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Voice Quality After Anterior Commissure Cordectomy Versus Marginal Cordectomy for cT1 Glottic Carcinoma: A Case-Series

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Abstract

Objectives. To compare the presurgical to postsurgical voice quality (VQ) outcomes of types I, II, III, and VI transoral laser cordectomies (TLC).

Study design. Prospective uncontrolled study.

Setting. Multicenter study.

Methods. Patients treated with TLC for a cT1 glottic squamous cell carcinoma were recruited from 2 European hospitals. The pre- to 3-, 6-, and 12-month post-TLC VQ was investigated with the voice handicap index (VHI), GRBAS, speech rate, maximal phonation time (MPT), and acoustic parameters. VQ was compared between types of TLC (types I, II, III, VI).

Results. Ninety-six patients completed the evaluations (16 females). The TLC consists of type I (N = 30), II (N = 27), III (N = 19), and VI (N = 20), respectively. The mean ages of groups ranged from 55.3 to 65.5 years. The VQ significantly improved from pre- to 3-, and 12-month post-TLC in types I, II, and III TLC groups. Only grade of dysphonia was significantly improved in type VI TLC after 6- and 12-month post-TLC. Type VI TLC reported higher values of F0, breathiness, and percent jitter than types I to III TLC 6- and 12-month after the surgery. Percent jitter, F0, and the breathiness were the voice outcomes that highlight the differences in VQ between TLC groups.

Conclusion. The pre- to 12-month post-TLC evolution of VQ is better in types I-II TLC compared to types III and VI. Type VI TLC reported the worse VQ at baseline and throughout the follow-up.

Keywords

cord, cordectomy, fold, laryngeal, laser, microsurgery, otolaryngology, otorhinolaryngology, vocal, voice

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Transoral CO_2 laser cordectomy (TLC) and radiotherapy are standards of care for early-stage vocal fold squamous cell carcinoma (VFSCC).[1] Overall survival and recurrence-free survival rates were comparable between both approaches.[1,2] TLC reports similar postoperative voice quality (VQ) compared to radiation, which can be attributed to the conservation of tissue of at least 1 vibratory unit/vocal fold, the possibility to reduce the glottic insufficiency with vocal fold augmentation procedures, and the benefit of voice therapy.[3,4] The depth and the type of TLC are important for the postoperative VQ. To date, it is commonly supported that types I to III TLC are associated with better postoperative VQ than types IV to VI according to the European Laryngological Society Classification.[5-7] A few authors have compared post-TLC VQ outcomes of types I to III,[8,9] but there is no study investigating the VQ outcomes of type VI versus marginal cordectomies (types I-III). Type VI TLC consists of the resection of the anterior commissure and a significant part of the anterior third of the vocal cords.[6,7] Given the importance of the anterior third of the vocal folds for the vibratory process, the type VI cordectomy could be particularly associated with post-TLC impaired VQ compared to types

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I to III cordectomy. The postoperative VQ evolution of type VI versus marginal TLC over time, and the related recovery process of voice are additional topics that have not been investigated in the literature. The type of TLC could have an important impact on post-TLC VQ outcomes and, depending on the type of TLC, some VQ outcomes may be useful or not in the follow-up.

In the present study, the presurgical to postsurgical VQ outcomes of types I, II, III, and VI cordectomies were compared.

Methods

Patients and Setting

Patients treated with TLC for a cTis or cT1 glottic squamous cell carcinoma were prospectively recruited and followed at the Departments of Otolaryngology–Head & Neck Surgery of the Georges Pompidou European Hospital (APHP, Paris, France) and EpiCURA hospital (Baudour, Belgium). Only native French-speaking patients were included. Patients were included if they completed the 12-month follow-up. Patients with the following criteria were excluded: history of neck radiation, other voice disorders affecting the VQ analysis (eg, history of vocal cord scaring, dystonia, vocal cord tremor, or any other dysphonia related to neurological disease), re-intervention on vocal folds during the follow-up, history of laryngeal trauma or surgeries prior to the TLC. For postoperative margins, the authors only included the data of patients with postoperative positive or unclear margins who did not require re-intervention. Precisely, in case of positive or unclear margins, the patients were all followed and re-evaluated at 2 months given the tissue retraction and CO_2 laser section of tumor samples and the related difficulties to reach an accurate histopathological examination. The local IRB approved the study protocol, and informed consent was obtained for all patients (APHP-201602; EpiCURA-P2022-039).

