

Functional and oncological outcomes of transoral laser versus robotic surgery in supraglottic squamous cell carcinoma

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ABSTRACT

Objective: To compare the surgical, functional and oncological outcomes of Transoral Laser Microsurgery (TLM) and Transoral Robotic Surgery (TORS) for the treatment of supraglottic squamous cell carcinoma.

Study Design:

Retrospective case series with prospective data.

Settings:

Tertiary Academic Medical Center.

Methods: A chart-review analysis, with prospective follow-up was performed on 122 patients treated for a supraglottic squamous cell carcinoma with either TLM or TORS between 2003 and 2019. Patients were grouped according to the surgical technique used. Clinical, surgical, functional and oncological outcomes were compared, including local and regional controls, DFS, and OS, and postoperative complications.

Results: A total of 122 patients, including 47 treated with TLM and 75 with TORS. Negative margins were observed in $n = 12/47$ (25.5 %) of TLM cases and $n = 4/75$ (5.3 %) of TORS cases ($p < 0.05$). There was no significant difference between the two techniques in terms of 5-year local and regional control, however a significant difference was found in disease-free survival and overall survival. The functional laryngeal preservation rate was 97.8 % in the TLM group and 100 % in the TORS group.

Conclusion: Both techniques appear to be safe and effective, though TORS shows superiority in achieving negative margins compared to TLM. Therefore, the choice of technique should be tailored to available resources, surgical team preferences, and experience, while also considering the learning curves associated with each approach.

Introduction

Laryngeal cancer accounts for 1 % of all cancer cases worldwide, ranking 20th, with 189,191 new cases in 2022 [1]. Squamous cell carcinomas of the larynx are classified into three categories based on their location: supraglottic, glottic and subglottic. Regarding the supraglottic stage, tumors are further divided into two locations: medial and anterior versus lateral supraglottic larynx.

In the past decades, technological advancements have revolutionized head and neck surgery, introducing minimally invasive and endoscopic techniques like Transoral Laser Microsurgery (TLM) and Transoral Robotic Surgery (TORS) for treating laryngeal and pharyngeal carcinomas. These innovations have significantly transformed the management of laryngeal and oropharyngeal cancers, offering alternatives to traditional open surgery and radiotherapy for locally confined tumors. Currently, TORS is widely accepted for managing cT1-T2 tumors in the

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oropharynx, while TLM is the preferred approach for glottic laryngeal tumors. Both techniques achieve cancer treatment outcomes comparable to radiotherapy and open surgery while minimizing functional impairment, thereby improving patients' quality of life [2–8].

While TLM and TORS have been extensively studied independently to assess their feasibility, research on their efficacy in treating supraglottic laryngeal carcinoma is scarce. Few studies to date have compared these two minimally invasive techniques for managing squamous cell carcinoma of the supraglottic larynx.

The aim of this study was to compare TLM and TORS supraglottic laryngeal squamous cell carcinoma (SGL-LSCC) in terms of surgical, functional, and oncological outcomes.

Methods

Ethical consideration

Consent was waived for this analysis because patient non-opposition was obtained for the use of anonymous data from their medical files. Study approval has been obtained by

Institutional Review Board (IRB) n°IRB-00012437.

Population characteristics

A retrospective review, with prospective follow-up, was conducted in a single center study on patients treated between 2003 and 2019 for cT1, cT2, and some selected cT3 supraglottic squamous cell carcinoma using a transoral approach. Patients were categorized into two groups based on the surgical technique employed: TLM or TORS. Patients were excluded if they met any of the following characteristics: age under 18 years, prior radiotherapy, non-invasive squamous cell carcinoma (SCC) tumors, cN3 tumors, metastases at the time of diagnosis, fixation of one or both vocal folds, salvage surgery. For inclusion, cT3 tumors could be supraglottic cancers with mild invasion of the pre-epiglottic space or involvement of one of the arytenoids. cT3 tumors were excluded in case of frank invasion of the pre-epiglottic space, invasion of the posterior commissure, retrocricoid invasion and immobility of both arytenoids.

The preoperative assessment included: awake nasofibroscope to evaluate the tumor and assess the mobility of the arytenoids and vocal cords, head and neck CT scans and PET CT or Chest CT scans to assess tumor extension.

All cases were reviewed by a multidisciplinary oncological board with radiotherapists, oncologists, histologists, radiologists and surgeons. The feasibility of transoral exposure was systematically evaluated during the initial head and neck endoscopy.

