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REVIEW ARTICLE

# Supracricoid partial laryngectomy for radiorecurrent laryngeal cancer: a systematic review of the literature and meta-analysis

**Armando De Virgilio[1] · Raul Pellini[2] · Giuseppe Mercante[2] · Giovanni Cristalli[2] · Valentina Manciocco[2] · Diana Giannarelli[3] · Giuseppe Spriano[2]**

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## Abstract

**Purpose** The objective of the current systematic review with meta-analysis was to report the pooled survival outcomes of supracricoid partial laryngectomy in the setting of radiorecurrent laryngeal cancer to investigate if and when an organ-sparing surgical treatment is adequate.

**Methods** The search included all original papers from 1990 to December 2017. The search terms included the following: cricohyoepiglottopexy; cricohyoidopexy; cricohyopexy; horizontal laryngectomy; and partial, subtotal, supracricoid, and supraglottic laryngectomy. Inclusion criteria were as follows: (1) data clearly distinguish results of partial laryngeal procedures; (2) clear description of tumor stage and selection criteria; (3) clear description or derivability of local control and survival rates.

**Results** Eleven out of 270 papers were analyzed, and a total of 251 cases were included. Two-year LC, 3-year DFS, and 5-year OS were 92, 80, and 79%, respectively. Heterogenicity evaluated with the $I^2$ parameter was 14, 0, 0%, respectively. The larynx preservation rate was 85.2%, the decannulation rate was 92.1%, and swallowing recovery was 96.5% (PEG dependence and the aspiration pneumonia rate were 3.5 and 6.4%, respectively).

**Conclusions** SCPL is oncologically sound, guaranteeing a high percentage of success. The homogeneity of data should encourage the use of SCPL as salvage treatment for recurrent LSCC.

**Keywords** Laryngeal squamous cell carcinoma · Open partial laryngectomy · Radiorecurrent laryngeal cancer · Supracricoid laryngectomy · Systematic review

## Introduction

In the recent decades, refinement in the treatment of laryngeal cancer has increasingly focused on tumor control, as well as preservation of functionality. In fact, the attention to function preservation and the conservative approaches are gradually replacing total laryngectomy as primary treatment, in favor of radiation, chemoradiation protocols, and conservative surgery [1–3].

The local recurrence rate after radiation therapy (RT) ranges from 5 to 13% for T1 laryngeal cancer and from 25 to 30% for T2 [4, 5].

Cancers that recur after radiation therapy often demonstrate aggressive behavior, arise in a field where lymphatic drainage is unpredictable, and are associated with poor control rates [6]. Furthermore the diagnosis is more difficult because of radiation sequelae edema and the low specificity of conventional diagnostic strategies.

Surgical management of recurrences after RT failure encompasses endoscopic laser excision [7–9] partial laryngectomies through an open-neck approach [10–20], and total laryngectomy, which still remains the most widely used procedure in such a scenario [21–24]. Total laryngectomy is in fact technically easy, and the outcomes are predictable. However, total laryngectomy is related to an increased risk

✉ Armando De Virgilio
armando.devirgilio@gmail.com

[1] Otorhinolaryngology Unit, Humanitas Clinical and Research Center, Viale Manzoni 56, 20089 Rozzano, MI, Italy

[2] Department of Otolaryngology-Head and Neck Surgery, Regina Elena National Cancer Institute, Via Elio Chianesi 53, 00144 Rome, Italy

[3] Department of Biostatistics and Bioinformatics, Regina Elena National Cancer Institute, Via Elio Chianesi 53, 00144 Rome, Italy

of complications and has far-reaching consequences for the patient in terms of function and quality of life (QoL).

Therefore, if on one hand, the only validated therapeutic option in recurrences of a laryngeal squamous cell carcinoma (LSCC) is total laryngectomy, on the other hand, several studies in the last decade also evaluated different conservative surgical procedures and, in particular, supracricoid laryngectomies.

Supracricoid partial laryngectomies [SCPLs; including both SCPL with cricohyoido-epiglottopexy (CHEP) and SCPL with crico-hyoidopexy (CHP)] can be adopted in many intermediate laryngeal cancers, strictly respecting tumor- and patient-related indications [13–15].

Several reports from different centers have been published about the effectiveness of supracricoid laryngectomy in terms of local tumor control and functional results in residual or recurrent cancer after radiotherapy [10–20]. However, most articles have been from a few centers, and the results included only a small number of patients. Thus, there is a need to pool results to achieve larger sample sizes and generate confidence in the use of this technique in the radiorecurrent setting. Paleri et al. published an interesting meta-analysis of 560 patients treated for radiorecurrent LSCC with open conservative laryngectomy but not focused on SCPL [25]; in their report, different partial laryngectomies techniques were considered. To update the results of the literature and to focus exclusively on SCPL, we decided to carry out this study. The objective of the current systematic review with meta-analysis was to report the pooled outcomes of SCPL in the setting of radiorecurrent laryngeal cancer.

## Materials and methods

The systematic review was performed by the first and last authors. We independently developed search strategies and searched the Medline and Embase databases. The search strategy is illustrated in Fig. 1. The search terms included the following, in various combinations to maximize the yield: cricohyoepiglottopexy (CHEP); cricohyoidopexy (CHP); cricohyopexy; horizontal laryngectomy; and partial, subtotal, supracricoid, and supraglottic laryngectomy. The references from all full texts that were selected were checked to identify suitable articles. Conference proceedings and book chapters were not considered. The search was performed for the first time on September 12, 2017, and was set to automatically update periodically until December 2017. Inclusion criteria for the articles were as follows: (1) articles published from 1990 onward; (2) data clearly distinguish results of partial laryngeal procedures if published along with other procedures; (3) clear description of tumor stage and selection criteria; (4) clear description or derivability of local control and survival rates; and (5) articles were published in the English language.

