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Review Article

Transoral laser microsurgery and open partial laryngectomy for limited-stage glottic cancer: a review of indications, oncologic and functional outcome, and prognosis

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Abstract: For early-stage (T1-T2) glottic cancer, transoral laser microsurgery (TLM) and open partial laryngectomy (OPL) are primary organ-preserving options. This review compares their indications, outcomes, and prognostic factors based on a systematic literature analysis (1995-2025). TLM and OPL show comparable oncologic efficacy for local control and survival, but TLM generally offers superior voice preservation, fewer complications, and faster recovery, making it the preferred approach for well-exposed lesions. OPL remains essential for tumors involving the anterior commissure or with poor endoscopic exposure. Functional outcomes and recurrence risk are closely tied to resection extent and margin status. Key prognostic factors include anterior commissure involvement, surgical margins, and cordectomy type. Both techniques achieve high laryngeal preservation rates, yet their functional profiles differ: TLM favors phonatory outcomes, while OPL provides stable airway and swallowing after rehabilitation. Individualized treatment should integrate tumor characteristics, surgical expertise, and patient priorities to optimize the balance between oncologic control and function preservation.

Keywords: Glottic carcinoma, transoral laser microsurgery, open partial laryngectomy, laryngeal cancer, function preservation

Introduction

Glottic carcinoma represents the most prevalent subtype of laryngeal cancer, accounting for approximately 60%-70% of all laryngeal malignancies and it primarily originates from the vocal cord region [1]. Epidemiologic data indicate that its development is closely associated with long-term smoking and alcohol consumption, with a significantly higher incidence in males than in females, and it occurs mainly in middle-aged and elderly populations [2]. Pathophysiologically, the mucosal epithelium of the glottic region undergoes a multi-stage evolution from epithelial hyperplasia and dysplasia to carcinoma *in situ* and invasive carcinoma under the long-term stimulation of carcinogenic factors. Due to the relatively sparse lymphatic drainage of the vocal cords, the rate of lymph node metastasis in localized glottic cancer is low, which provides a favorable biological foundation for local treatment [3]. The depth and extent of tumor infiltration are precisely evaluated using the Tumor, Node, Metastasis (TNM) staging system, with T1 and T2 stages classified as limited-stage tumors [4]. These lesions are relatively confined to the vocal cords or may extend to adjacent structures without causing vocal cord fixation. The early symptom of the disease is predominantly persistent hoarseness [5]. Due to its superficial location and easy visualization by laryngoscopy, early clinical diagnosis is often achievable [6]. Diagnosis mainly relies on endoscopic examination and pathologic confirmation by biopsy, while imaging studies [such as computed tomography (CT), magnetic resonance imaging (MRI)] are used to evaluate deep infiltration and cartilage invasion. The predominant pathologic type is well-differentiated squamous cell carcinoma, which grows relatively slowly and has a low cervical lymph node metastasis rate, providing an im-

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portant biological basis for local minimally invasive treatment.

For limited-stage (T1, T2) laryngeal cancer, several treatment approaches are available, including radiation therapy (RT), transoral laser microsurgery (TLM) and open partial laryngectomy (OPL). Owing to advances in surgical and radiological technology and techniques, limited-stage laryngeal cancer is a highly treatable disease with excellent 5-year survival rates of 80% to 90% [7]. Both radiation and larynx-preserving surgery can provide comparable survival and voice outcomes [8, 9]. However, according to the American Society of Clinical Oncology (ASCO) guidelines that laryngeal preservation is more likely to succeed with an initial surgical approach - preferably TLM when expertise is available, or OPL when exposure is inadequate or experience is limited [7].

The field of laryngeal cancer surgery has evolved substantially over the past few decades. The spread of TLM for laryngeal cancer treatment and the growing indications to include early and some intermediate stage tumors have improved the postoperative functional outcomes and lowered the cost for many patients [10]. While indications for OPL have been decreasing, laryngeal tumors that have poor transoral exposure or anterior commissure (AC) involvement often necessitate an open surgical approach [11], although there is an increasing number of case series reporting comparable oncologic outcomes of patients with limited-stage glottic tumors and AC involvement undergoing TLM [12, 13]. The increasing sophistication of surgical technique and the varying experience of surgical teams highlight the importance of patient selection for laryngeal preservation surgery. Tumor characteristics, patient morbidity, and surgical expertise are all important factors that contribute to prognosis [7].

The core clinical question this review aims to address is: For limited-stage (Tis-T2) glottic cancer, when faced with the two primary laryngeal preservation surgeries - TLM and OPL - how can clinicians systematically weigh their respective indications, differences in oncologic and functional efficacy, and key prognostic factors based on current evidence-based medical knowledge to formulate optimal individualized treatment decisions? Specifically, we will focus on: (1) clarifying the precise surgical indications and relative contraindications for TLM versus OPL; (2) comprehensively comparing the oncologic outcomes of both procedures, including local control, survival rates, and laryngeal preservation, as well as functional outcomes such as voice, swallowing function, and quality of life; (3) conducting an in-depth analysis of key prognostic factors affecting efficacy, such as anterior commissure involvement, surgical margin status, and extent of resection; and (4) based on this evidence, providing a clear and practical guidance framework for selecting the most appropriate surgical approach tailored to different tumor characteristics and patient conditions in clinical practice. Since many clinical studies reporting outcomes of limited-stage laryngeal cancer are concerned with the glottic type, our review aims to examine the characteristics of limited-stage glottic cancer for which laryngeal preservation surgery is applicable, compare oncologic and functional outcomes reported by recent studies, and gain new insight into the prognosis of patients treated by such surgeries.

