Transoral Laser Surgery for Supraglottic Cancer

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Abstract: The goal of treatment for supraglottic cancer is to achieve cure and to preserve laryngeal function. Organ preservation strategies include both endoscopic and open surgical approaches as well as radiation and chemotherapy. The challenge is to select the correct modalities for each patient. Endoscopic procedures should be limited to tumors that can be completely visualized during diagnostic microlaryngoscopy. If complete resection can be achieved, the oncologic results of transoral laser surgery appear to be comparable to those of classic supraglottic laryngectomy. In addition, functional results of transoral laser resection are superior to those of the conventional open approach, in terms of the time required to restore swallowing, tracheotomy rate, incidence of pharyngocutaneous fistulae, and shorter hospital stay. The management of the neck remains of paramount importance, as survival of patients with supraglottic cancer depends more on cervical metastasis than on the primary tumor. Most authors advocate bilateral elective neck dissection. However, in selected cases (T1, T2 clinically negative [N0] lateral supraglottic cancers), ipsilateral selective neck dissection could be performed without compromising survival. The authors conclude that with careful selection of patients, laser supraglottic laryngectomy is a suitable, and often the preferred, treatment option for supraglottic cancer.

Keywords: transoral laser surgery; surgical technique; supraglottic cancer; outcome; complications; treatment of the neck

The objectives of surgery for early to moderately advanced supraglottic cancer are cure of the tumor with preservation of voice, deglutition, and an intact airway. Key principles must be adhered to when determining patient eligibility for a surgical organ preservation approach. The eligibility of each patient is based on the site and the extent of tumor, not merely the T classification. Other factors that should be considered are the age of the...
patient, pulmonary function, family, and social structure, as well as comorbid factors such as neurologic disease.

The principles of conservation surgery are based on the known compartmentation of the larynx by cartilaginous and fibroelastic structures that act as barriers to the spread of cancer within the organ, as determined in the past by injection studies and examination of whole organ serial sections. Supraglottic cancer in its early stages tends to remain localized within the boundaries of the supraglottic larynx and pre-epiglottic space. This tendency formed the basis of the horizontal supraglottic laryngectomy (HSL), developed by Alonso in 1939 and subsequently modified, improved, and extended by later surgeons. These advances produced oncologically sound procedures with high cure rates and with improved preservation of function. HSL has become a well-accepted mode of treatment for early (T1,T2) or moderately advanced (selected T3) cancers of the supraglottic larynx, and may be considered the standard of comparison for evaluation of newer procedures. Supracricoid partial laryngectomy with cricothyroidopexy (SCPL-CHP) is another conservation surgical approach that has been employed during the past decade for management of supraglottic cancer and is preferred by many surgeons to the conventional HSL. Results of laser surgery must be measured against the results of both these external approaches.

Glottis-preserving partial laryngectomy using laser microsurgery has in recent years become a recognized alternative for transcervical HSL as surgical treatment for supraglottic laryngeal cancer. Strong and Jako introduced endoscopic treatment with the CO2 laser for laryngeal cancer in 1972. Vaughan first described CO2 laser resection of supraglottic larynx in 1978. In 1983, Davis et al reported the first series of 20 patients who underwent laser epiglottectomy for benign, obstructing epiglottic lesions and for limited suprahypoid epiglottic cancer. However, adequate surgical exposure was problematic at that time. Steiner introduced the use of a bivalved laryngofarynoscope for laser surgery of supraglottic cancer in 1988 with good results. In 1990, Zeitels and Vaughan described a modified version of the endoscope called the supraglottoscope, which had shorter, wider blades than the traditional laryngoscope. This increased the surgical working area and allowed full exposure of the supraglottis.

The oncological results of transoral laser surgery for early and moderately advanced laryngeal cancer appear to be comparable to those of classic supraglottic laryngectomy and supracricoid laryngectomy, provided that clear surgical margins are attained. All these surgical modalities have roles in laryngeal preservation. However, the endoscopic approach offers several advantages: tracheotomies can frequently be avoided, the incidence of pharyngocutaneous fistulas is reduced, rehabilitation of swallowing is faster, the incidence of aspiration pneumonia is lower, and hospital stay is shorter.

