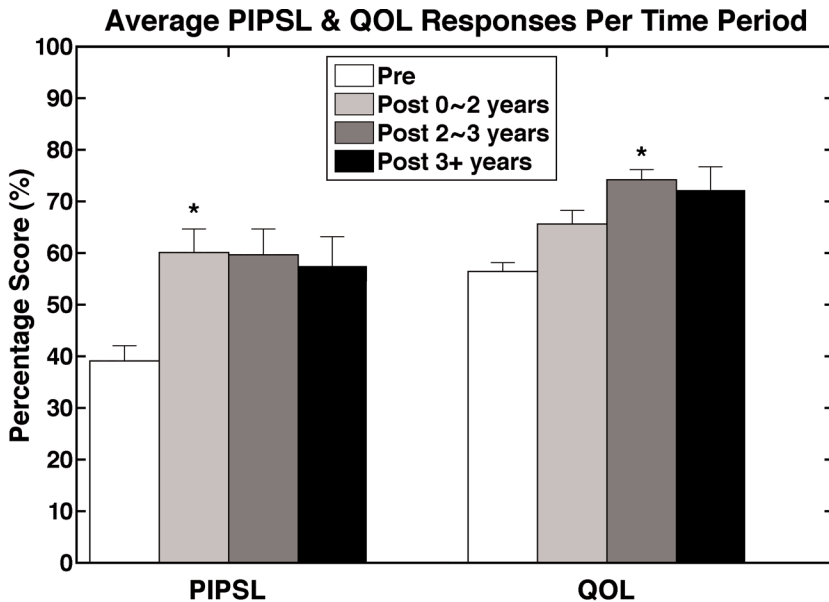


Figure 1. Average responses of 8 subjects on Performance Inventory for Profound and Severe Loss (PIPSL) and Quality of Life (QOL) over time. The percentage score is indicated on the y-axis versus PIPSL and QOL responses on the x-axis. The unfilled bar represents pre-implantation responses, the light gray bar represents post-implantation 0-2 years responses, the dark gray bar represents post-implantation 2-3 years, and the black bar represents post-implantation 3+ years. Standard errors are indicated for each time period. *indicates significant difference between pre-implantation and post-implantation.

Table 3

Selected Raw Scores from Performance Inventory for Profound and Severe Loss Items for Pre-Implant and Post-Implant Epochs. Data Represent the Average Responses of All 8 Cochlear Implant Users.

Grouping	Item #	Pre-implant rating	Post-implant rating		
			0-2 years	2-3 years	3+ years
Occupation	70 – Understand co-worker	2.67	4.83	4.75	4.67
	72 – Learn things connected with job	2.50	5.40	5.00	4.33
Family	31 – Communication in noise	1.00	3.14	4.00	3.50
	52 – Communication in quiet	3.00	4.86	4.50	3.75
	54 – Group conversation	3.30	4.60	4.75	4.33
Social	35 – Communication without lipreading	2.50	4.29	4.25	4.75
	67 – Communication in the store	2.00	4.43	4.25	3.25
Emotion	18 – Frustration with hearing loss	1.75	3.57	4.00	3.00

tially stable response in the 3 or more years time period ($M = 72.27$, $SD = 12.72$). The mean score difference between post-implantation 2 to 3 years and 3 or more years was not statistically significant.

For the perception of handicap, the significant improvement (Post Hoc Tukey HSD, $\alpha = 0.05$) occurred from pre-implantation ($M = 39.24$, $SD = 8.21$) to directly following implantation (0 to 2 year: $M = 60.27$, $SD = 12.98$). The responses in the 2 to 3 year time period ($M = 59.88$, $SD = 14.32$) and the 3 or more year time period ($M = 57.55$, $SD = 16.41$) were not statistically significant compared to the 0 to 2 year time period.

Table 3 lists some selected raw scores from PIPSL questionnaire items indicating improvements in different activity and participation aspects (work related, family, social, and emotional aspects) post-implantation. Data represents the average responses of all 8 CI users. Table 4 also lists some selected raw scores from both QOL and PIPSL questionnaires, which indicate different areas still needing improvement post-implantation.

