Assessment of the paraglottic space in supracricoid laryngectomy

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Background
Supracricoid laryngectomy (SCL) is largely affected by invasion of the tumor into the paraglottic space.
Aim of the work
The aim of this study was to histopathologically examine whether SCL provides adequate safety margins in terms of the paraglottic space or not.
Patients and methods
A prospective study was carried out on 20 patients with advanced cancer larynx staged as T2b, T3 and cases with failed radiotherapy where SCL was performed, followed by whole-organ transverse sections of the specimens to evaluate the relation of the tumor to the paraglottic space.
Results
The local success rate in this study was 90%; one case showed infiltrated surgical margins and the other showed local recurrence 6 months after the operation.
Conclusion
SCL allows for a safe enbloc resection of a malignant tumor in the larynx with complete resection of the paraglottic space. A safety margin of at least 4 mm is needed to eradicate the tumor as revealed by the whole-organ section technique.

Keywords:
paraglottic space, supracricoid laryngectomy, whole-organ section

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Introduction

Cancer larynx remains one of the most frequent head and neck cancers. It accounts for 1–2% of all malignancies worldwide and about 0.8% of all cancer deaths [1]. The therapeutic choices for the management of laryngeal malignancies are made according to the primary site of the tumor, stage of the tumor at the time seen, and feasibility of performing partial surgery or radiotherapy to preserve the functions of the larynx as far as possible [2].

Generally, early-stage laryngeal cancers (i.e. T1 and T2 lesions) are managed by a single choice, such as irradiation, endoscopic excision, or partial laryngeal surgery. Advanced lesions (i.e. T3 and T4 lesions) can be treated with a combination of chemoradiotherapy, whereas total laryngectomy remains the last choice for advanced stages of laryngeal cancers [3]. Total laryngectomy as a procedure to remove the larynx in cases with laryngeal carcinoma has been modified many times. In 1904, Professor Francesco Durante proposed and published a new technique for total laryngectomy where the respiratory tract was completely isolated from the digestive tract [4].

The conservation approaches such as vertical partial laryngectomy and radiotherapy have been advocated for the treatment of several stages of laryngeal carcinomas in an attempt to preserve the function of the larynx, while still achieving the same local control as traditional radical surgery. However, vertical partial laryngectomy has not always shown satisfactory oncologic results in more advanced cancers [3].

Infiltration of the paraglottic space is the main cause of failure in partial laryngeal surgeries [5]. The paraglottic space is a connective tissue compartment of the larynx and is important in the extension of laryngeal cancer. It communicates with the pre-epiglottic space superiorly and with the extralaryngeal region inferiorly through the gap within the cricothyroid membrane. Transglottic cancer of the larynx, which spreads within the paraglottic space, is characterized by a high incidence of laryngeal skeleton invasion and cervical metastasis. Determining the correct stage of transglottic cancer of the larynx is difficult, leading to therapeutic failure of partial laryngectomy in some cases [6].

The paraglottic space has been found to be penetrated by advanced tumors invading all the three levels of the larynx, transglottic tumors and by T3 glottic carcinoma. The difficulties in the diagnosis of this anatomical region have been stressed [7].

Supracricoid laryngectomy (SCL) allows the removal of vocal cords, vestibular folds, and the entire thyroid cartilage including the whole paraglottic space without the loss of laryngeal function [8]. In addition, SCL can be used in patients with failed radiotherapy before considering salvage total laryngectomy [9].

In this study, the aim was to histopathologically examine whether SCL provides adequate safety margins in terms of the paraglottic space or not.

