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Objective and Subjective Comparison of the Quality of Voice Between Two Available Surgical Approaches in T1b Glottic Cancer

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Abstract

Background: This study aimed to assess differences in the quality of voice results of open frontolateral partial laryngectomy with imbrications laryngoplasty and transoral laser microsurgery in T1b glottic carcinoma.
Methods: In this randomized clinical trial, 20 patients with T1b glottic cancer who were candidates for surgery were randomly (using the blocked randomization method) assigned to schedule for frontolateral partial laryngectomy with imbrications laryngoplasty (n = 7) or transoral laser microsurgery (Va extended cordectomy) (n = 10). The objective and subjective voice results were assessed using voice analysis parameters (jitter, shimmer, harmonics to noise ratio, and maximum phonation time). The Voice Handicap Index (VHI) questionnaire was used with 30 statements consisting of three domains including functional, physical, and emotional aspects of voice disorders.
Results: No statistically significant differences were noted between laser surgery and open procedure in objective voice analysis parameters. The voice was significantly disturbed after both procedures but subjective analysis of the voice by the VHI questionnaire showed more statistically significant patients' satisfaction in the laser group. The mean VHI was 77.29 $\pm$ 8.51 after vertical hemilaryngectomy and 65.60 $\pm$ 13.08 after laser cordectomy that was significantly lower in the latter procedure (P = 0.042).
Conclusions: Despite the imbrications of laryngoplasty in open surgery, no statistically significant differences were noted in objective voice parameters. However, more patients' satisfaction was noted regarding voice in laser surgery. When considering modality, we need to assess factors such as individual anatomic factors, complete tumor exposure (depth of tumor in anterior commissure), professional needs, quality of life, and cost-effectiveness. With regard to the semi-invasive nature of laser use and more patients' satisfaction based on the VHI questionnaire, this method is prioritized in comparison with the surgical procedure as vertical hemilaryngectomy.

Keywords: Cancer, Partial Laryngectomy, Transoral Laser Microsurgery, Patients' Satisfaction

1. Background

Laryngeal cancer is the second most common malignancy of the upper aerodigestive tract in the United States (1). The most common malignancy of the larynx is squamous cell carcinoma (SCC) that includes 85% to 95% of all laryngeal malignancies and arises from the epithelial lining of the larynx (2). The incidence of SCC in each of the three anatomic regions of the larynx, i.e. the supraglottis, the glottis, and the subglottis, differs based on the patient population. In the United States, Canada, England, and Sweden, glottic SCC is more common than supraglottic SCC, whereas, in France, Italy, Spain, Finland, and the Netherlands, the supraglottic SCC is more common. In Japan, the incidence rates of glottic and supraglottic SCC are the same, and primary subglottic SCC is scarce in the whole community (2). Among all 11300 diagnosed cases of laryngeal cancer in 2007 in the United States, approximately 3660 deaths were reported and the male to female incidence ratio was 3.8 (1). Concerning risk factors for laryngeal cancer, tobacco and alcohol use are the two major risk factors that act synergistically to increase the risk of cancer (3). No racial predilection is apparent (4). Some accused agents as the risk factors for laryngeal cancer include diesel exhaust, asbestos, organic solvents, sulfuric acid, mustard gas, certain mineral oils, metal dust, asphalt, wood dust, stone dust, mineral wool, and cement dust (5).

Nowadays, human papillomavirus (HPV), most commonly HPV16, is known as a risk factor for oropharyngeal SCC (6, 7). The genetic susceptibility is also responsible for developing laryngeal SCC (8). Commonly, dysphonia is the first, primary symptom of glottic SCC related to the impairment of the normal vocal cord vibration at the early onset of the disease, even with a small lesion. Therefore, if patients and the medical team are aware of this early presentation of glottic SCC, it will be diagnosed at earlier stages of the disease; on the other hand, if these symptoms are ignored, dyspnea and stridor as the indications of the advanced disease may arise. Glottic tumors have a tendency to remain localized in the glottis area for long periods because ligaments, membranes, and cartilages, which act as natural barriers, prevent the spread of the tumor. Furthermore, the relative poverty of lymphatics in the glottis area will be helpful (9). The proper definition of the term *early* in laryngeal cancer in the context of management options is applied only when it can be treated by conservative surgery (partial laryngectomy), by endoscopic excision, or by radiotherapy (RT) alone (10). Whereas in the context of the staging system, the term *early* is applied to stage 0, I, or II tumors and the term *late* refers to stage III or IV (11). There is still controversy over optimal management options for early glottic cancer including laser surgery, open surgery, and radiotherapy (12, 13). Staging of early glottis cancer based on clinical assessment of the degree of vocal cord mobility is as follows: Tumors limited to one vocal cord with normal mobility that may involve anterior or posterior commissure (T1a), tumors involving both vocal cords with normal mobility that may involve anterior or posterior commissure (T1b), and tumors extended to supraglottis or subglottis with normal mobility (T2a) (14). Sometimes, we use vocal function studies as visual feedback to define treatment goals and document the voice changes based on treatment results. Maximum phonation time (MPT) is defined as the longest period (in seconds) during which a patient can sustain phonation of a vowel sound; however, it is not fully explained by either vital capacity or laryngeal function. It can also be affected by resonance, practice, frequency, intensity, instructions, and the vowel choice (15, 16). No specific measure has emerged as obligatory for the diagnosis of voice disorders. The most noted measures are jitter, cycle-to-cycle variation in frequency, and shimmer, cycle-to-cycle variation in amplitude (17). The Voice Handicap Index was arranged in 1997 to show voice disability, "a social, economic, or environmental difficulty resulting from the impairment" (18, 19). The Voice Handicap Index questionnaire has 30 statements and consists of three domains including functional, physical, and emotional aspects of voice disorders. Patients need to rate the equal-appearing interval on a scale from one to five to indicate the frequency of the incident. The total possible score is 120 where a higher score demonstrates a higher handicap level. Although the score of functional, physical, and emotional subscales can be noted (20), it has been recommended that the total score is more significant (19).

