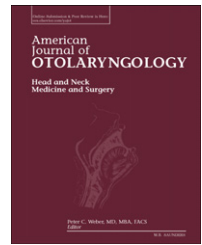


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# Subtotal supracricoid laryngectomy: changing in indications, surgical techniques and use of new surgical devices<sup>☆</sup>

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## ABSTRACT

**Purpose:** The aim of this study is to evaluate the evolution of supracricoid partial laryngectomy (SCPL) in indications, surgical techniques and outcomes through last decades.

**Materials and methods:** A retrospective analysis of 146 patients affected by laryngeal cancer treated with SCPL was carried on. We defined: (1) group A, 100 patients treated by cold instruments between 1995 and 2004; (2) group B, 46 patients treated by harmonic scalpel between 2005 and 2010. Complications rate, and functional and oncological results were documented and a comparison between the two groups was made; histopathological analysis of surgical margins was evaluated and correlated with local incidence of recurrence.

**Results:** Significant differences in age mean-value ( $p = 0.02$ ), T classification ( $p = 0.007$ ), and in indication for more advanced-staged patients were found in group B ( $p = 0.001$ ). Surgical procedure was shorter in group B ( $p < 0.001$ ), with shorter swallowing recovery ( $p = 0.003$ ). Oncological outcomes did not report any significant differences. Group B showed a higher incidence of post-operative arytenoid edema ( $p = 0.03$ ) associated with a lower rate of pneumonia ( $p = 0.038$ ). Despite a higher rate of close or positive-margins found in group B no higher incidence of local-recurrence was reported ( $p = 0.02$ ) compared to group A.

**Conclusions:** We documented changing in indications and surgical technique for SCPL because of the development of modern diagnostic techniques and the introduction of low-thermal injury device allowing a more challenging tumor excision as well as with a shorter swallowing recovery in our series.

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## 1. Introduction

Treatment options for laryngeal cancer include different radiation and surgical techniques, whose choice depends on

extension of the disease, clinical presentation and general health of patients. The main concern is tumor control together with organ function preservation when it is possible. Supracricoid partial laryngectomy (SCPL) provides a good surgical

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alternative to the conventional radiotherapy and total laryngectomy in the treatment of specific glottic and supraglottic cancers [1-4]. Supracricoid partial laryngectomy was initially introduced by Hofmann-Saguez in 1950 [5] and further discussed by Mayer and Rieder in 1958 [6]. In addition, the procedure was refined and found a practical validity and application by Labayle and Bismuth in 1971 [3], Alajmo in 1971 in Florence [7], and Piquet et al. in 1972 [8]. All of these surgeons proposed supracricoid partial laryngectomy as valid surgical alternative to total laryngectomy in elective T1 and T2 laryngeal cancer patients, describing it as a technique able to ensure recovery from the disease and laryngeal function preservation together.

So far, surgical indications have been changed and extended to more advanced staged cancers [1,4,9] because of the improvement of diagnostic technologies such as CAT scan and MRI [10,11], a more precise stage of the disease by endoscopic fiberoptic together with fluorescence or narrow banding imaging (NBI) exams [12-14], as well as because of the advent of new surgical devices [15] which allowed the improvement of the intraoperative management of the operation and the surgical technique as well. All of these changes, together with the help of frozen section analysis in the intraoperative control of resection margins [16,17], have determined a radical turn in the management of these laryngeal cancer patients during the last 40 years, furthermore, with the new concept that recurrent irradiated cancer has to be treated as a primitive one, with no worsening in staging status and surgical indication, with no absolute contra-indication for SCPL [18-20].

Accordingly, here we critically evaluated our personal experience in the last decades with SCPL with the aim to underline changing in indications, potential improvement in functional and oncological results and the impact of new surgical devices recently used at our Institute.

## 2. Materials and methods

### 2.1. Study population

We re-evaluated functional and oncological outcomes from 146 consecutive laryngeal cancer patients, treated at our academic tertiary referral center (First Clinic of Otorhinolaryngology, University of Florence, Azienda Ospedaliero Universitaria Careggi, Italy) between 1995 and 2010. The protocol for the retrospective controlled clinical study was approved by the Institutional Review Board, and it was conducted in accordance with all accepted standards for human clinical research. All patients gave written informed consent prior to study enrollment.

