

# Impact of secondary lymphedema after head and neck cancer treatment on symptoms, functional status, and quality of life

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**ABSTRACT:** *Background.* Lymphedema may disrupt local function and affect quality of life (QOL) in patients with head and neck cancer. The purpose of this study was to examine the associations among severity of internal and external lymphedema, symptoms, functional status, and QOL in patients with head and neck cancer.

*Methods.* The sample included 103 patients who were  $\geq 3$  months after head and neck cancer treatment. Variables assessed included severity of internal and external lymphedema, physical/psychological symptoms, functional status, and QOL.

*Results.* Severity of internal and external lymphedema was associated with physical symptoms and psychological symptoms. Patients with

more severe external lymphedema were more likely to have a decrease in neck left/right rotation. The combined effects of external and internal lymphedema severity were associated with hearing impairment and decreased QOL.

*Conclusions.* Lymphedema severity correlates with symptom burden, functional status, and QOL in patients after head and neck cancer treatment. © 2012 Wiley Periodicals, Inc. *Head Neck* 35: 1026–1035, 2013

**KEY WORDS:** head and neck cancer, lymphedema, symptom, functional status, quality of life (QOL)

## INTRODUCTION

Patients with locally advanced head and neck cancer are usually treated with aggressive multimodality treatment regimens.<sup>1</sup> These regimens often lead to a damaged lymphatic system and leave patients at risk for developing secondary lymphedema (accumulation of lymph fluid in the interstitial space).<sup>2,3</sup> Lymphedema is associated with chronic inflammation; thus, lymphedema may result in a progressive, self-perpetuating process. Chronic inflammation may lead to fibrosis, the end stage of severe lymphedema.<sup>2,3</sup> The European literature reports that 12% to 54% of patients developed secondary lymphedema as a late effect of head and neck cancer treatment.<sup>4–7</sup> The structures involved by lymphedema are related to the tissues damaged by surgery and/or radiation therapy.

Head and neck lymphedema may be categorized as involving external structures (e.g., skin and soft tissue of the face and neck), internal structures such as the mucosa and underlying soft tissue of the upper aerodigestive tract (e.g., pharynx and larynx),<sup>8–11</sup> or a combination of both.

It may be hypothesized that alterations in soft tissue architecture and pliability resulting from head and neck lymphedema and related fibrosis result in substantial symptom burden, functional loss, and decreased quality of life (QOL). For example, external lymphedema involving the face may lead to body image disturbance; internal lymphedema involving the pharynx may interrupt swallowing function. Studies are needed to directly and systematically examine the impact of lymphedema severity on QOL in patients after head and neck cancer treatment. Thus, the purpose of this study was to examine the associations of the severity of internal and external lymphedema with symptom burden, functional status, and QOL in patients with head and neck cancer.

## PATIENTS AND METHODS

### Participants and setting

Permission to conduct this descriptive, correlational study was obtained from the Institutional Review Board at Vanderbilt University and the Scientific Review Committee at Vanderbilt–Ingram Cancer Center. Of the 114 patients with head and neck cancer who were approached, 103 patients (90.4%) consented and were recruited into the study. Eleven patients (9.6%) approached did not participate in the study. Reasons for not participating included: no time ( $n = 4$ ), feeling overwhelmed ( $n = 4$ ), and lack of interest ( $n = 3$ ). Participants were included if they were (1)  $\geq 18$  years of age, (2)  $\geq 3$  months after

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head and neck cancer treatment, (3) currently free of evidence of cancer, and (4) able to provide informed consent.

Written informed consent was obtained from all participants. Participants underwent a detailed physical examination assessing: (1) external lymphedema, (2) cervical range of motion, (3) jaw range of motion, and (4) hearing. The first author (R.N.) conducted all assessments using a standard procedure to ensure consistency. Participants then completed the self-report instruments regarding symptom burden and QOL. Participants subsequently underwent routine endoscopic evaluation to assess internal lymphedema.

## Study instruments

**Demographic and medical information.** Demographic information included sex, date of birth, race, educational level, marital status, employment status, residence area, income, and alcohol and tobacco use. Medical information was obtained from the participants' electronic medical records, including date of diagnosis of head and neck cancer, site, histology, stage, and treatment type and dates.

## Lymphedema

**External lymphedema.** External lymphedema was graded using Földi "Stages of Lymphedema" (Földi stages; Appendix A). This scale was developed based on experience treating over 100,000 patients with lymphedema. Four stages are evaluated when using this scale, ranging from stage 0 to stage III.<sup>2,12</sup> A grade of stage 0 indicates no evidence of external lymphedema. External lymphedema was considered to be present if participants had at least stage I lymphedema.

**Internal lymphedema.** Internal lymphedema was ascertained via flexible fiber-optic endoscopic evaluation and graded using Patterson scale (Appendix B).<sup>13</sup> Patterson scale includes 11 laryngopharyngeal structures and 2 spaces. The scale has good intrarater reliability (weighted kappa, 0.84) and moderate interrater reliability (weighted kappa, 0.54).<sup>13</sup> Four grades are used to rate edema level, which include normal (no edema) to severe edema.<sup>13</sup> Internal lymphedema was considered present if 1 anatomic site on Patterson scale was edematous regardless of the severity of edema. The severity of internal lymphedema (possible range, 0–3) for each participant was the highest grade noted among all involved sites. A grade of 0 indicates that there was no evidence of internal lymphedema at any site. One of 2 study physicians conducted a routine endoscopic evaluation with assessment of internal lymphedema. The study physicians who conducted endoscopic examination and evaluated internal lymphedema were trained to grade the severity of internal lymphedema based on the Patterson scale. The first author was present at the endoscopic evaluation for the first 10% of participants each physician assessed to ensure there was no major deviation from the assessment process.