Transoral Laser Cordectomy

In both hospitals, the oncological check-up included in-office videostroboscopic examination with or without biopsy, and neck tomodensitometry. The patients with cT1 tumor were offered either CO_2 laser TLC or primary radiotherapy. Considering comparative good oncological outcomes, VQ outcomes, length of treatment, and the cost of treatment in our healthcare system, the authors considered TLC as the primary treatment recommendation unless otherwise contraindicated. Contraindications for TLC included: vocal process fixation, preoperative evidence of thyroid or cricoid cartilage invasion, medical comorbidities precluding general anesthesia, and anatomic limitations resulting in poor endoscopic exposure. The patients who accepted TLC were taken to the operating room.[6,7] Note that the type of TLC was based on the tumor size, location, and stage (after a discussion with the local oncological board). Precisely, the decision was based on stroboscopic analysis: location of the tumor (type VI for anterior commissure tumor), assessed depth at the stroboscopy and during the palpation step the day of the surgery (operating room), and the imaging. It was assumed that the largest tumors were treated with the largest TLC (types II and III) but the depth of invasion was the primary outcome for guiding the resection extent. The authors adhered to the European Laryngological Society (ELS) classification findings for the initial work-up and the indication of type VI TLC.[6,7] The authors did not perform extemporaneous analysis for the cT1 tumors. The CO_2 laser was used respecting the settings of previous protocols.[10,11] (The Sharplan CO_2 laser; Acuspot micromanipulator in continuous mode [1-5 W, 270 µm spot sizes; Sharplan Laser]). The TLC was classified according to the European Laryngological Society Classification.[6,7] Types I, II, and III are subepithelial, subligamental, and transmuscular resections, respectively. Type VI consists of the resection of the anterior commissure of the vocal cords. Patients having benefited from Types IV and V TLC were excluded. Type IV TLC consisted in a resection extended to the paraglottic space and is associated with poorer postoperative VQ and Type V combined different TLC types to varying degrees.[10] Prior to the TLC, surgeons assessed the laryngeal exposition and re-evaluated the vocal fold lesion with a rigid 0° or 30° endoscope. The vocal fold carcinoma was resected "en bloc" and sent to the pathological examination. Patients started oral intake within the 24-hour period following the TLC. Patients were recommended for a postoperative voice rest of 3 days. Patients benefited from voice therapy in the first 3 months of follow-up (once per week). The postoperative medication included 1-week of codeine-based syrup for controlling the cough, and a 3-month empirical proton pump inhibitors or alginate treatment for controlling the potential laryngopharyngeal reflux disease and improving the vocal fold healing.[12] In practice, most patients were treated with proton pump inhibitors. Only a minority of patients with a demonstrated alkaline reflux disease were treated with alginate (n = 3).

VQ Outcomes

The videolaryngostroboscopy, subjective and objective VQ evaluations were carried out prior to the TLC (baseline), at 3-, 6-, and 12-month post-TLC. The subjective VQ was evaluated with the French version of Voice Handicap Index (VHI)[13] and Grade, Roughness, Breathiness, Asthenia and Strain (GRBAS) scale.[14] GRBAS items were assessed retrospectively by 2 experienced laryngologists (SH and LCB) on connected speech and reading balanced text in a blind manner with respect to the type of TLC. Judges reported moderate-to-high interrater reliability ($r_s = 0.663$). The objective VQ included aerodynamic and acoustic measurements. Patients were recorded for 3 sustained /a/phonation at comfortable intensity and pitch level with a high-quality microphone (AKG 550; Sony)

placed 4 cm from the mouth. Aerodynamics consisted of the maximum phonation time (MPT), which was the best trial of the 3 sustained vowels. Acoustics included fundamental frequency (F0), standard deviation of F0 (STD), percent jitter (Jitt), percent shimmer (Shim), and noise-to-harmonic ratio (NHR). Acoustics were measured on the center of a sustained vowel/a/using the Multi-Dimensional Voice Program (MDVP®; Kay Elemetrics). The speech rate was assessed by reading of a balanced text to count the number of words per minute.

Statistical Analyses

The statistical analyses were performed with Statistical Package for the Social Sciences for Windows (SPSS version 30.0; IBM Corp.). The Wilcoxon rank test was used to investigate VQ outcome changes throughout the postoperative follow-up in types I, II, III, and VI TLC groups. Kruskal-Wallis and Mann-Whitney *U* was used for the comparisons of VQ outcomes between groups. The association between outcomes was investigated with the Spearman analysis. The outcome association was considered as low, moderate and strong for $k < 0.40$, 0.40 to 0.60, and $k > 0.60$, respectively. A level of significance of $P < .05$ was used.

Results

Ninety-six patients who underwent TLC for a cTis or cT1 glottic squamous cell carcinoma were included (**Table 1**). Types I, II, III, and VI TLC were carried out in 30 (31.3%), 27 (28.1%), 19 (19.8%), and 20 (20.8%) patients, respectively (**Table 1**). Patients were comparable for age, gender ratio, reflux, and tobacco consumption history. The mean age ranged from 55.3 to 65.5 years according to groups. There were 16 females (16.7%) in the study. According to the cTNM classification, the tumors of all groups were cT1. The numbers of cTis in types I, II, III, and VI were 9/30, 4/27, 2/19, and 1/20, respectively. Others were cT1. The proportion of cT1 was higher in Type VI group compared to others (**Table 1**). There was no patient with cN+ or metastasis. One patient from the type 2 TLC subgroup had a recurrence of the carcinoma after the end of the study and within 12 postoperative months. The positive margin status was described in **Table 1**.

Baseline VQ

The baseline VQ data of patients is reported in **Table 2**. Groups were comparable for VHI and acoustic assessments. The grade of dysphonia was significantly higher in patients who underwent a type VI TLC compared to the others. The MPT was shorter in type I and VI groups compared to type II to III groups. The number of words (fluency) was significantly reduced in type VI patients compared to the others.

