Partial Laryngeal Surgery in 2023

Chapter 9
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Introduction

Since the pioneering of total laryngectomy (TL) in 1873, the surgical approach to treating advanced laryngeal cancer (LC) has evolved significantly, emphasizing laryngeal preservation and functionality over the past 150 years [1, 2]. Originally, treatments prioritized loco-regional tumor control, with functional conservation being less important. However, a deeper understanding of LC's natural progression and epidemiology led to a shift in focus. The late twentieth century saw peak interest in partial laryngeal surgeries, particularly for early- and select intermediate-stage cancers, which helped preserve essential functions like speech, breathing and swallowing [3–6].

As the twentieth century ended, this optimism waned due to new chemoradiation protocols aimed at organ preservation, which promised better disease control and improved patient quality of life, even for more advanced stages [7, 8]. Despite initial enthusiasm, subsequent studies revealed limitations in survival rates, prompting a reassessment of the non-surgical strategies [9]. Recently, there has been a renewed interest in partial laryngeal surgeries, spurred by advances in understanding tumor biology, patient selection, surgical techniques and tailored surgical responses to tumor size [10–12].

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In this landscape, open partial horizontal laryngectomies (OPHLs) have become key in modern efforts to maintain laryngeal function. These surgeries have been validated over recent decades for effectively managing intermediate to locally advanced LC without extensive neck metastases [13].

Key Clinical and Pathological Issues for Preserving Surgical Function of the Larynx

Modern partial laryngeal surgery has advanced by leveraging the unique clinico-pathological features of tumors, broadening the scope of surgical intervention to encompass intermediate and advanced T stage tumors. This progression enables a greater number of patients with advanced disease to undergo surgeries that prioritize the preservation of laryngeal functions. Several critical factors underpin this approach:

1. **Comprehensive patient selection**. Selecting patients for partial laryngeal surgery goes beyond tumor characteristics to include a detailed assessment of clinical and demographic factors. This holistic approach helps pinpoint candidates who can handle the rigors of surgery and are likely to recover effectively, all while maintaining vital laryngeal functions. Factors to consider include the patient's overall health, age and potential for recovering from surgery-related complications [14].
2. **Patterns of local tumor spread in advanced LC**. The progression patterns of T3 and T4a LC are distinctive—T3 tumors penetrate deeper into the laryngeal tissues, while T4a tumors extend beyond the larynx into surrounding structures. Recognizing these patterns pre-operatively is vital for planning of precise surgeries that selectively target affected laryngeal areas while conserving crucial anatomical structures [15, 16].
3. **Reduced metastatic risk in advanced glottic cancer**. Advanced glottic laryngeal cancers typically have a lower risk to metastasize to the cervical lymph nodes than supraglottic ones. This feature is crucial for opting for surgical methods that focus on conserving laryngeal functionality, allowing for surgical treatment alone even at advanced stages. Such strategies significantly enhance quality of life by maintaining voice and swallowing functions [17].
4. **Differentiation of arytenoid fixation patterns**. Although arytenoid cartilage fixation was traditionally seen as a negative indicator for partial surgery, recent analyses suggest some patterns might still be conducive to successful laryngeal preservation. Identifying these patterns enables more accurate and safer patient selection for surgery [18].
5. **Pre-operative stratification based on topography**. The technique of classifying advanced tumors pre-surgery based on their topographical spread, especially using the "magic plane" concept, marks a substantial advancement. This strategy, focusing on tumor invasion into the posterior paraglottic space and considering arytenoid mobility, enhances surgical precision and expands the possible surgical directions, thus improving laryngeal preservation outcomes [13, 19, 20].

Recent Developments in Clinical and Radiological Assessments

The progress in treating locally advanced LC highlights the crucial importance of comprehensive endoscopic and radiological evaluations. Recent enhancements in endoscopic techniques include the adoption of high-definition videolaryngoscopy, narrow-band imaging (NBI), and the STORZ professional image enhancement system (SPIES) endoscopy. These tools provide detailed images of the mucosal surface and vascular structure, crucial for an early detection and precise delineation of neoplastic lesions, especially around their margins [21, 22].

