Evaluation of Voice Quality after Supraglottic Laryngectomy

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Abstract

Objective. Supraglottic laryngectomy is a surgical procedure that preserves laryngeal functions. This technique allows extensions including removal of tongue base or 1 arytenoid. We aimed to compare vocal results of supraglottic laryngectomy and extended procedures.

Study Design. Cross-sectional study.

Setting. Tertiary care hospital.

Subjects and Methods. Thirty-three males who underwent supraglottic laryngectomy were included in the study. Fifteen patients (45.5%) were applied standard supraglottic laryngectomy (standard supraglottic laryngectomy group). In 11 patients (33.3%), unilateral arytenoid cartilage was totally resected by separation at the cricoarytenoid joint (laterally extended group), and the tongue base was removed in 7 patients (anteriorly extended group) (21.2%). Twenty male smokers constituted control group. Acoustic and aerodynamic voice analyses were performed for the assessment of objective results. Grade, roughness, breathiness, asthenia, and strain scale (GRBAS) scores were analyzed for perceptual assessment. Voice Handicap Index-30 was used to evaluate subjective results.

Results. The comparison of supraglottic laryngectomy group with the control group revealed that the mean maximum phonation time and fundamental frequency were significantly lower in the supraglottic laryngectomy group (P < .001), and the mean jitter, shimmer, and noise-to-harmonics ratio were significantly higher in the supraglottic laryngectomy group (P < .001). Maximum phonation time and fundamental frequency were higher in the standard supraglottic laryngectomy group in comparison to extended groups. Jitter value was also lower in the standard supraglottic laryngectomy group compared to extended groups. Perceptual and subjective analyses revealed no difference among standard supraglottic laryngectomy and extended groups.

Conclusion. The results of this study indicate that supraglottic laryngectomy patients have acceptable voice quality, as determined by perceptual and subjective assessment.

Keywords

supraglottic laryngectomy, voice, larynx carcinoma, acoustic analysis, voice handicap index

Introduction

Supraglottic laryngectomy (SL) is a surgical procedure for the resection of supraglottic tumors that preserves the vocal, deglutition, and respiratory functions of the larynx.1,2 Epiglottis, aryepiglottic plica, and ventricular bands are removed during standard supraglottic laryngectomy (SSL). The base of the tongue, arytenoid cartilage, and the pyriform sinus can be resected during extended supraglottic laryngectomy (ESL) based on tumor boundaries. If extension is directed to the base of tongue, it is called anteriorly extended supraglottic laryngectomy (AESL), but if it is directed to arytenoid cartilage and pyriform sinus, it is called laterally extended supraglottic laryngectomy (LES).3

Vocal quality is an important determinant of quality of life, and the choice of supraglottic tumor treatment may affect vocal outcomes. Since false vocal folds add efficiency to vocal fold vibration and complete compression reduces the efficiency of voice production,4 voice quality may be affected by removal of the supraglottis. Moreover, resecting the base of the tongue or arytenoid cartilage may have additional effects on voice quality.

This study evaluated multiple aspects of voice quality following SL and the effects of the removal of the tongue base and arytenoid cartilage on voice quality.
Materials and Methods

Patients

The research protocol was approved by the Institutional Review Board of Istanbul University Faculty of Medicine. Seventy-seven patients underwent SL with transcervical approach between May 1999 and December 2011. Patients who died, patients with recurrence or metastasis, female patients, and patients who declined to join the study were excluded. Fourteen of 77 patients died, 9 due to recurrence or metastasis and 5 due to cardiac and pulmonary diseases. Two surviving patients, a patient with local recurrence and the other with regional recurrence, were also excluded from the study because total laryngectomy was applied on the patient who had local recurrence, and the other patient underwent extended radical neck dissection including hypoglossal nerve. We excluded 5 surviving female patients because the 2 genders have different vocal characteristics. Twenty-three patients refused to participate in the study. Completing 1 year postoperatively was accepted as the specific period to participate in the study. It is accepted that vocal parameters do not change significantly after 12 months postoperatively.5