Evolution of VQ in Groups

The evolution of VQ outcomes per group is reported in **Table 3** (type I), 4 (type II), 5 (type III), and 6 (type VI). **Tables 3** and **4** show that VHI and the grade of dysphonia are the most useful outcomes for highlighting the VQ evolution from baseline to 3-, 6-, and 12-month post-TLC in types I to II. Roughness, F0, and NHR outcomes significantly improved after 12-month post-TLC in type III (**Table 5**). Patients who underwent type VI TLC reported significant improvements in the grade of dysphonia after 6- and 12 months post-TLC (**Table 6**), while the other VQ outcomes did not change. **Figure 1** summarizes the

Table 1. Demographics and Clinical Findings

	Type of cordectomies				
Outcomes	Type I	Type II	Type III	Type VI	*P* value
N total	30	27	19	20	
Age (years, mean, SD)	63.3 (11.3)	64.8 (10.6)	55.3 (13.9)	65.5 (11.3)	.173
Gender					
Females (N, %)	6 (20.0)	2 (7.4)	2 (10.5)	6 (30.0)	.204
Males (N, %)	24 (80.0)	25 (92.6)	17 (89.5)	14 (70.0)	
Gastroesophageal reflux disease	7 (23.3)	1 (3.7)	1 (5.3)	3 (15.0)	.084
Tobacco (pack/years, mean, SD)	31.4 (27.5)	20.6 (31.1)	30.0 (18.3)	26.0 (27.8)	.664
cTNM					
cTis	9 (30.0)	4 (14.8)	2 (10.5)	1 (5.0)	
cT1	21 (70.0)	23 (85.2)	17 (89.5)	19 (95.0)	.010
cN0	30 (100)	27 (100)	19 (100)	20 (100)	
Local recurrence (12 months)	0 (0)	1 (3.7)	0 (0)	0 (0)	
Margins					
Positive	1 (3.3)	4 (14.8)	5 (26.3)	2 (10.0)	.077
Unclear	1 (3.3)	2 (7.4)	2 (10.5)	2 (10.0)	

Comparison between groups were carried out with Kruskal-Wallis test and Chi-square according to the type of data.
Abbreviations: N, number; SD, standard deviation.

Table 2. Baseline Features of Patient Groups

Outcomes	Type 1 (N = 30)	Type 2 (N = 27)	Type 3 (N = 19)	Type 6 (N = 20)	*P* value
Voice quality					
VHI	34.3 ± 25.1	29.4 ± 22.1	33.0 ± 23.1	37.9 ± 20.1	NS
VHI functional	9.0 ± 8.7	8.7 ± 8.1	9.1 ± 7.3	12.2 ± 7.6	NS
VHI emotional	10.0 ± 8.9	8.5 ± 7.5	8.4 ± 7.9	10.9 ± 6.6	NS
VHI physical	15.3 ± 8.5	12.4 ± 9.1	15.7 ± 8.9	14.9 ± 9.6	NS
GRBAS					
Grade of dysphonia	2.0 ± 0.8	1.7 ± 0.6	1.8 ± 0.7	2.4 ± 0.7	0.034
Roughness	1.8 ± 0.8	1.6 ± 0.6	1.8 ± 0.8	1.3 ± 0.8	NS
Breathiness	1.4 ± 0.6	1.4 ± 0.6	1.3 ± 0.5	1.9 ± 0.9	NS
Asthenia	0.1 ± 0.5	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	NS
Strain	1.2 ± 1.1	1.1 ± 0.7	1.1 ± 0.7	1.6 ± 0.8	NS
Acoustic measures					
F0 (Hz)	163.6 ± 53.7	149.5 ± 34.8	140.5 ± 55.7	158.8 ± 37.1	NS
STD (Hz)	7.1 ± 8.9	7.9 ± 7.6	5.0 ± 4.5	12.5 ± 15.9	NS
Jitter (%)	3.0 ± 2.9	2.7 ± 1.8	3.3 ± 2.7	4.3 ± 5.2	NS
Shimmer (%)	7.7 ± 5.0	6.8 ± 5.1	8.2 ± 5.4	9.4 ± 6.4	NS
NHR	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.3 ± 0.3	NS
Maximum phonation time	10.8 ± 4.6	14.7 ± 6.0	14.8 ± 4.4	11.1 ± 5.7	0.022
Fluency	137.8 ± 21.4	151.2 ± 12.3	144.3 ± 23.1	125.2 ± 28.2	0.016

Abbreviations: F0, fundamental frequency; M/F, male/female; NHR, noise-to-harmonic ratio; NS, non-significant; SD, standard deviation; STD, F0 standard deviation; VHI, voice handicap index.

