

Minimally Invasive Procedures for Laryngeal Carcinoma: Transoral Endoscopic Laser and Transoral Robotic Surgery

Review

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Abstract

Open partial or total laryngectomies with or without radiotherapy (RT) or chemoradiotherapy (CRT) are the only mainstays in the treatment of laryngeal carcinomas. However, minimally invasive procedures such as transoral endoscopic carbon dioxide laser microsurgery (TLM) or transoral robotic surgeries (TRS) are now being increasingly used in selected patients. The

laryngeal framework is not disturbed in these procedures; therefore, the postoperative swallowing function improves more rapidly, and routine tracheotomy is not usually required. Moreover, they have oncological results comparable with open procedures.

Keywords: Laryngeal carcinoma, laser surgery, robotic surgery, minimally invasive surgical procedures

Introduction

For years, total laryngectomy has become the only treatment choice for patients with advanced stage laryngeal carcinoma. In the last 20 years, important surgical improvements have been performed in protecting the functional integrity of the larynx. With the more widespread surgical use of microscope, endoscope, and laser at present, successful functional and oncologic results in laryngeal carcinoma can be obtained through transoral laser microsurgery (TLM) and/or transoral robotic surgeries (TRS).

Clinical and Research Impacts

Transoral laser microsurgery is a minimally invasive surgery performed using surgical microscope, microsurgical instruments, and surgical carbon dioxide (CO₂) laser during direct laryngoscopy. In 1972, Strong and Jako (1) were the first to use CO₂ laser in laryngeal carcinoma surgery. Although the approach of resecting a tumor in pieces rather than as en block according to traditional oncologic rules arouses suspicion, it is being increasingly used because it preserves the airway and thus causes less damage to swallowing and speech functions (2). Compared to radiotherapy (RT) and open partial laryngectomy, the advantages of TLM include the

application in the outpatient status, shorter treatment period, repetition in recurrences, choice of RT in second primary tumor and recurrent tumor cases, opportunity to perform salvage partial open surgery after TLM if needed, and no need of tracheostomy and feeding tube (3).

In TLM, delicate incisions performed with laser do not cause unnecessary laryngeal mucosa loss. In this way, postoperative speech and swallowing functions are preserved at the highest possible level, and early rehabilitation is enabled. In contrast, this situation often leads to positive surgical margins due to a 1-2 mm fine safety margin. The effects of this positivity on local control and survival are controversial. While some authors recommend routine second-look laryngoscopy, the high cost and high rate of a tumor-negative surgical specimen at the second look even as the first pathology margin is positive necessitate questioning this procedure (4). For solving this problem, Remacle et al. (5) have recommended frozen-section biopsy as an alternative to second-look laryngoscopy during the first surgery. The results of frozen-section biopsy, which is taken during transoral laser laryngectomy, and those of a routine histopathological examination are consistent at the rate of approximately



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Received Date: 13.10.2016

Accepted Date: 28.12.2016

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www.turkarchotorhinolaryngol.org

DOI: 10.5152/tao.2017.1930

94% (6). These findings indicate that frozen-section biopsy is a safe technique for reaching benign surgical margins. However, in the study of Fang et al. (7) on TLM patients, it has been stated that although negative margins were obtained with repeated excisions in the same session in patients whose frozen-section results were positive in the first surgery, the rate of recurrent tumor development in the first year was higher compared to patients with negative borders in the first surgery. Authors suggest that the follow-up controls of these patients should be conducted more frequently despite the no need for second-look laryngoscopy. A surgeon's inability to estimate tumor margins exactly at the first look and accordingly surgical margin positivity can be explained with possible field cancerization or possible submucosal spread beyond the clinically and microscopically identifiable tumor. As a result, even if excisions are repeated until negative margins are obtained with frozen section biopsy in the first surgery; the situation that has resulted from the invasive behavior of tumor negatively affects the survival (7).

In this type of surgeries, the main determinant for a successful outcome is the selection of appropriate patients. Carcinoma in situ and T1 glottic carcinomas not involving anterior commissure constitute the most optimal patient group for this technique (8). In early glottic cancers, the addition of "vestibulectomy," which was defined by Kashima et al. (9), to the surgical procedure expands the view during surgery and also allows better follow-up examinations. Patients can be followed up with repeated office laryngoscopic examinations in this manner (8). In case of any clinical suspect in these follow-ups, control direct laryngoscopy and biopsy should be performed. The causes of the clinical suspect were defined as newly developed hoarseness, local pain or otalgia, a suspicious appearance in the vocal cord in office laryngoscopy, or an anatomy preventing the entire vocal cord to be viewed (8).