The remaining 33 healthy males with a mean age of 67 years (range, 52-77 years) and who had completed 1 year of follow-up were included in the study (Table 1). Fifteen patients (45.5%) were applied SSL. Eleven patients (33.3%) whose unilateral arytenoid cartilage was totally resected by separation at the cricoarytenoid joint constituted the laterally extended group, and the tongue base was removed in 7 patients (21.2%), who composed the anteriorly extended group. The mucosal lining over the preserved arytenoid cartilage was partially resected or left intact based on the level of suspected tumor invasion. Bilateral neck dissection was performed in all patients. Therapeutic neck dissection was applied in all cases with N(+) disease, whereas in the case of N0 neck, prophylactic neck dissection was performed because there is a high risk of occult metastasis in supraglottic tumors. All patients had a histopathological diagnosis of squamous cell carcinoma. Twelve patients underwent postoperative radiotherapy because they had either more than 1 metastatic lymphadenopathy and/or capsule invasion or a positive tumor margin. The mean follow-up period was 104.60 months (range 40-164, months).

Acoustic and Aerodynamic Voice Analysis

All patients’ voices were recorded using a dynamic microphone maintained at a distance of 15 cm from the lip. After a deep inspiration, patients were asked to sound the vowel “ah” for the longest possible time. This action was repeated 3 times, and the longest recording time was accepted as the maximum phonation time (MPT). Additionally, patients were asked to read a passage from a famous Turkish story titled “Diyet” for 40 seconds in a relaxed voice. The Praat software (version 4.4.13, Boersma and Weenink, University of Amsterdam, Amsterdam, The Netherlands) was used for acoustic voice analysis. The fundamental frequency (F0), jitter, shimmer, and noise-to-harmonics ratio (NHR) were determined during acoustic voice analysis. The mean time between SL and the last acoustic voice analysis was 35.9 ± 17.2 months (range, 14-88 months). To compare postoperative results with normal values, the voices of 20 male smokers, of ages similar to the SL patients, were recorded and used as the control group. Mean age of the control group was 66.7. All of the patients had been admitted to outpatient clinic with problems that were not related to voice. All of them were evaluated with endoscopy for possible laryngeal problems, and patients without laryngeal disease were included in the study. Results were compared between the SSL group, the 2 extended ESL groups (anteriorly and laterally extended), and the control group.

Perceptual Analysis

Three judges blinded to the study groups evaluated and scored the final voice recordings of all participants in random order. The grade, roughness, breathiness, asthenia, and strain (GRBAS) scale was scored between 0 and 3 for each category (0 = normal, 1 = slight alteration, 2 = moderate alteration, and 3 = severe alteration). Scoring was performed twice by each judge. The mean time between SL and the perceptual analysis was 35.9 ± 17.2 months (range, 14-88 months).

Self-assessment

Each patient was asked to complete the Turkish version of Voice Handicap Index-30 (VHI-30) translated and validated by Kılıc et al.6 Patients chose a score between 0 and 4 to indicate the frequency with which they experienced the

<table>
<thead>
<tr>
<th>Table 1. Study Population Characteristics.</th>
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<tbody>
<tr>
<td>n</td>
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<tr>
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</tr>
<tr>
<td>SSL</td>
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<tr>
<td>LESL</td>
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<tr>
<td>AESL</td>
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<td>Total</td>
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</table>

Abbreviations: SSL, standard supraglottic laryngectomy; LESL, laterally extended supraglottic laryngectomy; AESL, anteriorly extended supraglottic laryngectomy.
Acoustic and aerodynamic voice analysis

Kruskal-Wallis tests were used to evaluate differences between groups. A probability value less than .05 was considered to indicate statistical significance.

All patients were decannulated at an average of 23.1 ± 8.5 days postoperatively, and all nasogastric feeding tubes were removed at an average of 27.1 ± 6.7 days. All patients were able to communicate vocally and eat a normal or near-normal diet.