All of these patients underwent supra-cricoid partial laryngectomy (crico-hyoid-epiglottis-pexy CHEP or crico-hyoid pexy CHP) [2,3] as primary or salvage treatment for squamous-cell laryngeal cancer. The principal exclusion criteria counted patients with T4 lesions, low index of Karnofsky ( $\leq 80\%$ ), respiratory deficiency, cardiopathies, diabetes, obstructive bronco-pneumopathies, arthritis, neurological deficits, not eligible for open laryngeal conservative approaches [21,22].

To follow our aim, we divided SCPLs into two different groups: (1) group A: 100 patients, treated between 1995 and 2004, who underwent tumor excision by traditional cold instruments; (2) group B: 46 patients, treated between 2005 and 2010, where

primary cases were treated by using harmonic scalpel, while the use of warm instruments was avoided for the remaining 7 salvage cases. We excluded from the histopathological analysis salvage SCPLs that account for a total of 17 patients, 10 of them belong to group A and the remaining 7 patients belong to group B. We decided to perform this comparison between two different time periods in order to analyze and compare changing in surgical indications and technique, and their possible influence on postoperative outcomes and histopathological parameters, because 2005 saw the introduction of harmonic scalpel as a new device in this surgical procedure at our Clinic and the use of more fully-developed diagnostic instruments (i.e.: new CAT scan and MRI) made the staging procedure more accurate, helping in the better classification of laryngeal cancer patient and in giving indications for conservative open partial laryngectomy.

Tumor excision was carried out in accordance with standard surgical practice and indications of head and neck surgical oncology, in the strict observance of sterile conditions in the operating room and in general anesthesia regimen. The harmonic scalpel always presented similar setting when used in each surgical procedure: 55.5 kHz alternative current, with a dissecting tip blade 10 mm long and gently curved. It is able to cut and coagulate at a lower temperature (max 150 °C) using mechanical vibration at 55,500 cycles per second [23,24]. We avoided the use of harmonic scalpel in salvage procedure to reduce the high potential incidence of diffuse edema on irradiated field.

A classic scalpel, blade number 15 was used during the cold procedure in group A and for the 7 salvage cases of group B.

### 2.2. Re-evaluation of functional and oncological outcomes of the historical series

We applied a functional study protocol to analyze clinical parameters of each patient during their admission. We calculated from patients' hospital records the following data: (1) operation mean duration time, expressed in minutes; (2) difference in preoperative and immediate postoperative hemoglobin (Hb) mean value (g/dL); (3) mean duration time of drainage removal in patients who underwent neck dissection (ND) (mL); (4) total drainage production in patients who underwent ND (mL); (5) decannulation mean time (day); and (6) mean time of removal of naso-gastric-feeding tube (NGT) (day).

To compare functional outcomes, parameters about voice results, expressed in voice-handicap-index values (VHI) [25-27], and dysphagia recovery, analyzed by MD Anderson Dysphagia Inventory (MDADI) [28,29], were evaluated together with the performance of fiberoptic endoscopic analysis, videolaryngeal stroboscopy after the removal of the tracheocannula and videofluoroscopy (VDFS) test in patients near to restarting oral feeding [30,31].

Outpatient clinical follow-up data were collected and they included monthly clinical examination with performance of fiberoptic endoscopy during the first year after surgery, each 2 months during the second year, every 3 months during the third year then, each 4 and 6 months during the last 2 years of follow-up. Imaging study was always complementary to clinical examination, by computer-tomography-scan of neck and chest.

Considering the day of the salvage surgery as the starting day of the observation, follow-up was for a minimum of 2 years or until death (mean 45 months; minimum 6, maximum 180).

Follow-up end points included evidence of local or regional recurrence, death from disease or from other causes.

**2.3. Histological re-evaluation of excised margins from the 129 historical cases by a hypothetical model**

We retrospectively re-evaluated histopathological reports for each patient, from the pool of 129 primary SCPLs patients, and we reclassified them according to surgical margins status in: close (within 1-5 mm far from the inked margin edge), negative ( $\geq 5$  mm far from the inked margin edge) and positive margins (distance from the inked margin edge  $< 1$  mm) [32].

For margins from patients treated by low-thermal-injury devices a histological unreadable tissue area (high thermal injury) was identified, and pathologists evaluated in these cases surgical margins as the distance from the true inked margin to the closest cancer cell belonging to the closest cluster of malignant cells, considering the line between the unreadable and readable area as surgical margins status evaluation limit [33].