## Symptoms

**Physical symptoms.** The 27-item Vanderbilt Head and Neck Symptom Survey (VHNSS) was used to assess

physical symptom burden related to head and neck cancer and its treatment.<sup>14,15</sup> Studies have reported good internal consistency for the total VHNSS scale (alpha = 0.94) and 5 subscales (i.e., swallow, nutrition, mucous/dry mouth, pain, and voice; alphas = 0.77–0.93), and adequate convergent and divergent validity.<sup>15</sup> The VHNSS scale also includes 2 single items (i.e., dentition and hearing). Mean scores on each VHNSS subscale can range from 0 (none) to 10 (a lot). Higher scores reflect greater symptom burden.<sup>14,15</sup> The internal consistency coefficients (Cronbach's alphas) in this study was 0.94 for the overall scale and ranged from 0.69 to 0.92 for the 5 subscales.

**Psychological symptoms.** Two instruments were used to assess psychological symptoms. The 14-item Hospital Anxiety and Depression Scale (HADS) was used to measure symptoms of anxiety and depression among the non-psychiatric population.<sup>16</sup> Good internal consistency has been reported in physically ill patients with or without cancer (Cronbach's alphas for HADS-anxiety range from 0.68 to 0.93 and for HADS-depression from 0.67 to 0.90).<sup>16</sup> Construct validity of the HADS has been supported.<sup>16</sup> Higher scores indicate greater anxious and/or depressive symptom burden.<sup>17–19</sup> In the current study, the Cronbach's alphas for HADS-anxiety and HADS-depression were 0.88 and 0.83, respectively.

The 10-item Body Image Scale (BIS) was used to examine participants' self-assessment of body image related to cancer and cancer treatment.<sup>20</sup> In previous research with a heterogeneous group of patients with cancer, the BIS has demonstrated high reliability (alphas ranging from 0.86 to 0.91) and good discriminant validity.<sup>21</sup> Higher scores represent increasing symptom/distress of body image. The Cronbach's alpha for the BIS in this study was 0.92.

## Functional status

**Cervical range of motion.** The cervical range of motion device, manufactured by Performance Attainment Associates (Lindstrom, MN), was used to measure the degree of neck movement.<sup>22,23</sup>

**Jaw range of motion.** The Common Terminology Criteria for Adverse Events v3.0 Trismus Grading Criteria was used to evaluate trismus.<sup>24</sup>

**Hearing.** The whispered voice test and the tuning fork test<sup>25</sup> were used to assess hearing impairment. Responses from these hearing tests were coded dichotomously as either intact (0) or abnormal (1). The whispered voice test has a sensitivity of 87% to 96% and a specificity of 70% to 90%.<sup>26</sup>

## Quality of life

Functional Assessment Cancer Therapy-Head & Neck (FACT-H&N) was used to assess QOL.<sup>27</sup> The FACT-H&N (39-item) is a psychometrically validated scale to measure QOL related to head and neck cancer treatment. The 5 subscales in the FACT-H&N are physical well-being (PWB), social/family well-being (SWB), emotional well-being (EWB), functional well-being (FWB), and head and neck cancer (HNC) subscale. FACT-general

(FACT-G) is scored by summing the 4 subscales scores, including the PWB, SWB, EWB, and FWB. FACT-H&N is scored by summing the FACT-G and HNC scores. The internal consistency of most of the subscales has been shown to be adequate (alphas = 0.59–0.79).<sup>27</sup> In the current study, the Cronbach's alphas for the 5 subscales were between 0.61 and 0.86.

## Statistical methods

Descriptive statistics were used to describe the sample and the distributions of the study variables. Frequency distributions were used to summarize the nominal and ordinal demographic and clinical data, including the severity of external and internal lymphedema. Most of the symptom, function, and QOL scores were, as expected, highly skewed; therefore, median and 25th and 75th interquartile ranges, representing the middle 50% of the distributions, were used to describe those values. Given this observation, all of these lymphedema severity, symptom, function, and QOL distributions were rank transformed before inclusion in linear regression analyses described below. Due to the limited sample size, the individual Földi and Patterson scores (specific lymphedema severity grades) were not contrasted in the analyses. Linear regression analyses were used to assess the multiple correlations of lymphedema severity with the continuous symptom, functional, and QOL dependent variables (e.g., VHNSS symptom scores, FACT-H&N scores); logistic regressions were used for the respective analyses of dichotomous functional measures (e.g., whispered voice test). Before conducting the main analyses, the associations of demographic and clinical characteristics with each of the dependent variables were examined to identify variables possibly contributing to the symptom, function, or QOL values. Statistically significant characteristics were entered into the initial step of each hierarchical regression analysis to control for those associations. Subsequently, the Földi (external) and Patterson (internal) scores were simultaneously entered into each regression model to arrive at an adjusted multiple correlation of those combined severity indices on the symptom, function, or QOL measure of interest.

From the hierarchical multiple linear regressions, *R* square and standardized coefficients will be reported in the Results and tables to summarize the association of both external lymphedema severity (Földi stages) and internal severity (Patterson scale) with the continuous dependent variables of interest. Standardized coefficients (beta) summarize the respective unique adjusted associations of each of the external (Földi stages) and internal (Patterson scale) lymphedema severity scores. In similar multiple logistic models, likelihood chi-square statistics were used to test the statistical significance of the adjusted multiple and specific associations of lymphedema severity with dichotomous dependent measures. Analyses of multicollinearity of the variables in the multivariate models were conducted as were residuals from those models, and no problems were detected. Even though a large number of statistical tests were conducted in this study, given the exploratory and preliminary nature of this research, an uncorrected alpha of 0.05 was used for evaluating statistical significance.

TABLE 1. Demographic characteristics.

Characteristic	Frequency (%) ( <i>N</i> = 103)
Sex	
Male	71 (68.9)
Female	32 (31.1)
Race	
White	92 (89.3)
Black	11 (10.7)
Education level	
<12th grade	11 (10.7)
≥12th grade	92 (89.3)
Marital status	
Single/widowed/other	37 (35.9)
Married/living with a partner	66 (64.1)
Employment status	
Employed	52 (50.5)
Unemployed/other	51 (49.5)
Residence area	
Metropolitan	65 (63.1)
Rural	38 (36.9)
Insurance coverage	
Medicare/Medicaid/TennCare/TriCare	58 (56.3)
Private insurance/HMO	37 (35.9)
None/other	8 (7.8)
Yearly household income	
≤\$20,000	19 (18.4)
\$20,001–\$50,000	15 (14.6)
>\$50,000	36 (35.0)
Do not care to respond	33 (32.0)
Smoking (any current or past use)	
Yes	68 (66.0)
No	35 (34.0)
Drinking alcohol (any current or past use)	
Yes	42 (40.8)
No	61 (59.2)
Age, mean, median	59.8, 60.2
IQR 25–75	51.9/66.6
min, max	33.1, 86.7

Abbreviations: HMO, health maintenance organization; IQR, interquartile range.