Materials and methods

Search strategy and information sources

A comprehensive literature review was conducted to summarize current evidence on the oncologic and functional outcomes of transoral TLM and OPL for limited stage glottic carcinoma.

Study selection and data extraction

Studies were identified through searches of the PubMed, Web of Science, and Scopus databases for articles published between January 1995 and August 2025. Reference lists of relevant reviews and guideline documents (e.g., ASCO, European Laryngological Society) were also screened to ensure literature completeness.

The search terms were combined using Boolean operators as follows: ("glottic cancer" OR "glottic carcinoma" OR "laryngeal cancer") AND ("T1" OR "T2" OR "early stage") AND ("transoral laser microsurgery" OR "CO_2 laser" OR "endoscopic cordectomy" OR "open partial laryngectomy" OR "vertical partial laryngectomy" OR "supracricoid partial laryngectomy").

Inclusion criteria were as follows: (1) Adult patients with limited-stage (Tis-T2) glottic squamous cell carcinoma; (2) Primary treatment

involving TLM or OPL (including vertical and supracricoid variants); (3) Reported oncologic outcomes (local control, disease-specific or overall survival, laryngeal preservation) and/or functional outcomes (voice, swallowing).

Exclusion criteria included: (1) Studies focusing solely on supraglottic or subglottic carcinoma; (2) Studies limited to radiotherapy or chemoradiotherapy; (3) Case reports, animal experiments, conference abstracts, and non-English publications.

Two authors independently screened titles and abstracts to determine eligibility. Full-text articles were reviewed for inclusion, and disagreements were resolved by discussion with a senior author.

Given that this is a narrative review and the included studies exhibit heterogeneity in design, patient populations, and outcome measures, a quantitative meta-analysis or standardized quality assessment scales were not employed. To ensure methodological rigor, we conducted a narrative assessment of the quality of the included studies, focusing on the following key aspects: (1) study design type (e.g., prospective cohort studies, retrospective cohort studies, case series) and their inherent levels of evidence; (2) sample size and representativeness; (3) clarity and comparability of key baseline characteristics (e.g., T-stage, anterior commissure involvement); (4) adequacy of description regarding surgical technical details (e.g., TLM resection types, OPL techniques); (5) reporting of follow-up duration and loss-to-follow-up rates; (6) clarity in the definition and completeness in the reporting of primary outcome measures (e.g., local control rates, survival rates, functional scale scores). This assessment aims to describe systematically the strengths and limitations of the evidence base, providing context for the interpretation of the results. From each eligible study, data were extracted on study design, patient characteristics, treatment modality, and oncologic and functional outcomes.

Results

Transoral laser microsurgery

Types and indications

In the treatment strategy of glottic cancer, TLM has become the first choice for larynx preservation in Tis-T2 limited-stage carcinomas. Depending on the depth and extent of laser resection and tumor location, the European Laryngological Society has proposed an updated classification of endoscopic resections of the vocal cord, namely, subepithelial (type I), subligamental (type II), transmuscular (type III), total (type IV), extended to the anterior commissure and contralateral vocal fold (type Va), extended to the ipsilateral arytenoid (type Vb), extended to the subglottis (type Vc), extended to the ventricle (type Vd), and extending from the anterior commissure (type VI) [14, 15]. The main concern during preoperative evaluation for TLM is the availability of adequate exposure of the tumor and its surrounding tissue in order to achieve negative resection margins [16]. Other limitations for employing TLM include tumors that impair vocal cord mobility by infiltrating the cricoarytenoid joint, involve the anterior commissure, invade the arytenoid, infiltrate the posterior paraglottic space, or extend to the ventricle [11, 17].

Oncologic and functional outcomes

Effectiveness as primary surgery: Two meta-analyses comparing the effectiveness of TLM vs. RT showed comparable or superior oncologic outcomes following primary TLM compared to RT, including disease-free survival, local control, laryngeal preservation, disease-specific survival and overall survival [18, 19]. Large comparative studies of TLM vs. RT reported higher rates of local control and laryngeal preservation [20, 21]. Interestingly, Mahler et al. reported a higher 5-year local recurrence rate among TLM patients, but the laryngectomy rate following recurrence was lower among TLM patients [22]. Thurnher et al. reported a lower local recurrence rate, longer disease-free survival, and lower mortality among TLM patients [23]. When contrasted with open partial laryngectomies, patients with T1 glottic carcinomas treated with TLM exhibited comparable disease-specific survival and local control rate compared to those treated with vertical partial laryngectomy (VPL), and fewer postoperative complications and a lower tracheotomy rate than those treated with VPL [24]. Marcotullio et al. confirmed the effectiveness of TLM compared to supracricoid partial laryngectomy (SCPL) in T1b glottic tumors and reported similar rates of local control and 10-year overall survival [25]. Furthermore, TLM yielded comparable recurrence-free survival and overall sur-