The re-interpretation of each histopathological report was carried on by referring to a quantitative model recently published by us (Table 1) [15]. Finally, the surgical margin status was correlated to the incidence of local recurrence as found by follow-up data.

**2.4. Statistics**

Statistical analysis was performed by STATA (Stata Corporation, College Station, TX, USA). Statistical significance was defined as  $p < 0.05$ . Kaplan-Meier disease-free survival was used to compare results among different groups.

**3. Results**

**3.1. Study population**

Clinical data of each patient-group and their statistical analysis are summarized in two different tables in order to simplify the visualization of their results (Tables 2 and 3). The sites and stage of the tumor have been classified according to the AJCC TNM, 2010 [34].

Among the primary treatment groups our results showed the presence of a significant difference in age mean-value between the two groups ( $p = 0.02$ ), where group A presented a mean value age of 57.4 years  $\pm 9.1$  SD (standard deviation), with a range of 24-70, while group B included a pool of older patients, with an age mean value of 61.2 years  $\pm 7.2$  SD, and 45 and 75 years as minimum and maximum values, respectively.

**Table 1 – Ranges, mean values and confident interval with standard deviation of measurable distances between calibrated margins )Reported from Mannelli et al. [13] [Epub ahead of print] ).**

	Harmonic scalpel-scalpel
Range	2.02-2.50 mm
mean value	2.226 mm
CI $\pm$ DS	2.08510-2.36748 $\pm$ 0.15266

No statistical differences were found in gender ( $p = 0.11$ ), alcohol consumption ( $p = 0.071$ ), smoke habits ( $p = 0.731$ ), and adjuvant postoperative radiotherapy ( $p = 0.24$ ) among the two study groups.

Group B presented a higher number of more advanced-staged laryngeal tumors, cT3 (28,2%), treated by open partial supracricoid laryngectomy than those performed at the same diagnostic stage in group A (20%), this value resulted to be statistically significant in our analysis ( $p = 0.02$ ). Moreover, the whole difference in T classification among the two groups was statistically outstanding ( $p = 0.007$ ), with a rise in number of more advanced patients who underwent this type of partial surgery, in association with an increasing in indications for CHEP than for CHP during the second period of analysis ( $p = 0.001$ ).

Among the salvage treatment groups our results showed no statistical differences in age mean-value between the two groups ( $p = 0.15$ ), where group A presented a mean value age of 57.60 years  $\pm 5.48$  SD, with a range of 48-66, while group B included a pool of older patients, with an age mean value of 60.71 years  $\pm 6.42$  SD, and 52 and 68 years as minimum and maximum values, respectively; neither significant  $p$  values was found in gender ( $p = 0.48$ ), alcohol consumption ( $p = 0.33$ ), smoke habits ( $p = 0.19$ .) among the two study groups.

Our results showed that before being treated with radiotherapy, 7 (41%) patients were initially seen with T1a carcinoma, 5 (29%) with T1b, 4 (24%) with T2 glottic cancer and 1 (6%) with T2 supraglottic carcinoma. Disease in all patients was clinically classified as N0, so that the series had 12 (70.5%) patients with stage I, and 5 (29.5%) patients with stage II. All tumors were biopsy proven squamous cell carcinomas. Patients were treated with curative radiation therapy; the total amount of laryngeal dose per patients ranged from 65 to 70 Gy (mean 66 Gy) fractionated over a period of 6 to 7 weeks. In the patients with stage II, neck lymphatic area of levels II-IV was included in the target volume with a dose of 50 Gy.

**Table 2 – Clinical characteristics of 129 historical cases.**

	Group A (90)	Group B (39)	$p$ value
Age (mean value, years)	57.4	61.2	0.02
Gender: male:female	82 (92.4%): 8 (7.6%)	39 (100%): 0 (0%)	0.11
Alcohol consumption	41 (45.6%)	10 (25.5%)	0.071
Smoke habit	71 (78.9%)	26 (66.7%)	0.731
postoperative radiotherapy	3 (3.3%)	4 (10.3%)	0.24
cT1a	16 (17.8%)	1 (2.6%)	0.02
cT1b	8 (8.9%)	8 (20.5%)	
cT2	47 (52.2%)	19 (48.7%)	
cT3	18 (20%)	11 (28.2%)	
cT4a	1 (1.1%)	0	
CHP <sup>a</sup>	73 (81.1%)	12 (30.8%)	0.001
CHEP <sup>a</sup>	17 (18.9%)	27 (69.2%)	
Local recurrences	17 (18.9%)	8 (20.5%)	0.27
Salvage total laryngectomy	13 (76%)	5 (62.5%)	0.78

<sup>a</sup> CHP (crico-hyoid pexy) and CHEP (crico-hyoid-epiglottis-pexy) [5,6].

