

Horizontal (vs. vertical) closure of the neo-pharynx is associated with superior postoperative swallowing after total laryngectomy

Giannis Thrasyvoulou, MD, PGCert Med, PhD; Petros V. Vlastarakos, MD, MSc, PhD; Michael Thrasyvoulou, BSc(Math); Aristides Sismanis, MD, FACS

Abstract

We conducted a cross-sectional study to compare the horizontal and vertical methods used in the surgical closure of the neo-pharynx after total laryngectomy in terms of their effect on swallowing function, swallowing-related quality of life (QOL), and overall QOL. We also assessed the potential influence of age (≤ 64 vs. ≥ 65 yr) and the type of treatment modality (primary, salvage, or total laryngectomy with radiotherapy) on outcomes. Our final study population was made up of 34 patients—31 men and 3 women, aged 49 to 89 years (mean: 66.8)—who had undergone a total laryngectomy. One year after surgery, all patients were asked to complete the M.D. Anderson dysphagia inventory (MDADI), which quantifies swallowing function and swallowing-related QOL, and the University of Washington quality-of-life questionnaire (UW-QOL), which quantifies overall QOL. Of the 34 patients, 16 had undergone a horizontal surgical closure of their neo-pharynx and 18 a vertical closure. According to the MDADI, patients in the horizontal group experienced significantly better swallowing function/QOL; the mean composite MDADI scores were 91.5 in the horizontal group and 68.3 in the vertical group ($p = 0.005$). We found no significant difference in terms of overall QOL, as the respective mean UW-QOL scores

were 81.0 and 80.8 ($p = 0.93$). The population correlation coefficient was positive in both groups, but more so in the horizontal group ($\rho_{\text{horizontal}} = 0.876$ and $\rho_{\text{vertical}} = 0.676$). Neither age nor the type of treatment modality employed influenced swallowing function/QOL ($p_{\text{age}} = 0.10$, $p_{\text{treatment modality}} = 0.78$) or overall QOL ($p_{\text{age}} = 0.08$, $p_{\text{treatment modality}} = 0.59$). We conclude that horizontal closure of the neo-pharynx is superior to vertical closure in terms postoperative swallowing function/QOL but not overall QOL.

Introduction

Despite advances in conservative laryngeal surgery, improvements in radiotherapy regimens and delivery methods, and the introduction of multimodality protocols, total laryngectomy remains the procedure of choice for advanced-stage laryngeal carcinoma around the world.¹⁻³ However, it is not only laryngeal cancer that has an impact on some of our most essential physiologic functions (e.g., speaking, swallowing, and breathing),⁴ so does a mutilated larynx. Indeed, a total laryngectomy and its aftermath correspond to a very real trauma, both at the individual and social levels. Total laryngectomy can result in disturbances of a delicately balanced system of functions that are vital for life sustenance, as well as communication and other social interactions.^{4,5}

A diagnosis of laryngeal cancer in itself can cause psychosocial problems that include anxiety, depression, loss of self-esteem, uncertainty about the future, isolation from friends, and tensions within families, all of which have a clear and direct influence on well-being and quality of life (QOL).^{6,7} Therefore, clinicians should

From the Department of Otolaryngology, Nicosia General Hospital, Nicosia, Cyprus (Dr. G. Thrasyvoulou and Mr. M. Thrasyvoulou); the Department of Otolaryngology, MITERA Infirmary, Athens, Greece (Dr. Vlastarakos); and the Department of Otolaryngology-Head and Neck Surgery, Virginia Commonwealth University School of Medicine, Richmond (Prof. Sismanis). The study described in this article was conducted at Nicosia General Hospital.

Corresponding author: Petros V. Vlastarakos, Department of Otolaryngology, MITERA Infirmary, 6 Erythrou Stavrou Str., Marousi-Athens 15123, Greece. Email: pevlast@hotmail.com

consider QOL as it pertains to both the disease and its proposed treatment. These are important factors in treatment planning, in obtaining informed consent, and in providing patients with realistic expectations for their outcome.

In this article, we describe our study to compare outcomes in patients who underwent either a horizontal or vertical surgical closure of the neo-pharynx after total laryngectomy.

Patients and methods

For this cross-sectional study, we recruited 52 patients who had undergone a total laryngectomy between Jan. 1, 2010, and Dec. 31, 2015, in the ENT Department at Nicosia General Hospital in Cyprus. During this time, our department underwent a change in the way we close the neo-pharynx after total laryngectomy; we now make the closure in the horizontal plane, whereas we had previously closed in the vertical plane. This change prompted us to compare the two types of closure. We also assessed the potential influence of age (≤ 64 vs. ≥ 65 yr) and treatment modality (e.g., primary, salvage, and total laryngectomy with radiotherapy) on outcomes. Our hospital is a tertiary care treatment and follow-up center for patients with laryngeal cancer, and it accepts referrals on a nationwide level.