Patients and methods

This study was carried out on 20 patients with proved advanced cancer larynx staged as T2b and T3 and cases of failed radiotherapy who were admitted in Kasr El Eini Hospital from November 2006 till April 2009. SCL was performed for all patients either by cricohyoidopexy (CHP) or by cricohyoidepiglottopexy (CHEP). Sharp dissection of the paraglottic space from the pyriform sinus mucosa was performed to obtain complete resection margins while preserving the pyriform sinus mucosa, especially on the healthy side. Whole-organ microscopic examination of the specimens was performed using transverse sections to detect the invasion of the paraglottic space and the safety margin distance from the pyriform sinus mucosa. In this study, there was no age-related contraindication but special care was provided to patients older than 70 years of age, especially those with poor pulmonary functions. Each patient was subjected to full assessment of history including all the symptoms related to cancer larynx and any history of illness or chest disease. Physical examination of the neck for any swelling such as a lymph node or thyroid together with chest examination was performed. Indirect or flexible laryngoscopy was performed for proper mapping of the tumor and assessment of the vocal cord and arytenoids mobility as a fixed arytenoid is a contraindication for SCL. Computed tomography was used to detect the actual site and extension of the tumor together with assessment of possible lymph node infiltration. MRI was used in cases of recurrence after radiotherapy to differentiate the recurrence from postradiation edema. Chest radiograph and abdominal ultrasound were performed in all cases to exclude distant metastasis. General conditions, especially chest condition, were assessed. Pulmonary function tests were performed to detect tolerability of the patient to aspiration. If the forced expiratory volume1 was less than 50% of expected, it was considered a contraindication for SCL. Endoscopy was performed to exclude any subglottic extension.

Exclusion criteria

Extensive pre-epiglottic space invasion, gross thyroid cartilage destruction, interarytenoid or bilateral arytenoid involvement, fixed arytenoid, and subglottic extension more than 1 cm anteriorly or more than 0.5 cm posteriorly and finally inadequate pulmonary reserve were determined.

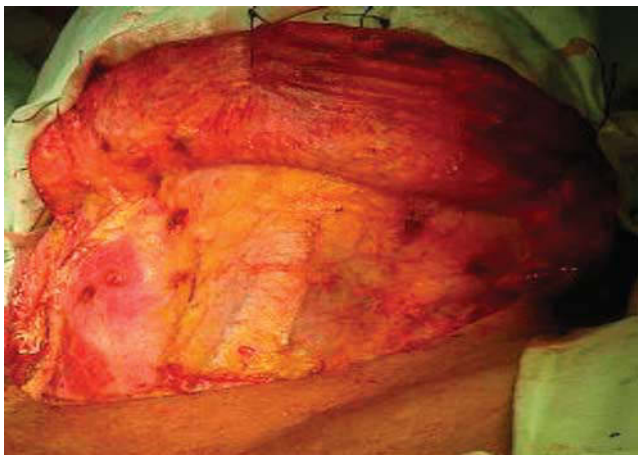
The patients were subjected to SCL either with CHP or with CHEP, where the most important key steps were as follows.

(1) Elevation of the skin flaps to ~ 2 cm above the hyoid bone to prevent tethering of the skin in the closure postoperatively; elevation more than this distance will result in severe postoperative edema (Fig. 1).
(2) The sternohyoid muscle is cut along the superior aspect of the thyroid cartilage to expose the deep musculature (Fig. 2).
(3) After transecting the deep layer of strap muscles and transfixing the thyroid isthmus, blunt finger dissection of the cervicomediastinal trachea is performed to the level of the carina. This step is important to facilitate the pexy without tension. This technique is preferred over suprahyoid drop, which will affect swallowing postoperatively (Fig. 3).
(4) The constrictor muscles are then transected along the posterior and superior–lateral aspect of the thyroid cartilage, and the pyriform sinus mucosa with the inner thyroid perichondrium are elevated off the internal surface of the thyroid cartilage bilaterally and marked by two vicryl 3-0 stitches that will be ligated together later on (Fig. 4).
(5) A Freer elevator is used to disarticulate the cricothyroid joint bilaterally with care to protect the recurrent laryngeal nerves, taking into consideration that these nerves are not actually visualized and the area posterior and lateral to the inferior cornu of the thyroid cartilage is avoided. If disarticulation is difficult, it is recommended to cut through the inferior cornu itself (Fig. 5).
(6) A transverse cricothyrotomy is performed just above the cricoid cartilage as an extra safety margin. The under surface of the vocal folds and the subglottis are then inspected for possible tumor extension, and the endotracheal tube is removed from above and placed in the cricothyrotomy (Fig. 6).
(7) After the laryngectomy, the reconstruction then begins with pulling the arytenoid cartilages forwards with a 3-0 vicryl suture material by placing a stitch just at or just above the vocal process and sewing them (or the posterior arytenoid mucosa in unilateral arytenoid resection) anterolaterally to the cricoid cartilage. In this way, the arytenoid will not prolapse posteriorly postoperatively, causing dysphagia to the patient (air-knot suture) (Fig. 7).
(8) The impaction of the cricoid to the hyoid is performed with three centrally placed 1-0 vicryl sutures on a 65-mm needle. The three tongue base sutures should be placed precisely 1 cm apart and arched up deeply into the tongue base. Perfect alignment between the cricoid cartilage and the hyoid bone should be created to reduce the risk of dysphagia postoperatively (Fig. 8).