**Table 3 – Clinical characteristics of 17 salvage SCPL historical cases.**

	Group A (10)	Group B (7)	p value
Age (mean value, years)	57.60	60.71	0.15
Gender: male:female	8 (80%): 2 (20%)	7 (100%): 0 (0%)	0.48
Alcohol consumption	4 (40%)	1 (14%)	0.33
Smoke habit	7 (70%)	4 (57%)	0.19
cT1a	5 (50%)	2 (28%)	0.32
cT1b	3 (30%)	2 (28%)	
cT2	2 (20%)	3 (44%)	
rT1a <sup>a</sup>	0 (0%)	1 (14%)	0.75
rT1b <sup>a</sup>	3 (30%)	1 (15%)	
rT2 <sup>a</sup>	5 (50%)	4 (57%)	
rT3 <sup>a</sup>	2 (20%)	2 (28%)	
Stage I	8 (80%)	4 (57%)	0.39
Stage II	2 (20%)	3 (44%)	
Stage III	0 (0%)	0 (0%)	
rStage I <sup>a</sup>	3 (30%)	1 (14%)	0.46
rStage II <sup>a</sup>	5 (50%)	4 (57%)	
rStage III <sup>a</sup>	2 (20%)	2 (28%)	
salvage CHP <sup>b</sup>	8 (80%)	4 (57%)	0.59
salvage CHEP <sup>b</sup>	2 (20%)	3 (44%)	
Neck dissection	2 (20%)	2 (28%)	1
Local Recurrences	1 (10%)	0 (0%)	1
Salvage total laryngectomy	1 (10%)	0 (0%)	1

<sup>a</sup> The sites and stage of the tumor have been classified according to the AJCC TNM, 2010 [31], where “r” means “recurrence”.

<sup>b</sup> CHP (crico-hyoid pexy) and CHEP (crico-hyoid-epiglottis-pexy) [5,6].

All radiotherapy failures were biopsy proven; contrast-enhanced CT scan of the neck and direct microlaryngoscopy under general anesthesia assessed the extension of the recurrent disease, and thoracic CT scan ruled out pulmonary metastases.

There was no statistical significance in cT classification of the primary tumor ( $p = 0.32$ ), rT classification of the recurrence ( $p = 0.75$ ), clinical stage of the pre-radiotherapy treatment tumor ( $p = 0.39$ ) and of the recurrence after radiotherapy failure ( $p = 0.46$ ), among group A and B.

In 8 (47%) patients with recurrent tumors, the restaging after radiotherapy was unchanged, while in the remaining 11 patients an upstaging was recorded (53%): in 5 (29.5%) patients we had a progression from stage I to stage II, in 3

(17.6%) patients from stage I to stage III, and in 1 (5.9%) patient from stage II to stage III. All 17 patients agreed with the procedure and signed an informed consent form to undergo SCPL: CHP was performed in 12 (70.6%) cases, while the remaining 5 (29.4%) patients underwent CHEP. Neck dissection was performed in 4 (24%) cases, homolateral elective selective neck dissection (SND) of levels II–IV was performed in 3 N0 patients, a therapeutic homolateral functional neck dissection of levels II–V was performed in 1 patient clinically N1. No significant  $p$  values were shown by statistical analysis of salvage SCPL ( $p = 0.59$ ) and neck dissection ( $p = 1$ ).

### 3.2. Re-evaluation of functional and oncological outcomes of the historical series

#### 3.2.1. Functional assessment

Perioperative, intraoperative and postoperative main functional parameters of the 146 SCPLs are summarized in Table 4.

