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Review

Survival, Surgical, and functional outcomes of transoral laser microsurgery for cT1-T3 supraglottic laryngeal Cancers: A systematic review

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ABSTRACT

Background: This review aimed to investigate the surgical, functional, and oncological outcomes of transoral laser microsurgery supraglottic laryngectomy (TOLM-SGL) for cT1-T3 laryngeal cancers.
Methods: PubMed, Scopus, and Cochrane Library were searched by two independent investigators for studies investigating the surgical, functional, and oncological outcomes of TOLM-SGL using the PRISMA statements. A bias analysis was carried out with MINORS.
Results: Twenty-four studies were included (937 patients), including 206 (25.9 %) cT1, 467 (58.7 %) cT2, and 123 (15.4 %) cT3 cases. Most patients were cN0 (63.9 %). The mean hospital stay of TOLM was 10.1 days. Aspiration (5.5 %), and bleeding (5.3 %) were the most prevalent complications. The laryngeal preservation rate was 93.7 %. Temporary tracheotomy was performed in 18.0 % of patients, with a mean time of decannulation of 6.8 days. A feeding tube was placed in 59.9 % of patients. The oral diet restarted after 6.4 days. Definitive gastrostomy was necessary in 2.4 % of cases. The 5-year OS and DFS were 70.1 % and 82.0 %, respectively. Distant metastasis, local, and regional recurrence occurred in 4.6 %, 11.6 %, and 5.1 % of patients. There was an important heterogeneity between studies for inclusion criteria, patient profiles, TOLM indications, and details of surgical, functional, and oncological outcomes.
Conclusion: TOLM supraglottic laryngectomy is a safe, and effective procedure associated with adequate functional, surgical, and oncological outcomes. Future studies are needed to define the place of TOLM in advanced LSCC; the role and timing of concomitant bilateral neck dissection, the indications of tracheotomy and feeding tube.

Introduction

Head and neck squamous cell carcinoma (HNSCC) is the 6th most prevalent adult cancer worldwide, corresponding to 5.3 % of all cancers [1]. Of the HNSCC group, laryngeal squamous cell carcinoma (LSCC) is the second most common carcinoma, accounting for 211,000 new cases and 126,000 deaths per year worldwide [2]. Surgery is one of the most adopted therapeutic strategies for early, intermediate, and advanced LSCC [3]. The surgical approaches of LSCC progressively changed in the past five decades, with the development of surgical laser and robot (Da Vinci, Flex) dedicated to transoral microsurgery of glottic and supraglottic LSCC [4,5]. Nowadays, most supraglottic LSCC can be treated with transoral laser microsurgery (TOLM) or transoral robotic surgery (TORS) [4–6]. The current indications for partial supraglottic laryngectomy (SGL) include the cT1, cT2, and some selected cT3 LSCC. Several studies have been conducted in the past 3 decades to explore the surgical, functional, and oncological outcomes of TOLM-SGL, reporting variable data of complications, laryngeal preservation, oncological, and functional outcomes. This systematic review aimed to investigate the current literature on surgical, functional, and oncological outcomes of TOLM-SGL.

Abbreviations: DFS, disease-free survival; EBL, evidence level; OS, overall survival; TOLM, transoral laser microsurgery; TORS, transoral robotic surgery; SGL, supraglottic laryngectomy.

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Materials and methods

The review was conducted with the Preferred Reporting Items for a Systematic Review and Meta-analysis (PRISMA) checklist [7]. The criteria for considering studies for the systematic review were based on the population, intervention, comparison, outcome, timing, and setting (PICOTS) framework [8].

Studies

The systematic review included prospective and retrospective, controlled, uncontrolled, or randomized studies published in English-language peer-reviewed journals between 1994 and 2024. To be included, the authors had to investigate the safety and effectiveness of TOLM-SGL through clinical, surgical, functional, or oncological outcomes. The preliminary studies on animals and the cadaveric studies were not considered in this review.

Participants and inclusion criteria

The information related to the types and clinical stages of LSCC, the surgical approach for TOLM-SGL, inclusion and exclusion criteria were carefully considered to include studies in the review. In studies reporting findings for glottic and supraglottic LSCC, authors only included studies with specific data for TOLM-SGL. Regarding the current consensus for the surgical treatment of supraglottic LSCC, the authors only included the studies reporting findings for cT1, T2, and T3 LSCC. The studies pooling information for cT1 to cT4 LSCC were not included regarding the lack of consensus for treating cT4 LSCC through TOLM-SGL [4,9]. Only the studies reporting data for $\geq$ 10 cases were considered.

