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Long-Term Evaluation After Supracricoid Partial Laryngectomy

Suprakrikoid Parsiyel Larenjektomi Sonrası Geç Dönemin Değerlendirilmesi

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ABSTRACT Objective: Supracricoid partial laryngectomy is one of the partial laryngectomy procedures designed to maintain adequate functionality. We intend to determine the effects of voice, respiration functions that effect life quality in the long term, and how much they differ based on the chosen surgical procedure after supracricoid partial laryngectomy. **Material and Methods:** We assessed 26 patients with supracricoid partial laryngectomy (SCPL) with cricohyoidopexy, 9 patients with SCPL cricohyoidoepiglottopexy and 10 healthy individuals within our research. All of the patients were evaluated with acoustic and perceptual voice analysis, aspiration, dysphagia, voice handicap index, laryngostroboscopy one year after supracricoid partial laryngectomy with cricohyoidopexy or cricohyoidoepiglottopexy. **Results:** Thirty-five patients (34 male, 1 female) were included in the study group to determine the postoperative, long term functional effects of SCPL. We found that, even though patients suffered from disabilities related with voice, findings in fuctional results in supracricoid partial laryngectomy patients were favorable. **Conclusion:** As a conclusion, SCPL could be performed in chosen cases of advanced laryngeal malignancies as an alternative surgical method, preserving swallowing, speaking and swallowing functions, providing acceptable functional results as expressed by patients. When SCPL patients were evaluated postoperatively in the long-term, using acoustic voice analysis, laryngostroboscopic examination and voice handicap index, even though they suffered from voice weaknesses, functional results were generally found to be acceptable.

Keywords: Laryngectomy; partial; voice; swallowing; hoarseness

ÖZET Amaç: Suprakrikoid parsiyel larenjektomi, yeterli fonksiyonların devamını sağlayan parsiyel larenjektomi tekniklerinden biridir. Suprakrikoid parsiyel larenjektomi sonrası, hastaların geç dönemde yaşam kalitesini etkileyen ses, solunum fonksiyonlarının, uygulanan cerrahi tekniğe göre ne ölçüde değiştiğini ortaya çıkarmayı amaçladık. **Gereç ve Yöntemler:** Değerlendirmeye suprakrikoid parsiyel larenjektomi krikohyoidopeksili 26, suprakrikoid parsiyel larenjektomi krikohyoidoepiglottopeksili 9 olgu ile birlikte, kontrol grubu olarak 10 kişi alınmıştır. Çalışmada Suprakrikoid parsiyel larenjektomi-krikohyoidopeksi ve suprakrikoid parsiyel larenjektomi-krikohyoidoepiglottopeksi yapılan olgularda en az 1 yıl sonra, akustik ve algısal ses analizi, aspirasyon, yutma güçlüğü, ses handikap indeksi, larengostroboskopik farklılıkları değerlendirildi. **Bulgular:** Suprakrikoid parsiyel larenjektomi (SCPL) operasyonu uygulanan hastaların postoperatif geç dönem fonksiyonel sonuçlarının incelendiği bu araştırmanın çalışma grubunda 35 kişi (34 erkek, 1 kadın) yer almaktadır. Suprakrikoid parsiyel larenjektomi yapılan olguların geç dönemde ses ile ilgili yetersizlikleri olmasına karşın, genel olarak olumlu fonksiyonel sonuçlar alınmıştır. **Sonuç:** SCPL, seçilmiş ileri evre laringeal malignitelerde konuşma ve yutma fonksiyonlarını koruyan, hastaların kabul edilebilir fonksiyonel sonuçlarıyla da desteklenen alternatif bir cerrahi yöntem olarak kullanılabilir. SCPL hastaları akustik ses analizi, laringostroboskopik muayene ve ses handikap indeksi ile postoperatif olarak uzun dönemli değerlendirildiğinde ses zayıflığı olmasına karşın fonksiyonel sonuçlar genel olarak kabul edilebilir düzeydedir.

Anahtar Kelimeler: Larenjektomi; parsiyel; ses; yutma; ses kısıklığı

Supracricoid partial laryngectomy (SCPL) is an effective conservation surgery which could be performed in cases of advanced laryngeal malignancy. In this procedure, there are two different reconstruction

methods (cricohyoidopexy=CHP, cricohyoidoepiglottopexy= CHEP) based on whether the epiglottis is preserved or not.[1,2] Voice always gets modified after SCPL operation. The degree of dysphonia could significantly vary between different patients.[3,4]

This study plans to evaluate the extent of changes in functions that affect quality of life such as voice, breathing, based on the performed surgery.

