Published in final edited form as:

Otolaryngol Head Neck Surg. 2013 January ; 148(1): 82–88. doi:10.1177/0194599812461755.

Auditory-Perceptual Speech Outcomes and Quality of Life after Total Laryngectomy

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Abstract

OBJECTIVE—i) To determine potential relationships between speech intelligibility, acceptability, and self-reported quality of life (QOL) after total laryngectomy; and ii) to determine whether relationships are stronger when QOL is measured by a head and neck cancer-specific or discipline-specific QOL scale.

STUDY DESIGN—Cross-sectional.

SETTING—University-based laboratory and speech clinic.

SUBJECTS AND METHODS—Twenty-five laryngectomized individuals completed disease-specific (*University of Washington Quality of Life*; UW-QOL) and discipline-specific (*Voice Handicap Index-10*; VHI-10) QOL scales. They also provided audio recordings that included the *Sentence Intelligibility Test* and a reading passage. Thirty-three listeners transcribed the SIT sentences to yield intelligibility scores. Fifteen additional listeners judged speech acceptability of the reading passage using rating scales.

RESULTS—QOL scores were moderate across the UW-QOL physical (mean = 77.63) and social-emotional (mean = 78.02) subscales, and VHI-10 (mean = 17.91). Speech acceptability and intelligibility varied across the samples, with acceptability only moderately related to intelligibility ($r = 0.41$, $p < .05$). Relationships were weak between ratings of intelligibility and self-reported QOL (range $r = 0.00 - 0.22$), and weak to moderate between acceptability with QOL (range $r = 0.01 - 0.46$). The only statistically significant, but moderate, relationship was found between speech acceptability with the UWQOL speech sub-score ($r = 0.46$, $p < .05$).

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Note: Portions of this paper were presented at the 8th International Conference on Head & Neck Cancer in July 2012, in Toronto, Ontario, Canada.

CONCLUSION—Listeners' ratings of speech acceptability and intelligibility were not strongly predictive of disease-specific or voice-related QOL, suggesting that listener-rated and patient-reported outcomes are complementary.

Keywords

quality of life; total laryngectomy; speech outcomes; intelligibility

INTRODUCTION

Total laryngectomy continues to be a treatment for laryngeal cancer that results in unique challenges to verbal communication, airway, and swallowing. Consequently, individuals often report a significant impact on quality of life (QOL), particularly within the first 12 months post-surgery.¹ However, after a period of adjustment, some studies report no overall health-related QOL differences between those who have undergone total laryngectomy with the general population.²

While the importance of communication to QOL after total laryngectomy is well documented, a discrepancy related to post-laryngectomy communication outcomes is revealed when different types of QOL measures are compared.^{3,4} For example, patient-reported QOL scales typically include those that are disease-specific (i.e., investigating the influence of specific head and neck cancer (HNC) symptoms on QOL) or discipline-specific (i.e., measuring characteristics of interest within a discipline, such as vocal function on QOL). Some studies using HNC-specific QOL outcomes report no difference in communication outcomes between those who have undergone total laryngectomy with those treated by conservation procedures.⁵ In contrast, studies using discipline-specific QOL measures have shown that laryngectomized individuals continue to report poorer voice-related QOL scores than either those who have undergone (chemo)radiation protocols or normal controls.^{6,7}

One explanation for the discrepancy related to communication outcomes post-laryngectomy is that HNC-specific QOL scales often only include one question related to voice or speech function. As a result, some voice- or speech-related concerns may only be revealed with the addition of discipline-specific questionnaires.⁸ However, even with use of discipline-specific measures, wide variability in individual performance exists.^{9–10}

Although patient-reported measures have gained widespread use, other important outcomes after total laryngectomy include auditory-perceptual judgments by clinicians. In addition, unfamiliar listeners often are used in research studies to gauge the social penalty related to post-laryngectomy communication methods.¹¹ As a result, a few studies have sought to characterize the relationship between auditory-perceptual judgments with patient-reported outcomes. This work has consistently shown that listener-rated outcomes (e.g., speech intelligibility, acceptability) are only weakly to moderately related to patient-rated QOL using both overall and disease-specific scales.^{5,12–14}