Outcomes

The following clinical data were extracted: patient demographics (mean/median age; gender ratio); tumor stage (c/pTNM) and sub-location; additional treatments ((chemo)radiotherapy). The surgical outcomes consisted of the realization of concomitant or delayed neck dissection; margin status (positive versus negative); laryngeal preservation rate; mean hospital stay; and postoperative complications. Only the complications related to the surgical procedure were reviewed. The tardive complications associated with postoperative radiotherapy were not investigated in the present review. The functional outcomes included the features related to temporary or permanent tracheotomy, feeding tube, temporary and permanent gastrostomy. The following oncological outcomes were reviewed: the mean/median follow-up time, the overall survival (OS), disease-free survival (DFS), the metastasis rate; the local and regional controls (number of patients with local recurrence or local/regional relapse-free survival.

The heterogeneity in patient populations, inclusion/exclusion criteria, and outcomes measurements was analyzed using the Methodological Index for Non-Randomized Studies (MINORS) tool [10].

Intervention and comparison

Only the TOLM-SGL were considered as surgical procedures. The use of international classifications for TOLM-SGL was retrieved, e.g. the European Laryngological Society classification [11].

Timing and Setting

There were no criteria for specific timing in the 'disease process' of the study population. Only the data of cTis, cT1, cT2, and cT3 supraglottic LSCC were considered. cTis and cT1 were pooled into a cT1 group.

Search strategy

Two independent authors conducted the PubMed, Scopus, and Cochrane Library search for for relevant peer-reviewed publications related to the surgical, functional, and oncological outcomes of TOLM-SGL. The following keywords were used for the search strategy: Transoral Laser; CO2; Surgery; Larynx; Laryngeal; Cancer; Squamous Cell Carcinoma; Supraglottic; Partial Laryngectomy; Oncological; Survival; Outcome; and Complications. Only studies with database abstracts, available full-texts or titles containing the search terms were considered. The results of the research strategy were reviewed for relevance and the reference lists of some articles, especially reviews or *meta*-analyses, were examined for additional pertinent studies. The investigators analyzed studies for the number of patients, study design, inclusion and exclusion criteria, quality of trial/evidence-based level (EBL), patient features (number, age, and gender), follow-up, and outcomes. Critical attention was paid to potential overlap between cohort studies. Implications for practice were summarized. Ethics committee approval was not required.

Bias analysis

The bias analysis was performed with the MINORS tool. MINORS is a validated instrument designed for assessing the quality of non-randomized surgical studies [10], composed of 12 items related to the analysis of methodological points of comparative and non-comparative studies. The items were rated 0 if absent; 1 when reported but inadequate; and 2 when reported and adequate. The aim of the study's item was rated as clearly stated (2), unclear (1), or absent (0). The inclusion of patients was evaluated considering consecutive inclusion (0 or 2). The prospective data collection was rated as perfectly prospective (2), retrospective analysis of prospective recruited patients (1), or absent (0). The appropriateness of endpoints was assessed as high (2) if authors evaluated the functional, surgical, and oncological outcomes, which are considered objective. The investigation of one or two outcome groups was considered partial (1) regarding the aim of the study. According to the time for getting 5-year survival outcomes, a follow-up period of 60 months was considered adequate for all outcomes (2). A shortest follow-up period was considered partially adequate. Finally, the 5 % rate of lost to follow-up patients was considered as the threshold in the MINORS tool. The item related to the study size prospective calculation was only considered for prospective studies and judged as good (2), mentioned as unnecessary or not provided (1), or absent (0). The ideal MINORS score was 16 for non-comparative studies and 24 for comparative studies [10].

Results

Of the 220 identified studies, 24 studies met our inclusion criteria (Fig 1) [12–35]. Three studies were prospective (EBL: C) [13,16,18], and the others were retrospective (EBL: D). Two retrospective studies compared TORS and TOLM-SGL [22,33]. The data of TOLM were extracted from these two studies for the review. Panuganti *et al.* included two groups of TOLM patients according to the realization of post-operative radiation therapy [35]. Potential overlap can occur between two studies of Peretti *et al.* [19,27], while these studies did not report similar findings/aims. Eleven studies investigating the surgical, functional, or oncological outcomes of TOLM-SGL were excluded because they included cT4 LSCC and pooled data of all cases despite the tumor stage [36–46]. One TOLM-TORS comparative study and one glottic-supraglottic study were not included because lack of separate data between the two groups of procedures/tumor location [47,48]. The study of Fink *et al.* was excluded because the authors focused on TOLM partial laryngectomy as a salvage procedure in patients who underwent radiotherapy [49]. The laser used in all studies was the CO_2 laser. Functional, surgical, and oncological outcomes of studies are reported in Tables 1 and 2.