vival compared to SCPL in a small cohort study concerning T2-T3 intermediate-stage glottic carcinomas [26]. However, for T1-T2 stage glottic tumors involving the anterior commissure, current evidence indicates certain differences in the oncologic outcomes between TLM and OPL. Observations have found that TLM might yield a higher rate of local recurrence compared to OPL among patients who had T1-T2 glottic tumors that involve the AC, although the two types of surgery showed similar effectiveness in tumors without AC involvement [27]. A study that investigated the effectiveness of TLM vs OPL among patients who had T1-T2 glottic carcinomas with AC involvement found similar disease-free survival and overall survival, and 5-year local control rates that slightly favor OPL [11]. Further analysis revealed that grade 3 or 4 tumors as found via indirect laryngoscopy and tumors with infiltration depths of 3-5 mm were risk factors of local recurrence. Gong et al. investigated the effectiveness of TLM compared to those of VPL and supracricoid partial laryngectomy with cricohyoidoepiglottopexy (SCPL-CHEP) among patients with T1-T2 stage glottic carcinomas, and did not find significant differences in overall survival, disease-specific survival or laryngeal preservation [28]. Notably, the oncologic outcomes of patients with AC involvement were worse than those of patients without AC involvement. Results from another comparative study supported these findings [12]. Thus, the effectiveness of TLM as primary surgery for limited stage glottic carcinoma is widely recognized.

Effectiveness as salvage surgery: In the past decade, the application of TLM to early local recurrence of glottic cancer has been explored. Del Bon et al. administered TLM as salvage surgery to selected patients who had T1-T3 stage glottic carcinomas and who then developed local recurrence after primary RT [29]. The functional outcomes of these patients were observed to be comparable to those of patients who received TLM as primary treatment. Weiss et al. investigated the oncologic and functional outcomes in a large cohort where 93 patients with early recurrent tumors received salvage TLM, 52 patients with advanced recurrent tumors received salvage TLM, and 54 patients with advanced recurrent tumors received salvage total laryngectomy [30]. They concluded that TLM was an effective salvage option in early and selected advanced recurrent laryngeal cancer. In a more recent study conducted by Cai et al., it was confirmed that salvage TLM was an effective surgical option with fewer complications and better postoperative health-related quality of life compared to OPL for carefully selected patients with early locally recurrent glottic carcinoma [31]. To assess the effectiveness of TLM in treating early recurrent laryngeal carcinomas after primary RT, Meulemans and team compared the oncologic outcomes in patients who received TLM as primary vs. salvage surgery [32]. When administered to consecutive patients with primary vs. recurrent tumors staged T1-2N0, the recurrence-free survival and local control rate with laser alone in the salvage TLM group were significantly worse than those in the primary TLM group. However, no significant differences in disease-specific survival and overall survival were observed, and salvage TLM yielded a laryngeal preservation rate of 65%, saving a majority of patients in this group from total laryngectomy. In a recent meta-analysis, Russo et al. reported that, for salvage TLM after primary RT/ Chemoradiotherapy (CRT) and salvage TLM after primary TLM, the summary 5-year local control rates were 39.1% and 40.4%, respectively, and the summary 5-year disease-specific survival rates were 58.9% and 67.1%, respectively [10].

Functional outcomes: Voice Quality: For the evaluation of voice quality changes, the Voice Handicap Index (VHI) is the most commonly employed measure for self-rated quality of voice, and the Grade, Roughness, Breathiness, Asthenia, and Strain (GRBAS) scale is most often adopted for perceptive assessment. Multidimensional Voice Program (MDVP) allows objective analysis on a variety of parameters characterizing voice quality. Most studies reported a mild-to-moderate impairment to voice quality following TLM, which may be comparable to or greater than that following RT, but significantly milder than that following OPL [12, 20, 22, 28, 33-35]. The type of cordectomy performed on TLM was found to be a significant predictor of long-term voice quality measures [36, 37], but this may reflect the depth and extent of the tumor [19, 35]. This hypothesis was confirmed by two recent systematic reviews, which examined the degree of dysphonia as quantified by three types of data - the VHI scale for patient-reported data, the GRBAS scale for perceptual data, and acoustic and aerodynamics analysis for objective data - and

found a linear trend in the association between the degree of long-term voice impairment and the type and extent of cordectomy [14, 38]. Despite the long-term mild-to-moderate voice dysfunction after TLM treatment, the voice quality of patients with early glottic carcinoma often improve compared to their preoperative measurements [39-41]. In patients with early (T1-T2) glottic carcinoma that have involved the AC, Yin et al. found that the voice outcomes were better in patients who received TLM instead of OPL, while no significant differences were observed in oncologic outcome [12].

Swallowing function and quality of life: In patients with intermediate-stage (T2-3N0-1) laryngeal carcinoma who received either TLM or SCPL, Caicedo-Granados et al. found that more than 90% of patients in both groups scored 2 or better on Functional Outcome Communication Scale and Swallowing Scale, confirming the effectiveness of both types of surgery in this patient group [26]. Furthermore, the functional outcomes of patients receiving TLM as salvage surgery were comparable to those receiving it as primary treatment, including both speech and swallowing indicators, which were significantly better than those following OPL [29].