At their follow-up visit 12 months postoperatively, all patients were asked to complete the M.D. Anderson dysphagia inventory (MDADI), which measures swallowing function and swallowing-related QOL, and the University of Washington quality-of-life questionnaire (UW-QOL), which quantifies overall QOL. Of the original group of 52 patients, 34 patients—31 men and 3 women, aged 49 to 89 years (mean: 66.8)—completed both questionnaires (response rate: 65.4%), and their responses were included in the final analysis.

Of the 34 patients, 16 had undergone a horizontal surgical closure and 18 a vertical closure. Surgeries in the horizontal group included 2 primary surgeries, 9 salvage laryngectomies, and 5 total laryngectomies with postoperative radiotherapy. In the vertical group, the respective figures were 4, 11, and 3.

Dysphagia assessment. The MDADI questionnaire has been validated for patients with head and neck cancer. It comprises 20 statements related to dysphagia in four subscales: *global*, *emotional*, *functional*, and *physical*.⁸

- The global subscale measures the impact of swallowing on daily routine.

- The emotional subscale quantifies the emotional response to dysphagia.

- The functional subscale reflects the impact of swallowing on daily activities.

- The physical subscale measures patients' perceptions regarding swallowing ability.

There are five possible responses to each statement: *strongly agree*, *agree*, *no opinion*, *disagree*, and *strongly disagree*. Scores for each of the 20 statements range from 1 to 5, and the total score ranges from 20 to 100.⁸ Higher scores indicate better swallowing function.

Quality-of-life assessment. The UW-QOL questionnaire is a head/neck-cancer-specific, self-administered outcomes scale consisting of three distinct parts.⁹

- The first part comprises 12 domains: *pain*, *appearance*, *activity*, *recreation*, *swallowing*, *chewing*, *speech*, *shoulder function*, *taste*, *saliva*, *mood*, and *anxiety*. For each domain, there are three to five possible responses, and possible scores for each range from 0 to 100.

- In the second part, patients choose the three domains that have affected them most during the previous 7 days.

- The third part includes three general questions that ask patients to compare their current QOL with their QOL 1 month before their diagnosis, to rate their health-related QOL over the previous 7 days, and to rate their overall QOL over the previous 7 days.¹⁰

Higher questionnaire scores in each of the three parts reflect a better QOL.

Statistical analysis. Statistical analysis was performed with the MS Excel and R statistical software programs. Since our two study groups numbered fewer than 30 patients each, we used the nonparametric two-sided Mann-Whitney *U* test to make comparisons. We used the Spearman rank correlation coefficient to show the correlation between the mean MDADI and UW-QOL scores in the two groups. Statistical significance was accepted at $p < 0.05$.

Any observation outside the critical region led to statistically important observations. The following assumptions were considered: (1) all observations in both groups were independent of each other, (2) observations were ordinal, hence they could be ranked, (3) under the null hypothesis, the distribution of the two samples was the same, and (4) under the alternative hypothesis, the distribution of the two samples was not equal. In addition, we performed multiple linear

regression analysis to assess the relative contribution of postlaryngectomy speech and swallowing in our patients' postoperative QOL.

Potential differences between different treatment modalities (primary, salvage, or total laryngectomy with postoperative radiotherapy) were assessed with the Kruskal-Wallis test, taking into account the rather limited size of the study sample and the fact that each case was independent. Statistical significance was again accepted at $p < 0.05$.

Ethical considerations. The research protocol was approved by the ethics committee of the University of Athens and the research and ethics committee of Nicosia General Hospital before the commencement of the data collection. Participants were asked to sign a consent form before being enrolled in the study.

Results

Primary outcomes. The mean composite MDADI scores were 91.5 in the horizontal group and 68.3 in the vertical group. The difference was statistically significant ($p = 0.005$), suggesting that the postoperative swallowing function in the patients who underwent a horizontal neo-pharyngeal surgical closure was far better than that of their vertically closed counterparts (table).

The mean UW-QOL scores were 81.0 in the horizontal group and 80.8 in the vertical group. The difference was

not statistically significant ($p = 0.93$), suggesting that while the overall postoperative QOL was quite good, it was not influenced by the type of closure (table).