The surgical team was led by the senior surgeon (S.H.), who held responsibility for determining indications and overseeing follow-up. The senior surgeon was consistently present during each procedure and directly involved in the intervention. Under the senior surgeon's supervision, several assistant surgeons (non-residents) participated in procedures throughout the study; however, they were not considered accountable for the operative and oncological outcomes achieved. Patient selection was based on the senior transoral surgeon's expertise, experience with both techniques, all available imaging resources, prior endoscopic examination results, and guidelines pertaining to tumor size and location (TNM classification and the European Laryngological Society classification for endoscopic supraglottic laryngectomy published by Remacle et al. in 2009) [9].

The following patient and tumor characteristics were reviewed: age, gender, previous radiotherapy or surgery, histology of the tumor, clinical and pathological stage (according to the 8th TNM classification system; UICC) [10].

Transoral laser microsurgery setting and procedure

TLM was performed using a carbon dioxide (CO₂) laser coupled with

a micromanipulator and microscope, allowing for precise tissue resection, simultaneous hemostasis, and improved visualization. The larynx was exposed using a laryngoscope, which, once the lesion was adequately visualized, was secured with a suspension system, freeing both of the surgeon's hands.

Transoral robotic surgery setting and procedure

TORS was performed with the Da Vinci® system (Intuitive Surgical®, Sunnyvale, United-States.). The surgeon exposed the tumor with a Feyh-Kastenbauer (FK) (Gyrus Medical Inc., Tuttlingen, Germany) mouth retractor. A second surgeon was positioned at the patient's head to aspirate blood, smoke or adjust exposure. A clip was prepared for potential intraoperative bleeding.

Type of supraglottic laryngectomy

The classification of supraglottic laryngectomy (SGL) was based on the European Laryngological Society Classification published by Remacle et al. in 2009 [9]. Type I is a limited, small and superficial excision of any part(s) of the supraglottic larynx. Type II is a medial supraglottic laryngectomy without resection of the pre-epiglottic space. Type III is a medial supraglottic laryngectomy with resection of the pre-epiglottic space. Type IV consists of a lateral supraglottic laryngectomy involving excision of a threefold area, a ventricular band, an arytenoid unit, or the inner, medial and/or anterior part of the piriform sinus.

Neck dissection

Unilateral neck dissection was performed in the same surgery before the transoral time. If bilateral neck dissection was required, the contralateral neck dissection was performed one month later to reduce the risk of edema and tracheotomy.

Histopathological outcomes

Pathological examinations focused on evaluating the surgical and tumoral margin status, lymph node invasion, extracapsular lymph node spread and perineural or lymphovascular invasion. Surgical margins were classified as negative (R0) when equal to or greater than 3 mm on surgical specimen, close (R1) when less than 3 mm but greater than 1 mm and Positive (R2) when less than 1 mm.

Surgical and functional outcomes

The surgical, clinical, and functional outcomes evaluated included type of SGL [9], set-up time and operating time, estimated mean blood loss, tracheotomy, feeding tube or gastrostomy use, average length of hospital stay, and surgical revision.

Within each group, patients were further categorized into two subgroups according to the tumor's location and the type of SGL: Group A (medial and anterior supraglottic larynx) includes tumors that invaded the free border of the epiglottis, the epiglottis, or the pre-epiglottic space. Group B (lateral supraglottic larynx and piriform) includes tumors with an invasion of the aryepiglottic fold, the arytenoid cartilage, the three-fold area, the lateral side of the epiglottis, or the inner, medial, and anterior part of the piriform sinus.

The postoperative complications assessed were aspiration, pneumonia, *delirium tremens*, neck hematoma, minor (requiring medical treatment) and major (requiring surgical treatment) hemorrhages, and emergency postoperative tracheotomy.

Oncological outcomes

The oncological outcomes included: local recurrence (5-year local control), regional recurrence (5-year regional control), distant

recurrence (occurrence of metastases), disease-free survival (5-year DFS), overall survival (5-year OS), date and cause of death if applicable.

Adjuvant treatment

Depending on tumor histopathological characteristics some patients received postoperative adjuvant radiotherapy or chemoradiotherapy. If indicated by the tumor multidisciplinary board after surgical resection, adjuvant treatment protocols were similar in both groups. The standardized radiotherapy protocol involved conventional doses of 64 Gy, over 30 fractions in 6 weeks, starting 4 to 6 weeks after the surgical procedure. Chemotherapy was cisplatin (100 mg/m² of body surface area intravenously on days 1, 22 and 43).