Although these surgical treatments have produced significant progress in controlling the primary supraglottic cancer, they solve only part of the problem. The remaining issue is the high incidence of regional lymph node metastasis associated with supraglottic cancer, which ranges from 25% to 50%. Clinically, 30% to 50% of metastases are palpable, and 20% to 40% of clinically negative (N0) necks have occult metastasis. Most authors agree that, because of the high probability of occult neck metastasis, selective neck dissection should be performed even in patients with stages I and II disease.

We have critically analyzed the results of laser resection of supraglottic cancer, in comparison to the previously evolved open surgical approaches, in order to establish the place of laser surgery in current surgical management of supraglottic cancer.

**SURGICAL TECHNIQUE**

The technique of transoral laser resection of supraglottic cancer contradicts the classic rules of oncological surgery because in many cases tumors are sectioned and removed piecemeal. It is possible to do so because the hemostatic effect of the CO2 laser and the operating microscope allow the surgeon to detect the boundary between tumor and healthy tissue. Optimal exposure and visualization of the supraglottic region is critical for safe tumor resection. Ordinary tubular laryngoscopes are not suitable for procedures in this area. Bivalved laryngoscopes with spreadable blades are necessary. The blades may be separated by angulation or parallel distraction, thus providing flexibility in exposing various sites. Numerous adjustments of the position of the laryngoscope during surgery are usually necessary to achieve good visualization of the tumor and of the surrounding healthy tissue. Smaller tumors along the free margin of the epiglottis and of the aryepiglottic fold can be excised in 1 piece as an excisional biopsy. Larger tumors require piece-
meal resection, with consequent sectioning of the neoplasm. Specimens are labeled as to location and sent for frozen section, with particular attention to the resection margins. Several techniques have been described to improve access and visibility. The epiglottis may be initially divided sagittally or horizontally and then retracted into a plane tangential to the laser beam. When infrahyoid tumor extension is present, the pre-epiglottic space must be completely removed.5,6,19 The resection may be extended to include the false vocal cords and the paraglottic space. If cancer approaches the arytenoid cartilage, the arytenoid itself can be transected or resected completely. Consequently, the mucosal and endolaryngeal area that can be extirpated is comparable to that of the classic transcervical HSL, without resection of thyroid cartilage.

Based on the extent of resection that can be safely performed, most authors consider T1, T2, and selected T3 supraglottic cancers (limited extension to pre-epiglottic space) to be indications for curative laser resection, provided that the tumor has been fully visualized during preceding diagnostic microlaryngoscopy.3–6 However, others advocate transcervical tumor resection when tumor invades the pre-epiglottic space.20–22

**ONCOLOGIC RESULTS**

A number of authors in recent years have reported good oncologic results with laser microsurgery in the treatment of patients with supraglottic cancers. A summary of the results of these studies, including only the patients treated by laser surgery alone, is shown in Tables 1–3.3–6,20,21,23 In a multi-institutional study of 42 patients with supraglottic cancer, Zeitels et al20 reported that 19 patients with T1 or T2 tumors treated by laser microsurgery alone developed no local recurrences. Four of 23 patients, mostly with T2 tumors, who underwent laser surgery and postoperative irradiation, developed local recurrence and were salvaged by laryngectomy. One of these patients died of local disease. In the group that underwent surgery and postoperative radiotherapy, the authors regarded endoscopic laser resection as equivalent to excisional biopsy, with histologically controlled results.20 Eckel3 published the results of laser supraglottic laryngectomy in 9 T1 and 37 T2 supraglottic cancers. Sixteen patients received postoperative radiotherapy. Three of the 25 evaluable patients who had not received radiotherapy (12%) had local or locoregional recurrence. Ambrosch et al5 reported the results of laser microsurgery in 46 patients with supraglottic T1 and T2 cancer, with a 5-year local control rate of 100% for pT1 tumors and 88% for pT2 tumors. None of the patients required total laryngectomy for tumor recurrence or for functional reasons. Rudert et al6 reviewed the results of transoral laser surgery in 34 patients with T1–T4 tumors, 12 of whom were treated with a palliative intent. Of the 22 patients (4 T1, 10 T2, 5 T3, 3 T4) who had surgery for attempted cure, 5 (22.7%) developed local recurrence (none T1, 2 T2, 1 T3, and 2 T4). The authors concluded that the transoral approach could be recommended as curative treatment for T1 and T2 tumors and in selected T3 and T4 tumors. Iro et al4 reported on supraglottic cancer resections by laser microsurgery in 141 patients with the following T classifications: 39 T1, 54 T2, 15 T3, and 33 T4. Local recurrences were observed in 21% of T1, 13% of T2, 33% of T3,