## RESULTS

### Sample characteristics

From December 2009 through May 2010, 103 patients with head and neck cancer completed the study. Demographic, disease, and treatment characteristics of the sample are summarized in Tables 1 and 2. Eighty-one participants (78.6%) underwent endoscopy examination, whereas the remaining 22 participants (21.4%) did not have an endoscopic examination. Of those 22 participants, half of them (*n* = 11) had no endoscopy appointments scheduled, while the other half (*n* = 11) had an endoscopy examination scheduled beyond the study data collection period. The participants who had an endoscopy completed during the study period tended to have been diagnosed with head and neck cancer more recently (medians, 2.0 vs 3.3 years; *p* = .030) and completed cancer treatment more recently (medians, 17.7 vs 35.3 months; *p* = .034). No other demographic or clinical characteristics demonstrated statistically significant differences between the groups.

TABLE 2. Head and neck cancer disease and treatment characteristics.

Characteristic	Frequency (%) (N = 103)
<b>Location</b>	
Paranasal sinuses	5 (4.9)
Oral cavity	15 (14.6)
Nasopharynx	3 (2.9)
Oropharynx	49 (47.6)
Hypopharynx	4 (3.9)
Larynx	18 (17.5)
Salivary gland/other	9 (8.7)
<b>Tumor TNM stage at diagnosis</b>	
Stage I	6 (5.8)
Stage II	9 (8.7)
Stage III	16 (15.5)
Stage IVa	59 (57.3)
Stage IVb	8 (7.8)
Could not be staged	5 (4.9)
<b>Type of tumor</b>	
SCC	96 (93.2)
Non-SCC	7 (6.8)
<b>Complete treatment received</b>	
Surgery alone	8 (7.8)
Radiation alone	2 (1.9)
CCR	13 (12.6)
Surgery and radiation	10 (9.7)
Surgery and CCR	30 (29.1)
Chemoiduction and CCR	30 (29.1)
Surgery, chemoiduction, and CCR	10 (9.7)

Characteristic	Mean	Median	IQR	(25, 75)	Min	Max
Head and neck cancer duration, y	2.8	2.1	1.0	3.9	0.5	14.6
Time since treatment ended, mo	27.4	19.9	6.0	39.3	3.1	156.4

Abbreviations: SCC, squamous cell carcinoma; CCR, concurrent chemoradiation; IQR, interquartile range.

**Lymphedema**

Based on physical examination, 46.6% (n = 48) of all participants had external lymphedema, with 20.4% (n = 21) assessed at stage I and 26.2% (n = 27) assessed at

stage II. No participants were classified with stage III external lymphedema. The most common sites of external lymphedema were the neck and submental area. Of the 81 participants who had endoscopies and were graded using the Patterson scale for internal lymphedema, mild lymphedema was present in 23.5% (n = 19), moderate lymphedema in 30.9% (n = 25), and severe lymphedema in 13.6% (n = 11). Thirty-two percent (26 of 81) had no evidence of internal lymphedema. In these same 81 patients, 38.3% (31 of 81) had both (combined) internal and external lymphedema.

**Symptoms**

**Physical symptoms.** The median score for individual items on the VHNSS subscale were in the range of 0.00 to 3.00 on a 10-point scale. This suggests that most of the participants were in the recovery stages after head and neck cancer treatment and had mild symptom burden. Among the demographic and clinical variables demonstrating statistically significant associations with symptom burden, it was found that an increasing number of cancer treatment modalities received was associated with more swallowing-related symptoms (p = .012), as well as with mucous/dry mouth-related symptoms (p = .003). Length of time with a head and neck cancer diagnosis was found to be positively associated with more dentition-related symptoms (p = .037). Age was inversely associated with self-reported pain (p = .004).

The associations of the lymphedema severity and symptom scores on the VHNSS after adjusting for above reported associated demographic and clinical phenomena are summarized in Table 3. As shown, there were statistically significant associations of increased lymphedema severity with increased swallowing difficulties, nutrition problems, mucous/dry mouth-related symptoms, and voice problems. The association with swallowing and nutrition problems seemed to be explained more by the severity of external than internal lymphedema (external: beta = 0.32, p = .006 for both swallowing and nutrition; internal: swallowing, beta = 0.14, p = .216; nutrition, beta = 0.08, p = .516). On the other hand, the severity of internal lymphedema seemed to be more associated with higher levels of self-reported voice-related problems

TABLE 3. Standardized betas from hierarchal multiple regression analyses predicting symptom scores from lymphedema severity (n = 79).

	VHNSS													
	Swallow		Nutrition		Mucous/dry mouth		Pain		Voice		Dentition		Hearing	
	β	R <sup>2</sup> change	β	R <sup>2</sup> change	β	R <sup>2</sup> change	β	R <sup>2</sup> change	β	R <sup>2</sup> change	β	R <sup>2</sup> change	β	R <sup>2</sup> change
Final step: lymphedema severity		0.13**		0.12**		0.13**		0.05		0.09*		0.01		0.01
External (Földi stages)	0.32**		0.32*		0.20		-0.04		0.01		0.04		-0.10	
Internal (Patterson scale)	0.14		0.08		0.26*		0.23*		0.30*		0.08		0.06	
R <sup>2</sup> (Full model)		0.28**		0.12**		0.24**		0.16		0.09*		0.04		0.01

Abbreviation: VHNSS, Vanderbilt Head and Neck Symptom Survey.