Among these two groups, there was a significant difference in operation mean duration time between the two groups ( $p < 0.001$ ), with a significant reduction of about 26.76 minutes in surgery's duration mean time in group B than in group A. No statistical significances were found in blood loss, expressed in preoperative and postoperative Hb values (g/dL), neither in mean time of drainage removal or drainage amount production (mL) in those patients who underwent complementary surgical neck dissection, nor in decannulation mean time (days). On the other hand, naso-gastric-feeding tube (NGT) was removed earlier in group B than in group A, presenting a statistical  $p$  value of 0.003, associated with a faster recover of oral feeding intake.

Among the salvage treatment groups no statistical significances were found in operation mean duration time (minutes), blood loss, expressed in preoperative and postoperative Hb values (g/dL), neither in mean time of drainage removal or drainage amount production (mL) in those patients who underwent complementary surgical neck dissection, nor in decannulation mean time (days) and naso-gastric-feeding tube (NGT) removal between the two groups analyzed.

No significant differences were encountered in terms of VHI and MDADI scores in both two historical series analyzed. Swallowing function was studied also under videofluoroscopy vision 3 weeks after surgery, by following the secretion severity scale [35]. Patients were divided into three groups:

**Table 4 – Summary of functional parameters analyzed retrospectively of 129 historical cases.**

	Primary cases		Salvage cases	
	Group A (90)	Group B (39)	Group A (10)	Group B (7)
Operation mean duration time (minutes)	121.43 ± 35.57 SD	94.67 ± 25.01 SD	109.20 ± 11.02 SD	103.14 ± 5.81 SD
Difference in pre- and post- operative Hb mean value (g/dL)	1 ± 0.68 SD	0.82 ± 0.58 SD	0.9 ± 0.54 SD	0.89 ± 0.64 SD
Mean duration time of drainage removal in patients who underwent neck dissection (ND) (mL)	2.89 ± 0.87 SD	2.63 ± 0.75 SD	3.25 ± 0.81 SD	2.98 ± 0.92 SD
Total drainage production in patients who underwent ND (mL)	75.94 ± 47.22 SD	64.67 ± 45.92 SD	88.94 ± 56.21 SD	83.23 ± 38.09 SD
Decannulation mean time (days)	30 ± 21.5 SD (12–128)	26.1 ± 13.8 SD (13–70)	31.2 ± 25.61 SD	27.9 ± 11.6 SD
Mean time of removal of naso-gastric-feeding tube (NGT) (days)	27.4 ± 18.6 SD (2–104)	19.4 ± 13.6 SD (2–53)	30.3 ± 19.4 SD	29.1 ± 8.8 SD
VHI mean value	43/120	38/120	41/120	43/120
MDADI questionnaire	84.9	86.8	83.6	84.1

**Table 5 – Swallowing function analysis under videofluoroscopy vision, performed 3 weeks after surgery.**

Class	Group A		Group B		p value
	Primary SCPL (90)		Primary SCPL (39)		
I	15 (16.7%)	13 (33.3%)			0.535
II	44 (48.9%)	18 (46.2%)			
III	31 (34.4%)	12 (30.8%)			
Class	Salvage SCPL (10)		Salvage SCPL (7)		p value
	Primary SCPL (90)		Primary SCPL (39)		
I	2 (20%)	1 (15%)			0.637
II	5 (50%)	4 (57%)			
III	3 (30%)	2 (28%)			

(1) class I, with no evidence of saliva stagnation; (2) class II, with presence of saliva in the laryngeal vestibule; and (3) class III, with documented inhalation of saliva. Results of this clinical test are collected in Table 5. Neither this swallowing analysis showed statistical significant results.

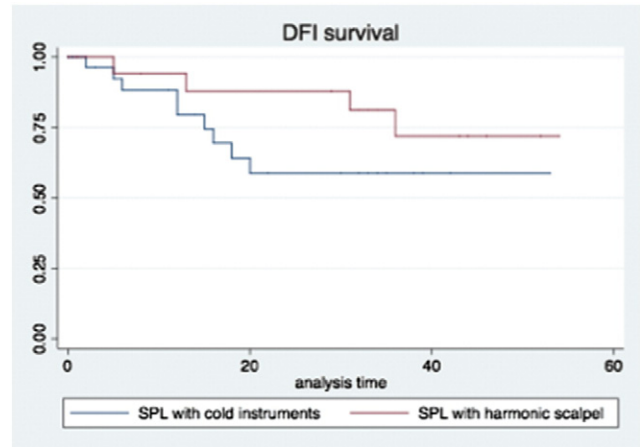
In addition, postoperative complications were evaluated for each patient during their recovery including: persisting dysphagia, dehiscence of the pexy, postoperative edema of the spared arytenoid unit, single or both, pharyngo-cutaneous fistula, *ab ingestis* pneumonia, neck abscess and postoperative bleeding. Their results are collected in Table 6.