In the management pathway for an OPHL, in-office endoscopy is pivotal. It assesses the superficial spread of the tumor, its potential pathways of extension, and the mobility of the vocal cords and arytenoids [18, 23]. Imaging techniques like computer tomography (CT-scan) and magnetic resonance imaging (MRI) are essential for visualizing the submucosal progression of the disease [24]. CT-scans are favored for their quick imaging, high resolution, and ability to assess cartilage involvement and extralaryngeal tumor spread, all key for surgical planning. MRI, with its superior contrast for soft tissues, excels in evaluating submucosal spread and involvement of critical areas like the paraglottic and pre-epiglottic spaces [25, 26]. Adding diffusion-weighted imaging (DWI) to MRI further enhances its utility by distinguishing tumor from peritumoral edema, aiding in the precise planning of conservative surgeries like OPHL, especially in salvage scenarios for radio-recurrent tumors [27, 28].

A thorough endoscopic assessment under general anesthesia finalizes the preoperative work-up, offering a comprehensive analysis of less visible growth patterns of the tumor, enabling lesion palpation and targeted biopsies. This step is integral for grasping the three-dimensional aspects of the tumor and planning the type of surgery required within a modular approach.

Effective collaboration between clinicians, radiologists and pathologists is indispensable, especially in complex cases. This teamwork should be a dynamic, cyclic process of precise inquiries and targeted responses to refine diagnostic and therapeutic strategies [29]. This collaborative approach ensures that each surgical plan is tailored to the patient's specific condition, enhancing both the precision and efficacy of the treatment.

Innovations in Surgical Techniques for LC

Some studies emphasize the necessity for advancing the conventional methodologies of partial laryngeal surgery to treat progressively complex, locally advanced tumors. This development underlines the importance of adopting flexible, modular surgical methods that ensure complete tumor excision, even in intricate scenarios [30]. The surgical arsenal for advanced laryngeal cancer has been substantially enhanced by integrating supratracheal partial laryngectomy (STPL), a notable

progress in addressing glottic tumors that extend to the anterior, inferior, and/or posterior subglottic areas, including cases prone to extralaryngeal dissemination. This addition expands the range of surgical interventions available, providing a holistic solution to particularly challenging conditions [31, 32].

Historically, the primary surgical options to select for locally advanced supraglottic and glottic tumors, especially those with transglottic spread, have been supraglottic and supracricoid laryngectomies. The introduction of STPL aims to increase the thoroughness of surgical procedures in difficult tumor sites, improving the chances of complete tumor removal while attempting to maintain maximum laryngeal functionality [33].

The establishment of STPL and its proven success in both oncological and functional outcomes have led to the adoption of a new classification by the European Laryngological Society (ELS) [34]. This classification system divides OPHLs into three types, depending on the lower boundary of the surgical resection, each designed to conserve laryngeal function: type I (supraglottic laryngectomies), type II (supracricoid laryngectomies), and type III (supratracheal laryngectomies). Each type can extend to adjacent laryngeal and pharyngeal structures, involving one arytenoid (+ARY), the base of the tongue (+BOT), the piriform sinus (+PIR) and the cricoarytenoid unit (+CAU). OPHLs type II and type III may or may not preserve the epiglottis (indicated by suffix A or B). This system was devised to support a conservative, adaptable surgical approach to treating laryngeal cancer, offering surgeons a choice among twelve distinct procedures that balance oncological success with quality of life preservation [30].

In specific cases, the narrow margins of resection obtained from these surgeries, if confirmed disease-free through a detailed and standardized evaluation of the surgical sample, are adequate to provide positive oncological results, even for locally advanced tumors [35].

Furthermore, in the management of these tumors, it's vital to consider the heightened risk of lymphatic metastasis to level VI, notably in tumors with subglottic extension and anterior extralaryngeal spread, which necessitates critical VI level dissection [36]. Moreover, due to the potential for unrecognized extralaryngeal extension in advanced cases, the removal of strap muscles is essential to achieve a degree of radicality comparable to TL, a technique proven by Schindler and coll. to preserve swallowing function [37].