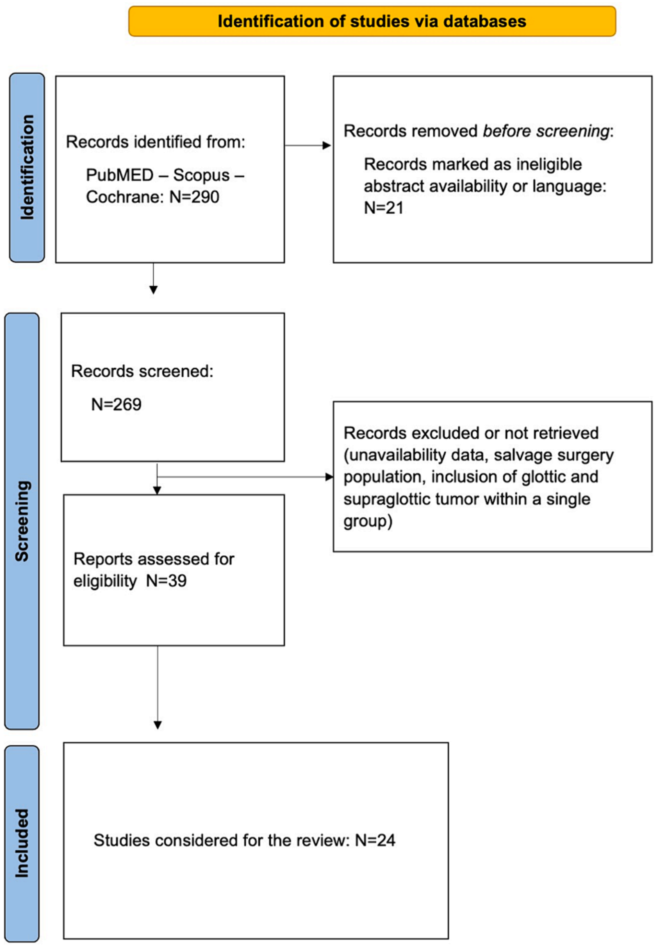

Figure 1. PRISMA flowchart.

Patient characteristics

A total of 937 patients underwent TOLM-SGL. There were 80 females and 619 males. The gender information was not provided in 5 studies [13,23,24,27,31]. The mean age of patients was 61.9 years. The median age ranged from 55.0 years to 68.0 years (Table 1). The tumor location was reported in 100 patients from four studies (Appendix 1) [14,15,20,32]. Tumors treated by TOLM-SGL were primarily located at the epiglottis (55 %), epiglottis and vallecula (16 %), and false vocal cords (10 %).

The details of TNM stages were reported in all studies except one study (Table 3) [32]. Pantazis *et al.* and Peretti *et al.* only focused on cT3 [25,27] LSCC, while Panaganti *et al.* only included cT2 LSCC [35]. Excluding these studies, the distribution of T1-3 cases was 206 (25.9 %), 467 (58.7 %), and 123 (15.4 %), respectively. Ambrosch *et al.* and Panuganti *et al.* only investigated data from patients with cN0 tumors [12,35]. The details of cN+were not provided in nine studies [13–15,17,18,22–24,31]. There were 489/765 (63.9 %) patients with cN0 and 276/765 (36.1 %) with cN+ (Table 3).

Adjuvant Therapies, surgical Features, and complications.

The details of the surgical and functional outcomes are reported in Table 1. Adjuvant radiotherapy or chemoradiotherapy was done in 224/662 (33.8 %) patients. Surgical margins were positive in 66/485 cases (13.6 %). The mean hospital stay was 10.1 days (Table 1). The laryngeal preservation information was available for 691 patients. The mean laryngeal preservation rate was 93.7 %, ranging from 86.0 % to 100 %. The review of postoperative complications is reported in Table 4. Complication details were available for 708 patients. Aspiration (5.5 %), bleeding (5.3 %), granulation tissue (4.1 %), and pneumonia (3.0 %) are the most prevalent complications of TOLM-SGL (Table 4). Only six studies did not provide information about neck dissection [13,23,28,29,31,32]. Neck dissection was performed in 380/608 patients (62.5 %). When specified, the neck dissection was unilateral and bilateral in 72/242 (29.8 %), and 170/242 (70.2 %), respectively (Table 1).

Functional outcomes

All studies reported at least one functional outcome(s) except two studies [17,35]. The tracheotomy was preventively performed in the majority of patients in four studies (Table 1) [15,22,29,30]. Considering studies providing detailed information for tracheotomy, the rates of temporary and permanent tracheotomy were 18.0 % (N=142/787), and 0.8 % (N=6/787), respectively. Decannulation was performed after 70.5 days and 3.0 months in the studies of Gokmen *et al.* [32] and Sievert *et al.* [33]. In the other studies, the mean time for decannulation was 6.8 days, ranging from 3 days to 15.9 days. The placement of tracheotomy does change over time comparing initial and recent studies.