Statistical Methods

Statistical analyses were performed using R Core Team 2020 software® (R Foundation for Statistical Computing) and Prism software (version 10, GraphPad Software, San Diego, CA, USA). The post-operative outcomes were analyzed through a comparison between two groups of patients Depending on the data distribution, appropriate statistical tests were used for group comparisons: Fisher's exact Test, Chi-Square Test, T-Student Test, and Mann-Whitney U Test. Survival outcomes, including five-year local and regional control, overall survival (OS), and disease-free survival (DFS), were analyzed using Kaplan-Meier survival analysis. A p-value of $p < 0.05$ was considered statistically significant.

Results

A total of 122 patients met our inclusion criteria and received transoral SGL between 2003 and 2019. Forty-seven patients underwent SGL with TLM between 2003 and 2019. Seventy-five patients underwent SGL with TORS between 2009 and 2017. In the TLM group, only eleven patients underwent a PET in the initial assessment, compared to all patients in the TORS group. The average follow-up period ranged from 2 to 5 years in both groups. All patients received a minimal 5-year follow-up according to the recommendations of the French Society of Otolaryngology guidelines [11]. Only one patient was lost to follow-up after the second year. Patient's clinical characteristics are presented in Table 1.

Table 1
Patient Characteristics.

Characteristics	TLM n = 47 No. (%)	TORS n = 75 No. (%)	p-Value
Sex			0.61
Male	37 (78.7)	62 (82.7)	
Female	10 (21.3)	13 (17.3)	
Mean age, yr. (range)	58.1 (35–77)	58.2 (41–78)	NS
Type of SGL			1.0
I	18 (38.3)	30 (40.0)	
II	13 (27.7)	21 (28.0)	
III	4 (8.5)	5 (6.7)	
IV	12 (25.5)	19 (25.3)	
Neck dissection			1.0
Performed	45 (95.7)	71 (94.7)	
Unilateral	19 (40.4)	31 (41.3)	
Bilateral	26 (55.3)	40 (53.3)	
Not performed	2* (4.3)	4* (5.3)	
Adjuvant treatment	17 (36.2)	26 (34.7)	0.18
Adjuvant RT alone	8 (17.0)	6 (8.0)	
Adjuvant RTCT	9 (19.1)	20 (26.7)	

Abbreviations: SGL, supraglottic laryngectomy; TLM, transoral laser microsurgery.

TORS, transoral robotic surgery.

*refusal and cN0 patients.

Regarding tumor characteristics, there were $n = 42/47$ (89 %) cT1-T2 in the TLM group and $n = 70/75$ (93 %) cT1-T2 in the TORS group. Few tumors were classified as cT3, with respectively $n = 4$ (11 %) and $n = 5$ (7 %) in the TLM and TORS groups. Regarding clinical nodal status, there were $n = 38/47$ (81 %) cN0-N1 in the TLM group and $n = 56/75$ (75 %) cN0-N1 in the TORS group. A few patients were classified as N2, with $n = 9$ (19 %) in the TLM group and $n = 19$ (25 %) in the TORS group. No cN3 patient was included.

Neck dissection, adjuvant treatment, and histopathological findings

Neck dissections were performed in both groups as shown in Table 1. Adjuvant treatments are presented in Table 1. The histopathological characteristics for both groups are presented in Table 2.

In the TLM group, patients with positive margins ($n = 12/47$ [25 %]) underwent a second look with re-resection one month after the initial TLM surgery. One patient with positive surgical margins refused a new surgery and received chemoradiotherapy instead. After 2nd-time resection, final positive-margins toll was $n = 3/47$ (6 %) in TLM.

In the TORS group, surgical margins of the *en bloc* excised tumor were positive in $n = 4/75$ cases (5.3 %), but the intraoperative revisions of the surgical margins using re-cuts during the initial surgery were all negative. The oncological board did not indicate adjuvant radiotherapy on the tumor site regarding the negative intraoperative re-cuts and considered all the patients as having negative margins.

Clinical and functional outcomes

With TLM, the estimated mean blood loss was less than 5 ml, except for two patients who had losses greater than 10 ml due to intraoperative hemorrhage. With TORS, the mean estimated blood loss was 20 ml.

Surgical, clinical, and functional outcomes are described in Table 3.

In the TLM group, tracheotomy decisions were influenced by patient age, hemorrhage control, and aspiration risk, especially in cT3 cases. The average tracheotomy duration was 4 days (range 2–6), and feeding tubes were used for an average of 5 days (range 3–7). Speech therapy facilitated a transition to a mixed diet, though three cT3 patients required temporary gastrostomies for 17 weeks on average due to aspiration and planned radiotherapy.

