Turkish Archives of Otorhinolaryngology
Türk Otorinolarengoloji Arşivi

Turk Arch Otorhinolaryngol 2018; 56(2): 64-9

# Is There a Change in the Treatment of T1 Glottic Cancer After $CO_2$ Laser? A Comparative Study with Cold Steel

Original Investigation

Uygar Levent Demir, Turgut Çevik, Fikret Kasapoğlu
Department of Otorhinolaryngology, Uludağ University School of Medicine, Bursa, Turkey

Abstract

**Objective:** Carbon dioxide ($CO_2$) laser provides high local control and disease-specific survival rates with minor morbidity and good quality of life in transoral cordectomy. We aimed to compare the oncological outcome and survival between cold steel and $CO_2$ laser in the treatment of early glottic cancer.

**Methods:** In this retrospective study, the participants were divided into two groups. The first group comprised patients who were operated upon between 2001 and 2007 using cold steel (group 1, n=38), and the second group comprised patients who were operated upon between 2008 and 2016 using $CO_2$ laser (group 2, n=88). Both groups were compared regarding age, gender, pathological grade, T stage, type of cordectomy, margin status, anterior commissure involvement, follow-up, locoregional recurrence, and disease-free survival (DFS).

**Results:** The overall survival rate and DFS were similar between the two groups (94.7% vs. 98.9% and 100% vs. 98.9%, respectively), and no association was found between surgical margin positivity and local recurrence. However, a significant association between the presence of anterior commissure involvement and recurrence was found in all 126 patients (p=0.016). Local recurrence was significantly higher in the group 2 (p=0.024), but it did not affect overall survival and DFS in these patients (100% vs. 94.1%).

**Conclusion:** Although $CO_2$ laser excision is considered to be superior to cold steel regarding surgical time and bleeding control, the local recurrence rates were found to be higher with the laser than the cold steel. Thus, we argue that cases should be selected more carefully concerning the anterior commissure, depth of tumor invasion lateral to vocal muscle, difficulty at endoscopic exposure for lesions with anterior commissure involvement, and reliability of surgical margins at frozen sections.

**Keywords:** Glottic cancer, $CO_2$ laser, cold steel, survival, oncological results

***ORCID IDs of the authors:***
*U.L.D. 0000-0002-9590-1420;*
*T.Ç. 0000-0003-2079-5827;*
*F.K. 0000-0001-8539-187X.*

***Cite this article as:*** *Demir UL, Çevik T, Kasapoğlu F. Is There a Change in the Treatment of T1 Glottic Cancer After $CO_2$ Laser? A Comparative Study With Cold Steel. Turk Arch Otorhinolaryngol 2018; 56(2): 64-9*

**This study was presented at the 4th Congress of European Otorhinolaryngology - HNS, October 7-11, 2017, Barcelona, Spain.**

**Corresponding Author:**
Uygar Levent Demir; uygardemir@hotmail.com

**Received Date:** 20.11.2017
**Accepted Date:** 31.01.2018



DOI: 10.5152/tao.2018.3053

## Introduction

Early glottic carcinoma involving only the true vocal cords has a very good prognosis if appropriate treatment with safe surgical margins is applied (1, 2). Endolaryngeal excision using cold steel has been reported to be useful in the management of early glottic carcinoma since 1920s, but it has gained more popularity after the advancement of laser technology coupled to operating microscope for laryngeal surgery (3, 4). In the last four decades, many studies have reported comparable oncological results, better preservation of laryngeal functions, less morbidity, and higher quality of life with endolaryngeal laser cordectomy than with open surgery (1, 2, 5-7).

At our department, we have used cold steel coupled with surgical microscope and telescopes in the treatment of early glottic carcinoma until 2007 with success, and since then, we have performed all endolaryngeal cordectomies using carbon dioxide ($CO_2$) laser (8). Despite reports favoring the use of laser in the treatment of glottic carcinoma (1, 2), we observed some problems regarding the intraoperative frozen section assessment of surgical margins. Since the $CO_2$ laser beam causes an acute thermal damage and severe coagulation in the tissues, the pathologists may sometimes encounter difficulty in deciding the safety of surgical margins. The histological effects of different surgical instruments, such as $CO_2$ laser, scalpel, and electrocautery, on oral mucosal incisions and tissue healing have been

studied on animal models (9, 10). These studies indicated that $CO_2$ laser exerted the highest extent of epithelial damage lateral to wound edge and that the extent of collagen denaturation with scalpel was the lowest. Furthermore, scalpel usage was related with better wound healing, tissue re-epithelialization, and tensile strength but with worse hemostasis compared with laser (10, 11).