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and 9% of T4 cases. The authors state that oncologic results of laser surgery are favorable if tumor-free margins are obtained. However, they advise caution in treatment of T3 lesions with transoral laser surgery. Davis et al21 treated 68 patients with T2 and T3 supraglottic cancers by laser resection; 38 underwent postoperative radiotherapy. Primary site control was maintained in 97% of combined-therapy patients and in all the surgery-only patients.

Ambrosch et al23 reviewed the results of transoral laser surgery in 50 patients with T3 tumors (40 stage III, 10 stage IV). In 41 patients (82%), the tumor was classified as T3 due to invasion of the pre-epiglottic space. Preoperative vocal cord fixation was present in 9 patients (18%). Thirteen patients (26%) also had invasion of the paraglottic space, and 9 (18%) had superficial tumor spread onto 1 or both vocal cords. These patients were treated by laser microsurgery as an alternative to extended supraglottic laryngectomy, SCPL-CHP, or total laryngectomy. Thirty-nine of the patients (78%) had unilateral or bilateral selective neck dissection. In 17 patients (34%), the neck dissection revealed 1 or more positive cervical lymph nodes. Thirteen patients (26%) were selected for postoperative radiotherapy, mostly for histologically confirmed cervical lymph node metastases. The Kaplan-Meier 5-year local control rate and definitive 5-year local control rate were 86% and 91%, respectively. Four percent of the patients underwent total laryngectomy for local tumor recurrence. Twelve percent of the patients died from tumor-related disease. The 5-year disease-free survival rate was 71%. All patients had good vocal function and were able to take an unrestricted oral diet after removal of the feeding tube. Special swallowing training was not required. None of the patients underwent a total laryngectomy for functional problems.

With standard or extended supraglottic laryngectomy, local control rates in excess of 90% for T1 and T2 cancers can be achieved, but the results drop to between 70% and 90% in T3 cancer.24,25 These results compare well to those of laser resection. This suggests that when complete resection is technically possible, supraglottic laryngectomy can be done endoscopically, as local control rates are comparable to those of open supraglottic laryngectomy. However, controversy still remains regarding the surgical approach to T3 cancer. Because of the higher incidence of local recurrence, some authors do not recommend laser surgery in these cases.21

Regardless of the surgical technique employed, negative margins are essential in limiting local recurrence. Blanch et al26 set out to analyze the relevance of margins in transoral laser microsurgery among 357 patients treated for cancer. This group found that tumor involvement of the surgical margin was associated with higher rates of local relapse, distant metastasis, and the necessity of salvage surgery, together with a lower specific actuarial survival rate. These findings highlight the importance of re-resection in those cases in which negative tumor margins have not been obtained. Jackel et al27 reviewed the role or reoperation in the event of positive tumor margins and found that survival of patients was similar whether clear resection margins were reached within the first surgical step or with revision surgery. However, patients in whom re-resection specimens contained residual cancer had an increased risk of locoregional failure and thus required further resection or at least a very close follow-up. Areas of concern may occur because of difficulty in exposing the larynx or when tumor extends submucosally. This is of particular concern in patients demonstrating paraglottic extension. In any event, radiation should not be the choice of therapy for positive margins unless there are circumstances that preclude reoperation.