Among primary SCPL groups, no reduction in postoperative complication rate was found in this comparison analysis among group A (41.1%) and group B (41%) ( $p = 1$ ). Complications that deserve to be counted are the incidence of postoperative arytenoid edema and of *ab ingestis* pneumonia. The first one presented a higher impact in group B (38.3%) than in group A (12.2%) with a statistical significant  $p$  value of 0.03; while, *ab ingestis* pneumonia showed a reduction in its incidence in the low-thermal injury device group (2.6%) than in group A (15.6%), presenting a  $p$  value of 0.038. The remaining complications did not report any statistical significances.

In salvage SCPL series no statistical significant  $p$  values were recorded; two patients experienced the edema of the spared arytenoid unit in the group B (28%), while in group A there was a total amount of 20% of complications rate, one of them was a pharyngo-cutaneous fistula (10%) and the other one the edema of the spared arytenoid unit (10%).

**3.2.2. Oncological outcomes**

Among the primary treatment groups, the incidence of local recurrence was of 18.9% in group A and of 20.5% in group B,



**Fig. 1 – Disease-free survival (DFS) analysis by comparing primary SCPL performed by cold instrument (group A) and by harmonic scalpel (group B) ( $p = 016$ ).**

without any significant  $p$  value ( $p = 0.27$ ) (Table 2). Consequently, salvage total laryngectomy was performed in 13 patients of 17 patients in group A (76%) and in 5 patients of 8 patients in group B (62.5%), without showing any statistical significance among the two analyzed groups ( $p = 0.78$ ) (Table 2).

Disease-free survival (DFS) ( $p = 0.16$ ) (Fig. 1) and actuarial survival (AS) ( $p = 1$ ) (Fig. 2) analysis did not evidence any statistical significant results between primary SCPL groups.

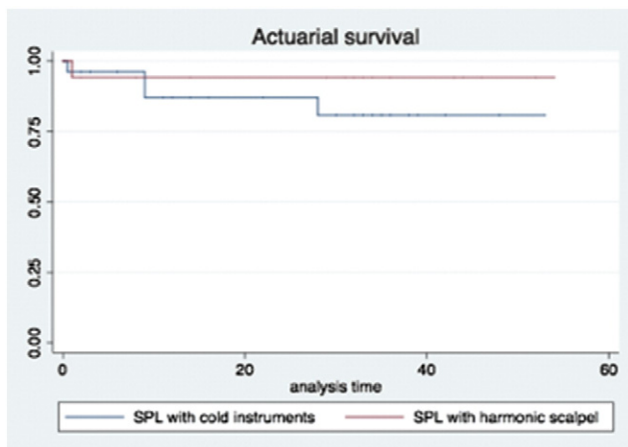
Among the salvage treatment groups one patient in group A underwent a totalization of the laryngectomy because of second local recurrence after 20 months. No statistical differences were found in the locoregional control between the two groups.

**3.3. Histological re-evaluation of excised margins from the 129 historical cases by a hypothetical model**

There were 79 negative-margins cases out of 90 in group A; this value reduced by about 18.6% in group B ( $p = 0.3089$ ), without showing any statistical significant difference in incidence of local recurrence between the two groups. The histopathological analysis showed an increase in number of positive margins, which passed from 5.5% in group A to a percentage of 12.8 in group B ( $p = 0.5238$ ), and of close-margins ( $p = 0.0291$ ) in the harmonic scalpel group than in group A,

**Table 6 – Postoperative complications evidenced in the 146 historical series.**

Complications	Primary SCPL			Salvage SCPL		
	Group A (90)	Group B (39)	p value	Group A (10)	Group B (7)	p value
Dysphagia	25 (27.8%)	13 (33.3%)	0.5	0	0	1
Dehiscence of the pexy	2 (2.2%)	0	0.12	0	0	1
Edema of one or both spared arytenoid unit	11 (12.2%)	15 (38.3%)	0.03	1 (10%)	2 (28%)	0.5
Pharyngo-cutaneous fistula	3 (3.3%)	1 (2.6%)	1	1 (10%)	0	1
Pneumonia <i>ab ingestis</i>	14 (15.6%)	1 (2.6%)	0.038	0	0	1
Neck abscess	1 (1.1%)	2 (5.1%)	0.217	0	2 (28%)	1
Postoperative bleeding	3 (3.3%)	3 (7.7%)	0.366	0	0	1
Total	37 (41.1%)	16 (41%)	1	2 (20%)	2 (28%)	1