Oncologic Outcomes Following OPHLs

OPHLs have significantly improved the conservative management of advanced LC, achieving stable and impressive results. These treatments are particularly effective when the tumors are confined within certain anatomical boundaries (the "magic plane") without causing arytenoid immobilization. This underscores the importance of understanding anatomical and functional divisions for predicting better outcomes in patients, a method that proves more insightful than the traditional TNM staging

system, emphasizing the importance of tumor positioning in treatment strategies. Initial studies indicated that posterior T3 tumors that invade the posterior paraglottic space and cause arytenoid immobilization are less responsive to OPHLs, leading to poorer oncologic results compared to anterior tumors [19]. Further research confirmed these observations, showing that survival rates for T3–T4a tumors treated with OPHLs are significantly better for anterior tumors compared to posterior ones, with notable differences in survival statistics. These insights, combined with a variety of surgical options, reveal a distinct prognostic advantage [20].

Another recent study showed that OPHLs can still be effective for tumors extending posteriorly and causing arytenoid immobilization, especially if the subglottic extension at the vocal cord's midline is under 10 mm [18]. Analyzing data from reviews on treatment-naïve patients with T3N0 LC, who demonstrate high local and loco-regional control and impressive 5-year overall survival rates, has become more understandable (Tables 9.1 and 9.2). Campo and coll. highlighted that OPHLs serve as an effective treatment for naïve pT3N0 LC patients. Additionally, the ability of OPHLs to maintain high rates of survival free from laryngectomy and laryngo-esophageal dysfunction in T3 patients highlights its capacity to balance oncological effectiveness with quality of life considerations [38].

The conservative approach to managing T4a tumors, often seen as limited to cases with minimal extralaryngeal tumor extension initially staged as cT3 and later identified as pT4a in pathological findings, has gained support from recent multicenter studies [39]. This strategy, particularly using type II and III OPHLs for T4a tumors with minimal extralaryngeal volume, aligns oncological outcomes with those of less advanced T–categories. The frequent understaging during clinical assessments highlights the effectiveness of a systematic and structured approach in managing these more complex and inherently riskier cases.

Table 9.1 Studies analyzing 5-year oncologic outcomes following OPHL for T3 LC

Authors and year	No. of patients	OS (%)	DSS (%)	DFS (%)	LRC (%)	LFS (%)
Laudadio et al. (2006) [40]	58	88.7	NA	77.6	NA	NA
Sánchez-Cuadrado et al. (2011) [41]	17	52	64	67	NA	NA
Mercante et al. (2013) [42]	32	87.3	NA	78.2	96.2	NA
Sperry et al. (2013) [43]	34	83.8	84.4	NA	85.2	92.6
Rizzotto et al. (2015) [32]	50	86.0	NA	86.0	86.0	NA
Succo et al. (2016) [12]	442	87.8	NA	87.9	89.7	93.3
Succo et al. (2018) [19]	390	90.1	94.5	87.4	88.8	86.8
Xia et al. (2018) [44]	106	65.8	73.6	72.1	NA	NA
Del Bon et al. (2019) [20]	67	74.1	80.5	63.4	NA	63.8
Gong et al. (2019) [45]	42	77.8	77.8	63.3	NA	NA
Mattioli et al. (2021) [46]	28	92.9	100	89.3	NA	89.3
De Vincentiis et al. (2022) [13]	116	79.3	85.3	81	NA	82.76

DFS disease-free survival, *DSS* disease-specific survival, *LFS* laryngectomy-free survival, *LRC* locoregional control, *NA* not available, *OS* overall survival