Scatterplots for the correlation between mean MDADI scores and mean UW-QOL scores in the horizontal group (figure 1) and the vertical group (figure 2) showed that the correlation coefficient was positive in both groups, but more so in the horizontal group ($\rho_{\text{horizontal}} = 0.876$ and $\rho_{\text{vertical}} = 0.676$, respectively).

Multiple linear regression analysis of the effect of postlaryngectomy speech and swallowing on our patients' postoperative QOL suggested a positive correlation between QOL and swallowing ($\beta_1 = 0.41$), but no correlation between QOL and speech ($\beta_2 = -0.02$).

Age. The mean composite MDADI scores were 90.5 for patients younger than 65 years and 79.1 in their older counterparts. The difference was not statistically significant ($p = 0.10$), suggesting that the postoperative swallowing function was not influenced by age (table).

The same applied for the mean postoperative UW-QOL scores ($p = 0.08$). The respective scores were 84.7 in the younger patients and 76.2 in the older ones (table).

Type of surgery. Finally, the mean composite MDADI scores according to the different treatment modalities were 88.5 for primary cases, 79.4 for salvage laryngectomies, and 81.4 for total laryngectomies with postoperative radiotherapy. These differences were not statistically significant ($p = 0.78$), suggesting that the postoperative swallowing function was not affected by the type of surgery (table).

Likewise, the mean postoperative UW-QOL scores were not statistically significant ($p = 0.59$). The respective scores were 81.5 for primary cases, 75.9 for salvage laryngectomies, and 82.4 for total laryngectomies with postoperative radiotherapy (table).

Discussion

Although no therapeutic option is without risk, the decision regarding the treatment modality for a patient with advanced laryngeal cancer requires acknowledging the impact that both the disease and its proposed treatment will have on some of the most essential physiologic functions, such as speaking, swallowing, and breathing. This is so we can provide patients with a realistic expectation of their outcomes.

During the past 15 years, QOL has been increasingly recognized as an important outcomes parameter in laryngeal cancer patients. Although survival is

Table. Summary of results in the two groups

Parameter	MDADI score	UW-QOL score
Type of closure		
Horizontal	91.5 ± 12.5	81.0 ± 11.7
Vertical	68.3 ± 18.4	80.8 ± 12.1
<i>p</i> Value	<i>p</i> = 0.005	<i>p</i> = 0.93
Age, yr		
≤64	90.5 ± 12.0	84.7 ± 9.2
≥65	79.1 ± 17.9	76.2 ± 15.4
<i>p</i> Value	<i>p</i> = 0.10	<i>p</i> = 0.08
Type of surgery		
Primary laryngectomy	88.5 ± 15.3	81.5 ± 18.4
Salvage laryngectomy	79.4 ± 15.0	75.9 ± 20.0
Total laryngectomy w/ radiotherapy	81.4 ± 22.5	82.4 ± 18.7
<i>p</i> Value	<i>p</i> = 0.78	<i>p</i> = 0.59

Key: MDADI = M.D. Anderson dysphagia inventory; UW-QOL = University of Washington quality-of-life questionnaire.

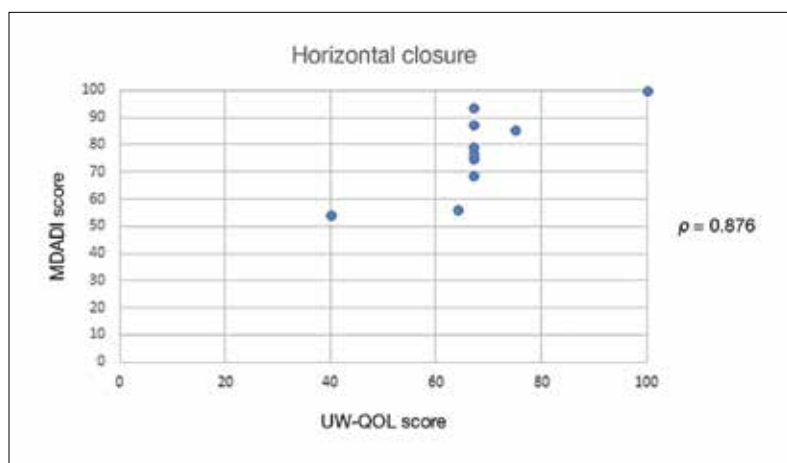


Figure 1. Scatterplot shows the positive correlation between the mean MDADI and UW-QOL scores in patients who underwent the horizontal neo-pharyngeal surgical closure.