An Octogenarian

One 88-year-old male, whose hearing loss was due to presbycusis, was examined in greater detail to determine the possible age-related effects to the QOL and PIPSL post implantation. This subject had over 10 years of hearing aid experience and subsequently received two implants, left side at the age of 82 years and

Table 4

Selected Raw Scores from Quality of Life and Performance Inventory for Profound and Severe Loss Questionnaire Items for Pre-Implant and Post-Implant Epochs. Data Represents the Average Responses of All 8 Cochlear Implant Users.

Grouping	Item #	Pre-implant rating	Post-implant rating		
			0-2 years	2-3 years	3+ years
Communication difficulty	61 – Friend/family member	2.50	4.83	4.75	4.67
	68 – Telephone	1.33	3.43	2.25	0.67
	73 – Co-worker	2.50	1.00	1.25	3.33
Hearing loss handicap	24 – Self	0.75	1.86	2.25	1.25
	48 – Others	2.75	2.14	2.75	1.00
Social	5 – Social activities	2.20	2.00	2.67	2.50
	27 – Activities requiring hearing	1.67	3.50	3.75	2.50

right side at the age of 83 years.

Table 5 displays this participant's speech recognition scores. There were clear improvements post-implantation 0 to 2 years and these scores continued to improve over time. Pre-implantation scores in the binaural condition with hearing aids were 24% for the NU-6, 19% for CNC words and 34% for CNC phonemes, and 25% for the HINT sentences. These scores continued to improve in the 3 or more years post-implantation with a score of 68% on the NU-6 test, 59% and 72% for the CNC words and phonemes, and the greatest improvement in the HINT with a score of 90%.

Figure 2 plots the QOL and PIPSL scores from this octogenarian pre-implantation and post-implantation. There were clear improvements over time in both

Table 5

Speech Recognition Scores for 1 of the 8 Cochlear Implant (CI) Users – An Octogenarian

Condition	Pre-implant (% correct) bilateral hearing aids	Post-implant (% correct) bilateral CIs		
		1-2 years	2-3 years	3+ years
NU-6	24	30	42	68
CNC words	19	30	38	59
CNC phonemes	34	45	61	72
HINT	25	75	82	90

Note. NU-6 = Northwestern University 6-Word Test. CNC = Consonant Nucleus Consonant. HINT = Hearing In Noise Test.

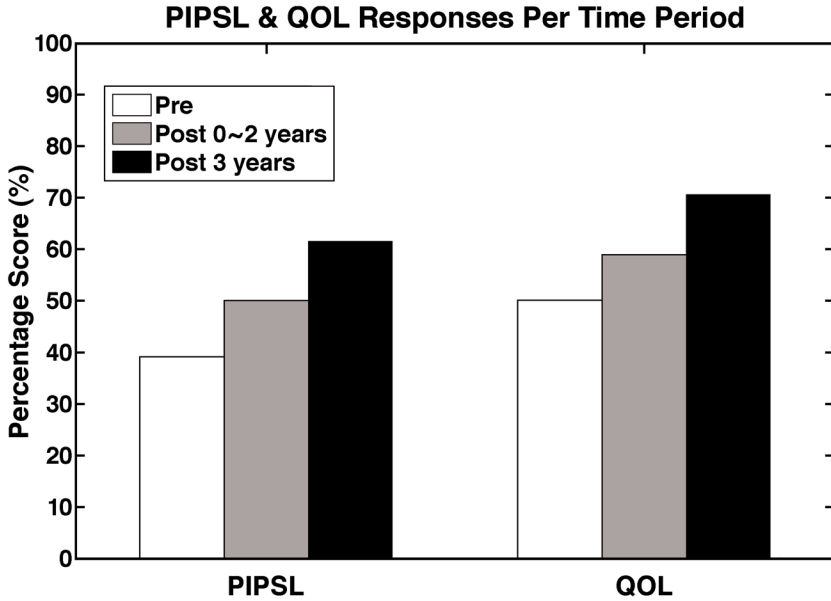


Figure 2. Performance Inventory for Profound and Severe Loss (PIPSL) and Quality of Life (QOL) responses of 1 octogenarian over time. The percentage score is indicated on the y-axis versus PIPSL and QOL responses on the x-axis. The unfilled bar represents pre-implantation responses, the gray bar represents post-implantation 0-2 years responses, and the black bar represents post-implantation 3+ years.