MATERIAL AND METHODS

This study was performed in our University Faculty of Medicine, Department of Otolaryngology. The study population included 35 patients treated with SCPL. Ten people without any complaints related with their voice, who showed no signs of abnormalities with indirect larynx examination, were included to study as control subjects. The study was approved by the ethics committee of the institution (Protocol number: TUTFEK-2006/205). Written informed consent was obtained from each patient. During the evaluation period of the SCPL patients, who spent more than a year in postoperative period (classified as long term evaluation) and control subjects we used videolaryngostroboscopic examination, pulmonary function tests and objective evaluation of voice. In addition, we used subjective evaluation of voice (personally by patient and clinician) and voice handicap index (VHI) in the study group.

FOLLOWING EXAMINATIONS WERE PERFORMED DURING FUNCTIONAL EVALUATION

1. Seventy degrees rigid endoscopy (Karl Storz, Germany) was used during videolaryngostroboscopic examination. Laryngostroboscopic images were classified based on glottic closure defects as longitudinal, dorsal, ventral, irregular, oval and watch cyrstal type. Deformities in mucosal wave motion were evaluated in terms of irregularities, mucosal wave disorders and asymmetries, then each was scored (1=mild, 2=moderate, 3=severe). All videolaryngostroboscopic examinations were performed by the same person and then recorded on a digital database.

2. Pulmonary function tests were performed in Department of Chest Diseases.

3. For subjective voice evaluation performed by patients, subjects were asked to score their voices between 0 and 5 (0= no voice, 1=very bad, 2=bad, 3=acceptable, 4=good, 5=very good). For subjective voice evaluation performed by the clinicians, GRBAS Scale (Grade, Roughness, Breathiness, Asthenicity, Strain) was used.[5]

4. During subjective voice evaluation, study performers interrogated the patients with questions of VHI translated to Turkish.[6] Every subject fulfilled the VHI survey. VHI is an assessment tool including a total of 30 questions, designed to evaluate emotional, physical and functional effects of voice disorders. VHI scoring system for every question ranges between 0 and 4; as 0 counts for never, and 4 counts for always. Minimum total score for a patient can be 0, and maximum score can be 120. Higher score indicates the severity of a voice problem.

5. During objective voice evaluation; All recordings were performed using a Computerized Speech Lab Model 4500 voice analyzing device (Kay Elemetrics Corporation), Multi-dimensional Voice Program (MDVP) Model 5105 software and a Micromic Phantom MPA III C 420 PP (Austria) microphone positioned 10 cm from the mouth with an angle 45° laterally. Acoustic analyses were performed using the MDVP software, with the attempt to prolong vowel 'a' for 10 seconds. Fundamental frequency (F_0), shimmer %, jitter %, noise to harmonics ratio (NHR), fundamental frequency variation (vF_0), amplitude perturbation quotient (APQ), soft phonation index (SPI) parameters were evaluated within the objective analysis. Maximum phonation time (MPT) was measured using a chronometer during the attempt to prolong vowel 'a' after a deep insprium. Phonation quotient was calculated as the percentage of MPT to functional vital capacity. The study group was also analyzed and compared according to each other type of reconstruction technique (SCPL with CHP versus SCPL with CHEP).

Kolmogorov Smirnov and Shapiro Wilk tests were used to check for normality distribution, since measurable data showed non-normal distribution, Kruskal-Wallis variant analysis and Mann Whitney U test were used for comparisons between groups. Pearson χ^2 test and Kolmogorov Smirnov two samples test were used to evaluate qualitative data. Data were given as median value (minimum-maximum) and mean values ± SD for descriptive analyses. P values <0.05 were considered to indicate statistical significance and after Bonferroni correction, p values<0.008 were considered as statistically significant.