Table 3. Voice Quality Changes in Type I Cordectomy Patients

Voice quality outcomes	Baseline	3 mo	*P* value	6 mo	*P* value	12 mo	*P* value
VHI	34.3 ± 25.1	16.8 ± 16.3	.014	14.3 ± 15.9	.031	13.3 ± 11.0	.006
GRBAS							
Grade of dysphonia	2.0 ± 0.8	1.4 ± 0.7	.029	1.1 ± 0.8	.002	1.1 ± 0.9	.012
Roughness	1.8 ± 0.8	1.2 ± 0.8	.038	1.2 ± 0.8	NS	1.1 ± 0.9	.029
Breathiness	1.4 ± 0.6	0.9 ± 0.8	NS	0.7 ± 0.7	.026	0.6 ± 0.5	.002
Asthenia	0.1 ± 0.5	0.1 ± 0.2	NS	0.1 ± 0.1	NS	0.1 ± 0.2	NS
Strain	1.2 ± 1.1	0.6 ± 0.7	.013	0.6 ± 0.8	NS	0.6 ± 0.8	NS
Acoustic measures							
F0 (Hz)	163.6 ± 53.7	158.3 ± 46.2	NS	149.1 ± 35.3	NS	154.2 ± 42.6	NS
STD (Hz)	7.1 ± 8.9	5.3 ± 10.0	NS	3.3 ± 2.4	.049	8.5 ± 19.5	NS
Jitter (%)	3.0 ± 2.9	1.8 ± 1.4	NS	1.5 ± 1.2	.024	1.5 ± 1.3	.011
Shimmer (%)	7.7 ± 5.0	5.5 ± 2.3	.033	5.5 ± 2.8	NS	5.9 ± 3.7	.049
NHR	0.2 ± 0.1	0.1 ± 0.1	NS	0.1 ± 0.1	NS	0.1 ± 0.1	NS
Maximum phonation time	10.8 ± 4.6	11.9 ± 5.2	NS	11.7 ± 5.7	NS	12.7 ± 5.7	NS
Fluency	137.8 ± 21.4	140.9 ± 24.2	NS	143.6 ± 18.9	.013	147.0 ± 21.2	.012

The voice quality outcome changes were evaluated from baseline to 3-, 6-, and 12-month post-TLC with Wilcoxon rank test.
Abbreviations: F0, fundamental frequency; NHR, noise-to-harmonic ratio; NS, non-significant; mo, month; SD, standard deviation; STD, F0 standard deviation; VHI, voice handicap index.

evolution of VHI, the grade of dysphonia, breathiness, and percent jitter according to the TLC types.

Comparison of VQ Outcomes Between Groups

At 3 months post-TLC, the grade of dysphonia, the breathiness, VHI, and the percent jitter were significantly higher in types III and VI compared to types I to II (**Table 7**). At 6 months post-TLC, breathiness, F0, and percent jitter were significantly higher in type VI compared to types I to III. Types III and VI reported higher F0 than types I to II. There were significant differences in the grade of dysphonia between groups with a higher score for type III and a lower score for type I. At 12 months post-TLC, types III and VI patients maintained significantly higher values of VHI, breathiness, F0, and percent jitter than types I to II patients.

Table 4. Voice Quality Changes in Type II Cordectomy Patients

Voice quality outcomes	Baseline	3 mo	*P* value	6 mo	*P* value	12 mo	*P* value
VHI	29.4 ± 22.1	18.0 ± 19.0	NS	17.9 ± 18.1	.017	10.9 ± 12.9	.001
GRBAS							
Grade of dysphonia	1.7 ± 0.6	1.4 ± 0.6	NS	1.2 ± 0.8	.009	1.2 ± 0.8	.005
Roughness	1.6 ± 0.6	1.5 ± 0.7	NS	1.3 ± 0.7	NS	1.2 ± 0.8	.007
Breathiness	1.4 ± 0.6	0.8 ± 0.7	.028	0.6 ± 0.7	.003	0.5 ± 0.6	.002
Asthenia	0.1 ± 0.1	0.2 ± 0.5	NS	0.1 ± 0.1	NS	0.1 ± 0.1	NS
Strain	1.1 ± 0.7	0.7 ± 0.8	NS	0.6 ± 0.7	.020	0.5 ± 0.5	.003
Acoustic measures							
F0 (Hz)	149.5 ± 34.8	152.6 ± 33.5	NS	144.0 ± 47.1	NS	148.4 ± 43.0	NS
STD (Hz)	7.9 ± 7.6	5.8 ± 6.4	NS	4.6 ± 4.2	NS	5.2 ± 7.5	NS
Jitter (%)	2.7 ± 1.8	2.1 ± 1.8	NS	1.9 ± 1.8	NS	2.2 ± 2.2	NS
Shimmer (%)	6.8 ± 5.1	6.0 ± 5.6	NS	6.4 ± 5.2	NS	7.3 ± 7.2	NS
NHR	0.2 ± 0.1	0.2 ± 0.2	NS	0.2 ± 0.1	NS	0.2 ± 0.1	NS
Maximum phonation time	14.7 ± 6.0	13.1 ± 8.6	NS	13.0 ± 4.7	NS	12.1 ± 4.9	.010
Fluency	151.2 ± 12.3	152.0 ± 14.3	NS	151.3 ± 16.8	NS	154.0 ± 15.1	NS

The voice quality outcome changes were evaluated from baseline to 3-, 6-, and 12-month post-TLC with Wilcoxon rank test.
Abbreviations: F0, fundamental frequency; mo, month; NHR, noise-to-harmonic ratio; NS, non-significant; SD, standard deviation; STD, F0 standard deviation; VHI, voice handicap index.