Notes: "β" is the standardized coefficient that reflects the specific adjusted association of external and internal lymphedema with each of the measures after controlling for all covariates. "R<sup>2</sup> change" is the amount of variance accounted for by including both types of lymphedema severity after any covariates have been controlled for. "R<sup>2</sup> (Full model)" is the amount of variance accounted for by the whole model which includes covariates as well as lymphedema severity scores.

\*p < .05, \*\*p < .01.

(external:  $\beta = 0.01$ ,  $p = .946$ ; internal:  $\beta = 0.30$ ,  $p = .014$ ). There seemed to be a pattern of both types of lymphedema severity contributing in a more balanced way to the multiple correlation found with mucous and dry mouth problems (external:  $\beta = 0.20$ ,  $p = .074$ ; internal:  $\beta = 0.26$ ,  $p = .020$ ). No statistically significant associations of lymphedema severity with self-reported pain, dentition-related symptoms, and hearing-related problems were observed.

**Psychological symptoms.** The BIS scores in this study ranged from 0 to 30 (mean = 6.03; median = 3.00). These results indicate most of the participants had mild body image issues. The values of 2 HADS subscales scores ranged from 0 to 16 (mean = 3.94; median = 3.00) for anxiety and 0 to 14 (mean = 3.31; median = 2.00) for depression. The results suggest that most of the participants had few or relatively minor anxiety and depressive symptoms.

Some statistically meaningful associations of the demographic and clinical variables with the psychological symptom measures were observed. Participants who were single or widowed and participants living in urban areas reported higher body image disturbance scores than participants who were married or living with a partner ( $p < .001$ ) and those living in rural communities ( $p = .046$ ). The only other demographic or clinical variable found to be associated with these psychological symptoms was age ( $p = .001$ ), which was inversely associated with reports of anxiety, that is, older participants tended to report less anxiety than younger participants. There was a statistically significant correlation of lymphedema severity with the BIS scores ( $R$  square change = 0.07;  $p = .049$ ). Essentially, all of this association was explained by the severity of external lymphedema ( $\beta = 0.26$ ;  $p = .024$ ) and not internal lymphedema ( $\beta = 0.02$ ;  $p = .866$ ). No statistically significant associations of lymphedema severity with self-reports of anxiety and depression were observed.

## Functional status

The median scores for 6 directions of neck movement were in the range of 31.3 to 53.3 degrees (normal range, 45–80). This suggests that most of the participants had mildly to moderately decreased neck range of motion after head and neck cancer treatment. Thirty-two percent (33 of 103) of all participants had trismus, 12.6% of the participants failed whispered voice tests, and 29.1% failed tuning fork tests. Scores on the functional status measures are summarized in Table 4. A number of statistically significant associations of the demographic and clinical variables with functional status were observed. Length of time with a head and neck cancer diagnosis and length of time after cancer treatment were inversely associated with several directions of the neck movement, including forward flexion (both  $p = .014$ ), left lateral flexion ( $p = .015$  and  $p = .028$ , respectively), left lateral rotation (both  $p = .003$ ), and right lateral rotation (both  $p = .032$ ). Increasing age was also found to be associated with less lateral flexion (right side,  $p = .042$ ; left side,  $p = .003$ ), right lateral rotation ( $p = .009$ ), and greater rates of failure on the whispered voice test ( $p = .002$ ).

TABLE 4. Functional status data.

Characteristic	Mean	Median	IQR, 25–75	Min	Max, degree, ( $n = 100$ )
<b>Cervical range of motion</b>					
Forward flexion	43.5	42.7	33.3–50.3	19.3	70.0
Extension	49.2	48.0	38.3–60.8	15.3	88.7
Left lateral flexion	32.8	32.0	23.3–41.0	13.3	58.7
Right lateral flexion	31.3	31.3	22.5–39.3	11.0	58.0
Left lateral rotation	54.6	53.3	45.0–62.7	29.3	80.7
Right lateral rotation	53.8	52.0	44.7–64.0	26.0	80.0
<b>Frequency (%) (N = 103)</b>					
<b>Trismus</b>					
None					70 (68.0)
Grade 1					16 (15.5)
Grade 2					14 (13.6)
Grade 3					3 (2.9)
<b>Whispered voice test</b>					
Pass					89 (86.4)
Fail					13 (12.6)
Not applicable					1 (1.0)
<b>Tuning fork test</b>					
Normal					73 (70.9)
Conduction deafness (left ear)					3 (2.9)
Conduction deafness (right ear)					2 (1.9)
Nerve deafness (left ear)					13 (12.6)
Nerve deafness (right ear)					11 (10.7)
Not applicable					1 (1.0)

Abbreviation: IQR, interquartile range.

An increasing number of cancer treatment modalities received was associated with greater rates of deafness based on the tuning fork test ( $p = .002$ ). Finally, participants who reported a history of smoking or were currently smoking demonstrated lower degree of neck movement (extension, right flexion, and rotation) than those who never smoked ( $p < .050$ ).

After adjusting for those statistically significant variables, only neck rotation demonstrated a statistically significant correlation with the severity of lymphedema ( $R$  square change = 0.07 for left rotation and 0.08 for right rotation; Table 5). In both of the directions, most of the inverse association with decreasing neck rotation was explained by increasing severity of external lymphedema and not internal. No statistically significant associations of the lymphedema severity with the severity of trismus were observed (data not displayed).

After controlling for the statistically meaningful demographic and clinical variable associations with hearing impairment, a statistically significant association was found between increasing severity of lymphedema and the presence of indicators of impairment (logistic regression for tuning fork test: overall likelihood chi-square [2,  $N = 102$ ] = 6.02,  $p = .049$ ; external: odds ratio [OR] = 1.77,  $p = .083$ , 95% confidence interval [CI], 0.93–3.38; internal: OR = 1.43,  $p = .205$ , 95% CI, 0.82–2.49; logistic regression for whispered voice test: overall likelihood chi-square [2,  $N = 102$ ] = 6.60,  $p =$

TABLE 5. Standardized betas from hierarchal multiple regression analyses predicting cervical range of motion scores from lymphedema severity (n = 80).