When neck dissection was needed, it was done through the same incision and according to the type of dissection needed.

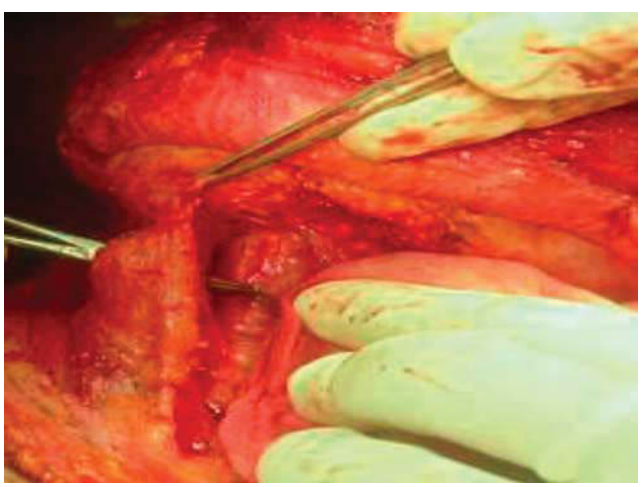
Then, the specimen was subjected to horizontal whole mount sections, where it was fixed in a buffered formalin saline solution for 24 h. Then, it was decalcified with an HCl–nitric acid solution for 4 days. The specimen was routinely processed until embedded in paraffin wax. Serial sections as thin as 9 μm are obtained using the Macrocut Tome sectioning system and stained with hematoxylin and eosin. In each case, the paraglottic

Figure 1



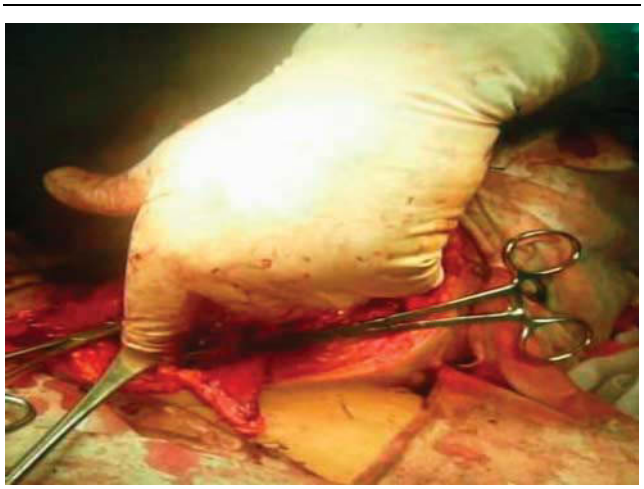
Elevation of the skin flaps.

Figure 2



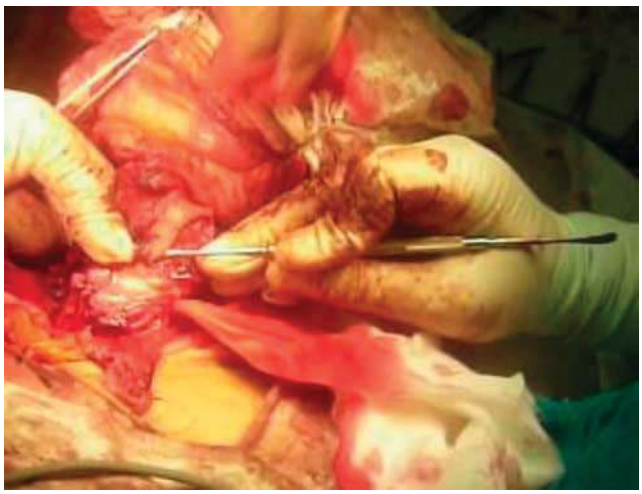
Sternohyoid muscle is cut to expose the deep musculature.