A feeding tube was placed at the end of the surgery or during the hospital stay in 379/633 patients (59.9 %). Some authors systematically placed feeding tubes in operated patients [12,14,16,34]. Oeken *et al.* and Sievert *et al.* reported that the patients with feeding tube/percutaneous gastrostomy restarted oral feeding after 2–9 months and a mean of 30.1 months, respectively (Table 1) [14,33]. The data of these two studies substantially differ from the others, where the time for removing the feeding tube and restarting the oral diet ranges from 1 day to 30 days (mean: 6.4 days). A trend of reducing the systematic placement of feeding tubes over time was observed because of the 4 studies where authors placed systematically the feeding tubes, 3 dated from before 2007 [12,14,16]. Percutaneous gastrostomy was temporarily placed in 73/547 patients (13.3 %), while 13/547 (2.4 %) patients kept the percutaneous gastrostomy over the long term for aspiration pneumonia (Table 1).

Survival outcomes

The details about the oncological outcomes are available in Table 2. Three studies did not provide sufficient survival data for the analysis [14,15,29]. Of the 22 studies providing survival findings, the mean 5-year OS and DFS were 70.1 % (N=717), and 82.0 % (N=569 patients), respectively. Local regional (neck node) recurrence occurred in 62/534 (11.6 %), and 26/506 patients (5.1 %), respectively. Among studies reporting the locoregional recurrence as local-relapse-free survival or nodal-relapse-free survival, these rates range from 83.0 % to 97.0 % (Table 2). Metastasis was detected in 12/259 patients (4.6 %) in the follow-up period, which reports a mean range from 33.3 months to 76.8 months.

Epidemiological analysis

The MINORS scores for studies are reported in Table 5. The mean MINORS 9.4 ± 1.9. Fifteen studies provided sufficient information related to functional, surgical, and oncological outcomes. The bias analysis reports some degrees of heterogeneity between studies for the inclusion and exclusion criteria, tumor characteristics, and postoperative findings. For tumor stage and anatomical considerations, some studies focused on specific stages, especially cT2 [23,35] and cT3 [25,27]. Some authors excluded LSCC with a pre-epiglottic space infiltration [20], while others did not [27,28]. In the same vein, some authors considered only cN0 patients [12,35], or cN0-cN2c [23]. Most authors only included LSCC. However, Puxeddu *et al.* included a basaloid carcinoma in the cohort [15]. Concerning functional outcomes, some teams systematically placed feeding tubes or performed

Table 1
Surgical and Functional Outcomes.

			Demographics				Adj. RT	Surgical outcomes			Functional outcomes				
References	Design	EBL	N	F/M	Age (y)	U/BND	N (%)	LP (%)	Margins+ (N)	HS (d)	t/p TC (N)	Deca (d)	Feeding (N,%)	t/p GA (N)	Oral Diet (d)
Ambrosch, 1998 (12)	Retrospective	D	48	6/42	61.0°	26/15	2 (4.2)	100	6 (12.5)	–	0/0	–	48 (100)	–	5.0°
Eckel, 1998 (13)	Prospective	C	46	–	55.0°	–	16 (34.8)	89.1	–	–	6/0	–	–	–	–
Oeken, 2001 (14)	Retrospective	D	14	3/11	59.0°	13	10 (71.4)	–	–	–	2/0	–	14 (100)	10/0	2–9 mo
Puxeddu, 2003 (15)	Retrospective	D	12	1/11	62.5	3/2	1 (8.3)	100	–	–	10/0	15.9	10 (83.3)	10/0	14.5
Agrawal, 2007 (16)	Prospective	C	34	12/22	64.0°	10	32 (94.1)	–	–	–	4/0	7.0	34 (100)	–/3	–
Cabanillas, 2008 (17)	Retrospective	D	26	1/25	59.0	0/26	–	86.0	–	–	–	–	–	–	–
Roh, 2008 (18)	Prospective	C	21	2/19	68.0°	0/21	5 (23.8)	100	0 (0)	–	3/0	–	–	0/0	–
Peretti, 2010 (19)	Retrospective	D	80	18/62	64.5	10/17	21 (26.3)	97.2	10 (12.5)	10	23/0	7.0°	33 (41.3)	0/0	7.0
Csanady, 2011 (20)	Retrospective	D	55	14/41	54.6	7	3 (5.5)	96.0	–	4–8	0/0	–	8 (14.5)	0/0	3.5
Gonzalez, 2012 (21)	Retrospective	D	49	3/46	60.0	2/43	13 (26.5)	90.0	8 (16.3)	–	6/0	–	42 (85.7)	–	10.8
Ansarin, 2013 (22)	Retrospective	D	10	1/9	65.0	2/2	3 (30.0)	–	2 (20.0)	13.0	8/0	–	4 (40.0)	0/0	8.0°
Canis, 2013 (23)	Retrospective	D	104	–	–	–	–	92.0	–	–	1/2	–	51 (49.0)	3/3	1–30
Wilkie, 2015 (24)	Retrospective	D	17	–	–	7	8 (47.1)	–	4 (23.5)	–	–	–	–	5/4	–
Pantazis, 2015 (25)	Retrospective	D	24	5/19	61.4	10/14	10 (46.7)	91.7	4 (16.7)	–	11/0	7–10	–	0/0	–
Chiesa-Estomba, 2016 (26)	Retrospective	D	31	2/29	61.5	4	24 (77.4)	–	–	13.3	–	–	25 (80.6)	4/0	1.5
Peretti, 2016 (27)	Retrospective	D	22	–	–	6/3	7 (31.8)	95.4	6 (27.3)	13.7	3/0	4.5	12 (54.5)	1/0	7.7
Piazza, 2016 (28)	Retrospective	D	96	25/71	65.0	–	–	92.6	–	9.0	7/0	4.0	32 (33.3)	–	7.0
Bertolin, 2017 (29)	Retrospective	D	15	3/12	–	–	4 (26.7)	–	–	9.4	13/0	4.0	–	–	3.6
Carta, 2018 (30)	Retrospective	D	42	9/33	61.8	21	8 (19.0)	90.7	5 (11.9)	9.8	23/0	9.7	36 (85.7)	0/0	5.9
Karatzanis, 2009 (31)	Retrospective	D	49	–	–	–	–	94.0	1 (2.0)	–	4/3	–	–	16/3	–
Gokmen, 2020 (32)	Retrospective	D	19	1/18	60.9	–	1 (5.3)	–	–	9.6	3/1	70.5	13 (68.4)	6/0	2.4
Sievert, 2020 (33)	Retrospective	D	30	8/22	60.8	5/18	17 (56.7)	–	0 (0)	15.1	13/0	3.0 mo	–	17/0	30.1 mo
Ozturk, 2021 (34)	Retrospective	D	17	1/16	66.5	8/9	8 (47.1)	100	0 (0)	12	2/0	14.5	17 (100)	1/0	
Panuganti, 2022 (35)	Retrospective	D	45	16/29	63.2	45	0 (0)	–	8 (17.8)	–	–	–	–	–	–
			31	10/21	61.9	31	31 (100)	–	12 (38.7)	–	–		–	–	–