We should consider both the pros and cons of treatment options while dealing with any disease, especially malignancy. In this regard, $CO_2$ laser usage in the treatment of early glottic cancer has feasible advantages beside some minor adverse effects on tissue repair. Thus, we aimed to compare cold steel and $CO_2$ laser regarding the associated oncological outcome and survival and also to determine the relevance of surgical margins and local recurrence in the treatment of early glottic cancer.

## Methods

This retrospective comparative study was conducted at the University of Uludağ, Department of Otorhinolaryngology and Head Neck Surgery on patients who underwent endolaryngeal cordectomy using either cold steel or $CO_2$ laser for T1 glottic carcinoma. The patients were classified into two groups according to the instrument used in cordectomy: the first group comprised patients operated upon between 2001 and 2007 using cold steel (group 1), and the second group comprised patients operated upon between 2008 and 2016 using $CO_2$ laser. The decision for endolaryngeal cordectomy was based on rigorous oncological principles, and cordectomy was performed by senior head and neck surgeons under general anesthesia. The exclusion criteria were as follows: (i) previous head and neck radiotherapy or chemotherapy, (ii) inaccessible pre- or postoperative records, and (iii) previous laryngeal surgery at another hospital.

All the patients were evaluated using laryngeal flexible endoscopy and videolaryngostroboscopy at the outpatient clinic before surgery. The contrast-enhanced computed tomography of larynx was performed if the lesion involved the anterior commissure or laryngeal ventricle or if there was a suspicion of paraglottic invasion. Routine chest x-ray imaging was performed before surgery in each patient. Tumors were staged according to the criteria of 2010 edition of American Joint Committee on Cancer. The background information of all patients including age, gender, pathological grade, T category, type of cordectomy, margin status, anterior commissure involvement, follow-up time, need for adjunct treatment, locoregional recurrence, and disease-free survival (DFS) time were retrieved from patient files. Subsequently, the patient groups were compared according to the collected clinical data. This retrospective study was approved by the ethical committee of Uludağ University School of Medicine (approval number, 2017-4/12).

After the induction of general anesthesia, we examined the larynx using 0˚ and 70˚ rigid laryngeal telescopes to assess the anterior commissure, subglottis, and ventricles prior to orotracheal intubation. Subsequently, the patient was intubated with a microlaryngeal tube (5-mm diameter). Endolaryngeal surgery was performed using surgical microscope and cold steel in group 1 and using $CO_2$ laser (Acupulse; Lumenis; Yokneam; Israel) coupled to microscope in group 2. The details of surgical techniques used for tumor resection have been mentioned in our previous study (8). Following resection, the safety of surgical margins [anterior, posterior, inferior, superior mucosal, and lateral (deep)] was evaluated by a pathologist using frozen sections. We performed additional resections at adjacent tissue until reaching safe margins, as confirmed by the pathologist. The surgical margins at frozen sections were prepared using cold steel to prevent any assessment bias or tissue artifacts. The surgery was completed after achieving surgical hemostasis in the field. No postoperative medications were ordered except corticosteroid injections, if necessary. We reported the extent of cordectomy in the surgical reports according to the classification of European Laryngological Society (12).

The patients were examined at 2nd and 4th postoperative weeks using endoscopy for the control of wound healing. In addition, oncological follow-ups were done at monthly intervals. We rescheduled the patients for endoscopic examination and control biopsy under general anesthesia if there was suspicion of recurrence, if permanent pathological slides showed conflicting results, new granulation tissue, or synechia formation, and if inadequate exposure to vocal cords was observed in the outpatient setting.

Statistical analyses were performed using SPSS 20.0 and MedCalc v12.3.0 (SPSS Inc., IBM, USA). Continuous and discrete variables were presented as median (minimum–maximum) and n (%). Pearson's $X^2$, Kaplan–Meier, and Fisher's exact tests were performed for between-group comparisons. Significance was set at $p<0.05$.