Figure 3



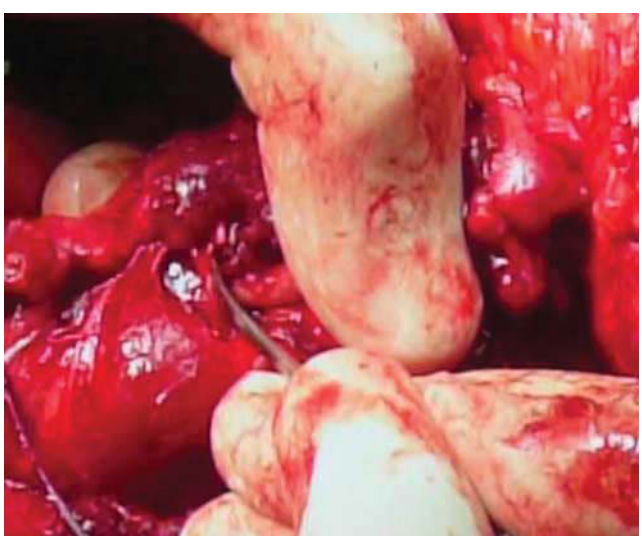
Blunt finger dissection of the cervicomediastinal trachea.

Figure 4



The pyriform sinus mucosa with the inner thyroid perichondrium are elevated off the internal surface of the thyroid cartilage.

Figure 5



A Freer elevator is used to disarticulate the cricothyroid joint.

spaces will be examined for tumor infiltration if any. If no tumor tissue is detected at 4 mm from the end of the surgical margins, they will be considered as safe with far free margins.

Results

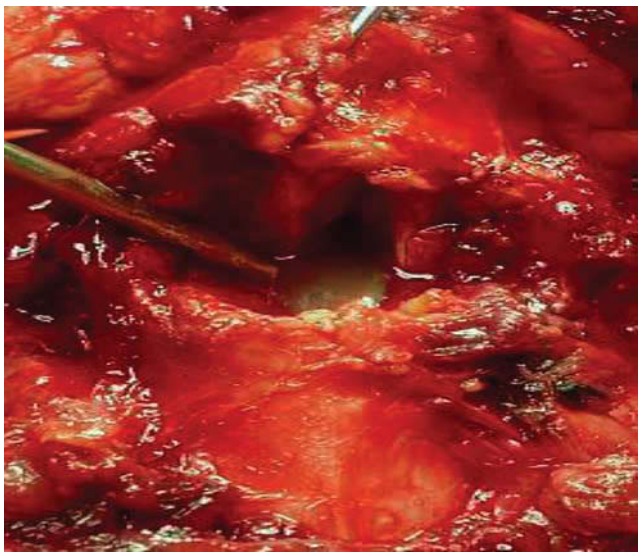
This is a prospective study that included 20 patients with cancer larynx staged as T2b or T3 and cases of recurrent cancer larynx after failed radiotherapy.

The age of the patients included is shown in Table 1.

There were 19 men and only one woman. The stage of the tumor included in these patients is shown in Table 2.

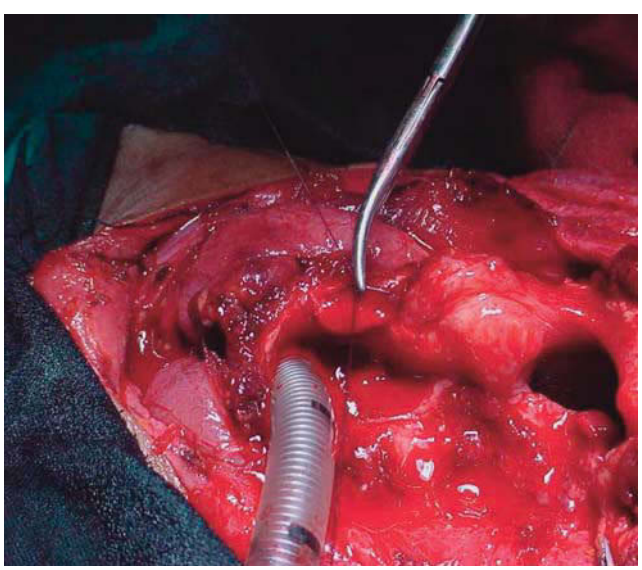
Eleven cases were staged as T3 (55%), eight cases were staged as T2b whereas only one case was recurrent after

Figure 6



A transverse cricothyrotomy is performed just above the cricoid cartilage as an extra safety margin.