The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTC QLQ-C30) and its head and neck cancer-specific module (QLQ-H&N35), are most adopted instruments for evaluations on quality of life. Based on multiple assessments throughout the postsurgical two years, Hendriksma et al. reported good long-term quality of life among patients who received TLM for early glottic carcinoma [39]. Cai et al. found that patients with early local recurrence who received salvage TLM had better quality of voice and better quality of life when assessed at minimally 12 months after surgery, as evaluated by the Voice Handicap Index (VHI) and EORTC QLQ-H&N35, compared to their counterparts in the salvage OPL group [31].

Open partial laryngectomies

Types and indications

In the early twentieth century, VPL was developed to replace the total laryngectomy in order to preserve the larynx [11]. The frontolateral type, described by Leroux-Robert [42] and later by Bailey and Biller [40], is still in use and indicated for some limited-stage glottic tumors that have involvement of the anterior commissure and thus are not adequately exposed by TLM. In this procedure, vertical incisions are made on the anterior aspect of the thyroid lamina, at approximately 3-5 mm deviation from the midline on the uninvolved side and approximately 8-12 mm deviation on the side involved by a tumor [43]. The affected vocal fold, the anterior commissure, the anterior portion of the unaffected vocal fold along with the anterior thyroid cartilage are removed [11]. Depending on the size of the thyroid cartilage defect, the incision may be closed directly, or glottic reconstruction can be made by using a false vocal fold flap [24]. The modification described by Bailey and Biller extended the indication of this surgery to glottic tumors with marked limitation or fixation of the vocal cord [44]. The development of endoscopic resection surgeries has reduced the indications of VPL, however, the latter procedure still has important applications in glottic carcinomas involving the anterior commissure.

Horizontal partial laryngectomy (HPL) broadened the range of glottic tumors that might be considered for larynx-preserving surgery. The most commonly used procedure is SCPL-CHEP or supracricoid partial laryngectomy with cricohyoidopexy (SCPL-CHP) [11]. In this procedure, the thyroid cartilage is removed; the conserved cricoid cartilage, hyoid bone and at least one set of arytenoid cartilage, muscles and joint are stabilized by suture to allow for the functioning of the remaining larynx [11]. This surgery may be indicated for T1, T2, and selected T3 glottic tumors with fixed vocal cord and mobile arytenoid cartilage, and for tumors with anterior commissure involvement [7].

Oncologic and functional outcomes

Oncological outcomes: Effectiveness of Vertical Partial Laryngectomy: Retrospective case-series reports generally demonstrated good oncologic and functional outcomes for VPL as primary surgery [45-48]. Multiple case-series reports as well as a comparative study conclude that VPL is an acceptable option as larynx-preserving surgery for patients who develop local recurrence after primary RT [45, 49, 50]. Gong et al. and Chen et al. conducted ret-

rospective cohort studies comparing the effectiveness of TLM, VPL, and HPL in patients with T1 or T2 limited-stage glottic carcinoma. Gong et al. reported comparable 5-year overall survival (OS), disease-specific survival (DSS), and larynx preservation rates among patients receiving the three treatment options [28], and Chen et al. reported comparable local recurrence rates among patients who received VPL or HPL, and higher local recurrence rates in patients who received TLM [51]. Zhang et al. compared the effectiveness of VPL and HPL-CHEP as primary treatment for limited-stage glottic carcinoma in a retrospective analysis, and found that the two groups had similar survival time, despite the fact that the HPL-CHEP group had a lower local recurrence rate, better locoregional control, and a higher rate of larynx preservation [52]. Lei et al. compared the effectiveness of the two partial laryngectomies in patients who had T1b glottic carcinoma with AC involvement, and reported similar OS, disease-free survival (DFS), and locoregional recurrence rates [53]. So far, results of functional outcomes from comparative analyses of different types of open partial laryngectomies are limited. Chen et al. reported that voice qualities among patients who received TLM, VPL, or HPL were significantly different, with TLM patients achieving the best voice quality [51]. Lei et al. found better voice outcomes in patients who received HPL compared to those who received VPL [54]. Singh et al. reported in an earlier comparative study that patients who received VPL or total laryngectomy had similar voice qualities which were both significantly worse than normal voice [54]. Other reports demonstrated good swallowing function for patients who received VPL [25, 45, 46, 52].

Effectiveness of supracricoid partial laryngectomy: Since early case-series such as those reported by Laccourreye et al. [55], Chevalier et al. [56], and Bron et al. [57] demonstrated that SCPL-CHEP resulted in increased survival, higher local control rates, and higher larynx preservation rates compared to historical controls treated by either VPL or RT, more institutions have confirmed the effectiveness of this surgical procedure [58-62]. SCPL-CHEP or SCPL-CHP has been proved to be an excellent alternative to total laryngectomy in selected patients with recurrent laryngeal cancer after RT or TLM, albeit with slightly worse oncologic and functional outcomes compared to those with primary laryngeal cancer managed with SCPL [58, 60, 61, 63-66]. It has progressively been used to treat selected advanced glottic carcinomas and has produced comparable or superior results of oncologic and functional outcomes compared to total laryngectomy [66-74].