RESULTS

Thirty-five patients (34 male, 1 female) were included in the study group to determine the postoperative, long term functional effects of SCPL. 1). TNM classification of 35 patients; T1N0= 9 cases, T2N0=21 cases, T2N1=1 case, T3N0=3 cases, T3N1=1 case. Twenty-six patients underwent SCPL-CHP and 9 patients underwent SCPL-CHEP operation. 2). In 6 of CHP cases arithenoids were removed bilaterally, in 26 of CHP cases unilaterally the arithenoid that was in at the tumor side were resected. 4) In 8 of 35 cases neck dissection was not performed. In 10 of 35 cases unilateral functional neck dissection, in 4 of 35 cases bilateral functional dissection, in 11 of 35 cases unilaterally radical neck dissection, in 2 of 35 cases unilateral functional and contralateral radical neck dissection were performed. 3) Post-surgical radiotherapy was not administered to any of the patients. The age of 26 patients who underwent SCPL-CHP varied between 45-76 and the median age was 53.5 years. The age of 9 patients who underwent SCPL-CHEP varied between 47-64 and the median age was 54 years. Ten people (9 male, 1 female) were in the control group and their ages were between 54-75 and their median age was 60.9.

When study and control groups were compared regarding the statistical analysis of acoustic voice parameters, both SCPL-CHP and SCPL-CHEP groups showed a significant loss in MPT when compared to control subjects (p=0.001), while the difference between SCPL-CHP and SCPL-CHEP groups was not statistically significant (p=0.382). Phonation quotient was significantly higher in both SCPL-CHP and SCPL-CHEP groups (p<0.001), when compared to control subjects, while the difference between SCPL-CHP and SCPL-CHEP groups was not statistically significant (p=0.128) (Table 1).

The mean F_0 parameter showed no statistical significance between study subgroups and control group (p=0.294). The acoustic voice parameters such as Jitter percentage, vF_0, shimmer percentage, APQ, NHR showed higher results in study groups when compared to control group, meanwhile SPI was lower in study groups, the differences between study groups and control group were statistically significant (p<0.001) (Table 2). The difference between SCPL-CHP and SCPL-CHEP subgroups was not statistically significant (p=0.486).

TABLE 1: Mean values of acoustic analysis parameters in study and control groups.

		Study Group	
Parameters	**Control Group Mean±SD**	**SCPL-CHP Mean±SD**	**SCPL-CHEP Mean±SD**
	Median Value (min-max)	**Median Value (min-max)**	**Median Value (min-max)**
MPT	16.4±5.3*	5.8±2.9	5.1±2.0
	15.5 (10-26)	5 (3-18)	4 (3-9)
Phonation quotient (ml/sec)	218.3±73.8*	574.9±237.5	748.2±270.1
	200.79 (113.46-335.45)	554.14 (153.88-1233.3)	812.50 (297.77-1040)

Kruskal Wallis Variant Analysis and Mann Whitney U test

*: Statistically significant difference when SCPL-CHP or SCPL-CHEP was compared to control group. SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy. SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy

MPT: Maximum phonation time.

TABLE 2: Mean values of acoustic analysis parameters control and study subjects, performed with phonation of wovel 'a'.

		Study Group	
Acoustic Voice Parameters	**Control Group Mean±SD Median Value (min-max)**	**SCPL-CHP Mean±SD Median Value (min-max)**	**SCPL-CHEP Mean±SD Median Value (min-max)**
F0 (Hz)**	140.6±34	158.8±71.5	123.3±28.6
	135.14 (94.63-193.03)	138.07 (76.52-393.57)	120.61 (89.90-180.39)
Jitter (%)	2.1±1.8*	12.1±8.5	13.3±7.4
	1.53 (0.52-6.63)	9.28 (2.09-37.45)	11.63 (4.90-24.14)
vF0 (Hz)	3.7±3.6*	14.6±6.3	22.4±9
	2.41 (0.98-13.47)	14.99 (1.95-26.50)	19.63 (13.02-35.38)
Shimmer (%)	5±5*	17.7±9	20.6±5.9
	2.97 (1.40-17.58)	16.77 (5.15-52.38)	21.31 (12.08-29.68)
APQ (%)	3.5±2.9*	12.7±5.3	15.7±4.3
	2.48 (1.34-10.90)	12.07 (3.95-28.12)	16.10 (9.01-21.57)
NHR (dB)	0.2±0.1*	0.5±0.3	0.6±0.2
	0.12 (0.10-0.58)	0.49 (0.16-2.17)	0.62 (0.31-0.90)
SPI	24.6±11.3*	7.3±5	8.2±6.7
	26.81 (1.85-38.74)	5.37 (2.01-20.70)	5.61 (1.85-20.37)

Kruskal Wallis Variant Analysis and Mann Whitney U test

*: Statistically significant difference when SCPL-CHP or SCPL-CHEP was compared to control group; **: 1 female patient with SCPL-CHP showed a value of F0a:201,88.