Table 9.2 Studies analyzing 5-year oncologic outcomes following OPHL for T4 LC

Authors and year	No. of patients	OS (%)	DSS (%)	DFS (%)	LRC (%)	LFS (%)
Laudadio et al. (2006) [40]	13	61.5	NA	53.8	NA	NA
Rizzotto et al. (2015) [32]	51	80.4	NA	60.8	62.7	NA
Succo et al. (2016) [12]	113	71.2	NA	68.1	71.7	93.3
Succo et al. (2018) [19]	89	81.9	91.3	71.2	75.5	72.9
Del Bon et al. (2019) [20]	18	71.8	71.8	43	NA	43.1
De Vincentiis et al. (2022) [13]	33	70.9	77.4	77	NA	66.67
Succo et al. (2023) [39]	134	82.1	89.8	75.7	NA	93.3

DFS disease-free survival, *DSS* disease-specific survival, *LFS* laryngectomy-free survival, *LRC* locoregional control, *NA* not available, *OS* overall survival

Assessment of Functional Outcomes After Partial Laryngeal Surgery

OPHL is recognized as a critical conservative surgical method for treating LC, spanning from the early and intermediate stages to certain advanced T4a LC [34]. These surgeries are noted for their effectiveness in cancer control, evidenced by high rates of overall survival (OS), disease-free survival (DFS), and laryngectomy-free survival (LFS) rates [12, 47]. Furthermore, OPHL aims to preserve the larynx's essential functions, such as swallowing, breathing, and speaking and reduce the likelihood of needing a permanent tracheostomy. Five-year rates of maintaining laryngeal function after OPHL are reported to be between 91.2% and 98.5%, depending on the initial severity of the disease, with types II and III OPHL showing similar functional outcomes [33, 37, 48].

Assessing functional results after OPHL is crucial for surgical planning and involves detailed preoperative analysis of patient-specific and disease-specific factors to develop personalized treatment plans. Recovery of voice, breathing, and swallowing functions is generally good, though there is notable variation. Type I OPHL typically results in better voice quality due to less impact on the vocal folds, while types II and III often experience a considerable reduction in voice quality, although rehabilitation techniques can help achieve effective verbal communication [49].

Post–OPHL, regaining swallowing ability poses a significant challenge, with initial post-surgery issues improving over 6 months, enabling most individuals to resume normal eating. Still, ongoing swallowing difficulties may increase the risk of complications like aspiration pneumonia. Differences in the duration of tracheal cannula usage, nasogastric tube (NGT) feeding, and hospital stays illustrate the variability in recovery as supported by existing studies [37, 50].

Recent research has highlighted favorable laryngeal function preservation rates, with a focus on identifying predictors of challenging recoveries to enhance pre-surgery patient selection [12, 47]. Factors such as older age, lower body mass index (BMI), smoking, existing health issues, osteophytosis, and advanced cancer stages have been linked to poorer health and functional outcomes post-surgery [14].

The focus has increasingly shifted towards not only the oncological results of partial laryngectomies but also their functional impacts, emphasizing the importance of quality of life post–OPHL. Recent literature underscores this interest, aiming to improve both survival and post-operative quality of life. Despite some initial disappointments in functional recovery, there are many therapeutic and surgical options available that can significantly enhance essential laryngeal functions [51, 52].

Recent advancements have shown significant potential for functional improvement through specific interventions, such as phonosurgical injection techniques to aid voice and swallowing, and transoral laser microsurgery for managing laryngeal stenosis to improve breathing. The PROEL (proprioceptive elastic) method is also being utilized for voice rehabilitation, showing promising early results in phonatory recovery [53]. These varied approaches highlight the comprehensive efforts to improve and manage post–OPHL functional recovery, focusing on both addressing physical deficits and enhancing remaining capabilities, customized to each patient's unique situation.

Management of LC Recurrence Post Radiotherapy or Laser Treatment

Research into the various surgical methods available after initial treatments like radiotherapy (RT), chemoradiation (CRT), or transoral laser microsurgery (TOLM) has become increasingly crucial. Historically, TL was the primary technique for managing treatment failures. Currently, however, the success of less invasive surgical methods in specific situations is acknowledged. These less invasive methods are proving to be effective alternatives to TL, providing both cancer control and maintaining laryngeal functions.