**Fig. 2 – Actuarial survival (AS) analysis by comparing primary SCPL performed by cold instrument (group A) and by harmonic scalpel (group B) ( $p = 1$ ).**

where they passed from a value of 6.7% to a value of 17.9%, respectively. Nonetheless, the higher rate of close and positive-margins reported in group B was associated with a statistically no higher incidence of true local recurrences ( $p = 0.02$ ) when compared with group A during follow-up period. Results of this retrospective analysis are summarized in Table 7.

Overall, all positive-cases underwent post-operative radiotherapy, while close-margins were admitted to strict follow-up. We also documented a better local control during follow-up, in group B compared to group A, particularly in patients with close/positive-margins report.

Harmonic scalpel probability distribution estimation for each measurement modality was applied, in accordance with published quantitative model of evaluation [15], to the respective distances that were observed for the 5 positive-margins and the 7 close-margin sections from our dataset (Table 7), and this method was also used to derive expected changes in margins status. The 50% of the sum of tissue retraction (S) and loss of readable tissue (SA) (Table 1) best described the margins analyzed; upon this setting, it is expected the following changes would occur if harmonic scalpel was replaced by traditional scalpel: 25% no change in classification, 40% of positive margins re-classified as potentially close or negative margins, and 58% of the total amount of close and positive margins re-classified as negative (Fig. 3).

#### 4. Discussion

The critical review of our historical series together with a literature comparison, highlighted the progressive changes in laryngeal open conservative surgery indications and techniques. A comparison among original indications to SCPL [3–8] and recent literature results [9,15,16], supports a clear development and more extended use of this procedure [33–37]. Progression in CAT scan and MRI [10,11], as well new diagnostic endoscopic laryngeal procedures [12–14], allow a millimetric evaluation of tumor extension with a

more accurate treatment planning, rendering the surgeon more confident in SCPL option.

Accordingly, here we reported a larger use of SCPL in older patients ( $p = 0.02$ ), T3 staged patients ( $p = 0.02$ ) and for CHEP than for CHP ( $p = 0.001$ ). These results are in accordance with those reported by other authors in literature [38,39]. In addition, SCPL has achieved a progressive more outstanding role as salvage conservative procedure after radiotherapy failure [40,41].

It is well known that open partial laryngectomy technique requires the preservation of specific anatomical units in order to maintain organ function [2,3], and the removal of a few millimeters of unaffected mucosa could compromise the conservative intent. Frozen section margins aim to help surgeons in obtaining disease-free resection [16,17], allowing considering 1–2 mm of healthy tissue as safe distance to keep far from the tumor front.