Functional outcomes: Voice Quality: To date, data from comparative analyses on the functional outcomes of different types of open partial laryngectomies remain limited. Chen et al. reported significant differences in voice quality among patients who underwent TLM, VPL, or HPL, with TLM patients achieving the best voice quality [51]. Lei et al. found that patients who underwent HPL had better voice outcomes compared to those who underwent VPL [53]. Singh et al., in an earlier comparative study, reported that the voice quality of patients who underwent VPL or total laryngectomy was similar, with both being significantly worse than normal voice [54]. Studies of long-term functional outcomes have shown that voice quality gradually improves over the postoperative year [75, 76]; the voice is often rough and breathy, but can achieve a level that is intelligible and satisfactory to the patient [63, 65, 67, 71, 77].

Swallowing Function: Other reports indicate that patients undergoing vertical partial laryngectomy (VPL) demonstrate favorable swallowing function [25, 45, 46, 52]. Arytenoid resection in extended SCPL may prolong decannulation time, delay recovery of normal swallowing, and increase the incidence of aspiration pneumonia [78-80]. Dysphagia and aspiration are very common in the early postoperative period [81], which often leads to aspiration pneumonia [67, 80], but the rate of nasogastric tube removal and return to a normal diet is high [65, 67, 70, 71, 77].

Comparative appraisal of TLM and OPL

The oncologic outcomes of TLM and OPL for early stage glottic carcinoma were compared. **Table 1** summarizes representative studies comparing oncologic outcomes of TLM and OPL for early stage glottic carcinoma. This provides a comparative overview of major studies evaluating the oncologic performance of TLM and OPL. Across most series, both techniques achieved comparable 5-year local control and laryngeal preservation rates. However, in cases with anterior commissure involvement or limit-

Table 1. Comparative oncologic outcomes of transoral laser microsurgery (TLM) and open partial laryngectomy (OPL) for early-stage glottic carcinoma

Study (Year)	Design/N (T stage)	Treatment Compared	Local Control (5 y)	Laryngeal Preservation (5 y)	Overall Survival (5 y)
Luo et al., 2021 [7]	Retrospective study, n=182 (T1-T2N0M0); 65 TLM, 117 OPL; all with anterior vocal commissure involvement	TLM vs OPL	TLM: 85.0%; OPL: 93.1% (no significant difference, *P*=0.073)	90-99% reported in literature review; specific 5-y laryngeal preservation not provided in results section (no direct comparative figure)	TLM: 94.7%; OPL: 96.5% (*P*=0.375)
Gong et al., 2022 [23]	Retrospective single-center study, n=425 (T1-T2N0M0); TLM=122, VPVertical Partial Laryngectomy (VPL) 167, CHCricohyoidoepiglottopexy (CHEP) 136	TLM vs VPL+CHEP	- (not directly reported; study analyzed OS, DSS, LFP instead of LC)	TLM 83.5%, VPL 89.1%, CHEP 86.4% at 5 years (**Table 2**); no significant difference (*P*=0.774)	TLM 88.4%, VPL 91.6%, CHEP 88.6% at 5 years (**Table 2**); no significant difference (*P*=0.688)
del Mundo et al., 2020 [39]	Retrospective single-institution study; n=55 (Tis-T2); all underwent CO_2 ser cordectomy	Single-arm study (TLM only; no RTradiation therapy (RT) OPL comparison)	91% relapse-free local control	100% larynx preservation	96% overall survival; cause-specific survival 100%
Vaculik et al., 2019 [13]	Systematic review & meta-analysis of 16 cohort studies (n=1987; T1N0M0)	CO_2 TLM vs RT	No significant difference (OR=1.19, 95% CI 0.79-1.81, P=0.40)	Favoured TLM (OR=6.31, 95% CI 3.77-10.56, P<0.00001)	Favoured TLM (OR=1.52, 95% CI 1.07-2.14, P=0.02)
Wolber et al., 2017 [22]	Retrospective single-center study; n=77 (T1-T2); 49 TLM vs 28 OS	TrTLM open surgery (OS)	TLM: 20.4% recurrence (38.1% if AC involved); OS: 10.7% recurrence (12.5% if AC involved)	Larynx preservation after recurrence treatment: TLM 77.8%, OS 0%	TLM: 93.9%; OS: 89.3%; no significant difference (*P*=0.47)
Marcotullio et al., 2014 [20]	Retrospective single-institution study; n=92 (T1bN0M0); 39 CO_2 laser cordectomy, 14 cricohyoidopexy (CHP), 39 cricohyoidoepiglottopexy (CHEP)	O_2 ser cordectomy vs supracricoid partial laryngectomy (CHP/CHEP)	Recurrence rates within 10 years: CO_2 ser 7 cases (21.8%), CHP 2 cases (16.6%), CHEP 6 cases (17.6%); differences not significant (*P*=0.22)	Not numerically stated; both procedures achieved “similar local control and survival rates”	3-year/5-year survival: CO_2 ser 92.3%/87.17%; CHP 85.7%/78.5%; CHEP 94.8%/84.6%
Del Bon et al., 2012	Retrospective single-institution study; n=35 (rpT1a-rpT3); all patients had prior radiotherapy and were treated by transoral CO_2 ser microsurgery (TLS) for recurrence or persistence	Single-arm study (salvage TLS after RT failure)	84% (entire cohort); 81% (recurrent/persistent only)	87% (entire cohort); 84.5% (recurrent/persistent only)	91% (entire cohort); 89% (recurrent/persistent only)

ed endoscopic exposure, OPL tended to yield more consistent local control. These findings suggest that while TLM can offer equivalent oncologic safety in well-exposed early-stage lesions, OPL remains indispensable for tumors extending to the anterior commissure or subglottic region (**Table 1**).