Some values were median°; the others being mean, percentages, or numbers. Abbreviations: Adj. = adjuvant; d = days; Deca = decannulation timing; EBL=evidence-based level; F/M=female/male; FT=feeding tube; GA=gastrostomy; HS=hospital stay; LP=laryngeal preservation; mo = month(d); N=number; PM=positive margins; RT=radiotherapy; t/p TC=temporary/permanent tracheotomy; U/BND=primary unilateral/bilateral neck dissection(s); y = years.

tracheotomy in most patients [12,15,14,16,29,34], while others clearly stated that they did not [19,26–28]. Chiesa-Estomba *et al.* placed a feeding tube only for cT3 LSCC and re-started oral diet in all patients after 6–48 h post-surgery [26]. This regimen contrasts with the protocol of Ambrosch *et al.* [12], and Agrawal *et al.* [16] who placed feeding tubes in all patients. The surgical outcome heterogeneity concerns the systematic realization of uni- or bilateral neck dissection or adjunctive radiotherapy. Bilateral neck dissection was carried out during the tumor operative time [16,18], or a few weeks after the tumor surgery for the contralateral side [26]. Peretti *et al.* and Ansarin *et al.* performed the bilateral neck dissection during the tumor operative time or a delayed operating time [19,22,27]. Some complications of TOLM-SGL were not systematically investigated in most studies such as dysphonia, tongue or airway edema, pharyngeal paresthesia, or postoperative pain [4].

Concerning influencing factors of survival outcomes, the findings related to the consumption of tobacco and alcohol were found in a few studies [17,20,21,25,30,32] and they can vary from one study to another. In the study of Pantazis *et al.*, 2 (9.1 %) patients were alcoholic [25], while Carta *et al.* reported data of 30 (71.4 %) alcoholic patients [30]. Similar observations were found for smokers, who reach a 100 % rate in the study of Chiesa-Estomba *et al.* [26]. Patients with recurrence were excluded from the survival analysis in some studies [18], whereas in others, they were included in the survival analysis [19,20,23,27,28]. The bias analysis reveals that a few authors specified the occurrence of intercurrent diseases, leading to death in some cases [12,23,28,30]. In the same way, the occurrence of a second primary cancer was detailed in seven studies [12,15,16,21,22,23,28].

Table 2
Oncological Outcomes.