## Results

Group 1 comprised 38 patients (37 males, 1 female) aged 41-75 (median, 60) years; group 2 comprised 88 patients (85 males, 3 females) aged 38-82 (median, 65) years in group 2. The two groups were similar regarding age and follow-up duration. T categories and cordectomy types performed in both groups are shown in Table 1. There was a significant difference between the groups regarding the cordectomy types (p=0.046), which indicated that a higher number of patients underwent type 1 cordectomy in the cold steel group (15.8%) than in the laser group (4.5%); conversely, a higher number of patients underwent type 4 and 5 cordectomies in the latter group (42%) than in the former group (26.3%). Positive surgical margins were reported in three patients at permanent sections, although all frozen sections were free of cancer in group 2. Among these three patients, one underwent postoperative radiotherapy, one underwent supracricoid partial laryngectomy, and the remaining one underwent revision endolaryngeal surgery to achieve a safe margin. Regarding the definitive margin status, there was no difference between the two groups (p=1.00, Fisher's exact test); furthermore, the pathological diagnosis was similar between the two groups (p=0.259, Fisher's exact test).

In group 1, two patients died due to secondary cancer of a different organ, and in group 2, one patient died due to primary cancer. Therefore, overall survival rate and DFS were 94.7% and 100%, respectively, in group 1, and both the overall survival rate and DFS were 98.9% in group 2. Local recurrence developed in two patients in the group 1, whereas recurrence was reported in 17 patients in the group 2. A statistically significant difference was found between the groups regarding local recurrence (p=0.024, Pearson's $X^2$ test), but no difference was found when patients with type 5 cordectomy in both groups were compared separately (p=1.000, Fisher's exact test) (Table 1). In the cold steel group, both recurrences were at the anterior commissure that extends to the ventricular bands. The exact locations of local recurrence in the laser group (n=17) were as follows: the anterior commissure, eight patients; anterior 1/3rd of the vocal cord, three patients; both the ventricular band and vocal cord, four patients; posterior 1/3rd of the vocal cord, one patient; and opposite to the vocal cord, one patient. Two patients with recurrence in the group 1 were successfully salvaged by open partial laryngectomy, and 17 patients in the group 2 were successfully salvaged by either open partial laryngectomy (n=6), total laryngectomy (n=1), radiotherapy (n=4), or revision endolaryngeal cordectomy (n=6). One patient died during hospital stay due to postoperative complications of primary cancer. The organ preservation rate and DFS of patients with recurrence in groups 1 and 2 were 100% vs 94.1% and 100% vs 94.1%, respectively.

**Table 1.** Demographic and clinical findings comparing two patient groups

| | Group 1 | Group 2 | p |
|---|---|---|---|
| Age (years; median) | 41-75 (60) | 38-82 (65) | |
| Follow-up (months; median) | 1-72 (24) | 4-86 (28.5) | |
| Cordectomy types | | | 0.046 |
| Type 1 | 6 (16%) | 4 (5%) | |
| Type 2 | 15 (39%) | 26 (29%) | |
| Type 3 | 7 (18%) | 21 (24%) | |
| Type 4 | - | 9 (10%) | |
| Type 5 | 10 (26%) | 28 (32%) | |
| T category | | | 0.045 |
| Tis | 7 (18%) | 4 (5%) | |
| T1a | 23 (60%) | 66 (75%) | |
| T1b | 8 (21%) | 18 (20%) | |
| Pathological diagnosis | | | 0.259 |
| Carcinoma in situ | 7 (%18) | 7 (8%) | |
| Microinvasive carcinoma | 3 (8%) | 9 (10%) | |
| Invasive carcinoma | 28 (74%) | 72 (82%) | |
| Positive surgical margin | 1/38 (3%) | 3/88 (3%) | 1.00 |
| Local recurrence | 2/38 (5%) | 17/88 (19%) | 0.024 |
| Recurrence after type 5a cordectomy | 2/10 (20%) | 6/28 (21%) | 1.00 |

**Table 2.** Clinical findings of patients with anterior commissure involvement in two patient groups

| | Group 1 | Group 2 | p |
|---|---|---|---|
| Anterior commissure involvement | 8/38 | 40/88 | 0.01 |
| Local recurrence | 1/8 | 15/40 | 0.24 |
| Organ preservation | 8/8 | 39/40 | 1.00 |
| Overall survival | 100% | 97.5% | 1.00 |
| Disease-specific survival | 100% | 97.5% | 1.00 |

In the groups 1 and 2, control suspension microlaryngoscopy for a second look was required in 18 (47.4%) and 37 (42%) patients and was required for a third time in two and nine patients, respectively, with no statistically significant difference between groups (p=0.580). Eight patients in the group 1 and 40 in the group 2 had an anterior commissure involvement. Although there was a statistically significant difference between the groups regarding the anterior commissure involvement (p=0.01, there was no difference regarding the recurrence rate (p=0.24) between patients with anterior commissure involvement on intergroup analysis. In addition, there was no difference between the groups with anterior commissure involvement regarding overall survival and DFS (p=1.000) (Table 2).