	Forward		Extension		Left lateral		Right lateral		Left rotation		Right rotation	
	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change
Final step: lymphedema severity		0.06		0.02		0.02		0.06		0.07*		0.08*
External (Földi stages)	-0.19		-0.14		-0.16		-0.25*		-0.28*		-0.27*	
Internal (Patterson scale)	-0.13		0.06		0.02		0.09		0.07		-0.06	
$R^2$ (Full model)		0.15		0.07		0.11		0.17		0.26*		0.23*

Notes: "β" is the standardized coefficient that reflects the specific adjusted association of external and internal lymphedema with each of the measures after controlling for all covariates. " $R^2$  change" is the amount of variance accounted for by including both types of lymphedema severity after controlling for all covariates. " $R^2$  (Full model)" is the amount of variance accounted for by the whole model which includes covariates as well as lymphedema severity scores.  
\*  $p < .05$ .

.037; external: OR = 0.40,  $p = .101$ , 95% CI, 0.14–1.20; internal: OR = 2.38,  $p = .036$ , 95% CI, 1.06–5.33). As noted by the ORs above, there were mixed results depending on the test used as to whether the association was due more to external or internal lymphedema severity.

Quality of life

In this study, the FACT-H&N subscale scores of participants' ranged from 2 to 28 for the PWB subscale (median = 25.00), 7 to 28 for the SWB subscale (median = 24.00), 1 to 24 for the EWB subscale (median = 22.00), 0 to 28 for the FWB subscale (median = 22.00), and 6 to 59 for HNC subscale (median = 44.50). These data indicate that most of the participants had a moderate to high degree of QOL. Age and marital status demonstrated the most commonly seen statistically significant associations of demographic or clinical variables with the FACT-H&N measures of QOL. Being single or widowed was associated with lower reports of SWB ( $p = .003$ ). Increasing age was associated with greater PWB ( $p = .003$ ), EWB ( $p = .001$ ), and FWB ( $p = .027$ ).

Although statistically significant adjusted multiple correlations of lymphedema severity were observed

between lymphedema severity and overall QOL (FACT-G and FACT-H&N total), the strongest specific multiple correlation seemed to be with FWB and HNC subscales (FWB:  $R$  square change = 0.13,  $p = .006$ ; HNC:  $R$  square change = 0.08,  $p = .037$ ) and likely explains most of the association with overall or total QOL. Most of the multiple correlation of lymphedema severity with FWB was explained by increased levels of external lymphedema severity and not internal lymphedema severity (external: beta = -0.31,  $p = .008$ ; internal: beta = -0.10,  $p = .374$ ). However, the combination of the severity of both types, not either type alone, contributed to the association with HNC score (Table 6).

DISCUSSION

This is the first study we are aware of to examine the associations between lymphedema severity with symptoms, functional status, and QOL in patients with head and neck cancer. The results clearly indicate that lymphedema is a frequent late effect of head and neck cancer. Forty-six percent (48 of 103) of participants had external lymphedema and 68% (55 of 81) had internal lymphedema for those undergoing endoscopy. Internal lymphedema was rated as severe in 20% (11 of 55) of

TABLE 6. Standardized betas from hierarchal multiple regression analyses predicting quality of life scores from lymphedema severity (n = 79).

	FACT-H&N													
	PWB		SWB		EWB		FWB		HNCS		FACT-G		FACT-H&N total	
	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change	$\beta$	$R^2$ change
Final step: lymphedema severity		0.03		0.02		0.01		0.13**		0.08*		0.09*		0.12**
External (Földi stages)	-0.16		0.04		-0.10		-0.31**		-0.21		-0.22		-0.30*	
Internal (Patterson scale)	-0.05		-0.13		-0.04		-0.10		-0.14		-0.15		-0.10	
$R^2$ (Full model)		0.15		0.11		0.11		0.16**		0.14*		0.13*		0.17**

Abbreviations: FACT-H&N, Functional Assessment Cancer Therapy-Head and Neck; PWB, physical well-being; SWB, social/family well-being; EWB, emotional well-being; FWB, functional well-being; HNCS, head and neck cancer subscale; FACT-G, PWB+SWB+EWB+FWB.  
Notes: "β" is the standardized coefficient that reflects the specific adjusted association of external and internal lymphedema with each of the measures after controlling for all covariates. " $R^2$  change" is the amount of variance accounted for by including both types of lymphedema severity after controlling for all covariates. " $R^2$  (Full model)" is the amount of variance accounted for by the whole model which includes covariates as well as lymphedema severity scores.  
\*  $p < .05$ , \*\*  $p < .01$ .

participants who were diagnosed with that condition. Furthermore, both types of lymphedema were associated with substantial symptom burden, functional deficits, and decreased QOL.

One of the most important findings was that external lymphedema severity was associated with self-reported swallowing difficulties. This finding is consistent with the reports from 3 previous studies with small sample sizes ( $N_s = 11-26$ ).<sup>28-30</sup> However, they only examined presence of lymphedema, whereas our study clearly showed that increased lymphedema severity was associated with increased severity of swallowing difficulties. Swallowing is a complex process that requires precise anatomic coordination of numerous structures.<sup>31,32</sup> It may be hypothesized that lymphedema-associated swelling or fibrosis alters anatomic structures, thereby affecting physiologic function.

The study also demonstrated that external lymphedema was associated with self-reported nutrition-related symptoms (e.g., losing weight). Lymphedema may contribute to nutrition-related symptoms through 2 possible mechanisms. First, impaired swallowing results in decreased oral intake, leading to decreased caloric intake and weight loss. Second, lymphedema is associated with chronic inflammation.<sup>3</sup> In a number of disease processes, acute and chronic inflammation have been associated with systemic effects, including cachexia.<sup>33,34</sup> It may, therefore, be hypothesized that lymphedema-associated chronic inflammation results in metabolic alterations that lead to weight loss. Further research evaluating the systemic manifestations of lymphedema is needed.

One of the notable findings in this study is that lymphedema severity was associated with mucous/dry mouth-related symptoms. There are 2 potential reasons for this association. First, dry mouth may be a marker of an increased dose or an extended field of radiation. If that is the case, increased radiation doses or a more extended field of radiation may result in an increased risk of late tissue damage as manifested by lymphedema and fibrosis. Second, dry mouth may result in ongoing mucosal irritation and injury. This may lead to increased susceptibility to the development of lymphedema and fibrosis.