perceptions of QOL and PIPSL. The QOL pre-implantation score was 50% with a slight increase to 58.95% in the 0 to 2 years post-implantation score. In the 3 or more years time period, there was an increase in score to 70.53%. The PIPSL pre-implantation score was 39.14%, the 0 to 2 year post-implantation score was 50%, and the 3 or more years score was 61.57%. The response pattern from this octogenarian was essentially consistent with the overall mean responses of the group. There is a continuation of perceived improvement regarding QOL; activity and participation limitation extends well beyond the immediate post-implantation time period.

DISCUSSION

The overall goal of a CI is to allow the users to hear sounds, which were considered difficult or inaudible due to their hearing loss. Hearing these sounds and beginning to communicate with others which was often a struggle in these deaf individuals, may now lead to a better QOL and an improved lifestyle physically, socially, and emotionally.

The results of the present study indicated significant improvements in QOL,

perception of handicap, and speech recognition ability post-implantation. The improvement of handicap perception was significant directly following implantation and was maintained over time, which is consistent with previous reports (Shipp et al., 2000; Spitzer et al., 1992). However, unlike Spitzer et al., responses from QOL questionnaire in this study did not reflect immediate improvement post-implantation. The significant changes occurred at post-implantation 2 to 3 years and were maintained thereafter, which might be due to individual differences in the time it took to adapt to the new electrical stimulation.

The continued improvement of QOL over time provides positive evidence of the effect of cochlear implantation, which indicates the importance of using audiologic rehabilitation. However, perceptions of both QOL and handicap would be affected by environmental and personal factors (Bradley et al., 1999; WHO, 2001). Adverse environments (e.g., noisy restaurants) or certain personal characteristics (e.g., shy personality) may curtail further improvement of those subjective perceptions. The purpose of current rehabilitation is to reduce activity and participation limitation, eventually leading to improved QOL. Audiologic rehabilitation provides patients with different communication skills to overcome those environmental and personal difficulties and participate in more social activities to help magnify the positive effect of CI. This implies the need for long term rehabilitation.

Results obtained from the octogenarian indicated immediate improvements post-implantation in both QOL and PIPSL measures and continued improvements over time. Also, there were clear improvements in speech recognition scores of all the subjects which continued to increase over time regardless of age. These improved scores are in agreement with Pasanisi et al. (2003), and further confirmed that there were no increased risks with CI use in the elderly population and that age at implantation should not be considered a major factor for adults when determining candidacy.

An interesting finding from both questionnaires (see Table 3 and Table 4) is that these CI users had significant improvements in familiar situations such as the family related situation. However, subjects still struggled with situations that they were not confident in, such as social activities that required hearing. In the familiar situations, the patients were constantly exposed/participating in different activities, which is similar to continued rehabilitation. In contrast, the patients may refrain from engaging in the situations that they were not confident in, which is similar to limited or no rehabilitation. This information further confirms the relationship reported by Mulrow et al. (1990), that the reduction of activity and participation limitation would lead to a better QOL. It also suggests the possible necessity of additional rehabilitation post-implantation. In addition, the information provides a great insight of CI individual responses in different areas, which may help both implant users and CI service teams be aware of the advantages and disadvantages of implantation and develop appropriate rehabilitation plans.

In summary, the results of this study revealed significant improvements in speech recognition ability and perception of QOL and handicap post-implantation. Also, there was no effect of advanced age on perception post-implantation in this small sample. Generally, the results of this study are consistent with previous reports, except for some variability with QOL post-implantation 0 to 2 years. The overall continued improvement in QOL and no impact of advanced age on both perceptions for one octogenarian subject in this study suggest that long-term CI rehabilitation may be necessary. This also indicates a need to examine effects over a longer time period to obtain more information on CI users' perceptions. The results of this study provide useful information for both CI users and CI service teams, and may help develop a better rehabilitation plan, and ultimately lead to an improved experience for CI users. However, a limited number of subjects was recruited in this study, future studies should include more subjects to overcome individual differences.

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