To date, no studies investigating these relationships post-laryngectomy have used voice-specific QOL scales, which may have reduced the sensitivity of results for detecting changes

in intelligibility or acceptability. Consequently, this study answered the following questions: (a) What is the relationship between speech intelligibility, speech acceptability and a patient's self-reported QOL after total laryngectomy, as measured by both disease-specific and discipline-specific measures; and, (b) Are relationships stronger when QOL is measured by a discipline-specific or a disease-specific QOL scale?

METHODS

Two groups of participants included 1) individuals who had undergone total laryngectomy (speakers); and 2) inexperienced listeners. All participants were native English speakers and reported no other speech, language, or voice symptoms above and beyond those associated with laryngectomy in the speaker group. The listeners all passed hearing screening tests at 20 dB for the octave frequencies of 250–8000 Hz. All participants were paid for their participation. Procedures were approved by the University of Washington Human Institutional Review Board.

Subjects

Speakers—Twenty-five individuals (20 males, 5 females) were recruited through support groups, professional listservs, and professional contacts. Individuals had undergone total laryngectomy at least 1 year prior to participation to avoid the fluctuation of QOL scores that occurs immediately post-treatment. The mean age for the entire group of speakers was 63.3 years, with a mean age of 64.8 years (range, 50–84y) for men and 59.2 years for women (range, 39–75y). Only subjects who used alaryngeal speech as their primary method of communication were included in the study.

Listeners—Thirty-three (22 females, 11 males; mean age = 23.9y) individuals were recruited from the broader community at the University of Washington to serve as listeners for the intelligibility protocol. An additional 15 listeners (10 females, 5 males; mean age = 26.4y) were similarly recruited to perform speech acceptability judgments. No listeners had prior experience with or exposure to alaryngeal speech.

Speaker Data Collection

Demographic measures—Speakers completed a set of questionnaires that included information related to age, sex, marital status, education, and primary speech method. Medical history included date of HNC diagnosis, date of total laryngectomy, and type(s) of treatment.

University of Washington Quality of Life (UW-QOL) questionnaire—The UW-QOL (V4) was used to measure disease-specific QOL.^{15,16} The UW-QOL consists of 12 items measuring health-related domains. Recently, Rogers et al¹⁷ recommended that outcomes from the UW-QOL be reported using 2 subscales of physical and social-emotional function in lieu of a composite score. Each subscale is based on the average of 6 items that are used to derive a QOL score ranging from “0” (worst health-related QOL) to “100” (best health-related QOL). The second part of the UW-QOL includes three questions related to global QOL. Each item is calculated independently to represent a global QOL score, ranging

from “0” (worst QOL) to “100” (best QOL). Because the first 2 global questions measure QOL and similarly relate to the subscales, only the general QOL question was included for analysis in this study. Thus, global QOL was derived from the question: “Considering everything in your life that contributes to your personal well-being, rate your overall quality of life during the past 7 days”.

Voice Handicap Index-10 (VHI-10)—The VHI-10 is a validated 10-item questionnaire that measures the impact of voice disorders, including those secondary to total laryngectomy, on voice-related QOL.^{18,19} Participants respond to each item indicating how frequently they have had each experience using a 5-point Likert scale. Responses are added to determine a VHI-10 total score ranging from “0” (no voice handicap) to “40” (high voice handicap).