An alternative partial laryngectomy for T3 cancer with high rates of local control is SCPL-CHP. The local recurrence rate after SCPL-CHP is very low, ranging from 0% to 7%.28,29 It should be noted, however, that most of the T3 tumors reported had only “minimal infiltration” of the pre-epiglottic space. Published data for T3 supraglottic cancer shows that laser microsurgery can be considered an effective alternative for such indications. Although local tumor recurrence rates are higher with laser microsurgery, the survival rates and organ preservation rates are comparable. When we consider that secondary laryngectomies are necessary after SCPL-CHP (at least in some series) due to intractable aspiration, the advantage of laser surgery for suitable cases is apparent. Significantly better local control and organ preservation are achieved with laser microsurgery, standard supraglottic laryngectomy and with SCPL-CHP than with primary radiotherapy. Primary radiotherapy can achieve local control rates of 77% to 100% for supraglottic T1 cancers and 62% to 83% for T2 cancers.30–34 Published data show that patients whose tumors could have been originally treated by partial laryngectomy with preservation of the glottis usually require a
total laryngectomy if they develop a recurrence after primary radiotherapy. Johansen et al. treated 117 patients with early supraglottic cancers by primary radiotherapy. Thirty-one per cent of the patients required a laryngectomy for tumor recurrence. In the cohort of Mendenhall et al., 14% of the patients had to undergo a secondary laryngectomy. In T3 cancers, primary radiotherapy can achieve local control rates of 50% to 76%. Hinerman et al. were able to preserve the larynx in 68% and Nakfoor et al. in 72% of their patients with these tumors. In the series of Sessions et al., laryngeal preservation was significantly better in patients treated with supraglottic laryngectomy (86% laryngeal preservation) than in patients treated with radiotherapy (72.7% laryngeal preservation).

FUNCTIONAL RESULTS

Functional results of laser supraglottic laryngectomy are considered by many authors to be superior to that of the transcervical approach, as measured by the time required to restore swallowing, reduced tracheotomy rate, lower incidence of aspiration pneumonia, lower incidence of pharyngocutaneous fistulae, and shorter hospital stay. These functional advantages can be attributed to the more conservative nature of the endoscopic procedure, because normal tissues are not disrupted during the operation. With open procedures, not only the skin but also the thyroid cartilage, soft tissues, and infrahyoid and suprahyoid muscles are divided, and the hyoid bone is frequently resected. There is invariably airway compromise and a need for a temporary tracheotomy. With endoscopic resection, tracheotomy is almost never indicated. In addition, swallowing in endoscopically resected patients tends to be restored more quickly, both for the reasons aforementioned and because the only tissues that are denervated by endoscopic resection are removed. Section of the superior laryngeal nerves during the transcervical approach leads to a sensory field defect that interferes with bolus detection and recognition, and to a weakening of the glottic closure response. In an analysis of this factor, Sasaki et al. demonstrated that the glottic closure reflex remained intact 48 to 72 hours after endoscopic laser supraglottic laryngectomy, in contrast to the persistent absence of this reflex in historical control patients operated on through a transcervical approach, observed 3 weeks to 12 years after surgery. The authors concluded that the sensory field defect caused by superior laryngeal nerve section is largely irreversible. Indeed, preservation of the glottic closure response appears to enhance recovery of swallowing following laser surgery, while compensatory mechanisms are learned.

Logemann et al. identified 2 critical factors in recovery of swallowing in supraglottic laryngectomy patients: airway closure at the laryngeal entrance (space between the arytenoids and base of tongue) and the movement of the tongue base to make complete contact with the posterior pharyngeal wall. In laser surgery, the integrity of the tongue base and pharyngeal musculature (permitting a normal pattern of mobility), preservation of mobile arytenoid cartilages, and preservation of the hyoid bone and strap muscles, which provide the normal anatomic suspension of the larynx, could also explain the earlier functional recovery. The disruption of 1 of these factors (airway closure) when 1 arytenoid cartilage is resected during the procedure may explain the higher incidence of deglutition problems and aspiration pneumonias in these cases. This should be taken into account when treating patients at high risk of aspiration problems such as elderly patients or patients with poor pulmonary function.

Although the above-mentioned functional advantages have been advocated for the endoscopic procedure, only 2 studies have directly compared the functional results of this approach with those of open supraglottic laryngectomy in 2 groups of patients with the same characteristics. These studies show that the rate of functional problems, as observed following conventional supraglottic partial resection, is not greatly decreased after transoral laser surgery; the main advantages of transoral laser surgery are the avoidance of temporary tracheotomy in most cases, the earlier restoration of swallowing (shorter duration of feeding tubes), and shorter hospitalization. In summary, swallowing following endoscopic resection tends to improve more quickly, but long-term results seem to be similar in both approaches.