F_0: Fundemental frequency; vF0: Fundemental frequency variation; APQ:Amplitude perturbation quotient; NHR:Noise to harmonics ratio; SPI: Soft phonation index. SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy. SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy.

When two study subgroups were compared with each other, mean VHI scores of total voice handicap index parameters (Table 3) showed no statistically significant difference (p>0.05). Perceptual voice analysis was performed in study subgroups, of which their results can be seen as numeric data in Table 4. GRBAS scale analysis was performed in study subgroups, and their results can be seen as numeric data in Table 5.

Glottic occlusion defects were classified as longitudinal, dorsal, ventral, irregular, oval and watch cyrstal type in study group, and their results can be seen as numeric data in Table 6. Irregular glottic occlusion defects were seen in 88.5% of patients who underwent SCPL-CHP and in 88.9 of patients who underwent SCPL-CHEP. The difference between SCPL-CHP and SCPL-CHEP subgroups was not statistically significant (p>0.05). Deformities in mucosal wave motion, in terms of irregularities, mucosal wave disorders and asymmetries were evaluated in study groups and their results can be seen as numeric data in Table 7. Results of objective voice analysis of control subjects can be seen in Table 8.

TABLE 3: Mean values of voice handicap index parameters in study group.

	Study Group	
Parameters	**SCPL-CHP Mean±SD Median (min-max)**	**SCPL-CHEP Mean±SD Median (min-max)**
Functional	14±9.7	16.2±11
	11.50 (1-38)	13 (0-39)
Physical	14.4±7.9	15±7.3
	12.50 (4-31)	15 (0-28)
Emotional	11.3±9.8	13.1±9.2
	10.50 (0-40)	14 (0-33)
Total	39.8±26	44.3±26.1
	35 (9-107)	43 (0-100)

SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy; SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy.

DISCUSSION

In this study, we evaluated patients after supracricoid partial laryngectomy and reconstruc-

TABLE 4: Self performed perceptual voice analysis.

	Study Group	
	SCPL-CHP	SCPL-CHEP
Voice	N (%)	N (%)
None	0	0
Very bad	0	0
Bad	4 (15,4)	3 (33,3)
Enough	15 (57,7)	5 (55,6)
Good	6 (23,1)	1 (11,1)
Very good	1 (3,8)	0

SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy; SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy.

TABLE 5: GRBAS scale evaluation (GRBAS: G(Grade): general voice quality, R(Roughness): voice with low frequency, rough structure or vocal fry B(Breathness): voice with audible air souds, A(Asthenicity): auditory impression of weakness S(Strain): auditory impression of excessive effort).

		Study Group	
		SCPL-CHP	SCPL-CHEP
GRBAS scale		N (%)	N (%)
Grade	Normal	0	0
	Slight	2 (7.7)	0
	Moderate	11 (42.3)	5 (55.6)
	Severe	13 (50)	4 (44.4)
Roughness	Normal	0	0
	Slight	3 (11.5)	2 (22.2)
	Moderate	9 (34.6)	5 (55.6)
	Severe	14 (53.8)	2 (22.2)
Breathness	Normal	7 (26.9)	0
	Slight	11 (42.3)	4 (44.4)
	Moderate	5 (19.2)	3 (33.3)
	Severe	3 (11.5)	2 (22.2)
Astenicity	Normal	1 (3.8)	1 (11.1)
	Slight	13 (50)	3 (33.3)
	Moderate	7 (26.9)	2 (22.2)
	Severe	5 (19.2)	3 (33.3)
Strain	Normal	0	0
	Slight	7 (26.9)	4 (44.4)
	Moderate	7 (26.9)	4 (44.4)
	Severe	12 (46.2)	1 (11.1)

SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy; SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy.

tion with either CHP or CHEP in order to determine the extent of changes in vocal function and life quality based on the selected surgical modality, and to compare the parameters of acoustic analyses of these patients with a control group of healthy individuals.