Speech Recordings and Preparation—Speakers were recorded using a headset microphone (Shure PG-81 or AKG C420) connected to a pre-amplifier (M-Audio Fast Track Pro) and acquired on a laptop computer using a specialized sound card and acoustic software (Sona-Speech II, Model 3650, KayPentax), as well as a portable digital audiotape recorder (Tascam DAP1). All speech samples were recorded in a quiet environment with low ambient noise at a sampling rate of 44.1kHz with 16-bit quantization. Speakers recorded six sentences of increasing length from the *Sentence Intelligibility Test* (SIT).²⁰ The sentences for each speaker were randomly chosen, and included sentences that were 5, 7, 9, 11, 13, and 15 words in length (n=60 words per speaker). Speakers also provided recordings of the Rainbow Passage.²¹

Speech stimuli from the SIT and the Rainbow Passage were edited and normalized for peak intensity using acoustic software (Sony Soundforge Pro 10) before being entered into two perceptual programs. One program was used to record typed responses to yield intelligibility scores from the SIT (Ecos/Win; Avaaz Innovations, 1998). Recordings from the second sentence of the Rainbow Passage were entered into a second program (rubyonrails.org), which was custom-designed to record speech acceptability responses on a rating scale. Both programs randomly generated speaker order for presentation of stimuli.

Listener Procedures

The first group of 33 listeners transcribed sentences for speech samples using the standard SIT protocol.²⁰ Listeners were familiarized with the task, and speech samples were presented over headphones (Samson Stereo Headphones, RH600) at a comfortable volume. Listeners transcribed the words they recognized and were allowed to listen to each sample sentence up to two times. Each listener transcribed a total of 180 words (3 speakers × 60 words per speaker = 180 words) such that no listener heard any repetitions of sentences. Thus, each speaker’s mean intelligibility rating (% words understood) was based on scores from at least three listeners.

The second set of 15 listeners participated in the speech acceptability protocol. Listeners were familiarized with the task, and judged the speech acceptability of the samples by “giving careful consideration to pitch, rate or speech, understandability, and voice quality. In other words, is the voice pleasing to listen to, or does it cause you some discomfort as a

listener?”^{22,23} Listeners made their judgments using a 100-mm visual analog scale, with the endpoints labeled “very unacceptable” and “very acceptable”. To calculate intrarater reliability, 20% (n=5) of the speech samples were repeated randomly (N=30 speech samples total per listener).

Data Analysis

Descriptive analyses were completed for the demographic data. Means, ranges and standard deviations were calculated for continuous variables such as age and time since laryngectomy. Frequencies were calculated for categorical variables such as type of treatment.

Disease- and discipline-specific QOL scores were calculated for each speaker using the physical and social-emotional subscales from the UW-QOL, one global UW-QOL score, the speech domain score from the UW-QOL, and the VHI-10 total score. Speech intelligibility was calculated by determining the number of words correctly identified (% understood). Each speaker's intelligibility was based on scores for 6 sentences and averaged across three listeners (n = 180 words per speaker × 3 listeners per speaker = 540 words per speaker). Acceptability ratings for each speaker were based on responses averaged across listeners. Relationships between each of the patient-reported QOL measures with auditory-perceptual measures (speech intelligibility and acceptability) were determined using Pearson Correlation Coefficients, and strengths of relationships were examined using variance scores (r^2). A pre-determined level of statistical significance ($p < .05$) was used for all analyses.

To determine intrarater reliability for the speech acceptability ratings, 20% (n=5) speaker samples were randomly repeated, and a Pearson Correlation Coefficient was calculated between original and repeated values. The mean reliability value (r) was .81 (SD = 0.16). Interrater reliability of speech acceptability was analyzed with an Intraclass Correlation Coefficient (ICC), with the group average being 0.96. These results indicate that reliability was adequate for judgments of listener-rated speech acceptability.

RESULTS

Demographics of Alaryngeal Speakers

Subjects were on average 7.6 years (range = 1–33y) post-laryngectomy, 92% (n=23) reported receiving radiation treatment, and 64% (n=16) used tracheoesophageal (TE) speech as their primary method of communication. Additional demographic information is presented in Table 1.