Other parameters, such as T classification, seem to have more influence on postoperative swallowing than surgical technique. It is not surprising that patients with larger tumors, and therefore requiring extensive resections, are more at risk of poor functional outcome than are those requiring simple epiglottectomy or resection of only 1 vestibular fold. On the other hand, when analyzing deglutition, dependence on the type of surgical approach or the extent of the operation is
overshadowed by another important factor, namely the psychological makeup of the patient. Motivation, in particular, plays an important role as to how the patient copes with swallowing problems.

It is generally accepted that most patients undergoing supraglottic laryngectomy aspire to some extent, but the reported frequency and severity vary considerably. The reduced tendency toward aspiration following transoral surgery is said to be 1 of the main functional advantages when compared with the transcervical approach. Köllisch et al.\(^4\) reported an incidence of aspiration pneumonia of 11.5% (3 of 26) in the laser surgery group compared to an incidence of 40% (8 of 20) in the transcervical surgery group. However, there were no differences in the incidence of aspiration pneumonia (0% to 11%) between the groups in other studies.\(^4\),\(^5\) This could be explained by the fact that, in the latter studies, patient characteristics that could have a better correlation with the incidence of aspiration pneumonia were well balanced between the 2 treatment arms. Age, or preoperative pulmonary function, may have more influence on the likelihood of aspiration pneumonia than the surgical approach. In the study of Cabanillas et al.,\(^4\) the mean age of the patients was significantly higher in those who suffered aspiration pneumonia than in those who did not. This study also showed a tendency, although not statistically significant, to a higher incidence of aspiration pneumonia for those patients who had poorer pulmonary function.

As expected, the choice between an endoscopic or transcervical approach to purely supraglottic cancer does not produce a significant difference in voice quality.\(^4\)

**COMPLICATIONS**

Surgical complication rate is another measurable parameter of treatment outcome. The main complications ascribed to conventional supraglottic laryngectomy are postoperative bleeding, pharyngocutaneous fistula, and laryngeal stenosis.\(^4\),\(^5\) The incidence of postoperative hemorrhage is similar in both endoscopic and open approaches and ranges from 3% to 14%.\(^5\),\(^6\),\(^4\),\(^1\)\(^2\) However, endolaryngeal bleeding in endoscopically treated, nontracheotomized patients is a serious and potentially lethal complication, not only because of the blood loss but also because of possible aspiration of blood, and hypoxia. With the endoscopic approach, it is therefore important to apply hemostatic clips to, and not to cauterize, larger vessels. Laryngeal stenosis, with delayed or impossible decannulation, also has a similar incidence (range 0% to 11% in different studies) in both approaches when similar patients are compared.\(^4\),\(^1\)\(^2\) However, pharyngocutaneous fistula is a complication never reported in endoscopically treated patients.

**TREATMENT OF THE NECK**

An important consideration in the patients treated by the transoral approach is treatment of the cervical lymphatics. Some authors perform neck dissection as a staged procedure after the laser surgery, but only in selected cases.\(^4\),\(^5\) This approach may not be oncologically sound, as even early supraglottic cancers are associated with a high rate of neck metastasis, which ranges from 25% to 50%. In addition, lymph node metastasis is the most important prognostic factor in supraglottic cancer.\(^4\),\(^5\)\(^7\) There is a consensus of opinion that neck dissection combined with postoperative radiotherapy offers the best rate of tumor control in a neck with metastasis, although there is less agreement about the type of dissection that should be performed. There is still a strong debate about when and how to treat the neck in patients with supraglottic cancer without clinical evidence of metastases.

A number of patients with N0 necks have metastases to regional lymph nodes at the time of treatment. Undertreating such patients will decrease their chances of survival, because the highest probability of survival is always obtained by the initial therapeutic approach: control of disease in the neck after bilateral elective neck dissection is more successful than after neck dissection performed only in patients who have late metastases.\(^1\),\(^8\),\(^4\),\(^6\) Therefore, most head and neck surgeons advocate elective treatment of the N0 neck with supraglottic cancer. On the other hand, routine use of elective bilateral neck dissection is more likely to produce pathologically negative neck specimens, usually in more than 50% of specimens, and this percentage could be increased to 70% to 80% in early-stage (T1, T2) tumors.\(^1\)\(^4\) The only way to avoid undertreatment or overtreatment is by knowing which N0 patients have neck disease at the time of surgery. The most recent techniques of CT, MRI, ultrasonography, positron emission tomography (PET), and ultrasound-guided fine-needle aspiration biopsy have reached a sensitivity of no more than 80% to 85%.
in detecting occult metastases.\textsuperscript{49,50} As a consequence, elective treatment of the N0 neck appears to be reasonable when weighed against the risk of neck relapse.