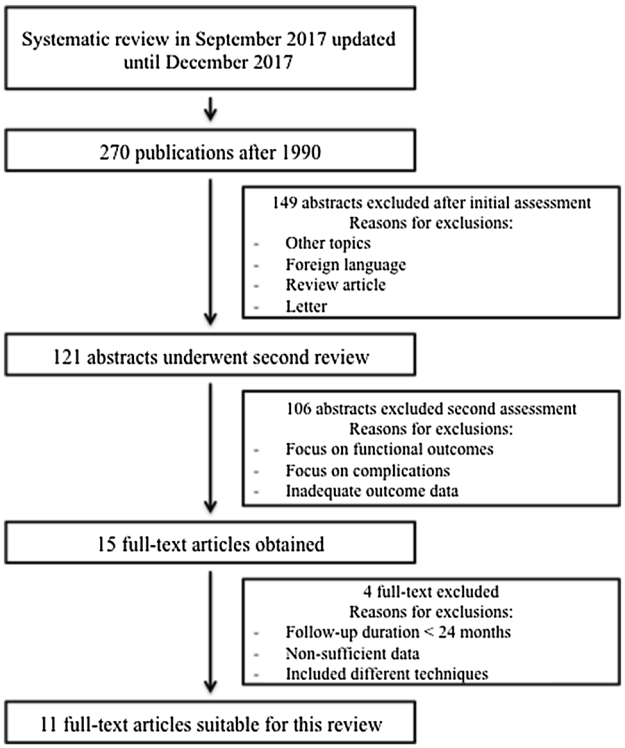


**Fig. 1** Review process flow chart: the process that was used to select articles for review

The inclusion criteria were deliberately kept wide to encompass as many articles as possible without jeopardizing the validity of the results. The search excluded articles that were published before 1990 because they were few in number and because many reported surgical procedures other than SCPL (endoscopic, others open partial and total laryngectomy). The survival and functional results reported also were not uniform, which made them difficult to compare or pool. For studies in which the results from upfront partial laryngectomy were included along with those from radiorecurrent tumors, the results from radiorecurrent tumors were separated out.

The abstracts were analyzed to identify articles that fulfilled the inclusion criteria. The abstracts obtained from the multiple database searches identified many duplicates that were removed using Endnote version X2 (Thompson Reuters, Carlsbad, CA). Data from the identified articles were entered into an Excel spreadsheet (Microsoft Corp., Redmond, WA) for further analysis.

### Outcome measures

Primary endpoints were local control (LC), disease-free survival (DFF), and overall survival (OS). We selected

the longest interval for each parameter derivable for each selected study. The secondary endpoints were related to functional results: decannulation rates, swallowing ability, PEG dependence rate, aspiration pneumonia incidence, and voice quality. Some studies exist outside the remit of this review that focus purely on assessing functional outcomes (voice and swallowing). Considering the variable reporting practices, the use of outcome measures that cannot be compared directly, and the need for different search strategies, we did not include functional outcomes in the current review apart from summarizing comparable data in articles that met the inclusion criteria. Both subjective and objective methods of evaluation of functional outcomes were considered. Although most articles discussed the duration of hospital stay, we did not choose to measure this variable, because of the interference of several local habits and health systems policies.

### Quality assessment

To our knowledge, no widely accepted measures of quality assessment of case series exist [26]. We used one of the quality-assessment forms that has been used by the National Institute for Health and Clinical Excellence [27] (Table 1). The maximum possible score for a given study using this scoring system is 8. The quality of each study was evaluated using the forest plot model.

### Statistical analysis

The data were entered into Microsoft Excel. The statistical package R version 2.9 (The R Foundation for Statistical Computing, Vienna, Austria) was used for all analyses. The effect of publication and other biases was assessed visually using a forest plot, and the $I^2$ statistic was calculated [28]. The $I^2$ statistic is a measure of heterogeneity between studies and ranges from 0 to 100%; high percentages indicate greater heterogeneity in the data. When studies have low heterogeneity (pragmatically, $I^2 < 25\%$), the differences between reported outcomes can be simply explained by the observed natural differences among patients. In this case, we can consider that all patients are part of the same larger pool. A fixed-effects meta-analysis is appropriate when each patient is given approximately equal weight.

## Results

The search strategy identified 3551 articles in Medline and 802 in Embase from 1950 to the search date. Only articles that were published after the 1990s were selected and imported into Endnote, and the duplicates were removed. The removal of duplicates yielded a total of 270 publications. The various stages of systematically assessing the abstracts and reasons for exclusion from the review are described in Fig. 1.

In particular, one study was excluded because, despite the pertinence of the topic, it did not provide sufficient survival data [29].

The process left us with 11 studies that reported on the outcomes of open partial laryngectomy in radiorecurrent tumors and satisfied all the inclusion criteria. Nine studies had a quality score > 6 (good) [10, 12–18, 20], and 2 studies had a score of 4 or 5 (fair) [11, 19]. All articles that satisfied the inclusion criteria were published after 1995. Two articles that were included were published by the same authors [10, 14], but those authors clearly indicated that the results were from procedures that were performed at different centers.

Six of the selected articles were from Italy [10–15], 2 were from France [16, 17], 1 was from Spain [18], 1 was from Mexico [19], and 1 was from Japan [20].