an undisputed measure of treatment success, QOL after laryngectomy has many facets that need to be acknowledged. In this context, due emphasis has recently been placed on swallowing after total laryngectomy, in addition to the traditional interests regarding speech rehabilitation.^{2,11-13}

Our study used validated questionnaires and robust statistical analysis to assess outcomes after the closure of the pharyngeal defect that remains after a total laryngectomy. We found that a horizontal plane closure was superior to a vertical closure in terms of postoperative swallowing function and swallowing-related QOL ($p = 0.005$). This finding, which has not been previously reported in the literature, is very important because the etiology of dysphagia is poorly understood and its incidence is probably underestimated.¹³

In addition, the use of adjuvant treatments (e.g., radiotherapy and chemotherapy) and the existence of other comorbid factors such as aging and depression may further complicate the problem.

The horizontal closure of the neo-pharynx is performed in three layers:

- The first layer is constructed with a modified running Connell suture with a 4-0 polydioxanone stich, with the surgeon taking appropriate care to invert the pharyngeal mucosa. The stoma is viewed like a cycle; two stay sutures are placed at a horizontal plane to ensure an even closure, and they are kept retracted by a second surgeon. The needle is inserted in an oblique sub-

mucosal pattern in a “near inside-out” and “far outside-in” fashion. The pinch length is 5 to 10 mm, and the distance from the mucosal edge at the near inside-out side is 5 mm. The same pinch pattern is followed at the far outside-in side; a 5-mm gap followed by a 5- to 10-mm oblique pinch.

- The second layer is constructed with interrupted sutures to the submucosa and muscle with a 3-0 Vicryl stich.
- The third layer binds the inferior constrictors to the suprahyoid muscles, again with interrupted 3-0 Vicryl suturing.

Closure of the second and third layers is performed in a manner that does not interrupt the blood supply.

One advantage of closing the neo-pharynx with a modified running Connell suture in a horizontal plane is the prevention of overlap in the stitch points, as in cases of consecutive sutures. The prevention of overlap might result in improved blood and lymph circulation at the mucosal edges. Moreover, the spontaneous inversion of the mucosal edges with this stitch pattern might improve the postoperative sealing of the mucosal closure. Finally, the relaxation of the line of closure is prevented, as every stitch adds tightness and firmness to the previous one.¹⁴

It is interesting that despite the significantly better outcome in terms of postoperative swallowing/swallowing QOL ($p = 0.005$), our study found that the horizontal closure did not result in a significantly

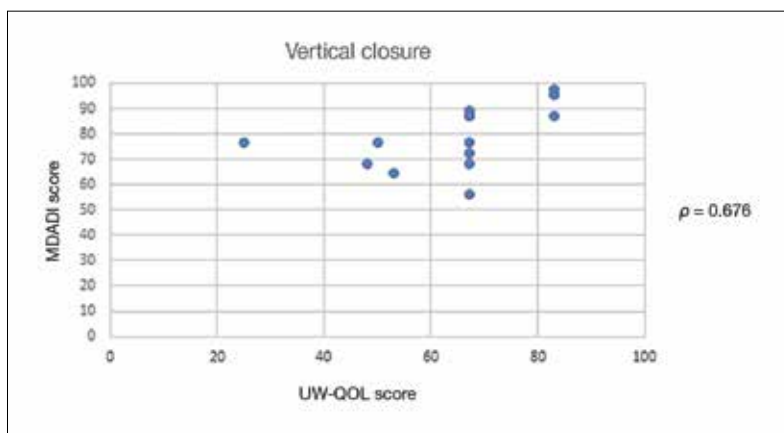


Figure 2. Scatterplot shows that the correlation between the mean MDADI and UW-QOL scores in patients who underwent the vertical neo-pharyngeal surgical closure was not quite as positive as it was in the horizontal closure patients.

better overall QOL ($p = 0.93$). While this finding might suggest that patients who undergo a total laryngectomy have a fairly good overall postoperative QOL,¹⁵ our regression analysis indicated that there was a positive correlation, although moderate to low in magnitude, between QOL and swallowing ($\beta_1 = 0.41$), whereas we found no correlation between QOL and speech ($\beta_2 = -0.02$). This finding distinguishes swallowing as a non-negligible determinant of postoperative QOL in patients who undergo a total laryngectomy. It also confirms the necessity of specialized speech and language therapy services to support swallowing rehabilitation, in addition to the traditional forms of speech rehabilitation.¹

However, since the correlation between the MDADI and QOL scores appeared to be stronger in patients who underwent a horizontal neo-pharyngeal surgical closure rather than a vertical closure ($\rho_{\text{horizontal}} = 0.876$ vs. $\rho_{\text{vertical}} = 0.676$), ENT surgeons should be aware of this advantage.