Table 5. Voice Quality Changes in Type III Cordectomy Patients

Voice quality outcomes	Baseline	3 mo	*P* value	6 mo	*P* value	12 mo	*P* value
VHI	33.0 ± 23.1	33.9 ± 23.1	NS	31.6 ± 22.4	NS	27.3 ± 20.7	NS
GRBAS							
Grade of dysphonia	1.8 ± 0.7	2.1 ± 0.7	NS	1.3 ± 0.9	NS	1.3 ± 0.9	NS
Roughness	1.8 ± 0.8	1.4 ± 0.9	.011	1.2 ± 0.9	NS	1.0 ± 0.8	.014
Breathiness	1.3 ± 0.5	1.3 ± 0.9	NS	0.7 ± 0.7	NS	1.0 ± 0.8	NS
Asthenia	0.1 ± 0.1	0.1 ± 0.1	NS	0.1 ± 0.1	NS	0.1 ± 0.1	NS
Strain	1.1 ± 0.7	0.8 ± 0.8	NS	0.6 ± 0.8	NS	0.6 ± 0.8	NS
Acoustic measures							
F0 (Hz)	140.5 ± 55.7	165.8 ± 39.2	NS	155.9 ± 29.0	NS	163.5 ± 40.4	.023
STD (Hz)	5.0 ± 4.5	4.0 ± 1.9	NS	3.8 ± 2.3	NS	5.2 ± 6.1	NS
Jitter (%)	3.3 ± 2.7	2.7 ± 1.8	NS	1.9 ± 1.2	NS	2.9 ± 4.7	NS
Shimmer (%)	8.2 ± 5.4	6.1 ± 2.7	NS	5.4 ± 2.2	NS	5.9 ± 4.8	NS
NHR	0.2 ± 0.1	0.2 ± 0.1	NS	0.1 ± 0.1	NS	0.2 ± 0.2	.034
Maximum phonation time	14.8 ± 4.4	10.1 ± 6.7	.044	11.5 ± 6.7	NS	11.2 ± 6.0	NS
Fluency	144.3 ± 23.1	139.7 ± 21.3	NS	149.1 ± 14.9	NS	148.7 ± 20.1	NS

The voice quality outcome changes were evaluated from baseline to 3-, 6-, and 12-month post-TLC with Wilcoxon rank test.
Abbreviations: F0, fundamental frequency; mo, month; NHR, noise-to-harmonic ratio; NS, non-significant; SD, standard deviation; STD, F0 standard deviation; VHI, voice handicap index.

Associations and Predicting Outcomes

The age was a predictor of the 12-month post-TLC VHI ($r_s = -0.412$; $P = .005$), the percent shimmer ($r_s = 0.315$, $P = .033$), the NHR ($r_s = 0.378$, $P = .010$), and the roughness ($r_s = 0.380$; $P = .009$). Among identified VQ outcomes, the baseline VHI was a predictor of the 3-month VHI ($r_s = 0.319$; $P = .008$) and 12-month VHI ($r_s = 0.279$; $P = .025$). At 12-month post-TLC, the grade of dysphonia was associated with percent shimmer ($r_s = 0.518$; $P = .001$); percent jitter ($r_s = 0.473$; $P = .001$); NHR ($r_s = 0.515$; $P = .001$), MPT ($r_s = -0.381$; $P = .001$), and fluency ($r_s = 0.372$; $P = .001$). The percent jitter was significantly associated with the breathiness ($r_s = 0.420$, $P = 0.001$), strain ($r_s = 0.371$; $P = 0.002$), and the MPT ($r_s = -0.291$; $P = .015$).

Discussion

The treatment recommendations for glottic carcinoma with an involvement of the anterior commissure remain controversial, with a debate focusing on the negative impact of anterior commissure resection on the post-operative VQ.[15] Because the postoperative VQ is a

Table 6. Voice Quality Changes in Type VI Cordectomy Patients

Voice quality outcomes	Baseline	3 mo	*P* value	6 mo	*P* value	12 mo	*P* value
VHI	37.9 ± 20.1	36.6 ± 25.4	NS	26.7 ± 19.8	NS	31.4 ± 124.8	NS
GRBAS							
Grade of dysphonia	2.4 ± 0.7	2.2 ± 0.6	NS	1.2 ± 0.8	.034	1.9 ± 0.9	.020
Roughness	1.3 ± 0.8	1.1 ± 0.9	NS	1.3 ± 0.7	NS	1.1 ± 0.7	NS
Breathiness	1.9 ± 0.9	1.8 ± 0.9	NS	1.6 ± 0.7	NS	1.7 ± 0.9	NS
Asthenia	0.1 ± 0.1	0.1 ± 0.1	NS	0.1 ± 0.1	NS	0.1 ± 0.1	NS
Strain	1.6 ± 0.8	1.3 ± 0.8	NS	0.6 ± 0.7	.029	1.3 ± 1.0	NS
Acoustic measures							
F0 (Hz)	158.8 ± 37.1	165.5 ± 33.3	NS	169.0 ± 40.7	NS	180.1 ± 46.1	NS
STD (Hz)	12.5 ± 15.9	5.3 ± 1.6	NS	3.8 ± 1.4	NS	4.5 ± 3.3	NS
Jitter (%)	4.3 ± 5.2	4.5 ± 3.8	NS	4.1 ± 2.9	NS	4.0 ± 2.8	NS
Shimmer (%)	9.4 ± 6.4	9.6 ± 6.7	NS	7.7 ± 5.1	NS	7.6 ± 4.0	NS
NHR	0.3 ± 0.3	0.3 ± 0.2	NS	0.3 ± 0.2	NS	0.3 ± 0.2	NS
Maximum phonation time	11.1 ± 5.7	9.9 ± 4.1	NS	10.3 ± 3.2	NS	8.3 ± 4.6	NS
Fluency	125.2 ± 28.2	136.5 ± 21.9	NS	138.3 ± 28.6	NS	135.1 ± 24.6	NS

