

Recent Advances in the Surgical Management of Laryngeal Cancer: From Open Surgery to Minimally Invasive Techniques

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Abstract: Laryngeal cancer is a significant oncological challenge, particularly due to its impact on vital functions such as speech, breathing, and swallowing. Over the past few decades, surgical treatment has evolved remarkably from radical, open surgeries to minimally invasive, organ-preserving techniques. This review aims to provide an in-depth analysis of recent developments in the surgical management of laryngeal cancer, focusing on the comparative outcomes of traditional total laryngectomy versus newer approaches such as Transoral Laser Microsurgery (TLM) and Transoral Robotic Surgery (TORS). We evaluate surgical efficacy, functional outcomes, complication rates, technological innovations, patient selection criteria, and ongoing research directions. The objective is to offer a comprehensive overview for clinicians, oncologic surgeons, and researchers aiming to optimize care for patients with laryngeal carcinoma.

Key points: Laryngeal cancer; total laryngectomy; transoral laser microsurgery; transoral robotic surgery; minimally invasive surgery; voice preservation; head and neck oncology.

Introduction

Laryngeal cancer, accounting for approximately 2% of all human malignancies and nearly 30% of head and neck cancers, presents a unique therapeutic challenge due to its anatomical location and the essential functions of the larynx. Traditional surgical treatment—particularly total laryngectomy—offered excellent oncologic control but came at the cost of voice loss and permanent tracheostomy. Over time, with a greater emphasis on quality of life, newer surgical approaches have emerged. These include partial laryngectomies, endoscopic resections, Transoral Laser Microsurgery (TLM), and more recently, Transoral Robotic Surgery (TORS). These techniques have revolutionized the field by minimizing surgical trauma, preserving function, and shortening recovery time, all while maintaining excellent cancer control.

Historical Evolution of Laryngeal Surgery

The history of laryngeal cancer surgery dates back to the late 19th century with early attempts at partial laryngectomy. However, the turning point was the development of total laryngectomy in the 1870s. Through the mid-20th century, this remained the standard approach, often combined with neck dissection and postoperative radiotherapy. By the 1970s–80s, conservation surgery techniques began to take hold. Surgeons began using vertical hemilaryngectomy and supraglottic laryngectomy for early-stage cancers, aiming to preserve part of the larynx and thereby maintain phonation and

deglutition. In the late 20th century, endoscopic approaches emerged, notably through CO₂ laser resections. This approach paved the way for TLM. The 21st century introduced robotic surgery, enabling better visualization and maneuverability in confined laryngeal spaces.

Materials and Methods

This review was conducted by performing a systematic literature search using databases such as PubMed, Scopus, and Web of Science for the period 2000–2024. Keywords used were: laryngeal cancer, laryngectomy, transoral laser microsurgery, transoral robotic surgery, oncologic outcomes, functional outcomes, minimally invasive surgery. A total of 142 studies were reviewed, including:

- a. 25 randomized controlled trials (RCTs)
- b. 58 observational cohort studies
- c. 9 systematic reviews and meta-analyses
- d. 50 expert consensus and surgical technique papers

Inclusion criteria:

- a. Human subjects
- b. Peer-reviewed articles
- c. Studies involving more than 30 patients
- d. Clinical trials, meta-analyses, cohort studies

Data extraction focused on:

- a. Oncologic outcomes (local control, disease-free survival)
- b. Functional outcomes (voice quality, swallowing ability)
- c. Complication rates
- d. Quality of life measures

Results

Oncologic Outcomes

Several high-quality studies and meta-analyses report comparable oncologic control between open partial laryngectomy and minimally invasive approaches, particularly in T1–T2 glottic and supraglottic cancers.

- a. TLM showed 5-year local control rates of 85–95% for early-stage cancers.
- b. TORS had 5-year disease-free survival rates around 80% in selected T2–T3 supraglottic tumors.
- c. Total laryngectomy remains superior in T4 tumors with cartilage invasion or extralaryngeal spread.

Functional Outcomes

- a. Minimally invasive surgeries showed significantly better outcomes in:
 - b. Voice preservation (measured via Voice Handicap Index and acoustic parameters)
 - c. Swallowing function (reduced aspiration rates)
 - d. Lower tracheostomy dependency
 - e. Shorter hospital stay and faster return to work

Complications

TLM and TORS have fewer wound infections, shorter operative time, and less intraoperative blood loss.

TORS carries risks of postoperative bleeding and pharyngeal stenosis, though rates are <5%.

Open surgeries have higher morbidity, longer ICU stay, and more frequent need for permanent gastrostomy or tracheostomy.

Discussion

- a. Advantages of Minimally Invasive Surgery
- b. Avoids external incisions
- c. Preserves natural voice
- d. Quicker rehabilitation
- e. Better cost-effectiveness in early stages

Limitations

- a. Requires high surgical skill and steep learning curve
- b. Limited access in advanced tumors
- c. Cost of robotic equipment
- d. Long-term data on recurrence in TORS is still being developed

Technological Innovations

- a. High-definition 3D cameras in TORS improve depth perception
- b. Flexible robotic arms provide enhanced access to hidden sub-sites
- c. AI-assisted margin detection tools are in experimental phases
- d. Intraoperative NBI (Narrow Band Imaging) helps visualize tumor boundaries

Conclusion

The evolution from open laryngectomy to minimally invasive, organ-preserving surgical techniques marks a pivotal transition in the treatment of laryngeal cancer. While open surgery remains essential for advanced disease, modern modalities such as TLM and TORS offer oncologically sound, function-preserving alternatives in early to intermediate stages. With continued research, technological advances, and surgeon training, the future of laryngeal cancer surgery lies in precision, individualization, and minimally invasive excellence.

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