Salvage SCPL was indicated in rT2 LSCC with impaired cord mobility, anterior commissure extension, and rT3 with paraglottic space invasion and/or limited cartilage erosion. Contraindications included true arytenoid fixation, vallecula, base of tongue, interarytenoid region and relevant pre-epiglottic space involvement, significant (10 mm anteriorly, 5 mm posteriorly) subglottic involvement, extensive cartilage invasion, posterior/inferior paraglottic space invasion and extralaryngeal spread through the cricothyroid membrane.

**Table 1** Quality assessment for case series

| Each item is answered either yes (score = 1) or no (score = 0) |
|---|
| 1. Case series collected in more than 1 center (ie, a multicenter study) |
| 2. Is the hypothesis/aim/objective of the study clearly described? |
| 3. Are the inclusion and exclusion criteria (case definition) clearly reported? |
| 4. Is there a clear definition of the outcomes reported? |
| 5. Were data collected prospectively? |
| 6. Is there an explicit statement that patients were recruited consecutively? |
| 7. Are the main findings of the study clearly described? |
| 8. Are outcomes stratified (eg, by disease stage, abnormal test results, patient characteristics)? |

In total, 251 patients were identified from the articles that were included. Our meta-analysis included only patients who underwent SCPL after radiotherapy failure. Very few data are nowadays available for patients previously treated with chemoradiotherapy, who could be treated with SCPL and to our knowledge no case series are present in the contemporary literature.

Although all studies described local control rates, this was not the case with other endpoints, which we directly or indirectly calculated from the raw data. Table 2 summarizes the demographics, type of surgery, and T and N classes from the selected articles. Sixty-nine patients (27.5%) had rT1 tumors, 106 (42.2%) had rT2 tumors, 58 (23.1%) had rT3 lesions, and 18 (7.2%) had rT4 lesions. The surgical procedures included variations of SCPL with CHP or CHEP. It was not possible to obtain survival data stratifying patients according their T status.

## Oncologic outcomes

### Local control (LC) at 24 months

The pooled LC rate obtained from 11 studies with data on 251 patients was analyzed using a fixed-effects model ($Q = 11.64$; $I^2 = 14\%$; $P = 0.31$). Figure 2 provides the forest plot of studies that contributed to these results and the spread of data, with 95% confidence intervals for each study represented by horizontal lines. In summary, seven studies [10–12, 14–16, 20] reported a > 90% LC rate, three were between 80 and 90%, [13, 18, 19] and only one study [17] reported an LC rate < 80%. The pooled LC rate for all 251 patients was 92% (95% CI 88–95%).

### Disease-free survival (DFS) at 36 months

DFS data were available or calculated in all 11 studies, and data were analyzed using a fixed-effects model ($Q = 9.23$; $I^2 = 0\%$; $P = 0.99$). Figure 3 provides the forest plot of studies that contributed to these results and the spread of data, with 95% confidence intervals for each study represented by horizontal lines. In summary, seven studies reported a DFS between 80 and 90% [10–14, 16, 20] and four were between 70 and 80% [15, 17–19]. The pooled DFS rate for all 251 patients was 80% (95% CI 75–85%).

### Overall survival (OS) at 5 years

OS data were available or calculated in all 11 studies and data were analyzed using a fixed-effects model ($Q = 3.37$; $I^2 = 0\%$; $P = 0.90$). Figure 4 provides the forest plot of studies that contributed to these results and the spread of data, with 95% confidence intervals for each study represented by horizontal lines. In summary, six studies reported an OS between 80 and 90% [10–12, 14, 19, 20] and five studies were between 70 and 80%, [13, 15–18] while no studies reported an OS < 70%. The pooled OS rate for all 251 patients was 79% (95% CI 73–84%).

## Functional results

Main functional results are reported in Table 3. The larynx preservation rate was reported in 10 studies [10–14, 16–20]. The pooled mean larynx preservation rate was 85.2% (95% CI 0.78–0.90, 228 patients). Nine articles reported decannulation outcomes [10–18]. The pooled mean decannulation rate was 92.1% (95% CI 0.86–0.95) based on data reported for 213 patients. The time from surgery to decannulation could not be extracted reliably from the articles because of variable reporting methods and because some studies excluded from the analysis the patients who had delayed decannulation.

The incidence of laryngeal stenosis requiring further surgery to enhance airway patency and to facilitate tracheostomy decannulation was reported in six articles [10, 12, 14, 16–18], and the rates varied from 0 to 8%. The pooled mean rate of laryngeal stenosis was 3.9% (95% CI 0.01–0.08) based on data reported for 144 patients. Ten studies reported swallowing outcomes [10–19]. The pooled mean rate of efficient swallowing was 96.5% (95% CI 0.94–0.98) based on data reported for 221 patients. All studies reported the PEG dependence rate [10–20]. The pooled mean PEG dependence rate was 3.5% (95% CI 0.01–0.05) based on data reported for 251 patients. Ten studies reported the incidence of aspiration pneumonia [10–18, 20]. The pooled mean aspiration pneumonia rate was 6.4% (95% CI 0.03–0.09) based on data reported for 221 patients.

Total laryngectomy was performed in order to solve chronic aspiration in 2 cases, 1 reported by Laccourreye et al. [16] and 1 reported by Deganello et al. [13].