Our study did not find that age had any significant influence on postoperative swallowing function/QOL ($p = 0.10$) or overall QOL ($p = 0.08$). Indeed, age is believed to be a factor in only a limited percentage of global QOL scores,¹⁶ and it has rather limited, if any, predictive value regarding postlaryngectomy QOL.¹⁷ Nor did we find that adjuvant treatment significantly influenced postoperative swallowing function/QOL or overall QOL. Radiotherapy was not particularly detrimental in terms of the functional outcomes of laryngectomees postoperatively. This finding is consistent with that of Paleri et al,¹⁸ and it supports the continuation of organ preservation strategies as a good treatment modality for many patients with advanced laryngeal disease.

The limitations of our study include its cross-sectional nature and the possibility of selection and survival bias. Even so, the cross-sectional protocol allowed us to identify a subset of surviving patients and to study them with a single interactive activity (i.e., completing questionnaires).⁶

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References

1. Robertson SM, Yeo JC, Dunnet C, et al. Voice, swallowing, and quality of life after total laryngectomy: Results of the West of Scotland laryngectomy audit. *Head Neck* 2012;34(1):59-65.

2. Kapila M, Deore N, Palav RS, et al. A brief review of voice restoration following total laryngectomy. *Indian J Cancer* 2011; 48(1):99-104.
3. Silver CE, Beitler JJ, Shaha AR, et al. Current trends in initial management of laryngeal cancer: The declining use of open surgery. *Eur Arch Otorhinolaryngol* 2009;266(9):1333-52.
4. Babin E, Blanchard D, Hitier M. Management of total laryngectomy patients over time: From the consultation announcing the diagnosis to long term follow-up. *Eur Arch Otorhinolaryngol* 2011;268(10):1407-19.
5. Starmer HM, Tippett DC, Webster KT. Effects of laryngeal cancer on voice and swallowing. *Otolaryngol Clin North Am* 2008; 41(4):793-818, vii.
6. Kazi R, De Cordova J, Kanagalingam J, et al. Quality of life following total laryngectomy: Assessment using the UW-QOL scale. *ORL J Otorhinolaryngol Relat Spec* 2007;69(2):100-6.
7. Pruyn JE, de Jong PC, Bosman LJ, et al. Psychosocial aspects of head and neck cancer—a review of the literature. *Clin Otolaryngol Allied Sci* 1986;11(6):469-74.
8. Mohide EA, Archibald SD, Tew M, et al. Postlaryngectomy quality-of-life dimensions identified by patients and health care professionals. *Am J Surg* 1992;164(6):619-22.
9. Rogers SN, Gwanne S, Lowe D, et al. The addition of mood and anxiety domains to the University of Washington quality of life scale. *Head Neck* 2002;24(6):521-9.
10. Evans E, Carding P, Drinnan M. The voice handicap index with post-laryngectomy male voices. *Int J Lang Commun Disord* 2009; 44(5):575-86.
11. Coffey M, Tolley N. Swallowing after laryngectomy. *Curr Opin Otolaryngol Head Neck Surg* 2015;23(3):202-8.
12. Manikantan K, Khode S, Sayed SI, et al. Dysphagia in head and neck cancer. *Cancer Treat Rev* 2009;35(8):724-32.
13. Maclean J, Cotton S, Perry A. Variation in surgical methods used for total laryngectomy in Australia. *J Laryngol Otol* 2008; 122(7):728-32.
14. Haksever M, Akduman D, Aslan S, et al. Modified continuous mucosal Connell suture for the pharyngeal closure after total laryngectomy: Zipper suture. *Clin Exp Otorhinolaryngol* 2015; 8(3):281-8.
15. Vilaseca I, Chen AY, Bakscheider AG. Long-term quality of life after total laryngectomy. *Head Neck* 2006;28(4):313-20.
16. Eadie TL, Bowker BC. Coping and quality of life after total laryngectomy. *Otolaryngol Head Neck Surg* 2012;146(6):959-65.
17. Singer S, Danker H, Guntinas-Lichius O, et al. Quality of life before and after total laryngectomy: Results of a multicenter prospective cohort study. *Head Neck* 2014;36(3):359-68.
18. Paleri V, Stafford FW, Leontsinis TG, Hildreth AJ. Quality of life in laryngectomees: A post-treatment comparison of laryngectomy alone versus combined therapy. *J Laryngol Otol* 2001;115(6):450-4.