Finally, we evaluated the presence of any association between recurrence and other variables such as pathological diagnosis, T category, type of cordectomy, surgical margin positivity, anterior commissure involvement, age, and follow-up duration in all 126 patients. Overall, there was a significant difference only between the presence of anterior commissure involvement and recurrence (p=0.016) (Table 3). In regression analysis, the risk of recurrence was found to increase 3.56 times (HR 95%, 1.24:10.19) in the presence of anterior commissure involvement. In the laser group, this relation was also significant only for anterior commissure involvement and not others (p=0.021).

All patients were discharged the day after surgery. Oral intake of soft foods and liquids was allowed four hours after surgery. Antireflux treatment was ordered for patients who had laryngopharyngeal reflux symptoms. The perioperative complication rate was similar between the groups.

## Discussion

Although transoral cordectomy using cold steel had been reported almost 90 years ago, it was almost completely replaced with the transoral laser excision in the last 30 years, with high organ preservation and survival rates (1, 5, 13). In the last 20 years, $CO_2$ laser has been widely accepted because it offers the advantages such as better bleeding control, reusability for salvage surgery, and lesser morbidity with good quality of life compared with open external surgery (1, 2, 5). It also allows a precise removal of lesions with tiny and targeted surgical margins under

**Table 3.** Association between clinical variables and recurrence in all 126 patients

| | Recurrence (-) n=107 | Recurrence (+) n=19 | p |
|---|---|---|---|
| Cordectomy types | | | 0.082 |
| Type 1 (n=11) | 9 | 2 | |
| Type 2 (n=40) | 36 | 4 | |
| Type 3 (n=28) | 26 | 2 | |
| Type 4 (n=9) | 6 | 3 | |
| Type 5 (n=38) | 30 | 8 | |
| T category | | | 0.140 |
| Tis (n=10) | 9 | 1 | |
| T1a (n=90) | 79 | 11 | |
| T1b (n=26) | 19 | 7 | |
| Pathological diagnosis | | | 0.215 |
| Carcinoma in situ (n=14) | 12 | 2 | |
| Microinvasive carcinoma (n=12) | 11 | 1 | |
| Invasive carcinoma (n=100) | 84 | 16 | |
| Positive surgical margin | | | 0.295 |
| Negative (n=122) | 104 | 18 | |
| Positive (n=4) | 3 | 1 | |
| Anterior commissure involvement | | | 0.016 |
| Negative (n=78) | 73 | 5 | |
| Positive (n=48) | 34 | 14 | |
| Age (years) (median) | 38–82 (60) | 46–78 (64) | 0.412 |
| Follow-up duration (months) (median) | 1–78 (24) | 7–86 (31) | 0.644 |

microscopic guidance. The enhanced visualization in a bloodless surgical field encouraged surgeons to operate transorally on more extended tumors involving the anterior commissure, ventricular fold, supraglottis, or subglottis. This instrument enabled surgeons to excise more risky lesions with small surgical margins, and the early oncological results were promising. However, we argue that along with the benefits, laser technology carries the risk of underestimating or neglecting the depth and extent of the lesion. Another drawback of using the laser is the difficulty in pathological assessment of surgical margins, as the small-sized tissue excised during endolaryngeal cordectomy may contract *in vitro* and interfere with interpretation of safe surgical margins at frozen sections (14). Pathological assessment is technically more difficult with $CO_2$ laser as it may lead to some artifacts. It was argued that thermal coagulation and subsequent severe tissue damage may lead to these artifacts (10, 11). On the other hand, some others believe that frozen section assessment of surgical site after $CO_2$ laser is very reliable with high negative predictive value, especially when an acublade laser mode is preferred (15, 16). Thus, in the present study, to address our concerns regarding the reliability of surgical margins after $CO_2$ laser cordectomy, we decided to compare the oncological results, safety of surgical margins, and recurrence rates associated with $CO_2$ laser with our previous study results using cold steel in endolaryngeal cordectomy (8).