Acoustic and Aerodynamic Voice Analysis

Voice analysis results of the SSL group, the 2 ESL groups (anteriorly and laterally extended), and the control group are presented in Table 2. Comparison of SL and control groups revealed that the mean MPT and F0 values were significantly lower in the SL group (P < .001), and the mean jitter, shimmer, and NHR values were significantly higher in the SL group (P < .001).

The SSL group MPT was significantly higher than that of the anteriorly and laterally extended groups (P < .01). In addition, the anteriorly extended group had a higher MPT than the laterally extended group (P = .041). The F0 of the SSL group was significantly higher than that of the anteriorly and laterally extended groups (P < .01). There was no difference in F0 between the ESL groups (P = .113).

The jitter value of the SSL group was significantly lower than that of the ESL groups (P = .008) and did not differ among the other groups. Shimmer and NHR did not differ among the groups (P = .420 and P = .426, respectively).

Statistical Analysis

The NCSS (Number Cruncher Statistical System) 2007 and PASS (Power Analysis and Sample Size) 2008 (Kaysville, Utah, USA) statistical software packages were used for statistical analysis. Descriptive statistics (mean, standard deviation, median, minimum, and maximum) were calculated for each variable. Mann-Whitney U tests and Kruskal-Wallis tests were used to evaluate differences between groups. A P value less than .05 was considered to indicate statistical significance.

Table 2. Test Results.a

<table>
<thead>
<tr>
<th></th>
<th>Total Patients (n = 33)</th>
<th>Group 1 (n = 15)</th>
<th>Group 2 (n = 11)</th>
<th>Group 3 (n = 7)</th>
<th>P</th>
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<tbody>
<tr>
<td><strong>Acoustic and aerodynamic voice analysis</strong></td>
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<tr>
<td>Maximum phonation time (s)</td>
<td>13.42 ± 2.06</td>
<td>14.77 ± 1.95</td>
<td>11.18 ± 1.33</td>
<td>13.05 ± 1.21</td>
<td>.001</td>
</tr>
<tr>
<td>Fundamental frequency (Hz)</td>
<td>114.07 ± 8.86</td>
<td>122.77 ± 3.44</td>
<td>105.28 ± 2.18</td>
<td>109.23 ± 5.03</td>
<td>.001</td>
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<tr>
<td>Jitter (%)</td>
<td>1.48 ± 0.74</td>
<td>1.02 ± 0.32</td>
<td>1.95 ± 0.89</td>
<td>1.74 ± 0.6</td>
<td>.001</td>
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<tr>
<td>Shimmer (%)</td>
<td>6.18 ± 2.15</td>
<td>5.32 ± 1.31</td>
<td>6.94 ± 3.22</td>
<td>6.37 ± 1.12</td>
<td>.420</td>
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<tr>
<td>Noise-to-harmonic ratio</td>
<td>0.17 ± 0.06</td>
<td>0.15 ± 0.04</td>
<td>0.20 ± 0.07</td>
<td>0.19 ± 0.08</td>
<td>.426</td>
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<tr>
<td>Perceptual analysis (GRBAS scale)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Grade</td>
<td>1.54 ± 0.50</td>
<td>1.46 ± 0.51</td>
<td>1.60 ± 0.50</td>
<td>1.57 ± 0.53</td>
<td>.691</td>
</tr>
<tr>
<td>Roughness</td>
<td>2.03 ± 0.52</td>
<td>1.93 ± 0.59</td>
<td>2.18 ± 0.40</td>
<td>2.00 ± 0.57</td>
<td>.498</td>
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<tr>
<td>Breathiness</td>
<td>1.72 ± 0.62</td>
<td>1.53 ± 0.51</td>
<td>2.00 ± 0.63</td>
<td>1.71 ± 0.75</td>
<td>.191</td>
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<tr>
<td>Assthenicity</td>
<td>1.63 ± 0.65</td>
<td>1.60 ± 0.63</td>
<td>1.72 ± 0.64</td>
<td>1.57 ± 0.78</td>
<td>.797</td>
</tr>
<tr>
<td>Strain</td>
<td>1.51 ± 0.50</td>
<td>1.46 ± 0.51</td>
<td>1.63 ± 0.50</td>
<td>1.42 ± 0.53</td>
<td>.616</td>
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<tr>
<td>Functional score</td>
<td>5.03 ± 1.48</td>
<td>4.86 ± 1.59</td>
<td>4.92 ± 1.63</td>
<td>4.71 ± 1.49</td>
<td>.442</td>
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<tr>
<td>Physical score</td>
<td>5.15 ± 1.75</td>
<td>4.66 ± 1.44</td>
<td>6.18 ± 1.94</td>
<td>4.57 ± 1.51</td>
<td>.046</td>
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<tr>
<td>Emotional score</td>
<td>4.87 ± 1.91</td>
<td>4.53 ± 2.06</td>
<td>5.18 ± 2.08</td>
<td>5.14 ± 1.34</td>
<td>.495</td>
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<tr>
<td>Total score</td>
<td>15.12 ± 3.58</td>
<td>14.13 ± 2.97</td>
<td>16.9 ± 4.15</td>
<td>14.42 ± 3.20</td>
<td>.235</td>
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</table>