In the TORS group, tracheotomies were performed for hemorrhage control in four patients, with an average feeding tube duration of 6 days. Most patients resumed oral intake within a day under supervision. Two

Table 2
Histopathological Features.

Characteristics	TLM n = 47 No. (%)	TORS n = 75 No. (%)	p-Value
Margin status (1st time surgery)			
Positive (<1 mm)	12 (25.5)	4 (5.3)	0.004
Close (1–3 mm)	15 (31.9)	23 (30.7)	
Negative (> 3 mm)	20 (42.6)	48 (64.0)	
Margin status (2 nd time surgery)	11* (23.4)	NA	NA
Positive (<1 mm)	3 (6.4)		
Close (1–3 mm)	0 (0.0)		
Negative (> 3 mm)	8 (17.0)		
Margin status (after 1st and 2 nd time surgeries)			
Positive (<1 mm)	4 (8.5)	NA	NA
Close (1–3 mm)	15 (31.9)		
Negative (> 3 mm)	28 (59.6)		
Lymph node invasion (pN +)	24 (51.0)	39 (52.0)	1
Perineural Invasion	6 (12.8)	12 (16.0)	0.79
Lymphovascular invasion	5 (10.6)	13 (17.3)	0.57
Extracapsular spread	11 (23.4)	16 (26.7)	0.82

Abbreviations: TLM, transoral laser microsurgery; TORS, transoral robotic surgery; NA, not applicable.

*One patient with positive margins refused 2nd time surgery.

Table 3
Clinical and functional Outcomes.

Outcomes	TLM n = 47	TORS n = 75	p-Value
Transient tracheotomy, no. (%)	5 (10.6)	6 (8.0)	0.75
Transient feeding tube, no. (%)	5 (10.6)	8 (10.7)	1.0
Transient gastrostomy, no. (%)	3 (6.4)	2 (2.7)	0.37
Complications, no. (%)			
Aspiration pneumonia, no. (%)	3 (6.4)	3 (4.0)	0.67
Delirium tremens, no. (%)	3 (6.4)	1 (1.3)	0.30
Neck hematoma, no. (%)	1 (2.1)	3 (4.0)	1.0
Hemorrhage, no. (%)	9 (19.1)	12 (16.0)	0.81
Medical treatment, no. (%)	7 (14.9)	8 (10.6)	0.57
Surgical treatment, no. (%)	2 (4.3)	4 (5.3)	1.0
Postoperative tracheotomy, no. (%)	0 (0.0)	0 (0.0)	1
Mean hospital stay, d, median (range)	6.0 (2–25)	6.8 (4–28)	NS
Definitive tracheotomy, no. (%)	0 (0.0)	0 (0.0)	1
Definitive gastrostomy, no. (%)	0 (0.0)	0 (0.0)	1

Abbreviations: TLM, transoral laser microsurgery; TORS, transoral robotic surgery; NS, not significant.

patients required temporary gastrostomies due to recurrent aspiration and scheduled radiotherapy, which were removed after 2–3 months.

Oncological outcomes

The 5-year oncological outcomes are described in Table 4.

In the TLM group, the 6 patients with local recurrences were treated with TLM (n = 2), TLM + radiation (n = 2), total laryngectomy with bilateral neck dissection (n = 1), and one patient refused treatment and subsequently died. The median time to local recurrence was 15.7 months (range: 2–46 months). The overall functional laryngeal preservation rate was 97.8 %, with 100 % for cT1-T2 tumors and 75 % for cT3 tumors, with one case requiring a total laryngectomy.

In the TORS group, the six patients with recurrences were treated with TORS (n = 1), TORS + radiation (n = 1), TLM (n = 3), and TLM + radiation (n = 1). The median time to local recurrence was 22.0 months (range: 2–54 months). The functional laryngeal preservation rate was 100 %.

Comparative analysis with Kaplan-Meier survival curves about local recurrence and overall survival (OS) rates are described in Fig. 1.

Surgical outcomes

The mean laser set-up and operating time (excluding neck dissection and tracheotomy time) were 5 min and 57 min, respectively. The mean robotic set-up and operating time were 15 min and 38 min, respectively. Operating times according to the tumor's location are described in Table 5.

Discussion

A retrospective study comparing the outcomes of patients who underwent transoral supraglottic laryngectomy between 2003 and 2019, using either laser or robot-assisted surgery was conducted. To our knowledge, this is the largest European cohort published on this topic,

Table 4
Oncological outcomes.