In early glottic cancers, anterior commissure involvement was demonstrated in 37.1% of patients developing local recurrence after TLM (10). There is no common approach that is internationally accepted for glottic cancers developing in the anterior commissure or involving it. Although local control success rates of open partial laryngectomy are quite high in early glottic tumors with anterior commissure involvement, an important disadvantage is that the larynx is blindly entered during surgery only from the region preoperatively selected. Until the larynx is opened, tumor cannot be viewed (11). In contrast, tumor also may not be completely viewed in a single field during TLM, but it is still removed with the magnification advantage of a microscope. However, TLM is accepted as contraindicated by many surgeons. Nevertheless, some studies have suggested that a safe endoscopic surgery can be performed with some modifications (11-13). Shapshay et al. (12) reported successful results by using endoscopic and external approaches together and including a small part of the thyroid cartilage, which encounters with the anterior commissure, in specimen. In addition to early spread and low rates of local control, poor quality of voice after laser excisions in these tumors limits its advantage of use (14). Taylor et al. (15) compared primary treatment approaches of RT and TLM in a group of glottic cancer patients with anterior

commissure involvement (T1b), and they found no significant difference between the two groups with regard to voice quality. In the oncologic evaluation of results, the rates of two-year local control for TLM and RT were found to be 95% and 85.9%, respectively; the rates of larynx preservation were 100% and 85.9%, respectively; and the rates of disease-free survival were 88.7% and 88.9%, respectively. The authors concluded that TLM was at least as effective as RT from the oncologic perspective in patients. When TLM is used as a treatment option in glottic cancer cases with anterior commissure involvement, a planned second-look surgery allows early detection of possible recurrences (16).

Hinni et al. (17) conducted a multicentered study on patients with five-year follow-up and reported that the larynx was preserved at the rate of 92%. This was the first multinational and multicentered study in terms of the oncologic results of TLM and its practicability. In the series of Peretti et al. (18) on 595 patients treated with TLM, the rate of five-year disease-specific survival was reported as 100% in patients with T1-T3 glottic carcinoma and the rate of larynx preservation as 72.7% in T3 patients. In early-stage glottic cancers, the five-year disease-specific and general survival rates were approximately 95% and 80%, respectively (19). Local preservation, organ preservation, and survival rates were almost similar in RT, TLM, and open partial surgeries (vertical hemilaryngectomy).

Supraglottic cancers are detected in later stages, and their tumor control rates are lower than those of glottic cancers, because their tendency to neck metastasis is higher (20). Supraglottic open partial laryngectomy is an organ preserving surgery with a five-year survival rate of 70%-75% and disease-free survival rate of 90% (21). To provide disease control is easier in the primary region than in the neck in these tumors. In supraglottic laryngectomy with TLM, two main disadvantages become prominent. The first is the prolonged recovery period developing in association with a leaving surgical defect to secondary healing. The second is to perform an external surgery due to the need for bilateral neck dissection. In tumors that are endoscopically accessible, while TLM has similar local control and survival rates compared to open supraglottic laryngectomy, its functional outcomes are more satisfying (22, 23). In addition, when TLM is combined with postoperative RT in the neck, it provides high rates of local control and survival (88% for three years) (23).

The use of TLM in T1-T2 and carefully selected T3 glottic and supraglottic cancers appears oncologically satisfying. An insufficient view of the surgical site, anterior commissure involvement in the craniocaudal direction (T2), invasion of the posterior paraglottic space with arytenoid fixation, massive infiltration of the pre-epiglottic space, and the presence of minor thyroid cartilage erosion (T3) are the most controversial situations with regard to the use of TLM in glottic and supraglottic cancers (24).

The TRS device (Da Vinci robotic surgery system, Intuitive Surgical Inc., Sunnyvale, CA, USA) consists of a robotic tower including a surgeon console and four movable arms. The sur-

geon sits on the console including a high-resolution three-dimensional monitor and directs the robotic arms. The procedures, such as supraglottic laryngectomy, vertical partial laryngectomy, cordectomy, and laryngectomy, can be performed through this technique. Compared to TLM, TRS allows higher view quality and an opportunity to approach the target more easily. Surgical instruments articulated at the distal ends of the robotic arms provide an advantage of free movements and high degree of tissue manipulation. Nevertheless, the transoral approach creates a disadvantage with at least the present laryngoscopes. Particularly, patients with anatomic features, such as narrow mandibular arch, anteriorly located larynx, narrow pharynx, and existing and complete teeth are inappropriate candidates for TRS (25).