HNC-Specific and Voice-Related QOL Scores

Overall, results showed moderate QOL scores for the disease- and discipline-specific QOL scales (see Table 2). Scores also are reported as a function alaryngeal speech mode in Table 2. To determine whether the individual mode of alaryngeal speech influenced QOL scores, a post-hoc analysis was performed. Esophageal speakers (ES) were not included in this analysis because of the small sample size (n=2) of this group. Results revealed no significant differences as a function of speech mode for either of the disease-specific QOL subscales

(UW-QOL physical or social-emotional), global QOL (UW-QOL general question), or the discipline-specific QOL score (VHI-10) ($p > .05$). However, a significant difference was found between TE with electrolaryngeal (EL) speakers for the UW-QOL speech domain subscore ($t(20) = 2.06, p < .05$). Specifically, TE speakers reported significantly better speech function ($M=75.80; SD=15.11$) than EL speakers ($M=62.14; SD=12.85$).

Auditory-Perceptual Measures

The mean speech intelligibility score for all speakers was 89.74% ($SD=8.90$); for speech acceptability, the mean was 35.07 ($SD=18.76$). Average scores and scores differentiated by alaryngeal speech mode are reported in Table 3. A post-hoc analysis comparing TE ($n=16$) with EL speakers ($n=7$) revealed significantly better ratings for TE speakers for both listener-rated dimensions (intelligibility: $t(21) = 3.05, p < .01$; acceptability: $t(17.65) = 5.47, p < .01$). Results also showed that listeners' ratings of intelligibility were significantly related to ratings of acceptability ($r = 0.41, p < .05$), although the relationship was only moderate in strength.

Relationships between Auditory-Perceptual Measures and QOL Scores

The relationships between auditory-perceptual measures (intelligibility; acceptability) and disease-specific (UW-QOL) and discipline-specific (VHI-10) scales are shown in Table 4. Speech acceptability scores were in general more predictive of QOL scores, although relationships were only weak-to-moderate. A moderate, but statistically significant relationship, was shown between listener-rated acceptability and the UW-QOL speech domain subscore ($r = 0.46; p < .05$), with 21.4% of the variance predicted by acceptability.

DISCUSSION

This study investigated the relationship between listener judgments of speech intelligibility and acceptability with self-reported QOL measures post-laryngectomy. Results revealed mostly weak relationships between listener-rated outcomes with self-reported QOL, regardless of whether QOL was measured with a disease- or discipline-specific scale. The strongest and only significant relationship was found between speech acceptability and the UW-QOL speech domain, although this relationship was only moderate in strength. The results suggest that listener-rated outcomes make a unique contribution to assessment post-laryngectomy and complement self-report scales. Findings have implications for research and clinical practice.

HNC-Specific and Voice-Related QOL Post-Laryngectomy

Results of this study must first be considered in light of the sample of patients who participated. The sample was representative of the laryngectomy population and was comparable to demographics found in other research.² Most participants were recruited through support groups, had received radiation, and used TE speech as their primary mode of communication. While some of these factors could decrease speech function (e.g., radiation), other factors (e.g., TE speakers, support group members) could increase performance. Results related speech outcomes and QOL should be interpreted with these demographics and potential biases in mind.

Overall, results from this study revealed moderate disease-specific QOL scores after total laryngectomy, consistent with previous literature.^{17,24} In addition, voice-related QOL scores were also moderate in severity.^{6,7,19} Results from this study also showed no QOL differences related to alaryngeal speech mode (TE vs. EL speech) for the UW-QOL physical and social-emotional subscales, global QOL, or voice-related QOL (VHI-10) scores (see Table 2). These results are consistent with others who have reported no long-term self-reported difference in outcomes as a function of alaryngeal speech mode.^{19,25}

The one exception to these findings related to the UW-QOL speech subscore, which was sensitive to poorer self-reported speech function by EL speakers. These results suggest that individuals who use EL speech may perceive poorer speech performance; however, this reduced performance does not seem to translate to reduced satisfaction with voice, as indicated by the non-significant differences in VHI-10 scores between EL and TE speakers. Thus, the data suggest that despite the unique nature of EL speech, the effectiveness and satisfaction of meeting communication needs may not be as problematic as one might assume. Interpretation related to these findings must be made with caution due to the small number of EL speakers (n=7) who participated in this study. The significance of this result also needs to be reconciled with auditory-perceptual outcomes.