To determine the changes in voice quality, we performed acoustic and perceptual voice analyses which are commonly used in recent years. Acoustic analyses provide objective and numeric data, which allow us to perform further statistical evaluation.[7] Even though, perceptual analyses mostly performed with GRBAS scale provides subjective information, they can also be effectively used in various studies.[8-10]

Maximum phonation time, mean F_0, perturbation measurements (jitter, shimmer), NHR are some parameters that are widely used in acoustic voice analyses. The most important requirement to perform an accurate voice analysis is to receive voice correctly and record it in a standardized fashion.[9]

We performed acoustic analyses using the phonation of vowel 'a', in order to evaluate perceptual and acoustic features of the voice. Phona-

TABLE 6: Evaluation of glottic occlusion defects.

		Study Group	
		SCPL-CHP	SCPL-CHEP
		N (%)	N (%)
Longitudinal	Mild	4 (15.4)	3 (33.3)
	Moderate	2 (7.7)	2 (22.2)
	Severe	2 (7.7)	0
Dorsal	Mild	0	1 (11.1)
	Moderate	0	0
	Severe	0	0
Ventral	Mild	6 (23.1)	2 (22.2)
	Moderate	7 (3.8)	2 (22.2)
	Severe	1 (26.9)	1 (11.1)
Irregular	Mild	8 (30.8)	0
	Moderate	5 (19.2)	5 (55.6)
	Severe	10 (38.5)	3 (33.3)
Oval	Mild	0	0
	Moderate	1 (3.8)	0
	Severe	0	0
Hourglass	Mild	0	0
	Moderate	0	0
	Severe	0	0

SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy; SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy.

TABLE 7: Evaluation of mucosal wave motion disorders.

		Study Group	
		SCPL-CHP	SCPL-CHEP
		N (%)	N (%)
Irregularity	Mild	4 (15.4)	0
	Moderate	7 (26.9)	6 (66.7)
	Severe	15 (57.7)	3 (33.3)
Mucosal Wave Disorder	Mild	1 (3.8)	1 (11.1)
	Moderate	18 (69.2)	6 (66.7)
	Severe	7 (26.9)	2 (22.2)
Asymmetry	Mild	1 (4)	0
	Moderate	10 (40)	2 (22.2)
	Severe	13 (77.8)	7(77.8)

SCPL-CHP: Supracricoid partial laryngectomy-cricohyoidopexy; SCPL-CHEP: Supracricoid partial laryngectomy-cricohyoidoepiglottopexy.

tion of vowel 'a' is an optimal method to use for voice analyses, since it helps to determine disorders in glottal level, it minimizes the participation of vocal tract and structures at higher levels in phonation and it provides an easy and standardized voice production.[11]

Maximum phonation time is the most frequently and commonly used aerodynamic parameter. It is a simple and effective method to evaluate laryngeal function. Mean values of MPT are reported as 22-34 seconds in males and 16-25 in females.[12] In our study group, MPT was significantly lower in SCPL-CHP (3-18 seconds) and SCPL-CHEP (3-9 seconds) groups when compared to control subjects (10-26 seconds), meanwhile the difference between SCPL-CHP and SCPL-CHEP was not statistically significant. Loose and unstable occlusion of neoglottis after SCPL, causes substantial air loss during phonation since the closure is deficient (leads to shorter phonation time and higher phonation quotient).[13]

When laryngostroboscopic evaluation is compared with results of acoustic voice analysis, no direct correlation could be found between anatomic features and voice parameters such as F_0, jitter, shimmer and NHR. Researchers particularly stated that global measurements such as MPT are not affected by glottic closure. They concluded that MPT measurements concern the whole phonatary tract, thus cannot be directly correlated to a single anatomic laryngostroboscopic feature. They reported that glottic closure was correlated with epiglottic length and oral airflow, meanwhile they found it to be unrelated to supraglottic pressure.[14]

In a study performed by Crevier-Buchman et al., MPT was reported to be within normal levels in patients who underwent SCPL indicating that reconstructed neoglottis is efficient and adequate to produce sound.[15]

Phonation quotient defined as the percentage of MPT to functional vital capacity was significantly higher in both SCPL-CHP and SCPL-CHEP

TABLE 8: Objective voice analysis results of control subjects.