The study identified that internal lymphedema was associated with self-reported voice-related symptoms. Previous studies have demonstrated that patients who receive radiation therapy for vocal cord lesions experience alterations in voice characteristics and quality.<sup>35</sup> Although tissue edema and fibrosis are commonly ascribed mechanisms for alterations in vocal function, few prior reports have correlated lymphedema and voice-related symptoms. One study reported 16 patients with head and neck cancer who had voice dysfunction related to internal pharyngeal edema.<sup>29</sup>

This is the first study we are aware of to examine the association between lymphedema severity and body image in patients with head and neck cancer. Lymphedema may cause facial disfigurement and distress in patients with head and neck cancer<sup>36-38</sup>; thus, the finding of a significant relationship between external lymphedema and body image disturbance was not surprising.

These results are similar to those reported in the breast cancer population in which secondary lymphedema has been associated with body image issues.<sup>39-42</sup>

The lack of a statistically significant correlation between lymphedema severity and anxiety was unexpected. Although no studies are available for comparison regarding these relationships in patients with head and neck cancer, studies conducted in patients with breast cancer found that patients with more severe lymphedema had more anxiety.<sup>43-45</sup> Another interesting finding in this study is that participants with more severe lymphedema did not report more depressive symptoms. This finding was consistent with at least 1 study conducted in patients with breast cancer and secondary arm lymphedema, which reported that arm lymphedema severity was not correlated with depressive symptoms.<sup>41</sup> Nevertheless, small sample size may have contributed to the negative findings in the current study and further research is warranted.

Lymphedema severity was associated with decreased cervical range of motion. Specifically, participants with more severe external lymphedema had poorer left lateral and right lateral rotation. This finding is similar to studies in patients with breast cancer and arm lymphedema.<sup>40</sup> These patients frequently reported decreased arm range of motion. We hypothesized that lymphedema may contribute to trismus in patients with head and neck cancer if lymphedema-related fibrosis affects the muscles of mastication; however, study findings did not support this hypothesis. One possible explanation for this finding is that only 8 participants with facial lymphedema (swelling or fibrosis) were identified in this study, so the relationship between lymphedema and trismus could not be assessed with confidence. There is a need to recruit more participants with facial lymphedema and further examine the relationship between facial lymphedema/fibrosis and trismus.

Radiation therapy may cause Eustachian tube dysfunction and otitis media secondary to edema and tissue damage with associated secondary hearing loss.<sup>46-48</sup> In this study, the combined effects of external and internal lymphedema severity were related to decreased hearing as measured by the tuning fork test and whispered voice test. Although this correlation was expected, further testing of this correlation with more sensitive hearing measures (such as formal audiological testing) is warranted to clearly identify whether external and/or internal lymphedema contributes to hearing impairments in patients after head and neck cancer treatment.

Finally, this study demonstrated that lymphedema severity was associated with overall QOL. This finding is similar to the outcomes from 2 previous studies.<sup>10,11</sup> When evaluating QOL subscales, data suggest that external lymphedema severity tended to correlate most strongly with the functional and head and neck subscales. This is rational because the content of these 2 subscales is reflective of the expected deficits associated with lymphedema.

This study has some limitations that need to be acknowledged. Because of the race distribution and the

heterogeneity of the sample with respect to disease site, treatment modality, time since head and neck cancer diagnosis, time since completed treatment, and tumor stage, the study findings may not be generalizable to ethnic groups not represented in the study sample or to those with less severe disease, single modality of treatment, or shorter duration since completed cancer treatment. The majority of the participants (65%) in the current study had stage IV disease. It would be helpful for future studies to assess patients at uniform points in time after head and neck cancer diagnosis and receiving particular types of cancer treatment. This study was cross-sectional in design; thus, causal relationships cannot be determined nor could the trajectory of lymphedema and prognostic factors for lymphedema development be delineated. Given the exploratory and preliminary nature of this study, an uncorrected alpha of 0.05 was used for evaluating statistical significance, even though a large number of statistical tests were conducted. Care was taken to interpret the strongest and most apparent clinically meaning associations; however, the likelihood of the false-positive results is elevated in this study due to the large number of statistical tests conducted. Clearly, future replication of the findings from this study will be helpful.

Moreover, multiple studies conducted in patients with breast cancer and arm lymphedema have demonstrated that patients with lymphedema may have altered sensation-related symptoms, such as numbness in the affected skin area.<sup>41,49</sup> These sensation-related symptoms, however, were not captured in this study because valid instruments assessing lymphedema-specific symptoms were not available for the head and neck cancer population. Development of a lymphedema-specific symptom instrument for patients with head and neck cancer is currently underway. In this study, endoscopic evaluation was done as part of routine follow-up. It is possible that patients who undergo endoscopy for evaluation of symptoms may have a higher likelihood of lymphedema. However, we wanted an unselected patient sample to ensure generalizability to the overall population of patients with head and neck cancer (not restricted to those with overt symptoms). The endoscopic evaluation was conducted outside of the time limit specified by the study in 21.4% of participants. This limits our ability to capture the entire picture of internal lymphedema status

in the sample. Moreover, there might be other unmeasured differences between those who did versus did not undergo endoscopy examination in the study. In addition, due to physician scheduling difficulties, we were unable to directly examine interrater reliability of the internal lymphedema ratings for the entire sample. However, before data collection, the 2 physicians involved in the internal lymphedema data collection were trained regarding how to grade the severity of internal lymphedema. Moreover, the first author was present during the first 10% of the endoscopic examinations and did not find any significant differences for grading internal lymphedema between the 2 physicians. Thus, discrepancies between the 2 physicians who were grading severity of internal lymphedema seemed to be minimized.

Despite these limitations, some clinical implications are noteworthy. Healthcare professionals need to conduct physical examinations to detect external lymphedema (e.g., soft tissue and skin examination of the face and neck to identify any swelling and/or fibrosis) and internal lymphedema (e.g., endoscopic examinations). If lymphedema is identified, patients should be queried about associated symptoms. Referrals to lymphedema therapists, speech-language pathologists, and physical therapists should be made when appropriate.