Figure 7



Pulling the arytenoid cartilage forwards (air-knot suture) not to cause dysphagia after the operation.

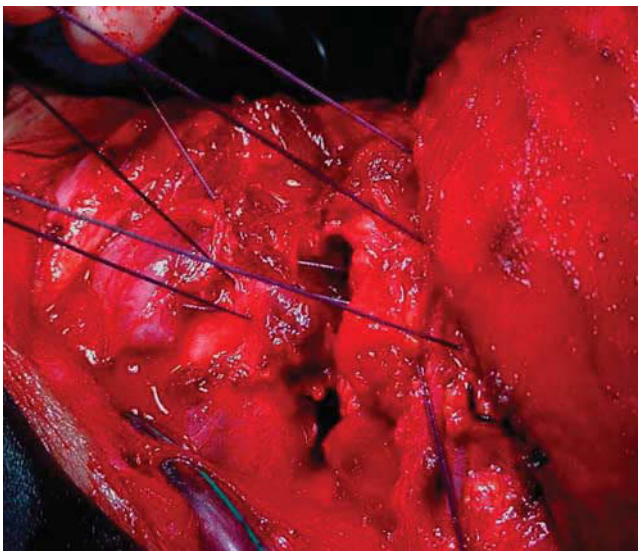
failed radiotherapy and was staged as T2b before the radiation dose.

No cases with palpable lymph nodes were found. The surgical procedure performed is shown in Table 3.

The functional results such as decannulation of the tracheostomy and removal of the Ryle tube inserted in the operation are shown in Table 4.

The pathological results showed free surgical margins more than 4 mm in 18 cases, with only one case with free surgical margins but less than 4 mm. Another case showed infiltrated subglottic margins and for this case total

Figure 8



The impaction of the cricoid to the hyoid is performed with three centrally placed 1-0 vicryl sutures.

Table 1 Age of patients included in the study

	Minimum	Maximum	Mean	SD
Age (years)	45	81	53.65	9.29

Table 2 The stage of the tumor in the patients included in the study

Case number	Stage	Case number	Stage
1	T3N0M0	11	T2bN0M0
2	T2bN0M0	12	T2bN0M0
3	T2bN0M0	13	T3N0M0
4	T3N0M0	14	T2bN0M0
5	T3N0M0	15	Salvage
6	T2bN0M0	16	T3N0M0
7	T3N0M0	17	T3N0M0
8	T3N0M0	18	T3N0M0
9	T3N0M0	19	T3N0M0
10	T2bN0M0	20	T3N0M0

laryngectomy was performed. Some pathological findings are shown in Figs 9 and 10.

Mortality occurred in one case 5 days after complete decannulation and removal of the nasogastric tube. The cause of death was pulmonary embolism.

Discussion

In the present study, 20 cases of SCL were performed. There were four patients over 60 years of age and their results did not show any significant difference from all the other younger patients.

It was found that age of the patient did not affect the functional outcome of the patient such as decannulation day or removal of Ryle tube [10,11]. Decannulation was performed successfully in 95% of patients with a mean time of 8.68 (± 0.82) days. The only patient, who failed