When surgery is decided upon as initial treatment, then the question arises as to whether or not an elective neck dissection should be done bilaterally. Several authors have proposed that all patients with supraglottic cancer should undergo bilateral neck dissection, even if the neck is clinically negative.\textsuperscript{15,17,18,46} They point to the high prevalence of bilateral or contralateral histologic disease in supraglottic cancer, even in lateral tumors.\textsuperscript{18} It is currently widely accepted that elective treatment of the neck is justified if the risk of metastasis exceeds 15\%\textsuperscript{51} In addition, bilateral neck dissection allows removal of subclinical and occult pathological metastases, thus allowing accurate staging and treatment of occult disease and assisting with patient counseling and prognostication.\textsuperscript{52} The information obtained from bilateral neck dissection permits judicious use of adjuvant therapy such as irradiation. In such a situation, the use of functional neck dissection (which removes all principal nodal groups in the neck, preserving internal jugular vein, spinal accessory nerve, submandibular gland, and sternocleidomastoid muscle) permits bilateral nodal clearance with little or no resultant functional disability. Moreover, reported studies have shown that bilateral neck dissection in patients with supraglottic cancer is associated with reduced neck recurrence.\textsuperscript{17,18,46,53}

On the contrary, other authors believe that routine bilateral neck dissection in N0 necks leads to overtreatment in 70\% to 80\% of cases, and propose a more conservative approach.\textsuperscript{14,54–56} A reasonable criterion to limit the number and the extent of neck dissections is based on the probability of involvement of the lymph node groups. Several authors have reported that in lateral supraglottic tumors, the prevalence of contralateral metastases is <10\% in the absence of ipsilateral metastases.\textsuperscript{14,54,56} This suggests that, in unilateral lesions with N0 necks, contralateral neck dissection may not be required or even justified. However, if nodal metastases are found when performing an ipsilateral neck dissection, the dissection of the other side of the neck is then justified, because in these circumstances, the risk of contralateral metastasis has been shown to be increased to more than 30\% of cases.\textsuperscript{57}

Recently, complete functional neck dissection has been considered unnecessarily extensive for treatment of the N0 neck. The lateral selective neck dissection, also called SND (II–IV), is now routinely employed as elective neck dissection.\textsuperscript{58} Preliminary multi-institutional prospective and molecular studies support preservation of sublevels IIB and IV for laryngeal cancer with a N0 neck and hence a more selective neck dissection limited to sublevels IIA and level III for these patients.\textsuperscript{59,60} In doing so, spinal accessory nerve dysfunction is minimized, chylous leaks and phrenic paresis is avoided, and operative time is reduced without adversely affecting oncological results.\textsuperscript{61}

**CONCLUSIONS**

Transoral laser resection, together with classic transcervical supraglottic and supracricoid laryngectomies, should be considered an established therapeutic modality for supraglottic cancer. The choice of surgical approach must be individualized according to technical skill, surgical experience, and tumor and patient factors. Transoral laser surgery is associated with fewer functional problems than conventional supraglottic partial resection. The fact that temporary tracheotomies are frequently not required is a major advantage of laser surgery compared with the transcervical approach. Although swallowing tends to improve more quickly in endoscopically resected patients, the long-term results seem to be similar with both approaches.

Occult lymph node metastases are present in a high percentage of patients with supraglottic cancer, emphasizing the need for elective treatment of the neck. If surgical treatment is selected, then elective neck dissection is warranted on the ipsilateral side. The rare occurrence of occult nodes on the contralateral side of the neck in early-stage (T1, T2) lateral lesions suggests that bilateral neck dissection may be well reserved for cases in which the probability of occult metastases is more likely, such as for central or bilateral tumors, and lateral tumors with clinically positive ipsilateral nodes.

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