References	Design	N	Stages (N) c/pT1-T2-T3	N+ (%)	Adj. RT N (%)	Survival outcomes TA	OS	DFS	LRec	NRec (N, %)	DM (N, %)	FU (mo)
Ambrosch, 1998 (12)	Retrospective	48	12–36-0	–	2 (4.2)	3/ 5y	85.0/ 76.0	87/ 83	97.0*	2	2	55.0°
Eckel, 1998 (13)	Prospective	46	9–37-0	33 (71.7)	16 (34.8)	5y	72.0	–	10	–	4	62.0
Puxeddu, 2003 (15)	Retrospective	12	3–9-0	3 (25.0)	1 (8.3)	–	–	–	0	–	–	33.3
Agrawal, 2007 (16)	Prospective	34	7–27-0	10 (29.4)	32 (94.1)	3y	88.0	79.0	1	2	–	69.0°
Cabanillas, 2008 (17)	Retrospective	26	3–8-15	10 (38.5)	–	5y	80.0	–	8	1	1	48
Roh, 2008 (18)	Prospective	21	5–5-11	15 (71.4)	5 (23.8)	3y	79.0	71.0	2	2	2	41
Peretti, 2010 (19)	Retrospective	80	22–38-20	71 (88.8)	21 (26.3)	5y	84.4	88.3	3	3	–	51.0
Csanady, 2011 (20)	Retrospective	55	38–17-0	7 (12.7)	3 (5.5)	5y	84.0	67.0	15	5	–	60–216
Gonzalez, 2012 (21)	Retrospective	49	12–17-20	19 (38.8)	13 (26.5)	3/ 5y	93.2/ 82.2	61.3	7	3	1	49
Ansarin, 2013 (22)	Retrospective	10	2–8-0	4 (40.0)	3 (30.0)	–	–	–	2	0	–	88°
Canis, 2013 (23)	Retrospective	104	0–104-0	–	–	5y	66.5	84.2	22		–	57.8
Wilkie, 2015 (24)	Retrospective	17	3–7-7	5 (29.4)	8 (47.1)	3y	88	–	0	0	–	34
Pantazis, 2015 (25)	Retrospective	24	0–0-24	14 (58.3)	10 (46.7)	5y	87.5	91.7	87.5	–	–	76.8
Chiesa-Estomba, 2016 (26)	Retrospective	31	2–15-14	7 (22.6)	24 (77.4)	3y	83.8	67.7	–	6		36
Peretti, 2016 (27)	Retrospective	22	0–22-0	12 (54.5)	7 (31.8)	5y	59.3	76.3	1	0	0	46.5
Piazza, 2016 (28)	Retrospective	96	28–46-22	–	–	5y	69.0	85.9	5	2		61
Carta, 2018 (30)	Retrospective	42	12–23-7	10 (23.8)	8 (19.0)	5y	64.9	93.1	90.5#	83.0#	–	39
Karatzanis, 2009 (31)	Retrospective	49	19–30-0	–	–	3y	87.0	–	87.0	–	–	67.0
Gokmen, 2020 (32)	Retrospective	19	–	–	1 (5.3)	5y	84.2	79.0	5	–	–	62.0
Sievert, 2020 (33)	Retrospective	30	20–10-0	24 (80.0)	17 (56.7)	5y	–	86.7	3	–	2	50.2
Ozturk, 2021 (34)	Retrospective	17	4–10-3	8 (47.1)	8 (47.1)	–	–	–	0	0	0	33.8
Panuganti, 2022 (35)	Retrospective	45	0–45-0	0 (0)	0 (0)	2/ 5y	91.9/ 67.8	–	–	–	–	44–58
		31	0–31-0	0 (0)	31 (1 0 0)	2/ 5y	67.4/ 47.5	–	–	–	–	

Some values were median (°). For local and regional recurrence, some authors reported local-relapse-free survival or nodal-relapse-free survival (#), Abbreviations: Adj. = adjuvant; d = days; DFS=disease-free survival; DM=distant metastasis; FU=follow-up; mo = month(d); N=number; PM=positive margins; L/N.FRec = local/ nodal free recurrence rate; OS=overall survival; RT=radiotherapy; SPS=Swallowing Performance Status Scale; TA=time of assessment (survival outcomes); y = years.

Table 3
Tumor Stages.

References	N	T stage cT1-is	cT2	cT3	N stage N0	N1	N2a	N2b	N2c	N3
Ambrosch, 1998 (12)	48	12	36	0	48	0	0	0	0	0
Eckel, 1998 (13)	46	9	37	0	13	33				
Oeken, 2001 (14)	14	3	8	3	0	1	5			0
Puxeddu, 2003 (15)	12	3	9	0	9	3				
Agrawal, 2007 (16)	34	7	27	0	24	10	0	0	0	0
Cabanillas, 2008 (17)	26	3	8	15	16	4	5			1
Roh, 2008 (18)	21	5	5	11	6	2	13			0
Peretti, 2010 (19)	80	22	38	20	62	6	0	4	3	5
Csanady, 2011 (20)	55	38	17	0	48	7	0	0	0	0
Gonzalez, 2012 (21)	49	12	17	20	30	6	1	5	6	1
Ansarin, 2013 (22)	10	2	8	0	6	3				1
Canis, 2013 (23)	104	0	104	0	–	–	–	–	–	–
Wilkie, 2015 (24)	17	3	7	7	12	3	2			0
Pantazis, 2015 (25)	24	0	0	24	10	8	0	1	4	1
Chiesa-Estomba, 2016 (26)	31	2	15	14	24	4	2	1	0	0
Peretti, 2016 (27)	22	0	0	22	15	4	0	3	0	0
Piazza, 2016 (28)	96	28	46	22	71	5	7	3	0	0
Bertolin, 2017 (29)	15	2	12	1	3	2	1	6	3	0
Carta, 2018 (30)	42	12	23	7	32	8	0	2	0	0
Karatzanis, 2009 (31)	49	19	30	0	–	–	–	–	–	–
Sievert, 2020 (33)	30	20	10	0	6	7	4	0	1	5
Ozturk, 2021 (34)	17	4	10	3	9	4	0	3	0	1
Panuganti, 2022 (35)	76	0	76	0	45	0	0	0	0	0
Total number	918	206	543	169	489	120	40	28	17	15