An extensive review of multiple studies shows that despite early detection of recurrences, approximately 30% of patients exhibit advanced disease in the tissue samples examined [12]. This highlights a common problem of mis-staging in these recurrent scenarios. Factors contributing to this include the biological nature of tumors that recur after radiation—hidden disease extent due to chronic swelling and scarring, more aggressive tumor growth, increased chances of spread beyond the larynx, and more frequent occurrence of undifferentiated tumors with invasion into blood vessels and nerves—and changes in anatomy and structure post–laser surgery [54–56].

OPHLs are now recognized as a viable surgical choice for recurring LC, suitable for a wide array of clinical situations. These include rT1 and rT2 tumors that are difficult to assess endoscopically or that extend across the commissure, rT2 tumors with reduced movement of the vocal cords, and rT3 tumors with limited impact on the spaces next to or in front of the glottis, including those affecting the thyroid cartilage without spreading outside the larynx [57].

Studies assessing the effectiveness of OPHL after RT and TOLM show local control (LC) rates of 70–95% after 2 years, DFS rates of 70–90% over 3 years, and OS rates of 70–90% over 5 years [58]. Even with these promising figures, some patients may still need a salvage TL. The rate of laryngeal preservation is reported at 85.2%, with a high success rate in removing breathing tubes, signifying effective airway management. Yet, laryngeal narrowing remains a significant complication. Most patients report good swallowing ability, although some require a feeding tube. Vocal results vary, with some experiencing major changes in voice quality [58].

In conclusion, for certain recurrent LC cases, OPHLs provide a treatment option that effectively balances cancer treatment with functional preservation, advocating for its wider use in clinical settings.

Discussion

The resurgence in partial laryngeal surgery, particularly directed at treating intermediate to advanced stages, is due to a better grasp of the disease's progression, the minimal occurrence of cervical metastases in glottic cancers, and the established spread patterns of LC. This knowledge has enhanced the application of OPHLs, which can provide outstanding oncological results with a one-time intervention if surgical completeness is verified through pathological examination. Recent developments in the selection of patients and tumors go beyond TNM classifications by integrating endoscopic, functional and imaging assessments, thereby improving the safety and effectiveness of conservative treatments at advanced stages. Innovations in surgery, such as the adoption of extended partial procedures like STPLs for tumors that approach the subglottic area and pose a high risk of extending beyond the larynx, have facilitated a modular surgical approach, increasing the variety of cases that are amenable to such surgeries. An improved understanding of areas prone to recurrence, particularly regional recurrence at the VI level, has improved loco-regional management with more precise and targeted surgical methods and planned dissections. There is a notable variation in functional outcomes after partial laryngeal surgeries, especially concerning voice quality and respiratory functions, which highlights the complexities of recovery after surgery. This variation emphasizes the urgent need for ongoing research into rehabilitation methods to improve these outcomes. While advanced surgical methods and post-operative treatments are designed to conserve as much functionality as possible, patient outcomes can still differ widely. Corrective surgeries, like injection laryngoplasties, are increasingly essential for enhancing functional results, particularly in terms of voice and breathing efficiency. There are ongoing debates regarding adjuvant treatments for advanced pT stage tumors, particularly about how post-operative radiotherapy might adversely affect functional outcomes without clearly benefiting oncological results in cases with positive margins [59].

Conclusions

Based on existing research and a detailed analytical review, it can be concluded that today OPHLs are pivotal in the conservative treatment of intermediate to advanced stages of LC. These procedures are competitive with non-surgical organ preservation methods in terms of oncological results and maintaining laryngeal functionality. Choosing suitable candidates for OPHLs is of utmost importance. Currently, surgeons have access to more precise parameters that aid in understanding and improving this intricate decision-making process, which largely depends on the physician's expertise. The main goal is to completely remove the cancer with one therapeutic approach, positioning OPHLs as a key strategy within targeted treatments. The necessity of turning to multimodal treatments due to unanticipated progression of the disease is seen as a limitation of single-mode surgical approaches that aim to preserve the function of the larynx. This emphasizes the need for thorough pre-operative evaluations and highlights the challenges of treating advanced cases, with the objective of retaining organ function while ensuring oncological safety.

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