Abbreviation: GRBAS, grade, roughness, breathiness, asthenia, and strain scale.

aScores are mean ± standard deviation. Group 1, standard supraglottic laryngectomy; Group 2, laterally extended supraglottic laryngectomy; Group 3, anteriorly extended supraglottic laryngectomy.

bValues for control group (n = 20) were as follows: maximum phonation time, 16.8 ± 5.65 seconds; fundamental frequency, 137.69 ± 26.71 Hz; jitter, 1.01% ± 0.47%; shimmer, 4.62% ± 1.19%; and noise-to-harmonic ratio 0.12 ± 0.04. Results were significantly different (P < .001). Mann-Whitney U tests and Kruskal-Wallis tests were used to evaluate differences between groups. A P value less than .05 was considered to indicate statistical significance.

Results

All patients were decannulated at an average of 23.1 ± 8.5 days postoperatively, and all nasogastric feeding tubes were removed at an average of 27.1 ± 6.7 days. All patients were able to communicate vocally and eat a normal or near-normal diet.

Statistical Analysis

The NCSS (Number Cruncher Statistical System) 2007 and PASS (Power Analysis and Sample Size) 2008 (Kaysville, Utah, USA) statistical software packages were used for statistical analysis. Descriptive statistics (mean, standard deviation, median, minimum, and maximum) were calculated for each variable. Mann-Whitney U tests and Kruskal-Wallis tests were used to evaluate differences between groups. A P value less than .05 was considered to indicate statistical significance.

Perceptual Analysis

The results of the perceptual analysis are presented in Table 2. There were no significant differences in the scores for grade, roughness, breathiness, asthenia, or strain according to the extent of resection (P = .691, P = .498, P = .191, P = .797, and P = .616, respectively).

Self-assessment

The mean VHI-30 scores and subscales are listed in Table 2. VHI-30 scores did not differ significantly according to the extent of resection (P = .235).
Discussion

Intelligible speech is a major determinant of quality of life following laryngectomy. Speech is not only a method of communication but also a part of one’s personality. Therefore, preservation of speech is one of the main goals of partial laryngectomy, in addition to oncologic control.

The oncologic control provided by SL is comparable to that of total laryngectomy. In addition, SL enables preservation of the glottis with acceptable functional outcomes. Vigili et al compared SL to horizontal laryngectomy and supracricoid laryngectomy and reported that SL had superior results in terms of quality of life. Although studies have examined vocal outcomes following SL, none have determined outcomes based on the extent of resection. In the present study, multiple parameters, including the extent of resection, were investigated to better understand the vocal aspects of SL.