**CONCLUSIONS**

Lymphedema is a frequent late effect of combined modality therapy for locally advanced head and neck cancer, and it is associated with substantial symptom burden and functional deficits. As expected, lymphedema was associated with poor body image and decreased QOL. Although data regarding the efficacy of therapeutic interventions are lacking, referral to appropriate specialty services is recommended for patients with head and neck cancer who also have symptomatic lymphedema. Studies exploring the temporal presentations of lymphedema and symptoms are needed to clearly elucidate the relationship between lymphedema, symptoms, and QOL. Interventional studies are needed to explore strategies regarding treatment of lymphedema, symptomatology, and improving QOL in patients with lymphedema after head and neck cancer treatment.

**APPENDIX A. Stages of lymphedema.**

Stage	Pathology	Signs and symptoms	Diagnosis
0 Latency	Focal fibrosclerotic tissue alterations	None	Functional isotope lymphography
I Reversible	High protein edema; focal fibrosclerotic tissue alterations	Pitting edema; elevation reduces the swelling; possibly "pain of congestion"	Basic diagnostic procedures
II Spontaneously irreversible	Extensive fibrosclerosis, proliferation of adipose tissue	Brawny, hard swelling that does not recede with elevation	Basic diagnostic procedures
III Elephantiasis	Extensive fibrosclerosis, proliferation of adipose tissue	Like Stage II; invalidism	Basic diagnostic procedures

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## APPENDIX B. Patterson scale for edema in larynx and pharynx.

Based upon your examination of the participant, please use the following scale to grade lymphedema/edema in the laryngopharyngeal structures.

Structures	Rating of edema			
	Normal	Mild	Moderate	Severe
1) Base of tongue	1) ___	___	___	___
2) Posterior pharyngeal wall	2) ___	___	___	___
3) Epiglottis	3) ___	___	___	___
4) Pharyngoepiglottic folds	4) ___	___	___	___
5) Aryepiglottic folds	5) ___	___	___	___
6) Interarytenoid space	6) ___	___	___	___
7) Cricopharyngeal prominence	7) ___	___	___	___
8) Arytenoids	8) ___	___	___	___
9) False vocal folds	9) ___	___	___	___
10) True vocal folds	10) ___	___	___	___
11) Anterior commissure	11) ___	___	___	___

  

Spaces	Normal	Mildly reduced	Moderately reduced	Severely reduced
12) Valleculae	12) ___	___	___	___
13) Pyriform sinus	13) ___	___	___	___