The voice quality outcome changes were evaluated from baseline to 3-, 6-, and 12-month post-TLC with Wilcoxon rank test.
Abbreviations: F0, fundamental frequency; mo, month; NHR, noise-to-harmonic ratio; NS, non-significant; SD, standard deviation; STD, F0 standard deviation; VHI, voice handicap index.

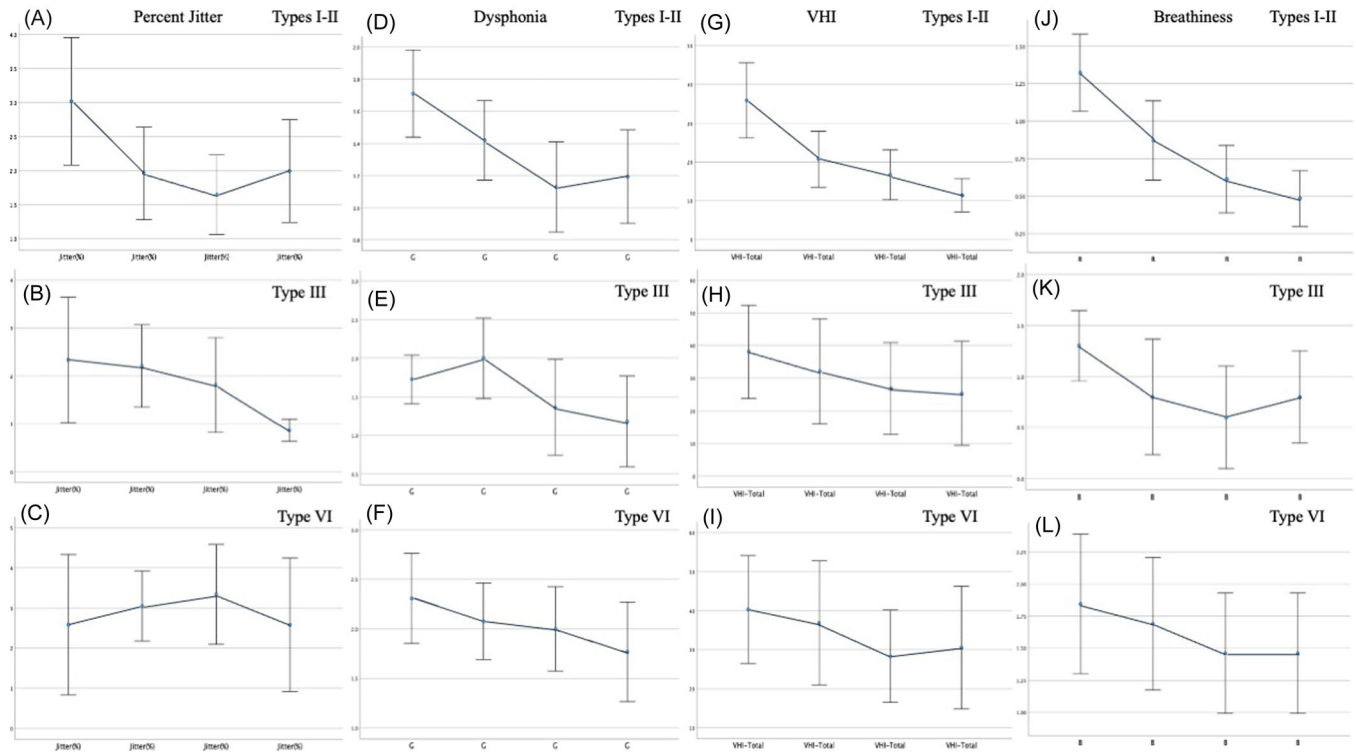

Figure 1. Summary of key voice quality parameter changes in types I-II, III, and VI cordectomies. VHI, voice handicap index.

primary outcome for patients who must choose between radiation and surgery, identifying the VQ evolution pattern throughout the postoperative follow-up is important for providing adequate information to patients. For practitioners, studying the post-TLC VQ evolution allows documenting and selecting the VQ parameters that highlight the changes over time.