Anterior commissure involvement and presence of positive surgical margins are the two main factors determining the prognosis in T1 glottic cancers. However, the definition of a safe surgical margin in transoral laser surgery is still under debate. Many authors believe that excision of the tumor with at least 2-mm clean margins from the tumor edge is acceptable to achieve an oncologically safe result. Ansarin et al. (17) revealed that patients with a positive surgical margin or those with a close margin (≤1mm) exhibited greater recurrence rates than those with a >1 mm safe margin. Similarly, in a study conducted by Crespo et al. (18), the presence of positive surgical margins at permanent sections in $CO_2$ laser cordectomy was significantly correlated with local recurrences. DFS and local control rate of patients with positive margins were found to be impaired in the study of Charbonnier et al. (14). They also pointed out the importance of vocal muscle involvement by tumor cells as a negative factor in prognosis. Mortuaire et al. (19) reported a similar finding that vocal muscle infiltration had a negative effect on DFS. On the contrary, some authors reported that surgical margin status did not have any significant effect on the oncological outcomes (20, 21). Michel et al. (20) revealed no difference in the overall or recurrence-free survival according to the resection margin histologic status after endoscopic laser cordectomy. In our study, three of 88 (3.4%) frozen sections were misinterpreted as negative but confirmed to be positive in permanent pathology sections in the laser group. Among these three patients, one had a recurrent lesion that was successfully treated with open partial laryngectomy; one had close follow-up with no recurrence; and the remaining one underwent adjuvant radiotherapy. In the cold steel group, in one of 38 (2.6%) patients, the surgical margin was found to be positive in the permanent section, and the patient was treated with a second endolaryngeal excision. According to the definitive margin status, there was no difference between the cold steel and laser groups. The overall survival rate and DFS were similar between the two groups with no significant difference. In addition, we did not find any association between surgical margin positivity and local recurrence in all 126 patients.

There is almost no debate on the association between anterior commissure involvement and worse prognosis in patients undergoing endolaryngeal cordectomy. Most authors have a consensus that such patients have a low DFS and overall survival and, thus, need to be treated more carefully concerning larger surgical margins. Mendelsohn et al. (22) reported 5/30 (16.7%) recurrence rate in their study with a group of patients who underwent $CO_2$ laser cordectomy involving anterior commissure. The overall organ preservation rate was 28/30 (93.3%) in that study. They pointed out that tumors arising from the anterior commissure had a more widespread oncologic mutational change. Thus, sub-

clinically involved peripheral margins at this location are more prone to local recurrences. In their study, Rödel et al. (23) revealed a negative impact of anterior commissure involvement on local disease control in T1 glottic lesions. Edizer and Cansız (24) also found a higher risk of local recurrence if the tumor involved the anterior commissure in transoral laser surgery for glottic cancers. Similarly, Chone et al. (25) reported a higher rate of local recurrence (21%) in patients with anterior commissure involvement compared with those without involvement (4%), but without statistical significance. Initial anterior commissure involvement was indicated to increase the risk of local recurrence regardless of the surgical approach, either external or transoral laser, in a study conducted by Sachse et al. (26). All the above-mentioned studies evaluated the local recurrence in patients with or without anterior commissure involvement who underwent endolaryngeal laser surgery. In our study, we also found that overall, anterior commissure involvement was significantly associated with local recurrence; however, there was no difference between the two groups with anterior commissure involvement regarding local recurrence, DFS, and overall survival. This may be due to less number of patients with anterior commissure involvement in the cold steel group and elaborate patient selection regarding the extent of lesion with cold steel use.

In this study, we realized that after $CO_2$ laser, there was a significant increase in the percentage of lesions with anterior commissure involvement that were excised via transoral route [group 1: 21% (8/38) vs group 2: 45% (40/88)]. We assumed that this may be due to very meticulous selection of low-risk lesions before laser with the concerns of bleeding at surgical site, difficulty of exposure, prolonged surgical time, and greater sacrifice of healthy surrounding tissue. However, after laser, surgeons feel more comfortable, safer, and somehow extremely self-confident with this powerful instrument. This may be a drawback in some circumstances as one may underestimate the extension or the depth of tumor and enforce to excise all the lesions via an endolaryngeal approach. In this study, anterior commissure involvement was reported in 40 patients at permanent pathology report in the laser group; however, we performed type 5 cordectomies in only 28 patients among group 2 in the first surgery. This indicates that we probably misdiagnosed or underestimated the extent of primary lesion and applied inappropriate cordectomy type. The local recurrence rate was higher in the laser group than in the cold steel group [19% (17/88) vs (5% or 2/38)]. We argued that this difference may be due to a higher percentage of patients with anterior commissure involvement in the laser group or due to artifacts caused by the thermal effect of laser that makes the assessment of surgical margins difficult at frozen sections if used in a continuous-wave mode (27). Whatever the reason, fortunately with successful salvage treatment modalities, we achieved very good and similar organ preservation and DFS rates in patients with local recurrences in both groups.