2. Methods

In this randomized clinical trial, 20 patients with T1b glottic cancer referring to Rasoul-e-Akram hospital in Tehran between January 2015 and July 2017 as candidates for surgery were initially included into the study and were randomly (using the blocked randomization method) assigned to schedule for frontolateral partial laryngectomy with imbrications laryngoplasty (n = 10) or transoral laser microsurgery (Va extended cordectomy) (n = 10). In the group planned for transoral laser microsurgery, all patients were included in the study; however, three patients in the other group were excluded because of unwillingness to participate in our final assessment. Finally, seven in frontolateral partial laryngectomy group and 10 in transoral laser microsurgery group were assessed. The exclusion criteria were as follows: (1) Female patients, (2) an age under 25 and over 80, (3) a history of laryngeal trauma, (4) a previous history of surgery on the larynx (except DL Bx), (5) a history of radiotherapy (before or after the surgery), (6) any other pathology except for SCC, and (7) a history of voice therapy after the surgery.

The term T indicates primary tumor staging. The tumors are staged as: T1a (the tumor is limited to a vocal cord with the normal motion of the vocal cords and the involvement of anterior or posterior commissure), T1b (the involvement of both vocal cords with the normal motion of the vocal cords and the involvement of anterior or posterior commissure), and T2a (the tumor spreading to the supraglottis or subglottis area with the normal motion of the vocal cords). In our study, only male patients with T1b glottis cancer (the involvement of both vocal cords with the normal motion of the vocal cords and the involvement of anterior commissure) were included. Before and three months after the surgery (without speech therapy), a voice analysis was performed using Voice Function Analyzer Aerophone II software (Model 6800) and the associated software to measure the parameters of jitter, shimmer, harmonics to noise ratio (HNR), maximum phonation time (MPT), and Voice Handicap Index (VHI). Finally, the results of voice analysis were compared within each group before/after the surgery and between the two groups undergoing two surgical methods. We also measured the mentioned parameters in a healthy control group (50 male

healthy individuals) to be assured of the agreement of determined normal limits of each parameter in our population with universal standards.

For statistical analysis, the data were presented as means ± standard deviation (SD) for quantitative variables and summarized by absolute frequencies and percentages for categorical variables. The normality of the data was analyzed using the Kolmogorov-Smirnov test. Because all variables followed a non-parametric pattern, quantitative variables were compared with the Mann U test. The significant changes were determined by comparing the parameters after surgery with those before by the Wilcoxon test. For the statistical analysis, the statistical software SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL) was used. P values of 0.05 or less were considered statistically significant.

3. Results

This study only included male patients whose pathology report findings indicated squamous cell carcinoma. There was no significant difference in the average age between vertical hemilaryngectomy group and laser cordectomy group (62.86 ± 11.15 years versus 52.10 ± 14.01 years, P = 0.112).

Comparing the mean values of jitter, shimmer, HNR, and MPT parameters between the two procedural groups showed no difference in all parameters before and after the surgery (Table 1).

The mean VHI was 77.29 ± 8.51 after vertical hemilaryngectomy and 65.60 ± 13.08 after laser cordectomy that was significantly lower in the latter procedure (P = 0.042). The mean difference in VHI after the procedural approach was also lower in the laser cordectomy group as compared to vertical hemilaryngectomy approach (5.10 ± 1.10 versus 7.00 ± 1.41, P = 0.013). Assessing the change in each vocal parameter following the procedures in both groups (Table 1) showed that except for Jitter parameter that remained unchanged in the laser cordectomy group, the changes in other parameters were significant after the two procedures. In this regard, in both surgery groups, MPT and HNR significantly reduced while Shimmer significantly increased. The assessment of each parameter in normal healthy individuals (Table 2) indicated the normal value of MPT in the range of 14.03 to 19.04, Jitter in the range of 0.27 to 1.31, Shimmer in the range of 1.87 to 3.79, and HNR in the range of 13.71 to 28.58.