Abbreviations: N=number; T=tumor.

Discussion

The TOLM is currently considered a surgical standard of care for cT1-T3 supraglottic LSCC. However, there was no systematic review summarizing the surgical, functional, and oncological outcomes of TOLM-SGL. With the development of alternative therapeutic approaches, such as TORS or IMRT, the summary of the TOLM functional, surgical, and oncological outcomes makes sense for further comparisons. The present review supports the safety and effectiveness of TOLM for treating cT1, T2, and some selected cT3 supraglottic LSCC. However, many points had to be clarified because they can bias the evaluation of TORS outcomes.

Table 4
Complications.

References	N	Bleeding	Abscess	Chondritis	Aspiration	Pneum.	Stenosis	DI	Granulations	SE	MI	Fistula	Dysphagia	GI	VCI	Hematoma	Seroma	LE
Ambrosch, 1998	48	2	0	0	0	1	1	0	8	0	0	0	0	0	0	0	0	0
Oeken, 2001	14	1	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–
Puxeddu, 2003	12	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Roh, 2008	21	0	0	0	3	0	3	0	15	0	0	0	0	1	5	0	0	0
Peretti, 2010	80	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Csanady, 2011	55	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–
Gonzalez, 2012	49	5	0	0	8	3	0	0	0	0	0	0	0	0	0	3	2	0
Ansarin, 2013	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canis, 2013	104	12	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0
Pantazis, 2015	24	1	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
Chiesa-Estomba, 2016	31	4	2	1	0	7	2	0	0	0	0	0	0	0	0	0	0	0
Piazza, 2016	96	4	0	0	0	2	0	0	0	2	1	1	0	0	0	0	0	0
Peretti, 2016	22	1	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0
Bertolin, 2017	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Carta, 2018	42	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Karatzanis, 2009	49	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Gokmen, 2020	19	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–
Ozturk, 2021*	17	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0
Total (N)	708	36/634	2/608	1/608	38/696	18/608	8/608	0/608	25/608	2/608	2/608	3/608	12/608	1/608	5/608	3/608	2/608	4/608
Rates	(%)	5.3	0.3	0.2	5.5	3.0	1.3	0.0	4.1	0.3	0.3	0.5	2.0	0.2	0.8	0.5	0.3	0.7

In the study of Ozturk*, some complications occurred during radiotherapy, making it difficult to determine the role of surgery versus radiotherapy. "-" = authors did not provide information but just performed post-operative swallowing examination. Abbreviations: DI=dental injury; GI=glottal insufficiency; LE=laryngeal edema; MI=Myocardial infarction; Pneum. = pneumonia; SE=subcutaneous emphysema; VCI=vocal cord immobility.

First, there is no clear consensus for the profile of patients. Among inclusion and exclusion criteria, some authors included patients with previous treatments, e.g., radiation [14,30], TOLM or open surgery [19,30], while others did not recommend TOLM for patients with a history of radiation or partial surgery [12,28]. Nowadays, the proposition of second, or third TOLM procedures in patients with local recurrence appears to be safe and effective for glottic and supraglottic LSCC [50]. However, the consideration of TOLM or open partial laryngectomies as salvage surgery in patients with a history of radiation remains controversial despite some encouraging studies [49,51]. The lack of consensus for indication of TOLM concerns cT3 and cT4 LSCC. Some authors excluded LSCC with a pre-epiglottic space infiltration [20], while others did not [27,28]. The OS and survival outcomes of patients from studies including cT3 with moderate pre-epiglottic space invasion are lower [20] than those of studies excluding this category of patients [27,28], but authors performing TOLM for cT3 cancer with pre-epiglottic space invasion reported satisfactory laryngeal preservation rate, DFS, and locoregional control in this population of patients. In the present study, we excluded the studies investigating the TOLM outcomes for cT4 LSCC because cT4 LSCC because partial laryngectomies are not commonly indicated for cT4 LSCC with cartilage invasion or important soft tissue involvement.