In this study, we observed that patients who underwent segmental cordectomies (types I-II) reported better postoperative VQ outcomes compared to anterior commissure TLC. The VQ improvement is slower in types III and VI. In the type III group, patients reported partial improvements of acoustic and perceptual VQ at 12 months post-TLC, which was not

Table 7. Group Comparison of Voice Quality Throughout Follow-Up

Voice quality outcomes	3-month					6-month					12-month				
	Type I	Type II	Type III	Type VI	*P* value	Type I	Type II	Type III	Type VI	*P* value	Type I	Type II	Type III	Type VI	*P* value
VHI	16.8 ± 16.3	18.0 ± 19.0	33.9 ± 23.1	36.6 ± 25.4	.011	14.3 ± 15.9	17.9 ± 18.1	31.6 ± 22.4	26.7 ± 19.8	NS	13.3 ± 11.0	10.9 ± 12.9	27.3 ± 20.7	31.4 ± 124.8	.003
GRBAS															
Grade of dysphonia	1.4 ± 0.7	1.4 ± 0.6	2.1 ± 0.7	2.2 ± 0.6	.001	1.1 ± 0.8	1.2 ± 0.8	1.3 ± 0.9	1.2 ± 0.8	.024	1.1 ± 0.9	1.2 ± 0.8	1.3 ± 0.9	1.9 ± 0.9	NS
Roughness	1.2 ± 0.8	1.5 ± 0.7	1.4 ± 0.9	1.1 ± 0.9	NS	1.2 ± 0.8	1.3 ± 0.7	1.2 ± 0.9	1.3 ± 0.7	NS	1.1 ± 0.9	1.2 ± 0.8	1.0 ± 0.8	1.1 ± 0.7	NS
Breathiness	0.9 ± 0.8	0.8 ± 0.7	1.3 ± 0.9	1.8 ± 0.9	.004	0.7 ± 0.7	0.6 ± 0.7	0.7 ± 0.7	1.6 ± 0.7	.014	0.6 ± 0.5	0.5 ± 0.6	1.0 ± 0.8	1.7 ± 0.9	.001
Asthenia	0.1 ± 0.2	0.2 ± 0.5	0.1 ± 0.1	0.1 ± 0.1	NS	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	NS	0.1 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	NS
Strain	0.6 ± 0.7	0.7 ± 0.8	0.8 ± 0.8	1.3 ± 0.8	NS	0.6 ± 0.8	0.6 ± 0.7	0.6 ± 0.8	0.6 ± 0.7	NS	0.6 ± 0.8	0.5 ± 0.5	0.6 ± 0.8	1.3 ± 1.0	NS
Acoustic measures															
F0 (Hz)	158.3 ± 46.2	152.6 ± 33.5	165.8 ± 39.2	165.5 ± 33.3	NS	149.1 ± 35.3	144.0 ± 47.1	155.9 ± 29.0	169.0 ± 40.7	.046	154.2 ± 42.6	148.4 ± 43.0	163.5 ± 40.4	180.1 ± 46.1	.042
STD (Hz)	5.3 ± 10.0	5.8 ± 6.4	4.0 ± 1.9	5.3 ± 1.6	NS	3.3 ± 2.4	4.6 ± 4.2	3.8 ± 2.3	3.8 ± 1.4	NS	8.5 ± 19.5	5.2 ± 7.5	5.2 ± 6.1	4.5 ± 3.3	NS
Jitter (%)	1.8 ± 1.4	2.1 ± 1.8	2.7 ± 1.8	4.5 ± 3.8	.001	1.5 ± 1.2	1.9 ± 1.8	1.9 ± 1.2	4.1 ± 2.9	.005	1.5 ± 1.3	2.2 ± 2.2	2.9 ± 4.7	4.0 ± 2.8	.029
Shimmer (%)	5.5 ± 2.3	6.0 ± 5.6	6.1 ± 2.7	9.6 ± 6.7	NS	5.5 ± 2.8	6.4 ± 5.2	5.4 ± 2.2	7.7 ± 5.1	NS	5.9 ± 3.7	7.3 ± 7.2	5.9 ± 4.8	7.6 ± 4.0	NS
NHR	0.1 ± 0.1	0.2 ± 0.2	0.2 ± 0.1	0.3 ± 0.2	NS	0.1 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	0.3 ± 0.2	NS	0.1 ± 0.1	0.2 ± 0.1	0.2 ± 0.2	0.3 ± 0.2	NS
Maximum phonation time	11.9 ± 5.2	13.1 ± 8.6	10.1 ± 6.7	9.9 ± 4.1	NS	11.7 ± 5.7	13.0 ± 4.7	11.5 ± 6.7	10.3 ± 3.2	NS	12.7 ± 5.7	12.1 ± 4.9	11.2 ± 6.0	8.3 ± 4.6	NS
Fluency	140.9 ± 24.2	152.0 ± 14.3	139.7 ± 21.3	136.5 ± 21.9	NS	143.6 ± 18.9	151.3 ± 16.8	149.1 ± 14.9	138.3 ± 28.6	NS	147.0 ± 21.2	154.0 ± 15.1	148.7 ± 20.1	135.1 ± 24.6	NS

The comparison of voice quality outcomes at 3-, 6-, and 12-month post-TLC was performed with Kruskal-Wallis test.
Abbreviations: F0, fundamental frequency; mo, month; NHR, noise-to-harmonic ratio; NS, non-significant; SD, standard deviation; STD, F0 standard deviation; VHI, voice handicap index.

observed for type VI TLC where the grade of dysphonia was the only improved outcome.