## Conclusion

We can achieve very good local control and high DFS with transoral $CO_2$ laser cordectomy in glottic tumors. Unfortunately, the tumors involving the anterior commissure exhibit worse prognosis irrespective of the surgical approach Although $CO_2$ laser excision is considered to be superior to cold steel regarding surgical time, bleeding control, precise and targeted incisions, and small surgical margins in the literature, we found an increased local recurrence rate compared with that in our previous study with cold steel. Thus, we argue that cases should be selected more carefully regarding the anterior commissure involvement and more attention should be paid to reliability of surgical margins at frozen sections. $CO_2$ laser provides oncologic outcomes similar to cold steel in the treatment of T1 glottic cancers and is a very useful instrument considering the additional benefits it offers.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Uludağ University School of Medicine (2017-4/12).

**Informed Consent:** Informed consent was not received due to the retrospective nature of the study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept - U.L.D.,F.K.; Design - U.L.D., T.Ç.; Supervision - U.L.D., F.K.; Resource - U.L.D., F.K.; Materials - U.L.D., T.Ç; Data Collection and/or Processing U.L.D., T.Ç., F.K.; Analysis and/or Interpretation - U.L.D., F.K., T.Ç.; Literature Search - U.L.D., F.K.; Writing - U.L.D., F.K.; Critical Reviews - U.L.D., F.K., T.Ç.

**Conflict of Interest:** The authors have no conflicts of interest to declare.

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

## References

1. Sigston E, de Mones E, Babin E, Hans S, Hartl DM, Clement P, et al. Early-stage glottic cancer: oncological results and margins in laser cordectomy. Arch Otolaryngol Head Neck Surg 2006; 132: 147-52. [CrossRef]
2. Bertino G, Degiorgi G, Tinelli C, Cacciola S, Occhini A, Benazzo M. $CO_2$ laser cordectomy for T1-T2 glottic cancer: oncological and functional long-term results. Eur Arch Otorhinolaryngol 2015; 272: 2389-95. [CrossRef]
3. Smith JC, Johnson JT, Cognetti DM, Landsittel DP, Gooding WE, Cano ER, et al. Quality of life, functional outcome, and costs of early glottic cancer. Laryngoscope 2003; 113: 68-76. [CrossRef]
4. Smith JC, Myers EN. Progress in laryngeal surgery. Head Neck 2002; 24: 955-64. [CrossRef]
5. Silver CE, Beitler JJ, Shaha AR, Rinaldo A, Ferlito A. Current trends in initial management of laryngeal cancer: the declining use of open surgery. Eur Arch Otorhinolaryngol 2009; 266: 1333-52. [CrossRef]
6. Hartl DM, de Monès E, Hans S, Janot F, Brasnu D. Treatment of early-stage glottic cancer by transoral laser resection. Ann Otol Rhinol Laryngol 2007; 116: 832-6. [CrossRef]
7. Sjögren EV, Langeveld TP, Baatenburg de Jong RJ. Clinical outcome of T1 glottic carcinoma since the introduction of endoscopic CO2 laser surgery as treatment option. Head Neck 2008; 30: 1167-74. [CrossRef]