Outcomes	TLM n = 47	TORS n = 75	p-Value
5-year local control (%)	92.5	93.2	NS
5-year regional control (%)	85.3	89.2	NS
5-year DFS (%)	80.4	94.3	0.02
5-year OS (%)	70.5	80.2	0.03

Abbreviations: TLM, transoral laser microsurgery; TORS, transoral robotic surgery; DFS, disease-free survival; OS, overall survival; NS, not significant.

with a total of 122 patients. These results are original. Indeed, comparisons between TLM and TORS for supraglottic laryngectomies are scarce in the literature [12,13]. This is the first study to provide 5-year survival results. According to us, this study demonstrates the superiority of TORS over TLM to achieve clear margins, with 100 % clear margins achieved after resection in TORS compared to 94 % in TLM, although the latter sometimes required two surgical interventions. Both techniques showed a similar safety profile and functional preservation.

Regarding surgical margins, this difference in favor of the TORS is consistent with the findings of Papazian *et al.* published in 2023, who reported positive margins in 30.5 % of patients treated with TLM compared to 16.9 % in the TORS group ($p < 0.001$) [13]. In our study, all patient with positive margins in the TLM group (n = 11) underwent a second TLM surgery one month later, except one who refused. In contrast, the four patients with positive margins in the TORS group did not require a second surgery, as we performed intraoperative revisions of the surgical margins during the initial surgery, which all resulted in negative margins. This finding highlights the importance of performing intraoperative revisions of the surgical margins using re-cuts and illustrates the additional difficulty to do so in TLM compared to TORS. Despite this significant difference, no significant difference was observed in terms of adjuvant treatment rates between the TLM group and the TORS group. Moreover, laryngeal preservation was 100 % in the TORS group versus 97.8 % in the TLM group.

Postoperative complication rates were similar between the two groups, with manageable incidences of hemorrhage and other complications. No significant difference was observed in the length of hospital stay, which averaged 6.0 and 6.8 days for the TLM and TORS, respectively. On the contrary, the study published in 2023 by Papazian *et al.* on 1,603 patients found a longer hospital stay in the TORS group, with an average of 6.8 days in hospital compared with 2.2 days in the TLM group ($p < 0.001$) [13]. This difference could be explained by a greater caution on the part of surgeons with TORS, reflected in longer postoperative monitoring in the hospital. Hence, TORS is a more recent surgical technique with which surgeons generally have fewer years of experience. It should be noted that these lengths of stay remain lower than the average lengths of stay found in the literature for open partial laryngectomy, which is close to 3 weeks [14,15].

From a functional perspective, there was no significant difference between TLM and TORS, particularly concerning the number and duration of enteral nutrition and tracheotomy. All patients were discharged home without a tracheotomy, and none required a permanent gastrostomy. This consistency in outcomes is expected, as TLM and TORS are based on the same surgical principle: remove all the tumor while preserving as much of the healthy larynx as possible. As a result, for two tumors of similar size and location, the resulting laryngeal resection is equivalent in transoral surgery, whether the procedure is performed using laser or robotic assistance.

Regarding the 5-year local and regional tumor control, we did not find any significant differences between the TLM and TORS groups. Both techniques demonstrate strong local and regional control with a low recurrence rate, with the 5-year local control rate exceeding 92 % in both groups. Achieving local disease control is a central goal of minimally invasive management for supraglottic laryngeal squamous cell carcinomas, which carry a high risk of local recurrence [16]. Effective local control is key to preserving the larynx, thereby maintaining essential functions such as breathing, swallowing, and phonation, which are crucial to patients' quality of life [17]. Avoiding radiotherapy, when possible as part of an initial transoral surgical approach—achieved in 30 out of 47 patients in the TLM group and 49 out of 75 in the TORS group—also lowers the chance of laryngeal sacrifice in the event of recurrence [18]. This factor, combined with the excellent local control rate, is crucial for achieving a higher rate of laryngeal preservation, provided that cases and patients are carefully selected.