Auditory-Perceptual Outcomes

In the present study, speech intelligibility ranged from 71.89% to 99.57% (mean = 89.74%) across the speakers, which is consistent with previous literature.¹¹ In addition, results revealed that speech acceptability for all alaryngeal speakers was on average more unacceptable than acceptable (see Table 4).^{23,26} For both auditory-perceptual measures, the small (n=7) subgroup of EL speakers were judged significantly less acceptable and less intelligible than TE speakers. These findings are consistent with others who have revealed that the mechanical nature of the electrolarynx may not only affect intelligibility, but also the social acceptability of speech.^{22,27} The results also highlight the sensitivity of listener-rated outcomes for differentiating performance for alaryngeal speakers.⁵

A moderate correlation ($r = 0.41$) was found between listener-rated speech acceptability and intelligibility in the present study. Other researchers^{28,29} similarly have found moderate, but somewhat stronger correlations between speech acceptability and intelligibility ($r = 0.63$ – 0.67) in ES and TE speakers. The inconsistency of the results are difficult to interpret, given the different methodologies and populations used in these studies. Regardless, the results suggest that while listeners may be able to understand most of the alaryngeal speakers, being understood is insufficient to render the speech “acceptable” to the listener. Thus, both outcomes appear to be measuring different constructs, and are necessary to provide a comprehensive measure of speech and voice function post-laryngectomy.¹¹

Relationships between Auditory-Perceptual Measures and QOL

This study investigated the relationship between listener-rated outcomes with patient-reported QOL outcomes after total laryngectomy. The relatively weak relationships found between listener-rated dimensions and both disease-specific (UW-QOL) and voice-related QOL (VHI-10) scales suggest that listeners are indeed measuring unique constructs that are

not represented on existing self-reported QOL tools. The results are consistent with others who have found weak to moderate relationships between self-rated QOL with listener-rated outcomes.^{12–14}

One possible reason why relationships were weak-to-moderate may relate to the multidimensional nature of QOL. For example, composite scores or even subscales derived from QOL scales may sometimes mask concerns in particular areas (i.e., high function in one domain combined with low function in another domain may result in cancelling effects).⁸ The multidimensional nature of these types of measures (global QOL, physical or social-emotional domains) may be one reason why these measures may not strongly relate to listeners' perceptions of speech acceptability or intelligibility.

In addition, disease-specific QOL scales often include a single question related to speech, which could reduce the sensitivity of these scales for measuring speech and voice outcomes.⁸ As a result, it was hypothesized a priori that listener-rated outcomes might be more strongly related to more comprehensive discipline-specific (i.e., voice-related) QOL. Yet, the results did not support this hypothesis. Listener-rated outcomes were only weakly related to voice-related QOL. Interestingly, the speech domain of the UW-QOL (which asks about perceived understandability) was most strongly predicted by listeners' ratings of speech acceptability ($r = 0.46$), and not intelligibility ($r = 0.22$). Together, results suggest that a patient's own assessment of speech performance after laryngectomy is more related to how different the speech sounds from what is normally expected (acceptability), than to the actual clarity or understandability of speech by the communication partner. In addition, while speech performance may be reduced, it does not necessarily translate to satisfaction with voice. How these judgments might relate to a broader measure of speech performance in context, such as communicative effectiveness, as well as determining potential relationships between listener judgments of multiple features inherent to the alaryngeal speech signal should be the subject of further study.^{11,13}

Future Research and Clinical Implications

Issues that underlie how listeners perceive and make systematic judgments of alaryngeal speech remain largely unexplored. Investigation of relationships between listener-rated and patient-reported outcomes will offer an improved understanding of the level of relative impact and associated disability that occurs with alaryngeal communication. Understanding these relationships is critical for providing intervention strategies, documenting outcomes, and providing adequate pre- and post-laryngectomy counseling.