Although the physiology of supraglottic activity is not well understood, false vocal fold compression appears to be related to voice production. Behrman et al concluded that medial compression of the ventricular folds was a normal laryngeal posture. Supraglottic pressure affects vocal fold vibration by accelerating and decelerating the air column. Supraglottic pressure is a part of input impedance, which is defined as supraglottal pressure to glottal flow and can have a profound effect on vocal fold oscillation. Titze stated that if supraglottic pressure is zero, no voice production can occur.

Alicandri-Ciufelli et al studied voice and deglutition functions in a series of 32 patients who underwent partial laryngectomy, including 9 supraglottic laryngectomy patients. They reported that preserving 2 arytenoids compared to 1 arytenoid did not influence vocal results. Our results revealed that ESL and SSL have statistically significant differences in MPT, F0, and jitter values.

MPT, which is important for prolonged vocalization and continuous speech, reflects the resistance and force generated at the glottal region. Roh et al reported MPTs of 14.2 seconds in the partial SL group and 13.7 seconds in the radical SL group. The present study revealed longer MPTs in the SSL group (average 13.7 s). Also, the anteriorly extended group had longer MPTs than the laterally extended group. These results may be related to a disturbance of the glottic closure mechanism in the ESL groups.

A listener’s perception of a speaker’s pitch depends primarily on the lowest frequency, termed F0, which is determined primarily by the elasticity, tension, and mass of the vocal folds. The mean F0 value in the present study was highest in the control group, and the SSL group had higher F0 values than both of the ESL groups, which demonstrates the effect of the supraglottic region on frequency. Perreti et al detected a median F0 value of 116.02 in open SL patients and 143.05 in endoscopic SL patients. Roh et al reported mean F0 values of 148 and 154 in partial and radical SL groups, respectively.

Jitter and shimmer percentages are used to evaluate the vibrational action of the glottis and represent the short-term (period-to-period) irregularity of pitch and the irregularity of the peak-to-peak amplitude of voice, respectively. The present study revealed that jitter is affected mainly in patients who underwent ESL. However, shimmer did not differ among the groups. Perreti et al reported median jitter and shimmer values of 1.23 and 6.24 in open SL patients and 1.31 and 6.89 in endoscopic SL patients, respectively. Roh et al reported mean jitter values of 2 and 2.4 in the partial and radical SL groups, respectively. In the same study, the mean shimmer values were 3.9 and 4.7 in the partial and radical SL groups, respectively.

An increase in the NHR ratio indicates an increase in the irregular versus regular components of voice. We detected no differences in NHR ratios among the groups. Reported NHR ratios range between 0.12 and 0.16. Because turbulence increases NHR, the arytenoid resected group had a higher NHR ratio.

Previous studies demonstrated no deterioration in perceptual parameters following SL. These previous findings are consistent with the satisfactory GRBAS results in the present study, which indicated no differences among the groups.

The VHI is an accepted tool for the self-assessment of voice quality. Roh et al reported mean VHI values of 14 and 19.6 in the partial and radical SL groups, respectively. Using the VHI-10, Park et al found that 90.9% of patients were satisfied with their voice after SL. In the present study, the VHI-30 was used for self-assessment, and SL patients had a mean score of 14.45 with no significant difference in scores among the groups.

Conclusion

The results of this study indicate that SL patients have acceptable voice quality in perceptual and subjective assessments. Although there was statistically significant difference in some objective parameters among SSL and 2 extended SL groups, there was no difference in perceptual and subjective assessment.

Author Contributions

İlhan Topaloglu, design of the study, analysis and interpretation of data, drafting and revising article, final approval, responsibility for content of manuscript; Ziya Salturk, acquisition of data, analysis and interpretation of data, drafting and revising article, final approval, responsibility for content of manuscript; Yavuz Atar, analysis and interpretation of data, revising article, final approval, responsibility for content of manuscript; Güler Berktîn, acquisition of data, revising article, final approval, responsibility for content of manuscript; Onur Büyükkoç, acquisition of data, revising article, final approval, responsibility for content of manuscript; Ozan Çakır, acquisition of data, revising article, final approval, responsibility for content of manuscript.

Disclosures

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