### Voice and speech

Voice and speech outcomes were assessed in only five studies. Spriano et al. [10] reported an "acceptable quality of the voice by most of patients." Voice quality was definitively hoarse in all patients, and the maximal phonation time ranged from 3 to 18 s (mean: 8.3 s). Marchese-Ragona et al. [11] and Leon et al. [18] reported "satisfactory voice intelligibility in all cases." Similar results were reported also by the Pellini et al. [14] study, in which voice was evaluated in decannulated patients as hoarse to varying degrees (19 patients were grade 1, 49 were grade 2, and 8 were grade 3). Maximal phonation time ranged from 2 to 18 s (mean: 7.9 s). Finally, Deganello et al. [13] reported "satisfactory voice production that allowed normal social interactions."

**Table 2** Demographics, T and N status, type of surgery

| Series | Mean age (range) | M/F | No. Pts submitted to salvage CHP/CHEP | rTN classification | Early/advanced |
|---|---|---|---|---|---|
| Laccourreye et al. [16] | 58 (40–85) | 10/2 | 12 (4 CHEP/6CHP/2 TCHEP) | 3 T1N0<br>7 T2N0<br>2 T3N0 | 10/3 |
| Spriano et al. [10] | 65.2 (58–73) | 15/0 | 15 (10 CHEP/5 CHP) | 4 T1aN0<br>3 T1bN0<br>7 T2N0<br>1 T2N1 | 14/1 |
| Makeieff et al. [17] | 62 (47–77) | 22/1 | 23 (18 CHEP/5 CHP) | 12 T1bN0<br>11 T2N0 | 23/0 |
| Marchese-Ragona et al. [11] | 64 (55–72) | 7/0 | 7 (all CHP) | 6 T2N0<br>1 T3N0 | 6/1 |
| Leon et al. [18] | 54.4 (43–77) | 9/0 | 9 (6 CHEP/3 CHP) | 4 T1N0<br>2 T2N0<br>1 T2N1<br>1 T3N2b<br>1 T4N0 | 6/3 |
| Pellini et al. [14] | 59.6 (33–76) | 78/0 | 78 (62CHEP/16CHP) | 8 T1aN0<br>18 T1bN0<br>16 T2N0<br>2 T2N+<br>22 T3N0<br>1 T3N+<br>8 T4aN0<br>3 T4aN+ | 42/36 |
| Piazza et al. [12] | NR | NR | 15 (1 HPL, 4 CHEP, 9 CHP, 1 TCHEP) | 1 T1a<br>6 T2<br>8 T3 | 7/8 |
| Deganello et al. [13] | 60.1 (40–72) | 29/2 | 31 (8 CHEP/23 CHP) | 6 T1bN0<br>14 T2N0<br>3 T3N0<br>5 T3N1<br>3 T4N1 | 20/11 |
| Luna-Ortiz et al. [19] | 67 (43–87) | 6/2 | 8 (all CHEP) | 1 T1N0<br>5 T2N0<br>1 T2N1<br>1 T3N1 | 6/2 |
| Nakayama et al. [20] | 62 | 29/1 | 30 (all CHEP) | 4 T1N0<br>1 T1N2b<br>13 T2N0<br>9 T3N0<br>3 T4N0 | 17/13 |
| De Vincentiis et al. [15] | 62 (39–71) | 21/2 | 23 (all CHP) | 4 T1bN0<br>11 T2N0<br>2 T2N1<br>1 T2N2c<br>4 T3N0<br>1 T3N2b | 15/8 |
| Total | 60.9[a] (33–87)[b] | 226/10[a] | 251 (150 CHEP, 97CHP, 3THEP, 1HPL) | 69 T1 | 165/86 |

[a]Piazza et al. excluded because of missing data

[b]Nakayama et al. study excluded because of missing data

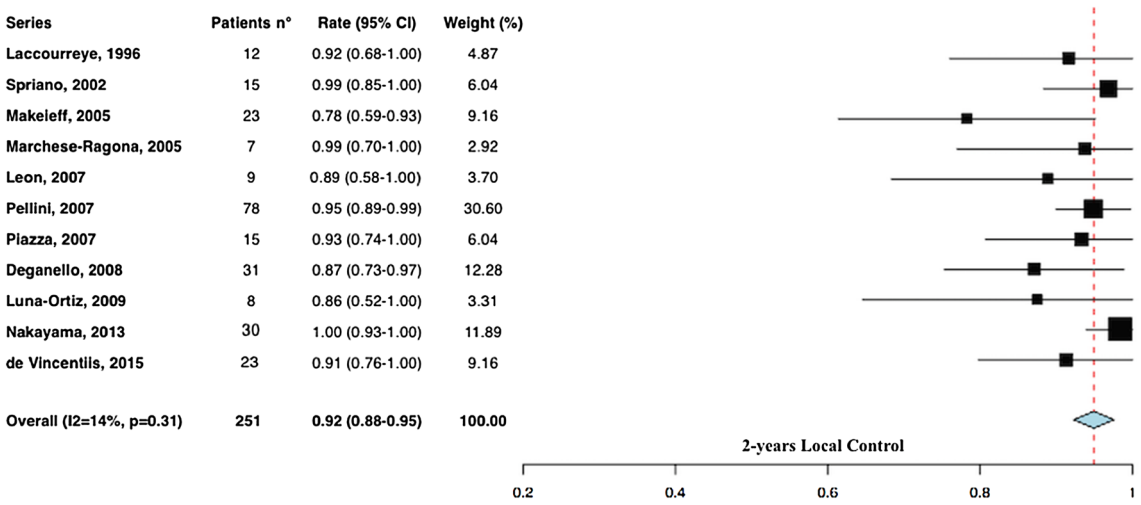


**Fig. 2** Local control: forest plot illustrating local control rates at 24 months for all studies. The overall estimation was calculated using a fixed-effect model. The bigger the square and the shorter the line, the more homogeneous the sample