Case No	Age	Sex	MPT	FQ	F0	Jitter%	vF0	Shimmer%	APQ	NHR	SPI
1	75	M	14	205.71	98.815	1.041	25.934	2.846	2.642	0.128	36.03
2	59	M	10	292.0	190.457	1.131	4.733	2.529	2.354	0.12	26.77
3	55	M	17	174.11	142.009	42.064	3.229	6.375	4.176	0.157	33.503
4	64	M	19	189.47	165.552	0.78	0.98	1.395	1.343	0.108	20.692
5	54	M	11	335.45	144.016	0.528	4.663	1.503	1.445	0.118	14.663
6	60	M	17	195.88	128.287	1.256	1.188	9.538	14.032	0.14	16.54
7	65	M	26	113.46	121.72	1.804	45.689	3.581	2.533	0.13	30.832
8	60	F	24	125.83	193.032	2.428	2.343	46.419	1.629	0.103	26.857
9	62	M	14	263.57	94.633	6.638	13.472	17.589	10.898	0.582	31.048
10	55	M	12	288.33	127.715	3.165	17.564	3.101	2.439	0.144	38.744

MPT: Maximum phonation time, FQ: Phonation quotient, F0: Fundamental frequency, vF0: Fundamental frequency variation, APQ: Amplitude perturbation quotient, NHR: Noise to harmonics ratio, SPI: Soft phonation index.

groups, when compared to control subjects, meanwhile the difference between two study subgroups was not statistically significant. Decline of MPT, inspite of a constant vital capacity could be due to deterioration in phonation ability. The rise in phonation quotient supports this assumption.

The reason of this deterioration of phonation ability is likely due to the loss of vibratory functions rather than the loss of motor functions. Performed surgery modifies both vibratory segment and airway structure, but findings about these two parameters suggest that the change in vibratory segment plays a bigger role in voice alteration.

In our study, there was no statistically significant difference between study and control groups in F_0, a parameter of acoustic voice analysis. Fundamental frequency, refers to the number of glottic cycles in a second. Changes in F_0 means the change of rate in glottic cycle. The most effective method to do that, is to change the mechanical features of the vocal cords. Fundamental frequency could be raised by the help of cricothyroid muscle.

In a study performed by Crevier-Buchman et al., mean F_0 was reported to be lower in study group, when compared to healthy individuals.[15] This finding could be explained by the vibratory part of neoglottis being thicker after SCPL when compared to healthy individuals. Lower F_0 shown in these patients supports the theory that voice disorders could develop after SCPL operation.

Titze et al. highlighted the correlation between voice and pulmonary pressure, vocal cord length, tension of intrinsic muscles and passive stress of mucous membranes.[16] All these parameters except pulmonary pressure get modified after SCPL operation, thus explaining the decrease in F_0.[15]

In a study performed by Crevier-Buchman et al., it is reported that there was no statistically significant difference in mean F_0 or F_0 with standard deviation levels in same study group before SCPL surgery and 6 months postoperatively.[11] These findings are in terms with previous studies of the same researchers, which compared patients before SCPL-CHEP and 18 months postoperatively. Mean F_0 values were reported to be 150 Hz in patients and 124 Hz in healthy individuals. However, the difference between standard deviation of F_0 values was statistically significant in SCPL patients. SCPL-CHEP patients showed greater variation in F_0 range which is related with features of neolarynx, such as mass, length and tension. The fact that there was no statistically significant difference in standard deviation of F_0 levels in our study, could be related to the few number of our study group.

In a study performed by Bron et al., it is reported that voices of male patients who underwent SCPL operation were significantly lower, when compared to healthy male subjects (F_0 70,1 Hz).[12] A voice within this frequency is quite similar to the esophageal voice frequency after total laryngectomy with a mean F_0 of 65,6 Hz (range 44,9-85,8 Hz). By applying more power and pressure during neoglottic occlusion, most patients harden their neoglottis and achieve a better vibratory function. Functional outcomes are a tiresome voice structure and a speech style with short sentences. Most patients usually talk less because they become short of breath.

In a study performed by Yücetürk et al., mean F_0 value was reported to be 100 Hz in SCPL patients. This value is significantly lower when compared to control subjects (138.76 Hz).[17] Low F_0 values in SCPL patients are probably related to vibrating arytenoids and large mass of tongue base. According to most researchers and as in results of our current study, SCPL patients seem to have lower F_0 values, however there are also some reports supporting otherwise.