ACKNOWLEDGMENTS

We gratefully acknowledge funding support from the National Institutes of Health/National Cancer Institute (1R03CA132525-01A1) (PI: Eadie). We also would like to thank the participants, clinicians and support group leaders who helped with recruitment, and members of the Vocal Function Laboratory, University of Washington for their help with data entry and sound editing. Finally, we are grateful to the International Association of Laryngectomees for help with recruitment.

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TABLE 1

Selected Demographic Characteristics (n=25 subjects).

Characteristic	No. (%)	Mean (SD)	Range
Sex			
Female	5 (20)		
Male	20 (80)		
Age (y)		63.64 (10.16)	39–84
Marital Status			
Married/committed relationship	16 (64)		
Single/widowed/divorced	8 (32)		
Not reported	1 (4)		
Education			
Some high school	2 (8)		
High school graduate	3 (12)		
Some college	11 (44)		
College graduate	6 (24)		
Post-graduate (e.g., Master's; Ph.D.)	2 (8)		
Not reported	1(4)		
Time since head and neck cancer diagnosis		8.74 (7.86)	1–33
Time since Total Laryngectomy (yrs)		7.58 (7.99)	1–33
Cancer treatment			
Surgery alone	1(4)		
Surgery and radiation	18 (72)		
Surgery and radio(chemo)therapy	5 (20)		
Not reported/unclear	1 (4)		
Alaryngeal Speech Mode			
Tracheoesophageal speech	16 (64)		
Esophageal speech	2 (8)		
Electrolaryngeal speech	7 (28)		

TABLE 2

QOL Scores as a function of alaryngeal mode of speech.

Speech Mode	n	UW-QOL Physical		UW-QOL Social-Emotional		UW-QOL Global		UW-QOL Speech		VHL-10	
		M	(SD)	M	(SD)	M	(SD)	M	(SD)	M	(SD)
Tracheoesophageal	15	76.86	(14.28)	76.51	(18.93)	70.67	(23.74)	75.80	(15.11)	17.67	(7.07)
Electrolarynx	7	74.09	(14.19)	79.74	(14.99)	62.86	(26.90)	62.14	(12.85)	21.00	(3.29)
Esophageal	2	95.83	(0.00)	83.34	(0.00)	90.00	(14.14)	100.00	(0.00)	10.50	(4.95)
Group Average	24	77.63	(14.48)	78.02	(16.78)	70.00	(24.32)	73.83	(16.90)	17.91	(6.56)

Note: One tracheoesophageal speaker did not complete the UW-QOL or VHL-10 scales. Consequently, group averages are based on N=24 speakers.

TABLE 3

Auditory-perceptual scores as a function of alaryngeal mode of speech.

	n	Intelligibility (%)	Acceptability
		M (SD)	M (SD)
Speech Mode			
Tracheoesophageal	16	92.39 (6.74)	41.90 (17.90)
Electrolarynx	7	81.74 (9.71)	16.30 (3.70)
Esophageal	2	96.58 (0.05)	45.80 (9.48)
Group Average	25	89.74 (8.90)	35.10 (18.80)

Pearson Correlation Coefficients and variance (r^2) demonstrating relationships among listeners' ratings of speech acceptability and intelligibility with self-reported QOL in 25 alaryngeal speakers.

TABLE 4

Auditory-Perceptual Dimension	QOL Scale				
	UW-QOL Physical	UW-QOL Social-Emotional	UW-QOL Global	UW-QOL Speech	VHI-10
Speech Acceptability	Correlation (variance) 0.218 (0.047)	Correlation (variance) 0.013 (0.00)	Correlation (variance) 0.159 (0.025)	Correlation (variance) 0.463* (0.214)	Correlation (variance) -0.219 (0.048)
Speech Intelligibility	Correlation (variance) -0.028 (0.001)	Correlation (variance) -0.192 (0.037)	Correlation (variance) 0.001 (0.00)	Correlation (variance) 0.222 (0.049)	Correlation (variance) 0.042 (0.002)

Note:

* Correlation is significant at the 0.05 level (2-tailed)