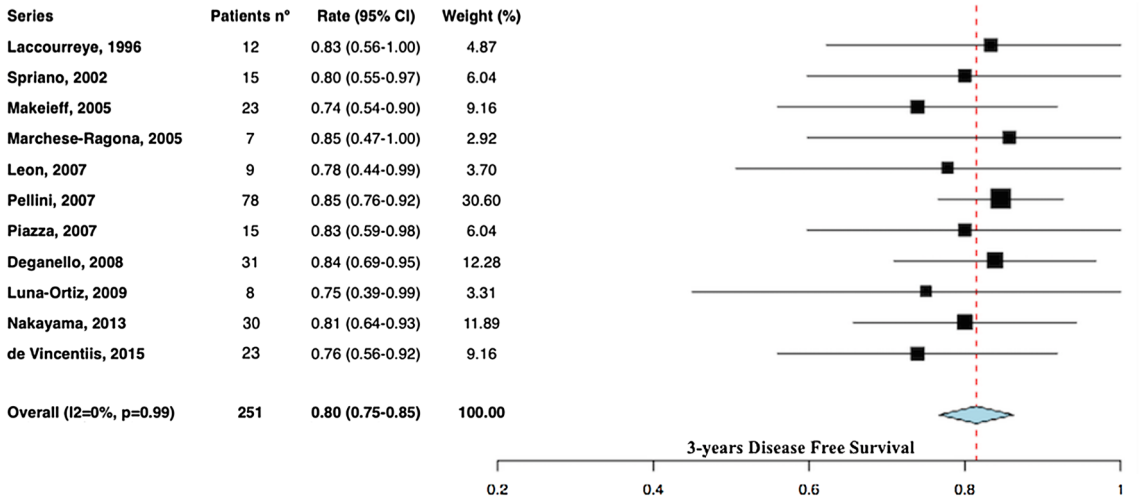


**Fig. 3** Disease free survival: forest plot illustrating disease-free survival rates at 36 months for all studies. The overall estimation was calculated using a fixed-effect model. The bigger the square and the shorter the line, the more homogeneous the sample

## Discussion

Among the head and neck subsites, the larynx represents the most salvageable area, with a reported overall survival higher than 60% at 2 years [30]. Moreover, recurrences are more frequent in the primary site than regional lymph nodes or distant sites [31, 32].

However, while in other head and neck areas we can observe either an improvement or a decrease in QoL after salvage surgery, laryngeal salvage surgery was associated with a decreased QoL and laryngeal function [30].

Recurrent LSCC management is challenging for many reasons. The diagnosis of recurrence doubles all the negative considerations of the patient and decreases the trust in treatment. Clinical T status is often upstaged due to radiation therapy: chronic edema could be interpreted either as a post-radiation sequela or a deep recurrence; arytenoid fixation could be interpreted either as a post-radiation fibrosis or a posterior paraglottic space involvement; difficulties in obtaining a representative biopsy due to edema, chronic inflammation, and fibrosis with higher chances of

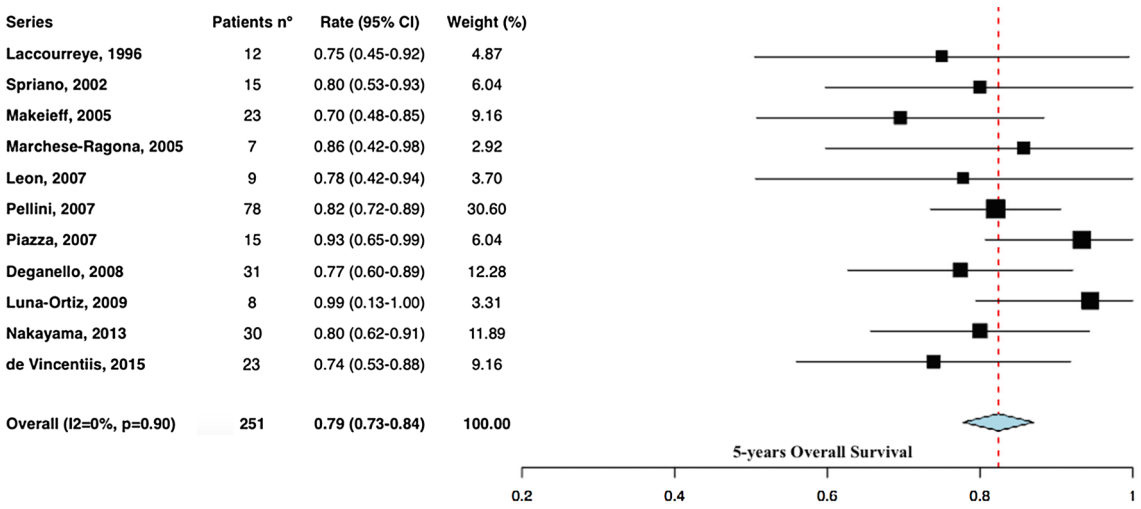


**Fig. 4** Overall Survival: Forest plot illustrating overall survival rates at 5 years for all studies. The overall estimation was calculated using a fixed-effect model. The bigger the square and the shorter the line, the more homogeneous the sample