In a study performed by Horii et al., shimmer and jitter analyses are considered to be useful in evaluating vibratory function of neoglottis.[18] During supracricoid larygectomy procedures, wide resection is performed in paraglottic space and intrinsic larygeal musculature. Moreover, the vibrating portion of mucus membrane of remaining arytenoid cartilages lies on a muscular structure which loses its stretching and adaptation abilities after surgery. These anatomical features could explain the unstable vibrational pattern and increased shimmer and jitter values.[17]

In results of our study, when study and control groups were compared in terms of jitter percentage as an acoustic analysis parameter, variability levels were significantly higher in both study groups when compared to control subjects, meanwhile the difference between SCPL-CHP and SCPL-CHEP subgroups were not statistically significant.

When study and control groups were compared in our study using the phonation of vowel 'a' in terms of shimmer as an acoustic analysis parameter, variability levels were significantly higher in both study subgroups when compared to control subjects.

Consistent with literature, shimmer and jitter values were found to higher in control subjects. Perturbation measurements (jitter and shimmer) can be useful in evaluating the vibratory activity of neoglottis. Mucosal wave motion of neoglottis after SCPL has a rough structure which causes higher perturbation levels.[17]

When study and control groups were compared in terms of vF_0 as an acoustic analysis parameter, variability levels were shown to be higher in the study group. Fundamental frequency variation levels can increase independent of irregularities in vocal pitch.

Any random, regular short term or long term changes could increase vF_0 levels. During prolonged phonation, normative threshold values assume F_0 to be constant, therefore all changes in F_0 values effect vF_0 measurements.

When we compared study and control groups in terms of APQ as an acoustic voice parameter, variability levels were shown to be higher in the study group. Amplitude perturbation quotient refers to irregularities of peak amplitude in short term voice. Amplitude irregularities between two cycles could be related to vocal cords inability to sustain periodic vibration in some periods causing irregular noises in voice signal. Breathy and low voices usually have higher APQ values.

In comparison of study and control groups in terms of NHR as an acoustic voice parameter, variability levels were shown to be higher in the study group. Increased NHR levels indicate spectral voice caused by variability of amplitude or frequency (e.g. shimmer or jitter), irregular noises, sub-harmonic elements or cracking voices.

Looking to results of our study, when study and control groups were compared in terms of SPI as an acoustic voice parameter, variability levels were shown to be higher in the study group. Soft phonation index is used to describe how tight and complete vocal occlusion occurs. Increased SPI usually indicates vocal cord occlusion to be loose and incomplete during phonation.

Bron et at. demonstrated significant increase after surgery in jitter, shimmer, NHR values of acoustic voice analysis parameters.[12]

In a study performed by Zacharec et al., MPT reported to be halved after SCPL surgery, when compared to control subjects.[19] Every patient tries increasing their neoglottal durability and subglottal pressure in order to compensate the loss of air. They have to pay twice the effort when compared to healthy speakers. Thus every patient suffers from vocal exhaustion caused by this extra effort when speaking. Low frequency, high jitter and shimmer values, high NHR levels are some acoustic abnormalities which exist in these patients and they are related to mucosal vibrational pattern of an unstable structure of valve mechanism in reconstructed larynx without adaptive abilities.

In a study performed by Yücetürk et al., every acoustic parameter except voice intensity were found to be significantly different in post SCPL patients.[17] Fundemental frequency and NHR were reported to be lower, while jitter, jitter percentage and shimmer values were reported to be higher.

Characteristic acoustic features in patients with acoustic abnormalities such as low F_0 and high jitter, shimmer, NHR levels are related to slower, unstable and inadequate vibratory function of newly constructed neoglottis.[17]

One of the primary results in a study reported by Yücetürk et al. is the finding that number of preserved arythenoids were not correlated to voice and speech parameters.[17] This situation could be related to incomplete neoglottal occlusion after SCPL

operation regardless of the number of arytenoids preserved. Acoustic parameters were shown to be significantly different when compared to control subjects. As a result of the study, voice after SCPL was reported to be rough, breathy, unpleasant but acceptable. Quality and perception of the voice were reported to be adequate in terms of communication and social acceptance.