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## REFERENCES

- Vokes EE, Kies MS, Haraf DJ, et al. Concomitant chemoradiotherapy as primary therapy for locoregionally advanced head and neck cancer. *J Clin Oncol* 2000;18:1652–1661.
- Földi M, Földi E, Strobenreuther RHK, et al. Földi's textbook of lymphology, 2nd ed. München, Germany, Urban & Fischer;2006.
- Lymphoedema Framework. Best practice for the management of lymphoedema. International Consensus. London:MEP Ltd;2006.
- Büntzel J, Glatzel M, Mücke R, Micke O, Bruns F. Influence of amifostine on late radiation-toxicity in head and neck cancer—a follow-up study. *Anticancer Res* 2007;27:1953–1956.
- Dietz A, Rudat V, Nollert J, Helbig M, Vanselow B, Weidauer H. Chronic laryngeal edema as a late reaction to radiochemotherapy. [Article in German]. *HNO* 1998;46:731–738.
- Schieffe F, Akdemir M, Weber A, Akdemir D, Singer S, Frerich B. Function, postoperative morbidity, and quality of life after cervical sentinel node biopsy and after selective neck dissection. *Head Neck* 2009;31:503–512.
- Wolff HA, Overbeck T, Roedel RM, et al. Toxicity of daily low dose cisplatin in radiochemotherapy for locally advanced head and neck cancer. *J Cancer Res Clin Oncol* 2009;135:961–967.
- Hammond T. The treatment of head and neck lymphedema, 04/12 update. <http://www.lymphnotes.com/article.php?id/378/>.
- Zimmermann T, Leonhardt H, Kersting S, Albrecht S, Range U, Eckelt U. Reduction of postoperative lymphedema after oral tumor surgery with sodium selenite. *Biol Trace Elem Res* 2005;106:193–203.
- Bruns F, Büntzel J, Mücke R, Schönekaes K, Kisters K, Micke O. Selenium in the treatment of head and neck lymphedema. *Med Princ Pract* 2004;13:185–190.
- Micke O, Bruns F, Mücke R, et al. Selenium in the treatment of radiation-associated secondary lymphedema. *Int J Radiat Oncol Biol Phys* 2003;56:40–49.
- Földi M, Földi E, Kubik S. Textbook of Lymphology. München, Germany: Urban & Fischer;2003.
- Patterson JM, Hildreth A, Wilson JA. Measuring edema in irradiated head and neck cancer patients. *Ann Otol Rhinol Laryngol* 2007;116:559–564.
- Murphy BA, Wells NL, Cmelak AJ, Netterville JL, Burkey BB, Smith KZ. Reliability and validity for the Vanderbilt Head and Neck Symptom Survey (VHNSS): a new tool to assess symptom burden in patients undergoing chemoradiation. 2004 ASCO Annual Meeting Proceedings. *J Clin Oncol* 2004;22:14s (abstract 5569).
- Murphy BA, Dietrich MS, Wells N, et al. Reliability and validity of the Vanderbilt Head and Neck Symptom Survey: a tool to assess symptom burden in patients treated with chemoradiation. *Head Neck* 2010;32:26–37.
- Bjelland I, Dahl AA, Haug TT, Neckelmann D. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. *J Psychosom Res* 2002;52:69–77.
- Razavi D, Delvaux N, Bredart A, et al. Screening for psychiatric disorders in a lymphoma out-patient population. *Eur J Cancer* 1992;28A:1869–1872.
- Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67:361–370.
- Moore S, Greer S, Watson M, et al. The factor structure and factor stability of the hospital anxiety and depression scale in patients with cancer. *Br J Psychiatry* 1991;158:255–259.
- Cash TF, Pruzinsky T. Body image: a handbook of theory research and clinical practice. New York:Guilford Press;2002.
- Hopwood P, Fletcher I, Lee A, Al Ghazal S. A body image scale for use with cancer patients. *Eur J Cancer* 2001;37:189–197.
- Reynolds J, Marsh D, Koller H, Zeneer J, Bannister G. Cervical range of movement in relation to neck dimension. *Eur Spine J* 2009;18:863–868.
- Williams MA, McCarthy CJ, Chorti A, Cooke MW, Gates S. A systematic review of reliability and validity studies of methods for measuring active and passive cervical range of motion. *J Manipulative Physiol Ther* 2010;33:138–155.
- Common Terminology Criteria for Adverse Events, Version 3.0 (CTCAE v3.0), 8/06 update. [http://ctep.cancer.gov/protocolDevelopment/electronic\\_applications/docs/ctcae3.pdf](http://ctep.cancer.gov/protocolDevelopment/electronic_applications/docs/ctcae3.pdf).
- Fix JD. Neuroanatomy (3rd ed). Philadelphia:Lippincott Williams & Wilkins;2002.
- Pirozzo S, Papinczak T, Glasziou P. Whispered voice test for screening for hearing impairment in adults and children: systematic review. *BMJ* 2003;327:967.
- List MA, D'Antonio LL, Cella DF, et al. The performance status scale for head and neck cancer patients and the functional assessment of cancer therapy—head and neck scale. A study of utility and validity. *Cancer* 1996;77:2294–2301.
- Eisbruch A, Schwartz M, Rasch C, et al. Dysphagia and aspiration after chemoradiotherapy for head-and-neck cancer: which anatomic structures are affected and can they be spared by IMRT? *Int J Radiat Oncol Biol Phys* 2004;60:1425–1439.
- Machtay M, Moughan J, Trotti A, et al. Factors associated with severe late toxicity after concurrent chemoradiation for locally advanced head and neck cancer: an RTOG analysis. *J Clin Oncol* 2008;26:3582–3589.
- Piso DU, Eckardt A, Liebermann A, Gutenbrunner C, Schäfer P, Gehrke A. Early rehabilitation of head-neck edema after curative surgery for orofacial tumors. *Am J Phys Med Rehabil* 2001;80:261–269.
- Manikantan K, Khode S, Sayed SI, et al. Dysphagia in head and neck cancer. *Cancer Treat Rev* 2009;35:724–732.
- Murphy BA, Gilbert J. Dysphagia in head and neck cancer patients treated with radiation: assessment, sequelae, and rehabilitation. *Semin Radiat Oncol* 2009;19:35–42.
- MacDonald N. Cancer cachexia and targeting chronic inflammation: a unified approach to cancer treatment and palliative/supportive care. *J Support Oncol* 2007;5:157–162; discussion 164–166.
- Delano MJ, Moldawer LL. The origins of cachexia in acute and chronic inflammatory diseases. *Nutr Clin Pract* 2006;21:68–81.
- Verdonck-de Leeuw IM, Keus RB, Hilgers FJ, et al. Consequences of voice impairment in daily life for patients following radiotherapy for early glottic cancer: voice quality, vocal function, and vocal performance. *Int J Radiat Oncol Biol Phys* 1999;44:1071–1078.
- Murphy BA, Gilbert J, Ridner SH. Systemic and global toxicities of head and neck treatment. *Expert Rev Anticancer Ther* 2007;7:1043–1053.
- Ridner SH. Lymphedema of the head and neck: an overview. *National Lymphedema Network Lymph Link* 2008;20:1–3.
- Smith BG, Lewin JS. Lymphedema management in head and neck cancer. *Curr Opin Otolaryngol Head Neck Surg* 2010;18:153–158.
- Jäger G, Döller W, Roth R. Quality-of-life and body image impairments in patients with lymphedema. *Lymphology* 2006;39:193–200.
- Morgan PA, Franks PJ, Moffatt CJ. Health-related quality of life with lymphoedema: a review of the literature. *Int Wound J* 2005;2:47–62.
- Ridner SH. Quality of life and a symptom cluster associated with breast cancer treatment-related lymphedema. *Support Care Cancer* 2005;13:904–911.
- Speck RM, Gross CR, Hormes JM, et al. Changes in the Body Image and Relationship Scale following a one-year strength training trial for breast

- cancer survivors with or at risk for lymphedema. *Breast Cancer Res Treat* 2010;121:421–430.
43. Heppner PP, Tierney CG, Wang YW, et al. Breast cancer survivors coping with lymphedema: what all counselors need to know. *J Couns Dev* 2009; 87:327–338.
  44. Meeske KA, Sullivan–Halley J, Smith AW, et al. Risk factors for arm lymphedema following breast cancer diagnosis in black women and white women. *Breast Cancer Res Treat* 2009;113:383–391.
  45. Ridner SH. The psycho-social impact of lymphedema. *Lymphat Res Biol* 2009;7:109–112.
  46. Hsin CH, Chen TH, Young YH, Liu WS. Comparison of otologic complications between intensity-modulated and two-dimensional radiotherapies in nasopharyngeal carcinoma patients. *Otolaryngol Head Neck Surg* 2010; 143:662–668.
  47. Liang KL, Su MC, Twu CW, Jiang RS, Lin JC, Shiao JY. Long-term result of management of otitis media with effusion in patients with post-irradiated nasopharyngeal carcinoma. *Eur Arch Otorhinolaryngol* 2011; 268:213–217.
  48. Schultz C, Goffi–Gomez MV, Pecora Liberman PH, Pellizzon AC, Carvalho AL. Hearing loss and complaint in patients with head and neck cancer treated with radiotherapy. *Arch Otolaryngol Head Neck Surg* 2010; 136:1065–1069.
  49. Armer JM, Radina ME, Porock D, Culbertson SD. Predicting breast cancer-related lymphedema using self-reported symptoms. *Nurs Res* 2003;52: 370–379.