**Table 3** Functional results

| Series | Larynx preservation (%) | Decannulation (%) | Swallowing (%) | PEG dependence (%) | Aspiration pneumonia (%) |
|---|---|---|---|---|---|
| Laccourreye et al. [16] | 75 | 83 | 100 | 0 | 9 |
| Spriano et al. [10] | 100 | 100 | 100 | 0 | 20 |
| Makeieff et al. [17] | 74 | 81 | 96 | 4 | 17 |
| Marchese-Ragona et al. [11] | 72 | 100 | 100 | 0 | 29 |
| Leon et al. [18] | 100 | 100 | 100 | 0 | 0 |
| Pellini et al. [14] | 99 | 97 | 97 | 3 | 9 |
| Piazza et al. [12] | 83 | 100 | 100 | 0 | 13 |
| Deganello et al. [13] | 87 | 97 | 97 | 3 | 3 |
| Luna-Ortiz et al. [19] | 88 | N/R | 88 | 0 | 0 |
| Nakayama et al. [20] | 94 | N/R | N/R | 3 | N/R |
| De Vincentiis et al. [15] | N/R | 95 | 87 | 13 | 0 |
| Pooled data | 85.2 | 92.1 | 96.5 | 3.5 | 6.4 |

*TL* total laryngectomy, *PEG dep* percutaneous endoscopic gastrostomy dependence; in 'Pooled data' raw, data have been pooled including only the available data

false negative results [6]. Furthermore, CT and MR imaging have a low specificity after radiation therapy [30].

Recurrent and persistent LSCC after radiotherapy are associated with more aggressive growth patterns (infiltrative with multiple foci), have a higher tendency for extralaryngeal spread and subglottic extension, are more often undifferentiated, and more frequently present intravascular and perineural invasion than primary tumors [6].

For these reasons, total laryngectomy is the most performed salvage procedure in case of recurrent/persistent LSCC after radiotherapy. However, salvage total laryngectomy is associated with an increased risk of wound and systemic complications. In the review of the literature performed by Goodwin et al. [30], major complications ranged from 5 to 48%, while pharyngocutaneous fistula rates ranged from 30 to 80% [12, 33–35]. The higher chances of complications are obviously related to higher health system costs.

Finally, salvage total laryngectomy after radiotherapy nowadays represents a mutilating and expensive strategy with high complication rates.

In these scenarios, SCPL could now represent a valuable alternative for selected recurrent LSCC. For these reasons, we performed a systematic review of the literature in order to examine the oncologic efficacy of SCPL in the setting of radiorecurrent cancer.

From the analyzed studies, common general concepts emerged. Salvage SCPL indications and contraindications were the same of SCPL performed for primary LSCC.

However, authors particularly stressed the accuracy of the restaging process since tumor extension and margins may vary after radiotherapy and their identification can be difficult. Superficial and deep extensions into the larynx, including cartilage framework, should be carefully evaluated. All patients in the studies were examined by fiberoptic laryngoscopy/laryngostroboscopy, and computed tomography/magnetic resonance imaging. The authors recommended an endoscopic assessment with 0° or 30° and 70° rigid endoscopes and additional biopsies under general anesthesia in case of doubts. Each case should be re-discussed during the disease management team meeting.

We filtered the studies to ensure that only data from centers that had published on at least five partial laryngectomies were included in the review; this was done as a quality-assurance measure, because several case series in the literature published the results from single case reports.

We considered different survival outcomes measures, giving priority to the LC rate. In fact, there is strong evidence in the literature that OS alone is not a suitable endpoint for comparing outcomes across centers worldwide, while LC really reflects the oncologic efficacy of the tested treatment on the primary tumor. The results revealed a very good LC rate, which was 92% at 24 months with a narrow confidence interval (0.88–0.95) and a low $I^2$ value (14%). Considering the variability of the rT status, we can conclude that when the patient is correctly staged and when the indication is correctly done, salvage SCPL can be a valuable treatment strategy in radiorecurrent tumors. The LC rates offered by open partial laryngectomy are at least comparable than those observed after transoral laser-assisted resection [7–36].

In our analysis, we included as endpoint the DFS at 36 months, which was 80% with a narrow confidence interval (0.75–0.85) and an $I^2$ of 0%. This is strong evidence of reproducibility. It reflects the percentage of the patients who were alive and without disease. Consequently, DFS evaluates not only local control, but also regional control and distant metastases, thus the global efficacy in terms of LSCC eradication by the proposed treatment. The DFS results are excellent if we consider that we are faced with a recurrent/persistent disease. Finally, we evaluated 5-year OS, which also depends on the presence of comorbidities, synchronous/metachronous second primaries, and other diseases. Five-year OS was 79% with a narrow confidence interval (0.74–0.84), and an $I^2$ of 0%, demonstrating that SCPL is a valuable treatment in cases of a good preoperative selection. In this setting we should emphasize that only few studies reported the preoperative performance status. Pooled Karnofsky performance status data could have been useful to establish a possible cutoff value for SCPL indications and contraindications. In Paleti et al.'s meta-analysis [25], the results reported on 149 SCPLs; the oncological results in terms of 2-year LC, DFS, and OS were, respectively, 93.9, 89.6, and 81.1%. These results can be considered very similar to ours, and 5 out of 11 papers were included in our analysis.

For the included studies, we collected functional outcomes that are comparable to those reported in the literature for primary SCPL [10–20]. Functional results are partial, however, in part due to poor reporting and in part due to the lack of established, validated outcome measures for swallowing and voice after surgery.

In this meta-analysis, there are 69/251 (27.5%) classified as rT1. The alternative of endoscopic resection as salvage for radiation failure has stricter criteria in terms of tumor extension, with less reliable oncologic outcomes in spite of better functional outcomes [7–9].

An essential prerequisite for endoscopic approach is an adequate laryngeal exposure as determined during the initial microlaryngoscopic examination. Furthermore, endoscopic resection indications are confined to rT1a tumors, rT1b tumors with limited anterior commissure involvement, and rT2 tumors with normal cord mobility [7–9].