Table 1. Vocal Analysis Results Before and After Surgical Procedures

Parameter	VHL Group	Laser Group	P Value
MPT			
Before	8.68 ± 2.48	9.05 ± 1.53	0.710
After	11.19 ± 1.62	11.52 ± 2.07	0.728
P value	0.002	< 0.001	
Jitter			
Before	3.24 ± 1.65	3.57 ± 1.23	0.645
After	0.60 ± 0.18	1.76 ± 3.42	0.389
P value	0.050	0.139	
Shimmer			
Before	8.42 ± 2.06	7.51 ± 1.61	0.320
After	4.07 ± 0.85	4.19 ± 0.53	0.711
P value	0.002	< 0.001	
HNR			
Before	11.02 ± 2.87	10.55 ± 3.99	0.793
After	18.95 ± 2.83	18.37 ± 1.99	0.628
P value	< 0.001	< 0.001	

4. Discussion

The analysis of vocal quality after any procedure for the treatment of laryngeal cancers, especially glottic cancers, is considered an important factor in the evaluation of this procedure. In this regard, two invasive treatments including vertical hemilaryngectomy and transoral laser cordectomy were evaluated in terms of vocal quality after the procedure. The outcome of these two procedures was tested and compared in the treatment of early glottic cancers. Evaluating the indicators of vocal quality, such as the maximum time a person can continuously produce voice, cycle-to-cycle variations in voice frequency, cycle-to-cycle variations in voice amplitude, and the mean of a disturbance in the vibration of vocal cords that caused violent voice, in our study showed no statistically significant differences between laser surgery and open procedures with regard to objective voice analysis parameters. All of the voice indices were significantly disturbed after both of the procedures except for Jitter parameter that was changed after laser cordectomy but according to the P value, this change was not significant. Nevertheless, the subjective analysis of the voice by VHI questionnaires showed statistically significant patients' satisfaction in the laser group. When considering modality, we need to assess factors such as individual anatomic factors, complete tumor exposure (depth of tumor in anterior commissure) professional needs, quality of life, and cost-effectiveness. However, with regard to the semi-invasive nature of laser use and more patients' satisfaction based on the VHI questionnaire, this method is prioritized in comparison with surgical procedures such as vertical hemilaryngectomy.

One of the strengths of this study was that all the patients were in the same stage of the disease (T1b) and therefore, the tumor resection was ultimately almost the

Table 2. Normal Limits of Vocal Parameters in Healthy Individuals

Parameters	MPT	Jitter	Shimmer	HNR
Mean	16.01	0.72	2.77	20.94
Median	15.82	0.70	2.89	20.71
Standard deviation (SD)	1.61	0.28	0.55	4.20
Minimum	14.03	0.27	1.87	13.71
Maximum	19.04	1.31	3.79	28.58

same. In addition, both subjective and objective aspects of the voice in patients were analyzed. On the other hand, the small sample size was considered as a limiting factor in achieving significant differences in our study indices. Nonetheless, in various studies, different results have been obtained which in most cases refer to laser preference for invasive surgery. In a study in 2003, the voice quality in patients undergoing hemilaryngectomy without laryngoplasty was unsatisfactory compared to a normal control group (21). In a study in 2009, patients with glottic cancers were treated with cordectomy, vertical hemilaryngectomy, and frontolateral partial laryngectomy. The results of this study showed that there was no statistically significant difference in the survival of the patients when comparing the laser-operated surgical group with the open surgical group. However, laser-operated patients had significantly fewer complications and less tracheotomy. Finally, the study concluded that laser surgery is an effective method for the treatment of patients with T1 glottic cancer, which has better results and fewer complications than open surgery (22). They did not consider the voice quality in their study. Another study in 2012 was conducted on 20 patients undergoing surgery for glottic cancer treated with vertical hemilaryngectomy or laser. The study showed that some of the acoustic and aerodynamic parameters were significantly different between the patient and control group so that the subharmonic parameters (NSH and DSH) and the degree of voice break (DVB) were significantly better in the laser group than in the hemilaryngectomy group (23). However, we did not consider these parameters in our study. In contrast, some studies also focused on the limitations of the laser cordectomy method. Bertino et al. in 2001 showed that the repair of vocal cords after cordectomy did not significantly improve the quality of voice even with speech therapy (24). Therefore, there is no preference for a surgical procedure over another one. Nunez Batalla et al. also showed that there was no significant difference in the voice quality between radiotherapy and laser cordectomy (25).

4.1. Conclusions

Despite imbrications of laryngoplasty in open surgery, no statistically significant differences were noted in objective voice parameters. However, more patients' satisfaction was noted in regards to voice in laser surgery. When considering modality, we need to assess factors such as individual anatomic factors, complete tumor exposure (depth of tumor in anterior commissure), professional needs, quality of life, and cost-effectiveness. By considering the semi-invasive nature of laser use and more patients' satisfaction based on the VHI questionnaire, this method is preferred over surgical procedures such as vertical hemilaryngectomy.

Footnotes

Authors' Contribution: Study concept and design and critical revision of the manuscript for important intellectual content: Aslan Ahmadi, Farzad Izadi and Afsaneh Montazemi; acquisition of data, analysis and interpretation of data, drafting of the manuscript, and statistical analysis: Afsaneh Montazemi and Taraneh Montazemi; administrative, technical, material support and study supervision: Aslan Ahmadi and Farzad Izadi.

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