Surprisingly, significantly higher 5-year disease-free survival (DFS) and overall survival (OS) were observed in the TORS group ($p < 0.05$),

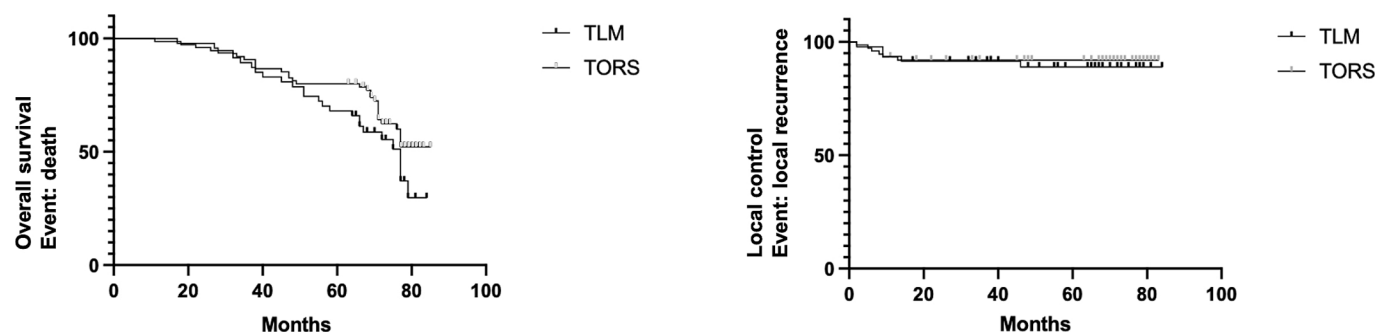


Fig. 1. Kaplan-Meier survival curves showing the probability of survival (left) and local control (right) between Transoral Laser Microsurgery (TLM) (black) and Transoral Robot Surgery (TORS) (grey) for supraglottic squamous cell carcinoma. Data were analyzed using Prism software (version 10, GraphPad Software, San Diego, CA, USA).

Table 5
Mean operating time (minutes) according to the tumor's location.

Type of SGL	TLM			TORS			p-Value
	Group A	Group B	All n =	Group A	Group B	All n =	
	n = 27	n = 20	47	n = 42	n = 33	75	
I	20	30	24	20	30	24	NS
II	30	NA	30	20	NA	20	0.02
III	100	NA	100	70	NA	70	0.01
IV	NA	120	120	NA	70	70	0.01

Abbreviations: TLM, transoral laser microsurgery; TORS, transoral robotic surgery; SGL, supraglottic laryngectomy; NA, not applicable. Group A: anterior or medial supraglottic larynx; Groupe B: Lateral supraglottic larynx or piriform sinus.

which contradicts the findings of Papazian et al [13]. Indeed, a possible bias might be identified: only eleven patients (23.4 %) in the TLM group had a PET scan during the initial assessment, compared to 100 % in the TORS group. Studies have shown that PET scans significantly improve diagnostic accuracy and staging in head and neck cancers by detecting metastases that conventional imaging (CT or MRI) might miss [19,20]. PET scans in the initial workup allow for a more accurate evaluation of the disease stage, thereby influencing the surgical and therapeutic decisions proposed.

Regarding the surgical procedure, a significantly shorter set-up time for TLM, averaging 5 min compared with 15 min for TORS ($p < 0.05$) has been found. Conversely, we observed a significantly shorter mean operating time in with TORS compared to TLM for type II to IV SGL($p < 0.05$). This finding aligns with the results of Ansarin et al. published in 2014, who reported a mean operating time of 215 min in the TLM group compared to 124 min in the TORS group [12]. The difference in operative time is even more pronounced for type IV supraglottic laryngectomies. This observation suggests that TORS may be easier to use for extensive supraglottic laryngectomies, particularly for lateral supraglottic tumors requiring excision of the three-fold area, the ventricular band, an arytenoid unit, or the inner, medial, and/or anterior part of the piriform sinus.

Our study's limitations include its retrospective, single-center but academic, design. In the comparative study by Papazian et al., which involved 1,603 patients (271 with TORS and 424 with TLM), TORS has proven effective for SGL [13]. Unlike our study, which has a minimum five-year follow-up, Papazian et al. assessed patients only at Day 30 and Day 90. Additionally, a bias remains due to the higher use of TORS in academic centers, as reported by Papazian et al. The monocentric homogeneous population of this study prevented it. Finally, Papazian et al. did not evaluate functional outcomes, which we show to be comparable between techniques. Future research should incorporate both subjective patient questionnaires and objective physician evaluations to better assess long-term laryngeal function, particularly for swallowing,

phonation, and quality of life. Cost considerations and the availability of robotic systems versus lasers also warrant further investigation, as there is actually insufficient data on whether the higher costs of robotic systems are offset by reduced operating times.