In our study, the total mean score of VHI of SCPL-CHP was 35 and the total mean score of VHI of SCPL-CHEP was 43. Thus, both groups presented moderate voice disorder, without significant difference between them. This result suggests that patients with SCPL have a voice quality enough to perform a normal conversation. In a study performed by Kandoğan et al., VHI scoring system was interpreted as '0-30: minimal voice disorder, 31-60: moderate voice disorder, 61-120: severe voice disorder'. Results of our study supports the same.[20]

In a study reported by Schindler et al. mean scores of VHI survey in SCPL patients were 29,9 +/- 22,8 (3-79), emotional scores 7,6 +/- 8,9 (2-32), physical scores 9,7 +/- 6,9 (3-21) and functional scores 12,2 +/- 9,4 (4-33).[13] Life quality is based on several different factors, including psychosocial, cultural and ethnical factor. Therefore it is not surprising to find different results in VHI scores at studies performed with small number of patients. Moreover voice is used more frequently in daily conversations leading faster exhaustion.

Subjective evaluation performed by patients of value for final results. Scores between 0 and 5 were used during self performed voice evaluation. According to most patients in our study group their voice was adequate to perform a conversation.

When SCPL-CHP and SCPL-CHEP were compared, some patients had worse acoustic parameters in SCPL-CHP group. These results also suggest that preserving epiglottis plays an important role during speech and swallowing. When their epiglottis got resected, patients had to use their tongue base to perform these functions.

Regarding speech and swallowing functions, dynamic tongue and tongue base are not as safe as epiglottis to perform a neoglottal function.[21]

GRBAS scale was used during subjective evaluation performed by the clinician. Patients who underwent SCPL generally had moderate and severe voice disorders. There was no patient without hoarseness and difficulty in phonation. Fifty-three point eight (53,8%) of SCPL-CHP and 55,6% of SCPL-CHEP patients reported to have moderate hoarseness in their voice. Only 7 of the SCPL-CHEP patients did not have breathy voice, the rest of the patients presented moderate air flow and breathiness. This result is related to an incomplete occlusion of larynx with deformed anatomy after SCPL-CHEP operation. Only 1 patient in each group did not have asthenicity. Generally patients who underwent SPCL presented a breathy, weak and hoarse voice with difficulties in phonation.

In a study performed by Dejonkere et al. with a study group of 943 patients from various European countries, GRBAS scale was reported to provide reliable and consistent results.[22] By the power of this information, Crevier-Buchman et al. performed another study to evaluate patients who underwent SCPL-CHEP operation, comparing them before and 6 months after surgery, and reported hoarseness to be the only parameter to worsen after operation.[11] These data are in terms with the study results performed by Rydel et al. who evaluated 36 T1a glottic carcinoma patients (18 laser cordectomy, 18 radiotherapy) and reported hoarseness to be the only perceptual voice parameter to worsen in patients who underwent surgical operation.[23] Hoarseness is related to irregular glottal motion so it is expected of this perceptual voice parameter to change after surgery in patients with glottic carcinoma.[11]

When mucosal wave motion was evaluated by laryngostroboscopy, patients with SCPL showed severe asymmetry and moderate mucosal wave disorders, but in terms of irregularities it was severe in 15 of 26 patients with SCPL-CHP, moderate in 6 of 9 patients with SCPL-CHEP.

In our study group voice and speech parameters were found to be consistent with stroboscopic evaluation. A previous study performed by Yuceturk et al. supports our results.[17]

Only one of the previous studies reviewing laryngostroboscopic evaluations, found out that patients with the best acoustic parameters (F_0, jitter, shimmer) showed the best symmetry and periodicity scores.[14]

Supracricoid partial laryngectomy is an effective conservational surgery as an alternative method to total laryngectomy to be performed in chosen cases of advanced stage laryngeal malignancies. In a study performed by Zacherek et al.[16] SCPL operation preserved vocal, speaking and swallowing functions, even though final outcomes were variable. Neoglottal incompatibility caused a loss of voice quality.

CONCLUSION

As a conclusion, SCPL could be performed in chosen cases of advanced laryngeal malignancies as alternative surgical method, preserving, speaking and swallowing functions, providing acceptable functional results as expressed by patients. When SCPL patients were evaluated in the long-term postoperatively, using acoustic voice analysis, laryngostroboscopic examination and voice handicap index, even though they suffered from voice weaknesses, functional results were generally found to be acceptable.

Compliance with Ethical Standards

Conflict of interest

All authors have no conflict of interest to declare.

Research involving Human Participants and/or Animals

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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