Table 2 summarizes representative studies assessing postoperative functional outcomes of TLM and OPL. Overall, TLM provides superior voice quality and comparable swallowing recovery compared to OPL. However, SCPL-CHEP procedures often require longer swallowing rehabilitation and early aspiration, though most patients ultimately return to an oral diet. Most studies report superior or comparable functional outcomes following TLM compared with OPL. TLM ensures better voice quality due to limited structural disruption, while OPL-especially SCPL-CHEP-achieves stable airway and acceptable swallowing with longer rehabilitation. Dysphonia after TLM correlates with the extent of cordectomy, and aspiration following SCPL is typically transient. These findings emphasize that while TLM ensures better phonatory outcomes, OPL remains functionally effective with adequate rehabilitation (**Table 2**).

Prognostic factors

As the TLM approach for limited-stage glottic carcinoma has largely replaced OPLs and gained approval for its effectiveness and some preference over RT among patients [7], uncovering the prognostic factors that increase locoregional recurrence and worsen local control after resection has become a matter of great interest.

Anterior commissure involvement

AC involvement by glottic cancer is recognized as a potential predictor for recurrence; however, the findings so far on the impact of AC involvement on local control and survival have been controversial. Some authors report that AC involvement significantly worsens local control with laser as well as survival outcomes [81-84], while others fail to find such a significance [85]. A systematic review by Hendriksma et al. conclude that a binary (yes/no) definition of AC involvement may introduce variability among studies, thereby leading to conflicting results [86]. Recent studies have started to regard AC involvement as an ordinal variable instead of a binary one. Carta et al. found a statistically significant association of increased recurrence and reduced survival with more advanced AC involvement, but not with early involvement [88]. Furthermore, there is some evidence suggesting a negative linear trend between AC involvement classification and survival outcome [88]. A small study that included clinical and radiological variables suggested that the vertical length of tumor at the AC relative to that of the glottis, and the thyroid interlaminar angle were significant predictors of survival and local control with laser, offering new insight into the underlying mechanism of this association [89].

Surgical margins

Surgical margin status is another intensely researched indicator of prognostic value [85, 87]. When pT category, surgical margin status, tumor differentiation, and surgical wound biopsy status were taken into account, Hendriksma et al. found that a positive margin status did not significantly worsen local control with laser alone, but a positive biopsy status taken from the surgical wound during TLM were significantly associated with recurrence [90]. Carta et al. reported that positive margin status was associated with reduced 5-year local control rate, and in patients with negative margin status, subglottic spread and AC involvement of grade 3 (Rucci's classification) were significant predictors of poorer local control [87]. In a large retrospective analysis, after categorizing margin positivity by negative/close/positive, superficial/deep, and single/multiple, Fiz et al. found that although all positive margin scenarios were associated with more recurrences, they did not negatively impact disease-specific survival when the positivity was single and superficial [91].

Other factors of limited-stage glottic carcinoma that may impact oncologic outcomes have been suggested, such as tumor stage [83, 85], spread to the subglottis [85], and type of cordectomy [83].

Prognostic factors for voice quality after TLM

In addition to the extensive research on prognosis of oncologic outcomes, there has been increasing attention to long-term voice quality

Table 2. Functional and quality-of-life outcomes after transoral laser microsurgery (TLM) and open partial laryngectomy (OPL) in early-stage glottic carcinoma