Table 3 The surgical procedure performed in cases of the study

Case number	Stage	Surgery	Neck dissection
1	T3N0M0	CHP with preserved left arytenoid	–
2	T2bN0M0	CHP with preserved left arytenoid	–
3	T2bN0M0	CHEP with preserved right arytenoid	–
4	T3N0M0	CHP with preserved left arytenoid	–
5	T3N0M0	CHP with preserved left arytenoids	–
6	T2bN0M0	CHEP with preserved right arytenoid	–
7	T3N0M0	CHP with preserved right arytenoid	–
8	T3N0M0	CHP with preserved right arytenoid	–
9	T3N0M0	CHEP with preserved left arytenoid	–
10	T2bN0M0	CHEP with preserved left arytenoid	–
11	T2bN0M0	CHP with preserved right arytenoid	–
12	T2bN0M0	CHEP with preserved left arytenoid	–
13	T3N0M0	CHP with preserved right arytenoid	Bilateral SND
14	T2bN0M0	CHEP with preserved left arytenoid	Right SND
15	Salvage	CHP with preserved right arytenoid	–
16	T3N0M0	CHP with preserved left arytenoid	–
17	T3N0M0	CHP with preserved left arytenoid	–
18	T3N0M0	CHP with preserved left arytenoid	Right SND
19	T3N0M0	CHP with preserved left arytenoid	–
20	T3N0M0	CHP with preserved left arytenoid	–

CHEP, cricohyoidepiglottopexy; CHP, cricohyoidopexy; SND, selective neck dissection.

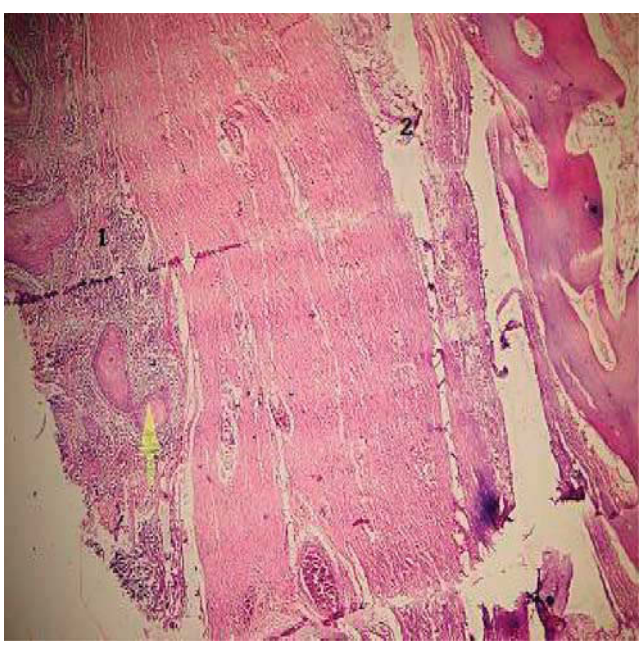
Table 4 Functional results of the patients in the study as regards day of decannulation and day of Ryle removal

	Minimum	Maximum	Mean	SD
Day of decannulation	8	10	8.68	0.82
Day of Ryle removal	15	20	16.94	1.77

Figure 9

Whole-organ transverse section of the larynx with the tumor and its relation with the paraglottic space. 1, tumor (cell nests); 2, the musculosa and the subserosa; 3, the paraglottic space; 4, the inner thyroid perichondrium; 5, the thyroid cartilage; 6, the outer muscle layer.

Figure 10



The distance between the tumor tissue (1) and the paraglottic space (2).

decannulation, underwent completion total laryngectomy as his surgical margins were infiltrated by malignancy. The incidence of successful decannulation in the literature varies between 86.3% [12] and 100% [13]. The time of decannulation varies between 7 days [13], 8 days [12], and 18 days [14,15]. The most important factor that caused delay in decannulation is the development of postoperative edema, which persisted for 37 days [16], and this was avoided in the current work by administering the patients the proper doses of corticosteroids postoperatively.

In the current study, removal of the nasogastric tube was performed in 95% of patients with a mean time of 16.94 (± 1.77) days. The patient, who failed removal of the nasogastric tube, underwent total laryngectomy because of infiltrated surgical margins. Day of removal of the nasogastric tube in the literature ranged from 12 days [12] to 23 days [14]. In our view, the most important factor in

regaining normal swallowing function and subsequently removal of the nasogastric tube is pyriform sinus repositioning performed in both CHP and CHEP and the presence of epiglottis in CHEP, which helps decrease the aspiration postoperatively.

In this study, 14 cases were subjected to CHP whereas six cases underwent CHEP. The functional results were almost the same in both groups, with only 1 day earlier in both decannulation and removal of the nasogastric tube in the group of CHEP. Better functional results were obtained after CHEP more than with CHP [17,18].