The drawing of reliable conclusions about the functional outcomes of TOLM is challenging according to the variability of protocols across studies. Indeed, some teams systematically placed feeding tubes or performed tracheotomy in most patients [12,15,14,16,29,34], while others clearly stated that they did not [19,26–28]. Interestingly, the systematic use of feeding tubes in postoperative time appears to have decreased from the end of the nineties to now, which highlights a change of procedure to a fastest postoperative oral diet intake. In practice, as demonstrated by Chiesa-Estomba *et al.*, the re-start oral diet can be proposed in all patients after 6–48 h post-surgery [26]. The feeding tube can be placed according to the tumor location, the stage (cT3), the related extent of surgical extension, and the risk of aspiration and pneumonia, which consider the general health and comorbidities of the patient. Similarly to the feeding tube findings, the data of the review suggest that tracheotomy can be performed depending on the tumor, surgery, and patient findings. As for TORS-SGL [4], the tracheotomy can be avoided in patients requiring bilateral neck dissection if the contralateral dissection is performed a few weeks after the first procedure [26]. Among surgical outcomes, the hospital stay duration, and the complication rate associated with TOLM-SGL appear to be primarily low, and comparable with TORS-SGL [4]. The lower duration of hospital stay of TOLM compared to open supraglottic laryngectomy is an important cost-effective argument for favoring TOLM in cT1-T3 supraglottic LSCC.

The data summarized in the present review support that TOLM-SGL reports comparable OS, DFS, and loco-regional control rates than TORS or radiation [4,52]. However, to the best of our knowledge, there is no study comparing TOLM, TORS, to (chemo)radiotherapy for supraglottic LSCC and, to date, only a small number of studies retrospectively compared oncological outcomes between TOLM, TORS, or open SGL [22,53,54], which limits us for providing definitive conclusions. Indeed, the survival and the development of local and regional recurrences depend on many factors, including the tumor stage, the intercurrent diseases, or the continuation of alcohol and tobacco consumption. The findings related to the consumption of tobacco and alcohol were found in a few studies [17,20,21,25,30,32] and they can vary from one study to another. The low number of studies providing data for intercurrent diseases [12,23,28,30] or second primary cancer [12,15,16,21,22,23,28] can considerably influence the drawing of definitive conclusions for survival outcomes associated with TOLM-SGL. Finally, patients with recurrence were excluded from the survival analysis in some studies [18], whereas in others, they were included in the survival analysis [19,20,23,27,28], which is an additional factor able to influence survival outcomes.

Table 5
MINORS analysis.

References	Clearly Stated Aim	Inclusion of consecutive patients	Prospective data collection	Endpoints appropriate to study	Unbiased endpoint assessment	Follow-up adequate period	<5% of lost of follow-up	Study size prospective calculation	Total MINORS score
Ambrosch, 1998 (12)	2	1	0	2	1	1	0	0	7
Eckel, 1998 (13)	2	1	2	2	1	2	2	0	12
Oeken, 2001 (14)	2	1	0	1	1	0	2	0	7
Puxeddu, 2003 (15)	2	1	0	1	1	1	2	0	8
Agrawal, 2007 (16)	2	1	2	2	2	2	2	2	15
Cabanillas, 2008 (17)	2	1	0	1	1	1	2	0	8
Roh, 2008 (18)	2	1	2	2	2	1	2	0	12
Peretti, 2010 (19)	2	1	0	2	1	1	2	0	9
Csanady, 2011 (20)	2	1	0	2	1	2	2	0	10
Gonzalez, 2012 (21)	2	2	0	2	2	1	2	0	11
Ansarin, 2013 (22)	2	1	0	1	1	2	0	0	7
Canis, 2013 (23)	2	1	0	2	2	1	2	0	10
Wilkie, 2015 (24)	2	1	0	1	1	1	2	0	8
Pantazis, 2015 (25)	2	1	0	2	2	2	2	0	11
Chiesa-Estomba, 2016 (26)	2	1	0	2	2	1	2	0	10
Peretti, 2016 (27)	2	1	0	2	2	1	0	0	8
Piazza, 2016 (28)	2	1	0	2	2	2	2	0	11
Bertolin, 2017 (29)	2	1	0	1	1	1	2	0	8
Carta, 2018 (30)	2	2	0	2	1	1	2	0	10
Karatzanis, 2009 (31)	2	1	0	2	1	2	2	0	10
Gokmen, 2020 (32)	2	1	0	1	1	2	2	0	9
Sievert, 2020 (33)	2	1	0	1	1	1	2	0	8
Ozturk, 2021 (34)	2	1	0	2	1	1	2	0	9
Panuganti, 2022 (35)	2	1	0	1	1	1	2	0	8

Many studies excluded patients who were lost of follow-up from their analysis, which supports the high results of this item. Abbreviation: –.

Conclusion

The TOLM-SGL is a safe, and effective procedure associated with adequate functional, surgical, and oncological outcomes. However, future studies are needed to define the place of TOLM in advanced LSCC; the role and timing of concomitant bilateral neck dissection, and the indications of tracheotomy and feeding tube.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

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