In the meta-analysis performed by Ramakrishnan et al., which included 11 articles (249 patients), 24-month LC was 56.9% [37] and crT1 was 67% of the total. However, endoscopic laser $CO_2$ surgery has the advantage of being repeatable and, in this paper, the reported DFS and OS were, respectively, 70.9 and 74.8%.

Vertical partial laryngectomy has been proposed as salvage treatment since 1970 by Biller et al., with a control rate of 70–100% [25], even with different types of reconstruction with the aim of improving the quality of voice.

In our study, advanced rT3 and rT4 were 76/251 (30.2%). These patients would be submitted to a total laryngectomy almost worldwide despite a surgical organ-sparing treatment. In spite of a challenging postoperative period with possible complications and difficulty recovering functions (6.4% aspiration pneumonia rate; 3.5% PEG dependence rate), more than 90% of patients recover normal larynx function. The weakness point is the quality of voice.

Even total laryngectomy, however, is related to a high risk of complications (i.e., pharyngocutaneous fistula), which often require further surgical steps and a prolonged hospitalization stay, and incur high costs.

Regarding the quality of voice in the study by Kummer et al., it is clearly documented that tracheo-esophageal puncture is related to a high risk of failure and complications when performed after salvage total laryngectomy [38].

Our study has some limitations. In fact, patients who undergo SCPL are likely to have smaller volume recurrences compared to patients who undergo salvage total laryngectomy. However, in our analysis, 86 out of 251 were rT3 or rT4. This cohort of patients also is likely to have good pretreatment performance status, because good pulmonary function is a prerequisite for SCPL. If we look at

the demographics, the average age was 54–77 years, with a global range of 33–87 years, and all series included patients older than 70. This demonstrates that even in the salvage setting, SPL could be used in a larger spectrum of patients.

Like all systematic reviews, there may be a publication bias with respect to centers publishing good outcomes. Thus, the results of our current review cannot be compared directly to other salvage techniques' data.

## Conclusions

SCPL produces excellent oncologic and acceptable functional outcomes. From the current review, it is evident that SCPL should be included as a valid option in radiorecurrent LSCC with a wider spectrum of indications: rT1 and rT2 lesions with limited endoscopic exposure and/or transcommissural extension, rT2 lesions with impaired cord mobility, rT3 lesions for limited paraglottic/pre-epglottic space invasion, recurrent LSCC with involvement of the thyroid cartilage without extralaryngeal extension. These results should encourage more centers to consider SCPL rather than total laryngectomy in selected recurrent LSCC. In a organ-sparing era, SCPL allows treatment to couple oncological and functional outcomes in a still-"conservative" scenario.

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### Compliance with ethical standards

**Conflict of interest** The authors declare no conflict of interest.

## References

1. Forastiere AA, Goepfert H, Maor M et al (2003) Concurrent chemotherapy and radiotherapy for organ preservation in advanced laryngeal cancer. N Engl J Med 349:2091–2098
2. Adelstein DJ, Li Y, Adams GL et al (2003) An intergroup phase III comparison of standard radiation therapy and two schedules of concurrent chemoradio- therapy in patients with unresectable squamous cell head and neck cancer. J Clin Oncol 21:92–98
3. Rizzotto G, Crosetti E, Lucioni M et al (2015) Oncologic outcomes of supratracheal laryngectomy: critical analysis. Head Neck 37:1417–1424
4. Budach W, Hehr T, Budach V, Belka C, Dietz K (2006) A meta-analysis of hyperfractionated and accelerated radiotherapy and combined chemotherapy and radiotherapy regimens in unresected locally advanced squamous cell carcinoma of the head and neck. BMC Cancer 6:28
5. Bonner JA, Harari PM, Giralt J et al (2006) Radiotherapy plus cetuximab for squamous-cell carcinoma of the head and neck. N Engl J Med 354:567–578
6. Zbären P, Nuyens M, Curschmann J, Stauffer E (2007) Histologic characteristics and tumor spread of recurrent glottic carcinoma: analysis on whole-organ sections and comparison with tumor spread of primary glottic carcinomas. Head Neck 29:26–32
7. Steiner W, Vogt P, Ambrosch P, Kron M (2004) Transoral carbon dioxide laser microsurgery for recurrent glottic carcinoma after radiotherapy. Head Neck 26:477–484
8. Quer M, Leon X, Orus C, Venegas P, Lopez M, Burgues J (2000) Endoscopic laser surgery in the treatment of radiation failure of early laryngeal carcinoma. Head Neck 22:520–523
9. Puxeddu R, Piazza C, Mensi MC, Ledda GP, Argiolas F, Peretti G (2004) Carbon dioxide laser salvage surgery after radiotherapy failure in T1 and T2 glottic carcinoma. Otolaryngol Head Neck Surg 130:84–88
10. Spriano G, Pellini R, Romano G, Muscatello L, Roselli R (2002) Supracricoid partial laryngectomy as salvage surgery after radiation failure. Head Neck 24:759–765
11. Marchese-Ragona R, Marioni G, Chiarello G, Staffieri A, Pastore A (2005) Supracricoid laryngectomy with cricohyoidopexy for recurrence of early-stage glottic carcinoma after irradiation. Long-term oncological and functional results. Acta Otolaryngol 125:91–95
12. Piazza C, Peretti G, Cattaneo A, Garrubba F, De Zinis LO, Nicolai P (2007) Salvage surgery after radiotherapy for laryngeal cancer: from endoscopic resections to open-neck partial and total laryngectomies. Arch Otolaryngol Head Neck Surg 133:1037–1043
13. Deganello A, Gallo O, De Cesare JM et al (2008) Supracricoid partial laryngectomy as salvage surgery for radiation therapy failure. Head Neck 30:1064–1071
14. Pellini R, Pichi B, Ruscito P et al (2008) Supracricoid partial laryngectomies after radiation failure: a multi-institutional series. Head Neck 30:372–379
15. de Vincentiis M, De Virgilio A, Bussu F et al (2015) Oncologic results of the surgical salvage of recurrent laryngeal squamous cell carcinoma in a multicentric retrospective series: emerging role of supracricoid partial laryngectomy. Head Neck 37:84–91
16. Laccourreye O, Weinstein G, Naudo P, Cauchois R, Laccourreye H, Brasnu D (1996) Supracricoid partial laryngectomy after failed laryngeal radiation therapy. Laryngoscope 106:495–498
17. Makeieff M, Venegoni D, Mercante G, Crampette L, Guerrier B (2005) Supracricoid partial laryngectomies after failure of radiation therapy. Laryngoscope 115:353–357
18. Leon X, Lopez M, Garcia J, Viza I, Orus C, Quer M (2007) Supracricoid laryngectomy as salvage surgery after failure of radiation therapy. Eur Arch Otorhinolaryngol 264:809–814
19. Luna-Ortiz K, Pasche P, Tamez-Velarde M, Villavicencio-Valencia V (2009) Supracricoid partial laryngectomy with cricohyoidoepiglottopexy in patients with radiation therapy failure. World J Surg Oncol 7:101
20. Nakayama M, Okamoto M, Hayakawa K et al (2013) Clinical outcome of supracricoid laryngectomy with cricohyoidoepiglottopexy: radiation failure versus previously untreated patients. Auris Nasus Larynx 40:207–210
21. Jorgensen K, Godballe C, Hansen O, Bastholt L (2002) Cancer of the larynx-treatment results after primary radiotherapy with salvage surgery in a series of 1005 patients. Acta Oncol 41:69–76
22. Weber RS, Berkey BA, Forastiere A et al (2003) Outcome of salvage total laryngectomy following organ preservation therapy: the Radiation Therapy Oncology Group trial 91-11. Arch Otolaryngol Head Neck Surg 129:44–49
23. Johansen LV, Grau C, Overgaard J (2004) Nodal control and surgical salvage after primary radiotherapy in 1782 patients with laryngeal and pharyngeal carcinoma. Acta Oncol 43:486–494
24. Ganly I, Patel SG, Matsuo J et al (2006) Results of surgical salvage after failure of definitive radiation therapy for early-stage