In the current study, all the cases underwent SCL with removal of the arytenoid involved. No cases of bilateral arytenoid resection were performed and thus the difference in the functional outcome between the two procedures was not noticeable. If both arytenoids have to be removed for oncologic safety (extended SCL), better functional results can still be obtained by the preservation of both superior laryngeal nerves and fashioning of mucosal folds from the pharyngeal mucosa to replace the resected arytenoids [19]. According to other opinions, sparing the two arytenoids yielded better laryngeal functions [20].

The paraglottic space is defined as a small space composed of fat bordering the thyroarytenoid muscle medially, the thyroid cartilage laterally, and the pyriform sinus dorsally [21].

In this study, all the 20 cases included had a sufficient safety margin between the tumor and the pyriform sinus mucosa even in T2b and T3 stages and also in the only case of failed previous radiotherapy.

According to the study by Pinar *et al.* [22], SCL led to reliable oncologic results in cases of locally advanced laryngeal carcinoma. We found a local failure rate of 10%, where one case had infiltrated surgical margins and total laryngectomy was performed for this case. The other case showed local recurrence 6 months after surgery. This particular case had free surgical margins but less than 4 mm and strict follow-up was advised then. None of the cases showed thyroid cartilage invasion in the computed tomography (CT) or intraperatively. There was no local recurrence after SCL in some series [10,16]. In some studies, chemotherapy was provided postoperatively to control the local or nodal recurrence after surgery; yet, nine of 118 cases showed recurrence [23].

In the current study, the case with infiltrated surgical margins could have been avoided if frozen section of the subglottic region was performed, whereas the other case with recurrence after 6 months could have been avoided if a safety margin of more than 4 mm had been obtained in the partial laryngectomy procedure.

We did not find any case of regional recurrence and this was supported by some studies with no regional recurrence [13]. However, other studies reported an incidence of regional recurrence [24]. This may be explained by the proper selection of cases in our series and the selective neck dissection that was performed whenever a case was suspected to have a nodal involvement intraoperatively.

In this study, the small number of cases of radiation failure did not allow for a clear idea of the efficiency of SCL in the management of recurrent cases of laryngeal cancer after failed radiotherapy. SCL is an excellent procedure in the management of recurrent laryngeal carcinoma after failed radiotherapy irrespective of a relevant delayed recovery of laryngeal functions [25]. Nakayama *et al.* [26] reported that the risk of infection was significantly higher in previously irradiated patients; however, functional and oncologic results were stable irrespective of the radiation history of the patient.

Spriano *et al.* [27] reported that there was no local or regional recurrence in 12 of 15 patients of salvage SCL over 36 months of follow-up, whereas the remaining three patients died later because of heart failure or lung metastasis.

In the present study, whole-organ transverse sectioning of the laryngeal specimen allowed complete evaluation of tumor growth and spread with the optimal assessment of all the laryngeal tissues and their relations with the tumor itself. Sprinzl *et al.* [28] reported that total organ sections have proven to be useful in the evaluation of the clinical growth behavior of malignant tumors and thus ensuring the complete eradication of malignant tumors.

In the present study, no complications occurred postoperatively. Karasalihoglu *et al.* [17] reported that out of 24 patients, two patients with CHP developed a postoperative wound infection for which total laryngectomy was performed. They also reported that one patient with CHEP had a ruptured pexy and a second reconstruction was performed for him.

In this work, the fact that none of the patients had serious systemic morbidity and only one patient had previous radiotherapy might have decreased the rate of postoperative complications. Proper and meticulous surgical technique and postoperative continuous care and follow-up are mandatory for the success of SCL without noticeable complications.

Conclusion

Supracricoid partial laryngectomy is a procedure that enable a safe enbloc resection of malignant laryngeal tumor. For oncologic control, the paraglottic space should be completely resected to ensure complete eradication of the tumor. Whole-organ sectioning allows full study of the tissues in question and enables the complete eradication of the tumor by studying the picture of tumor spread. A safety margin of 4 mm or more is considered as the least tumor-free area, which ensures complete eradication of the tumor.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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