Study (Year)	Surgery Type/Patient Group	Voice Assessment Tools	Results (Voice)
Hendriksma et al., 2019 [38]	Prospective longitudinal cohort; n=61 (T1a=29, T1b=19, T2=13); treated with CO_2 TLM: unilateral type III or bilateral type II resections	VHI (Voice Handicap Index), GRBAS scale (Grade only), EORTC QLQ-HN35 (speech-related items)	VHI: improved from 30.5 (pre-op) → 21.8 (at 2 years) (Δ=-8.7, *P*=0.003); major improvement within 6 months (Δ=-7.2). Females showed greater improvement (VHI 8.7 vs 23.9 in males, *P*=0.023). GRBAS (Grade): mean 1.5 (pre-op) → 1.4 (at 2 years); scores stabilized after 6 months; T1a tumors showed improvement (Δ=-0.29), T1b-T2 no change (*P*=0.001 across stages). EORTC QLQ-HN35 Speech: speech problems significantly improved (Δ=-24, *P*<0.001); at 2 years, mean scores: male 14, female 7 points; female patients reported better outcomes.
Vaculik et al., 2019 [13]	Systematic review & meta-analysis; 16 cohort studies (n=1987, T1N0M0 glottic SCC); compared CO_2 TLM vs RT	No direct voice assessment (study focused on oncologic outcomes)	No functional/voice data were analyzed. The meta-analysis evaluated only overall susurvival (OS), disease-specific susurvival (DSS), laryngeal preservation, and local control. Results: • Overall susurvival (OS): favoured TLM (OR=1.52, 95% CI 1.07-2.14, *P*=0.02). • Disease-specific susurvival (DSS): favoured TLM (OR=2.70, 95% CI 1.32-5.54, *P*=0.007). • Laryngeal preservation: favoured TLM (OR=6.31, 95% CI 3.77-10.56, *P*<0.00001). • Local control: no difference between TLM and RT (OR=1.19, 95% CI 0.79-1.81, *P*=0.40).
Caicedo-Granados et al., 2013 [21]	Retrospective cohort; 60 patients with stage II-III laryngeal SCC (T2-T3, N0-N1); 32 underwent TLTLM28 underwent SCL (supracricoid laryngectomy with CHEP or CHP)	Communication Scale (CS) to assess speech quality	At last follow-up, 97% of all patients had CS ≤ 2 (functional voice). TLM group 100%, SCL group 92% retained functional voice. [L239-L240] In SCL patients, CS worsened significantly from 1.50 to 2.04 (*P*<0.001); no significant change in TLM group (0.88 → 1.06, *P*=0.146). [Ta40-L241] Overall, laryngeal preservation with functional speech was achieved in 88% of the entire cohort. [L240]
Aaltonen et al., 2014 [33]	Randomized controlled trial; n=56 (T1aN0M0, male patients only); compared Transoral CO_2 ser microsurgery TLS (n=31) vs RT (n=25, 66 Gy/33 fx over 6.5 weeks)	GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain); VAS (self-rated hoarseness & impact on daily life); Videolaryngostroboscopy	Expert-rated voice: overall grade (G) similar between groups (*P*=0.967). Breathiness: significantly higher after TLS (1.52 vs 0.28 at 24 months, *P*<0.001). Asthenia: slightly higher in TLS (0.74 vs 0.11, *P*=0.003). Self-rated hoarseness (VAS): similar between groups (*P*=0.144); both improved vs baseline (TLS 59.0 → 43.1, *P*=0.04; RT 53.1 → 35.4, *P*=0.026). Impact on daily life (VAS): improved more in RT (8.4 vs 32.4, *P*=0.007). Videolaryngostroboscopy: TLS showed more incomplete/irregular glottal closure (*P*<0.05). Summary: overall voice quality comparable; RT produced less breathy voice and less daily inconvenience.

after receiving primary TLM. Recently, it has been recognized that the type of cordectomy according to the European Laryngological Society (ELS) classification or the extent of the laryngeal tissue removed is an important stratifying variable when making comparisons on long-term voice outcomes. In a systematic review on this matter, Colizza et al. compared the voice outcomes between the group of limited (subepithelial, subligamental) cordectomies and the group of extended (transmuscular, total, extended) cordectomies, and found significant differences in all three types of voice outcomes (acoustic and aerodynamic indices, GRBAS scale and VHI) [35]. The authors propose that the findings are related to the depth and extent of excision, the amount of lost tissue, and the resultant scarring to the remaining tissues. Sjögren et al. further analyzed the voice outcomes by each type of cordectomy in the ELS classification and revealed negative linear trends between the type of cordectomy and all three measures of voice outcomes [36]. More studies are needed to explore the influencing factors of voice quality prognosis.

Discussion

According to this review, TLM and OPL remain the two principal methods for the surgical management of limited stage glottic carcinoma, each offering high rates of oncologic control and laryngeal preservation. Our synthesis of the current literature indicates that both procedures yield comparable oncologic outcomes, yet their functional profiles and clinical applicability differ markedly.

From an oncologic standpoint, multiple retrospective series and meta-analyses have demonstrated that TLM and OPL achieve similar 5-year overall and disease-specific survival rates in appropriately selected patients [23, 33, 34]. However, several methodologic limitations must be acknowledged. Most of these studies are single-center and retrospective in design, with heterogeneous inclusion criteria and limited adjustment for confounding variables, which introduces selection bias. Moreover, AC involvement remains a subject of controversy. Some authors reported that AC invasion is associated with higher recurrence and poorer local control following TLM [83, 87], while others observed no significant difference if adequate exposure and negative margins are achieved [85, 88, 89]. This inconsistency highlights the need for prospective, exposure-stratified studies to clarify whether AC involvement is an independent prognostic determinant or simply reflects technical limitations during laser surgery.

In terms of functional outcome, TLM generally provides superior or equivalent voice quality compared to OPL, accompanied by shorter hospitalization and faster recovery [5, 6, 35, 36]. Nevertheless, the extent of resection plays a crucial role: the depth of cordectomy, as defined by the European Laryngological Society classification, correlates inversely with postoperative voice quality [35, 36]. Therefore, “function-preserving” surgery should not only refer to the surgical modality but also to the extent of tissue excision and reconstruction strategy. Conversely, OPL-especially SCPL-offers durable airway protection and satisfactory long-term swallowing outcomes once rehabilitation is completed [55-62], despite a slower initial recovery. These findings suggest a trade-off between early phonatory recovery and stable airway function, emphasizing individualized treatment planning.