Pros and cons of the two technologies used for treating squamous cell carcinoma of the supraglottic larynx can be summarized as follows: the laser has the advantages of being readily available and having a lower implementation cost. The robot, on the other hand, offers greater speed of use, likely due to its superior dexterity, cutting capacity and potentially shorter learning curve. Although no studies have directly compared these elements for supraglottic laryngectomy, the literature seems to suggest that the learning curve for TLM is longer than for TORS in head and neck carcinomas [21–24]. The safety profile is excellent for both technologies, with a low and similar incidence of bleeding, aspiration, tracheotomy, and non-functional larynx in both groups.

Conclusion

Both techniques appear to be safe and effective, though TORS shows superiority in achieving negative margins compared to TLM. However, this advantage did not translate into a significant difference between the two techniques in terms of 5-year local and regional control. However, confirmation through randomized studies is required. Therefore, the choice of technique should be tailored to available resources, surgical team preferences, and experience, while also considering the learning curves associated with each approach.

Research involving participants and/or animals

Study approval has been obtained by Institutional Review Board (IRB) n°IRB-00012437.

Language

This manuscript has been reviewed by U.S. academic medical editorial staff.

CRediT authorship contribution statement

Charlotte Loubieres: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Robin Baudouin:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marta Circiu:** Writing – review & editing, Validation, Investigation, Data curation. **Florent Couineau:** Writing – review & editing, Validation, Investigation, Data curation. **Lise Crevier-Buchman:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Tiffany Rigal:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **Clémence Forges:** Writing –

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Declaration of competing interest

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Data availability

Data will be made available on request.