The negative impact of the resection of the anterior commissure on postoperative voice recovery was supported by Mendelsohn et al who reported moderate post-TLC values of VHI (36.9), abnormal MPT (mean of 7.4 s), and moderate-to-severe grade of dysphonia (2.1) in a single cohort of patients.[15] The post-TLC values of VHI, MPT, and grade of dysphonia found in the present study corroborate those of the study by Mendelsohn et al[15] and were commonly worse than those of segmental cordectomies.[16,17]

In 2015, Lee et al investigated the pre- to post-TLC VQ outcomes of 57 patients who underwent types I to VI cordectomies.[18] Interestingly, the authors reported that patients with an anterior commissure or bilateral vocal cord resection showed a tendency toward deterioration in VQ at 6 months post-TLC according to the grade of dysphonia and roughness which was not observed for the marginal cordectomy. The differences between the postoperative VQ evolution of the anterior commissure and the marginal cordectomy groups corroborate our results. However, our analysis did not support a deterioration of VQ in the anterior commissure group, but a slow improvement, which can be observed only after 6 months of follow-up. The mismatch between both observations can be primarily attributed to the lack of postoperative voice therapy rehabilitation follow-up, and the consideration of patients with bilateral cordectomy and anterior commissure cordectomy within the same group by the authors.[18]

In the same vein, Roh et al have compared the postoperative perceptual VQ and VHI of patients who underwent types I to II TLC with those who underwent extended (types III-V) or anterior commissure cordectomy (type VI).[19] The authors observed worsened VHI values in types II to VI TLC groups compared to type I, while the grade of dysphonia only improved a year after the surgery in segmental cordectomy groups. Similarly to Lee et al, Roh et al pooled in the same group patients with bilateral cordectomy with those who underwent anterior commissure cordectomy. Moreover, they included patients with anterior glottic web or stenosis in their analyses, which can also limit the comparison between our and their findings. However, according to these 2 studies[18,19] and ours, we can support that patients who underwent an anterior commissure resection for cT1 carcinoma report a slowly pre- to post-TLC evolution of VQ, and represents a specific group. Perceptual VQ (grade of dysphonia and breathiness) can be used for the follow-up of patients and appears to be associated with acoustic parameters according to our correlation study.

The worsened VQ outcomes of this group of patients can lead to improve the postoperative strategies for voice rehabilitation. The recommendation of a well-conducted voice therapy rehabilitation protocol is mandatory and

could be associated with better improvement of VQ.[20] The poorer postoperative VQ outcomes in type VI patients can be attributed to a larger glottic gap, bilateral loss of mucosal wave in a significant part of the anterior third of the vocal fold, and the related scarring. These anatomical changes lead to a more reduced volume, compliance, and ineffective biomechanical properties of the remaining tissue that participates to the vibratory process in type VI patients compared to types I to III. However, note that some of these changes can be similarly highlighted in segmental cordectomies where patients did not improve their aerodynamic parameters over time (MPT).[15,19] The use of strategies of rehabilitation can be particularly important in aging patients who may present worsened acoustic measurements in our analysis, which supports previous results.[21] Regarding the potential impact of TLC for tumors of the anterior commissure on VQ, future studies can moreover compare the VQ of type VI TLC with the VQ of radiation.

The primary strengths of the present study are its originality and the prospective collection of VQ outcomes from pre- to post-TLC. To the best of our knowledge, there is no similar study comparing segmental and true anterior commissure TLC in the literature. Indeed, previous studies pooled bilateral and anterior commissure in the same group, which can be biased because they are characterized by significant postoperative anatomical and physiological differences.[18,19] Given the rarity of carcinoma located in the anterior commissure, the number of patients in our type VI group is low (N = 20), which is the primary limitation of the study. There was a significantly higher number of cT1 in type VI group compared to others, which can be an additional limitation. There was no statistical power calculation in the present study. Concerning the numbers of patients in other groups, they are comparable or higher than numbers of subjects found in other publications,[18,19,22,23] making the current study one of the largest focusing on types I, II, III, and VI TLCs. The lack of consideration of gender differences is an additional limitation of the study. Gender is an important factor to consider in the analysis of VQ evaluations regarding the gender-related vocal fold anatomical and histological differences,[24] and the influence of gender on the postoperative inflammatory and healing processes.[25]

Conclusion

The pre- to 12-month post-TLC evolution of VQ is better in types I to II TLC compared to types III and VI. Type VI TLC reported the worse VQ at baseline and throughout the follow-up.

Author Contributions

Jerome R. Lechien, design, acquisition of data, drafting, final approval, and accountability for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Stephane Hans**, data analysis & interpretation, and proofread of the paper, final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Robin Baudouin**, design, acquisition of data, drafting, final approval, and accountability for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Marc Remacle**, design, acquisition of data, drafting, final approval, and accountability for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Lise Crevier-Buchman**, design, acquisition of data, drafting, final approval, and accountability for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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