A major limitation across the current literature is the inconsistency in functional assessment. Studies employ diverse scales such as the VHI, GRBAS, and EORTC QLQ-H&N35, making inter-study comparisons difficult. In addition, long-term patient-reported outcomes and late complications (e.g., chronic dysphonia, aspiration) are rarely assessed beyond two years of follow-up. Standardized and validated assessment tools are urgently needed to accurately evaluate post-treatment quality of life and facilitate data pooling across centers.

Another gap in evidence is the paucity of prospective randomized trials directly comparing TLM and OPL. The available randomized data predominantly involve TLM versus radiotherapy rather than open surgery [5, 6], Consequently, most surgical comparisons rely on retrospective observational data, which may overestimate the benefits of one technique depending on institutional expertise. Future multicenter registries and prospective cohort studies incorporating surgeon experience, learning curve, and patient comorbidity profiles are warranted to provide a more balanced appraisal of outcomes. In addition to conducting high-quality

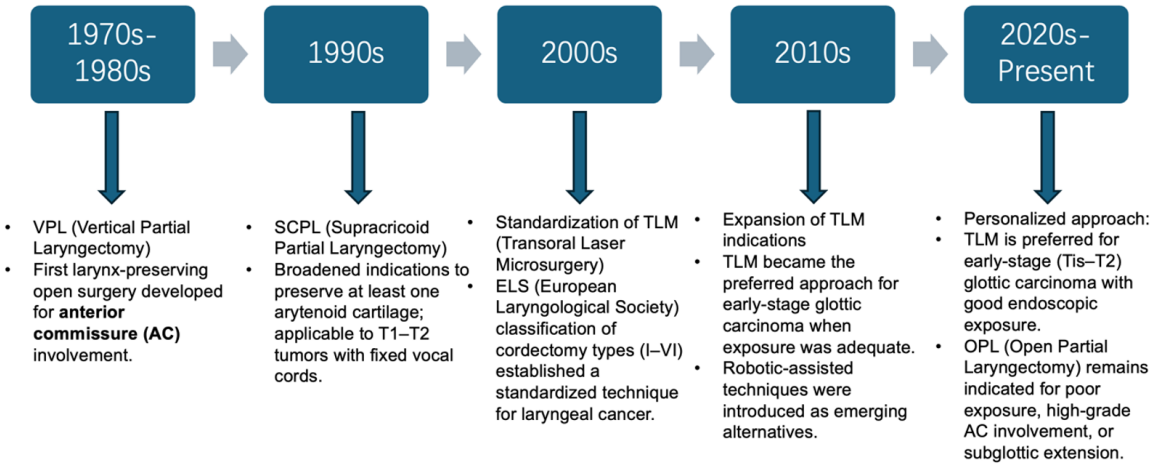

Figure 1. Evolution and current indications of transoral laser microsurgery (TLM) and open partial laryngectomy (OPL) for limited stage glottic carcinoma.

prospective studies, future research should focus on developing more precise individualized prediction tools. Specific recommendations include: (1) Developing radiomics models or artificial intelligence algorithms based on preoperative high-resolution imaging (e.g., CT, MRI) to predict TLM margin status (positive/negative/close) and key parameters of postoperative voice function (e.g., fundamental frequency, harmonic-to-noise ratio), thereby assisting preoperative decision-making and patient counseling. (2) Promoting the establishment of prospective, multicenter cohort studies or registries that employ unified, standardized functional assessment protocols (e.g., specified versions of VHI, standardized acoustic analysis protocols) to ensure data comparability and enable the accumulation of large-scale real-world evidence. (3) For complex cases (e.g., extensive anterior commissure involvement), designing and evaluating hybrid surgical strategies or modified techniques that combine the advantages of endoscopic and open approaches, aiming to explore the possibility of further optimizing functional outcome while ensuring oncological radicality.

Finally, while TLM is often perceived as superior in cost-effectiveness and voice preservation [18, 36], such advantages must be interpreted within the context of case selection and institutional capacity. High-volume centers with advanced laser facilities may preferentially treat fewer complex lesions endoscopically, thereby inflating the apparent benefit of TLM. Conversely, OPL remains indispensable for tumors with limited transoral exposure, extensive anterior commissure invasion, or cartilage infiltration [65, 89]. The optimal management strategy should therefore be individualized, integrating tumor characteristics, patient factors, and surgical expertise to balance oncologic control and functional preservation.

Conclusions

Accompanying the advances in surgical techniques, the indications of TLM for the treatment of laryngeal cancer have been expanding. However, for some limited-stage tumors that cannot be operated on with laser, the role of OPLs in laryngeal preservation is still important. A timeline illustrating key milestones in the development of larynx-preserving surgery, highlighting major innovations and the evolving clinical roles of OPL and TLM (**Figure 1**). For surgeons in training, knowing the advantages and limitations of each surgical approach and learning to balance oncologic and functional outcomes in treatment strategy will be crucial to successful patient management. Finally, understanding the nuanced aspects of oncologic and functional prognosis is key to effective communication and management of patient expectations.

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Disclosure of conflict of interest

None.

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