8. Kasapoglu F, Erisen L, Coskun H, Basut O. Endolaryngeal cordectomy using cold instruments for treatment of T1 glottic cancers. Eur Arch Otorhinolaryngol 2007; 264: 1065-70. [CrossRef]
9. Liboon J, Funkhouser W, Terris DJ. A comparison of mucosal incisions made by scalpel, CO2 laser, electrocautery, and constant-voltage electrocautery. Otolaryngol Head Neck Surg 1997; 116: 379-85. [CrossRef]
10. Carew JF, Ward RF, LaBruna A, Torzilli PA, Schley WS. Effects of scalpel, electrocautery, and CO2 and KTP lasers on wound healing in rat tongues. Laryngoscope 1998; 108: 373-80. [CrossRef]
11. Sinha UK, Gallagher LA. Effects of steel scalpel, ultrasonic scalpel, $CO_2$ laser, and monopolar and bipolar electrosurgery on wound healing in guinea pig oral mucosa. Laryngoscope 2003; 113: 228-36. [CrossRef]
12. Remacle M, Eckel HE, Antonelli A, Brasnu D, Chevalier D, Friedrich G, et al. Endoscopic cordectomy. A proposal for a classification by the Working Committee, European Laryngological Society. Eur Arch Otorhinolaryngol 2000; 257: 227-31. [CrossRef]
13. Jäckel M, Martin A, Steiner W. Twenty-five years experience with laser surgery for head, neck tumors. Report of an international symposium, Göttingen, Germany, 2005. Eur Arch Otorhinolaryngol 2007; 264: 577-85. [CrossRef]
14. Charbonnier Q, Thisse AS, Sleghem L, Mouawad F, Chevalier D, Page C, et al. Oncologic outcomes of patients with positive margins after laser cordectomy for T1 and T2 glottic squamous cell carcinoma. Head Neck 2016; 38: 1804-9. [CrossRef]
15. Remacle M, Matar N, Delos M, Nollevaux MC, Jamart J, Lawson G. Is frozen section reliable in transoral CO(2) laser-assisted cordectomies? Eur Arch Otorhinolaryngol 2010; 267: 397-400. [CrossRef]
16. Remacle M,Delos M, Lawson G, Jamart J. Accuracy of histological examination following endoscopic $CO_2$ laser-assisted laryngectomy. Otorhinolaryngol Nova 2002; 12: 16-20. [CrossRef]
17. Ansarin M, Santoro L, Cattaneo A, Massaro MA, Calabrese L, Giugliano G, et al. Laser surgery for early glottic cancer: impact of margin status on local control and organ preservation. Arch Otolaryngol Head Neck Surg 2009; 135: 385-90. [CrossRef]
18. Crespo AN, Chone CT, Gripp FM, Spina AL, Altemani A. Role of margin status in recurrence after $CO_2$ laser endoscopic resection of early glottic cancer. Acta Otolaryngol 2006; 126: 306-10. [CrossRef]
19. Mortuaire G, Francois J, Wiel E, Chevalier D. Local recurrence after $CO_2$ laser cordectomy for early glottic carcinoma. Laryngoscope 2006; 116: 101-5. [CrossRef]
20. Michel J, Fakhry N, Duflo S, Lagier A, Mancini J, Dessi P, et al. Prognostic value of the status of resection margins after endoscopic laser cordectomy for T1a glottic carcinoma. Eur Ann Otorhinolaryngol Head Neck Dis 2011; 128: 297-300. [CrossRef]
21. Hoffmann C, Hans S, Sadoughi B, Brasnu D. Identifying outcome predictors of transoral laser cordectomy for early glottic cancer. Head Neck 2016; 38: 406-11. [CrossRef]
22. Mendelsohn AH, Kiagiadaki D, Lawson G, Remacle M. $CO_2$ laser cordectomy for glottic squamous cell carcinoma involving the anterior commissure: voice and oncologic outcomes. Eur Arch Otorhinolaryngol 2015; 272: 413-8. [CrossRef]
23. Rödel RM, Steiner W, Müller RM, Kron M, Matthias C. Endoscopic laser surgery of early glottic cancer: involvement of the anterior commissure. Head Neck 2009; 31: 583-92. [CrossRef]
24. Edizer DT, Cansız H. Transoral laser microsurgery for glottic cancers – complications and importance of the anterior commissure involvement. Istanbul Med J 2013; 14: 12-5. [CrossRef]
25. Chone CT, Yonehara E, Martins JE, Altemani A, Crespo AN. Importance of anterior commissure in recurrence of early glottic cancer after laser endoscopic resection. Arch Otolaryngol Head Neck Surg 2007; 133: 882-7. [CrossRef]
26. Sachse F, Stoll W, Rudack C. Evaluation of treatment results with regard to initial anterior commissure involvement in early glottic carcinoma treated by external partial surgery or transoral laser microresection. Head Neck 2009; 31: 531-7. [CrossRef]
27. Makki FM, Rigby MH, Bullock M, Brown T, Hart RD, Trites J, et al. $CO_2$ laser versus cold steel margin analysis following endoscopic excision of glottic cancer. J Otolaryngol Head Neck Surg 2014; 43: 6. [CrossRef]