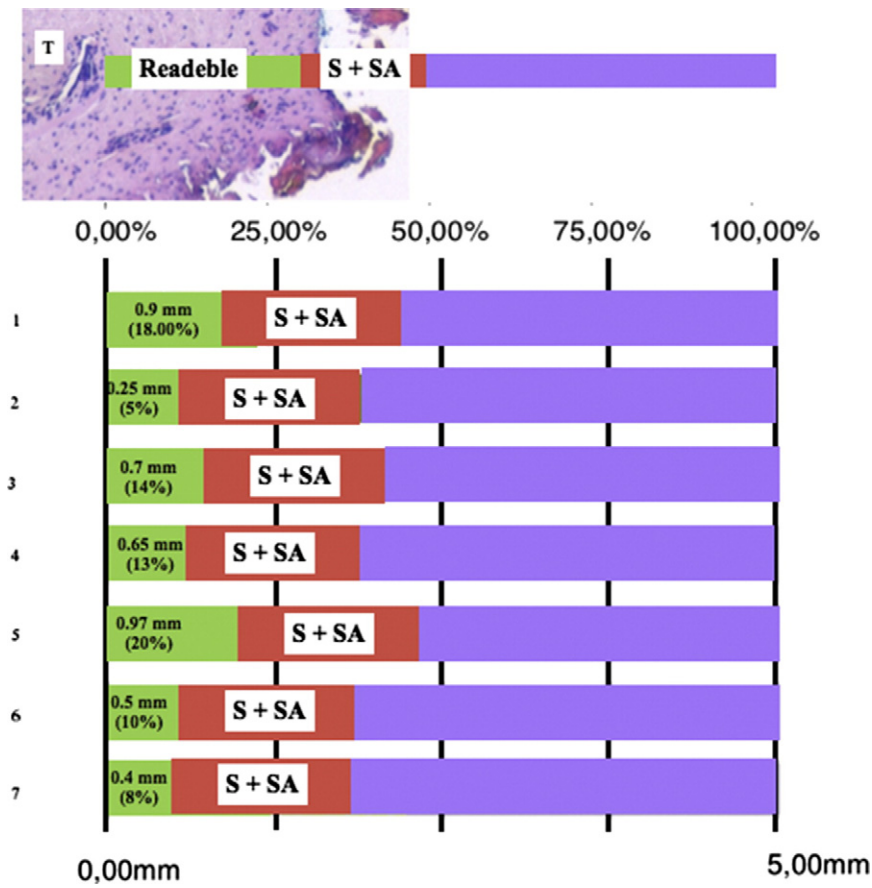
Obviously, the changes in the last decade according to extended indications and good functional results, could be due also to improvement in learning curve usually documented for more challenging surgery, although we compared patients surgically treated by different surgeons of different generations.

Because of these changes, thus, we would expect a higher incidence of close and positive margins at the final histopathological report, with an increase risk for patients treated by SCPL. Interestingly, despite the higher number of close and positive margins declared in the harmonic scalpel group study, no higher incidence of local recurrences was reported ( $p = 0.02$ ). This potential discrepancy in group B patients versus group A, might be explained according to a model recently reported by us [15] suggesting that the use of low-thermal-injury device affects the assessment of surgical margins. In accordance with this model, considering its thermal effect on the healthy tissue, we documented a conversion of margins definition approximately 52%.

Additionally, our analyses demonstrated that the use of harmonic scalpel did not offer, in comparison with classic scalpel surgical dissection, any improvements in terms of postoperative

**Table 7 – Surgical resection margins status of 129 comparative patients study.**

Type of margin	Primary (90)	Recurrence (18.9%)
Group A (90)		
Negative-margin	79 (87.8%)	8 (10.1%)
Positive-margin	5 (5.5%)	4 (80%)
Close-margin	6 (6.7%)	5 (83.3%)
Type of margin	Primary (39)	Recurrence (20.5%)
Group B (39)		
Negative-margin	27 (69.2%)	5 (18.5%)
Positive-margin	5 (12.8%)	2 (40%)
Close-margin	7 (17.9%)	1 (14.3%)
Type of margin	p value	
group A vs. group B		
Negative-margin	0.3089	
Positive-margin	0.5238	
Close-margin	0.0291	



**Fig. 3 – Probabilities of seven examples of 4 close margins and 3 positive margins change to negative margin status if traditional cold instrument were used for tumor excision. Each margin is associated with a readable area (green), and unreadable area (red) which is the result of the sum of S and SA for the harmonic scalpel, whose mean value is of 1.113 mm, which should be added to the value represented by the green area.**

outcomes, even if ultrasonic dissection guaranteed a reduction in operative duration mean time without any rise in risk for developing wound, bleeding or other functional postoperative complications.

## 5. Conclusions

This work demonstrates the increase in conservative surgery indications in older patients, for T3 staged cancer cases and for CHEP than CHP, developed during the last decade, together with the good oncological and functional results achievable in case of salvage surgery after radiotherapy failure. On primary treated patients, we showed that cold instruments and ultrasonic dissections appear to have similar outcomes. On the contrary, harmonic scalpel seems to ensure a better intraoperative bleeding control, with a reduction in operative time, an associated faster oral intake recovery and a significant less incidence in postoperative pneumonia *ab ingestis*. Nonetheless, even if warm instruments help surgeons in improving surgical accuracy and post-operative outcomes in conservative surgery, we suggest to use cold instruments when few millimeters represent a surgical margin limit for conservative intraoperative decision making, due to the

higher rate of close and positive margins reported. Moreover, the avoidance of warm instruments in case of irradiated fields is warranted to reduce the incidence of possible postoperative complications linked to diffuse mucosal edema and late wound healing.

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