In supraglottic surgeries performed with TLM, the lesion is excised not as en block, but in pieces. Moreover, surgeons work on a narrow laryngeal field with limited microscopic and laser line of sight. It is difficult to work with long instruments. In 2007, Weinstein et al. (26) published regarding supraglottic laryngectomy using the TRS technique. The three-dimensional microscopic view and bimanual use of robotic arms allow a delicate surgery in a restricted field. In TLM, particularly, the excision of pre-epiglottic region is difficult due to limited sight. However, TRS provides this region to be safely included in specimen as en block (27). Park et al. (27) reported the rate of one-year disease-free survival after supraglottic laryngectomy with TRS as 91%, the mean time of transition to oral feeding as 8.3 days, the mean length of tracheotomy as 11.2 days, and the mean length of inpatient treatment as 13.5 days. Of the total patients, 90.9% stated voice and swallowing functions to be satisfying. In the TRS series of Kayhan et al. (28) on 13 patients with T1-T2 supraglottic cancer, they reported that the average blood loss was below 40 mL in addition to the advantages of the short length of transition to oral feeding, short length of hospitalization, and no need for tracheotomy. In literature, local control rates after TRS supraglottic laryngectomy are reported to range between 80% and 100% (29-32). The robotic approach is used as an alternative to TLM also in early-stage glottic cancers (33). Disadvantages of laryngeal surgery using TRS are the limited type of surgical instruments, high cost, and absence of an optimal retractor for expanding the working site (27). Moreover, a large series including long-term survivals are needed for the oncologic safety.

Total laryngectomy is a treatment approach with proven surgical efficiency and results in laryngeal cancers recurring after RT. The method that is preferred by considering its safe oncologic results regardless of the location or stage of recurring disease is still open total laryngectomy in many centers (34). However, this approach can cause a complete organ or function loss even in very small tumors. Surgical developments for the protection of function have led to questioning the usability of more conservative approaches also in recurring cases after RT. In a meta-analysis published in 2014, local control rates provided by TLM applied in recurrent tumors after RT (56.9% in two years) were found to be lower compared to open partial laryngectomy (88.2% in two years) (35). This difference exists even after repeated TLMs

(63.8% in two years). TLM is a moderately protective surgery with an average larynx preservation rate of 72.3%. This rate is 84% in open partial surgeries (36). The low success rate in TLM, insufficient experience in open partial surgeries, and willingness to perform a complete oncologic surgery cause total laryngectomy to be preferred in recurrent tumors after RT. However, in another meta-analysis published in 2015, TLM used in the recurrence of early glottic cancers treated with primary RT was reported to provide high rates of survival, local control, and organ protection (37). The difficulty in the determination of cancer margins due to different forms of tumor growth, such as multifocal development and submucosal spread, which can be seen in recurrent tumors after RT, can decrease local control rates with TLM in recurrent laryngeal cancers. However, these are no longer the disadvantages with the use of frozen-section biopsies in surgery. In this manner, it is possible to remove the entire tumor with successive resections (38). In recent years, there are more studies reporting that total laryngectomy with TRS causes lower morbidity in recurrent cases after RT compared to open surgery. Smith et al. (25) applied total laryngectomy with TRS in recurrent cases after chemoradiotherapy and concluded that it was more advantageous than open surgeries in terms of wound healing and fistula formation. They stated that the need for the application of a flap in the neck for the risk of fistula would be reduced in this manner.

Conclusion

Transoral laser microsurgery or transoral robotic surgery, which are options for minimal invasive surgical treatment, are increasingly becoming more prominent in laryngeal surgery, because they give oncologically safe results and preserve the laryngeal functions to a great extent. However, further multicentered prospective studies are needed for overcoming restrictive factors, such as still developing instruments, equipment and surgical experience, and for correctly interpreting the oncologic safety when commonly used in large patient series.

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflict of interest was declared by the author.

Financial Disclosure: The author declared that this study has received no financial support.

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