squamous cell carcinoma of the glottic larynx. Arch Otolaryngol Head Neck Surg 132:59–66
25. Paleri V, Thomas L, Basavaiah N, Drinnan M, Mehanna H, Jones T (2011) Oncologic outcomes of open conservation laryngectomy for radiorecurrent laryngeal carcinoma: a systematic review and meta-analysis of English-language literature. Cancer 117:2668–2676
26. Dalziel K, Round A, Stein K, Garside R, Castelnuovo E, Payne L (2005) Do the findings of case series studies vary significantly according to methodological characteristics? Health Technol Assess 9:1–146
27. National Institute for Health and Clinical Excellence (NICE). Appendix 4: quality assessment for case series. http://www.nice.org.uk/nicemedia/pdf/Appendix_04_qualityofcase_series_form_preop.pdf. Accessed 5 Dec 2017
28. Higgins JP, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ 327:557–560
29. Clark J, Morgan G, Veness M, Dalton C, Kalnins I (2005) Salvage with supracricoid partial laryngectomy after radiation failure. ANZ J Surg 75:958–962
30. Goodwin WJ Jr (2000) Salvage surgery for patients with recurrent squamous cell carcinoma of the upper aerodigestive tract: when do the ends justify the means? Laryngoscope 110:1–18
31. Jesse RH, Sugarbaker EV (1976) Squamous cell carcinoma of the oropharynx: why we fail. Am J Surg 132:435–438
32. Shah JP, Cendon RA, Farr HW, Strong EW (1976) Carcinoma of the oral cavity. factors affecting treatment failure at the primary site and neck. Am J Surg 132:504–507
33. Johansen LV, Overgaard J, Elbrønd O (1988) Pharyngo-cutaneous fistulae after laryngectomy. Influence of previous radiotherapy and prophylactic metronidazole. Cancer 61:673–678
34. Sassler AM, Esclamado RM, Wolf GT (1995) Surgery after organ preservation therapy. Analysis of wound complications. Arch Otolaryngol Head Neck Surg 121:162–165
35. Weber RS, Berkey BA, Forastiere A et al (2003) Outcome of salvage total laryngectomy following organ preservation therapy: the Radiation Therapy Oncology Group trial 91-11. Arch Otolaryngol Head Neck Surg 129:44–49
36. Roedel RM, Matthias C, Wolff HA, Schindler P, Aydin T, Christiansen H (2010) Transoral laser microsurgery for recurrence after primary radiotherapy of early glottic cancer. Auris Nasus Larynx 37:474–481
37. Ramakrishnan Y, Drinnan M, Kwong FN et al (2014) Oncologic outcomes of transoral laser microsurgery for radiorecurrent laryngeal carcinoma: a systematic review and meta-analysis of English-language literature. Head Neck 36:280–285
38. Kummer P, Chahoud M, Schuster M, Eysholdt U, Rosanowski F (2006) Prosthetic voice rehabilitation after laryngectomy. Failures and complications after previous radiation therapy. HNO 54:315–322