References

- [1] Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA A Cancer J Clinicians* 2024;74:229–63. <https://doi.org/10.3322/caac.21834>.
- [2] Park YM, Byeon HK, Chung HP, Choi EC, Kim S-H. Comparison of treatment outcomes after transoral robotic surgery and supraglottic partial laryngectomy: Our experience with seventeen and seventeen patients respectively. *Clin Otolaryngol* 2013;38:270–4. <https://doi.org/10.1111/coa.12101>.
- [3] Peretti G, Piazza C, Ansarin M, De Benedetto L, Cocco D, Cattaneo A, et al. Transoral CO₂ laser microsurgery for Tis-T3 supraglottic squamous cell carcinomas. *Eur Arch Otorhinolaryngol* 2010;267:1735–42. <https://doi.org/10.1007/s00405-010-1284-1>.
- [4] Peretti G, Piazza C, Cattaneo A, De Benedetto L, Martin E, Nicolai P. Comparison of functional outcomes after endoscopic versus open-neck supraglottic laryngectomies. *Ann Otol Rhinol Laryngol* 2006;115:827–32. <https://doi.org/10.1177/000348940611501106>.
- [5] Ambrosch P, Gonzalez-Donate M, Fazel A, Schmalz C, Hedderich J. Transoral laser microsurgery for supraglottic cancer. *Front Oncol* 2018;8:158. <https://doi.org/10.3389/fonc.2018.00158>.
- [6] Razafindranaly V, Lallemand B, Aubry K, Moriniere S, Vergez S, Mones ED, et al. Clinical outcomes with transoral robotic surgery for supraglottic squamous cell carcinoma: Experience of a French evaluation cooperative subgroup of GETTEC. *Head Neck* 2016;38:E1097–101. <https://doi.org/10.1002/hed.24163>.
- [7] Karabulut B, Deveci İ, Sürmeli M, Şahin-Yılmaz A, Oysu Ç. Comparison of functional and oncological treatment outcomes after transoral robotic surgery and open surgery for supraglottic laryngeal cancer. *J Laryngol Otol* 2018;132:832–6. <https://doi.org/10.1017/S0022215118001305>.
- [8] Swanson MS, Low G, Sinha UK, Kokot N. Transoral surgery vs intensity-modulated radiotherapy for early supraglottic cancer: a systematic review. *Curr Opin Otolaryngol Head Neck Surg* 2017;25:133–41. <https://doi.org/10.1097/MOO.0000000000000345>.
- [9] Remacle M, Hantzakos A, Eckel H, Evrard A-S, Bradley PJ, Chevalier D, et al. Endoscopic supraglottic laryngectomy: a proposal for a classification by the working committee on nomenclature. *Eur Arch Otorhinolaryngol* 2009;266:993–8. <https://doi.org/10.1007/s00405-008-0901-8>.
- [10] Brierley J, Gospodarowicz MK, Wittekind C, editors. *TNM classification of malignant tumours*. Eighth edition. Chichester, West Sussex, UK ; Hoboken, NJ: Wiley Blackwell; 2017.
- [11] Barry B, De Raucourt D, Couloigner V, Tronch, Sophie. Actualisation de la recommandation de 2005 sur le suivi post-thérapeutique des carcinomes épidermoïdes des VADS de l'adulte. Société Française d'Oto-Rhino-Laryngologie et de Chirurgie de la Face et du Cou 2020.
- [12] Ansarin M, Zorzi S, Massaro MA, Tagliabue M, Proh M, Giugliano G, et al. Transoral robotic surgery vs transoral laser microsurgery for resection of supraglottic cancer: a pilot surgery: Robotic surgery in supraglottic cancer. *Int J Med Robotics Comput Assist Surg* 2014;10:107–12. <https://doi.org/10.1002/rcs.1546>.
- [13] Papazian MR, Chow MS, Jacobson AS, Tran T, Persky MS, Persky MJ. Role of transoral robotic surgery in surgical treatment of early-stage supraglottic larynx carcinoma. *Head Neck* 2023;45:972–82. <https://doi.org/10.1002/hed.27325>.
- [14] Hans S, Baudouin R, Cîrciu MP, Couineau F, Lisan Q, Crevier-Buchman L, et al. Open Partial Laryngectomies: History of Laryngeal Cancer Surgery. *J Clin Med* 2022;11:5352. <https://doi.org/10.3390/jcm11185352>.
- [15] Gokmen MF, Buyukatalay ZC, Department of Otorhinolaryngology, Ankara University School of Medicine, Ankara, Turkey, Beton S, Department of Otorhinolaryngology, Ankara University School of Medicine, Ankara, Turkey, Gokcan MK, et al. Functional and Oncological Outcomes of Open Partial Laryngectomy vs. Transoral Laser Surgery in Supraglottic Larynx Cancer. *Turk Arch Otorhinolaryngol* 2021;58:227–33. doi: 10.5152/tao.2020.5573.
- [16] Brandstorp-Boesen J, Falk RS, Evensen JF, Boysen M, Brøndbo K. Risk of recurrence in laryngeal cancer. *PLoS One* 2016;11:e0164068. <https://doi.org/10.1371/journal.pone.0164068>.
- [17] Murariu MO, Boia ER, Horhat DI, Mot CI, Balica NC, Trebuan CI, et al. Psychological well-being and quality of life in laryngeal cancer patients across tumor. *J Clin Med* 2024;13:6138. <https://doi.org/10.3390/jcm13206138>.
- [18] Mimica X, Hanson M, Patel SG, McGill M, McBride S, Lee N, et al. Salvage surgery for recurrent larynx cancer. *Head Neck* 2019;41:3906. <https://doi.org/10.1002/hed.25925>.
- [19] Zheng E, Khariwala SS. Do all patients with head and neck cancer require a positron emission tomography scan at diagnosis? *Laryngoscope* 2019;129:537–8. <https://doi.org/10.1002/lary.27458>.
- [20] Young AIMN Working Group, Cammaroto G, Quartuccio N, Sindoni A, Di Mauro F, Caobelli F. The role of PET/CT in the management of patients affected by head and neck tumors: a review of the literature. *Eur Arch Otorhinolaryngol* 2016;273:1961–73. <https://doi.org/10.1007/s00405-015-3651-4>.
- [21] Bernal-Sprekelsen M, Blanch J-L, Caballero-Borrego M, Vilaseca I. The learning curve in transoral laser microsurgery for malignant tumors of the larynx and hypopharynx: parameters for a levelled surgical approach. *Eur Arch Otorhinolaryngol* 2013;270:623–8. <https://doi.org/10.1007/s00405-012-2181-6>.
- [22] Sjögren E. Transoral Laser Microsurgery in Early Glottic Lesions. *Curr Otorhinolaryngol Rep* 2017;5:56–68. <https://doi.org/10.1007/s40136-017-0148-2>.
- [23] Lawson G, Matar N, Remacle M, Jamart J, Bachy V. Transoral robotic surgery for the management of head and neck tumors: learning curve. *Eur Arch Otorhinolaryngol* 2011;268:1795–801. <https://doi.org/10.1007/s00405-011-1537-7>.
- [24] White HN. Learning Curve for Transoral Robotic SurgeryA 4-Year AnalysisLearning Curve for Transoral Robotic Surgery. *JAMA. Otolaryngol Head Neck Surg* 2013;1. <https://doi.org/10.1001/jamaoto.2013.3007>.