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HEAD & NECK

How we improve the transoral resection for oral and oropharyngeal cancer: the CO_2 waveguide laser

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Abstract

Purpose The main aim of this study was to evaluate the CO_2 waveguide laser (CO_2 WGL) with flexible fiber (Lumenis, Santa Clara, CA) in the treatment of oral and oropharyngeal cancers specifically focusing on the lateral thermal damage (LTD) induced by this instrument and therefore on the reliability of the analysis of frozen sections collected during margin mapping.

Methods A total of 48 patients with oral and oropharyngeal cancers from T1 to T4a were prospectively enrolled in the study. We collected data about LTD, pathologic tumor and node stage (pTNM), surgical intervention, kind of reconstruction (no flap, local vs free flap), need for tracheotomy and time of removal, postoperative complications (such as bleeding, mucosal dehiscence, and fistula), need for feeding tube and time of removal.

Results Mean LTD was 164.7 ± 92.4 µm. Comparing frozen section histology before and after formalin embedding we found 5 true positives, 170 true negatives, 4 false positives and 4 false negatives, with a sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 55.6%, 98%, 55.6%, 98%, and 96.1%, respectively.

Conclusion CO_2 WGL is a very manageable tool, which allows a precise cut. However, its high costs, the inability to re-use the fibers and its low coagulation capability must be considered.

Keywords Oral cancer · Oropharyngeal cancer · Transoral surgery · CO_2 waveguide laser · CO_2 laser · Laser surgery

Introduction

Oncologic surgery for oral and oropharyngeal squamous cell carcinoma has clearly evolved in recent years in part as a result of the availability of new manageable and sophisticated cutting and sealing devices based on laser, radiofrequency, and ultrasound technology. Thanks to these cutting instruments, several well-established open approaches have been challenged by a new surgical trend in which the surgeon can remove oral and oropharyngeal tumors transorally in what is known as transoral mininvasive surgery [1]. These new approaches avoid the need for invasive open surgery such as mandibular swing, pull through or lateral pharyngotomy to reach the tumors as well as possibly the need for free flaps for reconstruction. This may allow shorter hospitalization, lower surgical morbidity and an increased quality of life without any worsening in prognosis [2, 3]. Indeed, from a more technical point of view, it is becoming evident that a narrow but free-from-disease surgical margin results in a control rate comparable to that obtained with wider resections [4]. Among the different cutting tools that can be used in transoral surgery is the CO_2 laser. The use of the CO_2 laser in head and neck cancer surgery is nothing new: the rationale of transoral laser microsurgery (TLM) was first introduced by Steiner more than 40 years ago for larynx cancer [5]. Originally, use of the CO_2 laser was limited to only a few anatomic sites because the laser beam had to travel to the target tissue in a straight line making access to some laryngopharyngeal regions challenging. Furthermore, the imposed direct line of energy delivery to the site could prevent access by means of small lumen devices or flexible endoscopes. These problems strongly restricted its use in areas like the sides and base of the tongue, the subglottis and the trachea. In recent years, this limitation has been overcome by the introduction of a new generation of

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CO_2 laser, known as the CO_2 waveguide laser (CO_2 WGL). The development of this new generation of laser made these devices suitable for all sites of the upper aerodigestive tract. The first waveguide was developed by OmniGuide (Boston, MA) at the end of 2000 and the fibers were called "waveguide fibers" to reflect the radiation-guiding mechanism by means of an omnidirectional mirror structure around the fiber's hollow core [6]. From a practical point of view, this tool does not need the laser beam to be aligned with the microscope so the beam can simply follow the surgeon's wrist movements. The possibility to combine CO_2 WGL with different magnification instruments, such as surgical loupes, rigid and flexible endoscopes (mounted on the surgical bed or in a robotic arm) and microscopes, makes it a highly versatile device.

To our knowledge, the use of the CO_2 WGL has never been assessed specifically in malignant oral and oropharyngeal lesions. The main aim of this study was thus to evaluate CO_2 WGL with flexible fiber (Lumenis, Santa Clara, CA) in the treatment of oral and oropharyngeal cancers, specifically focusing on lateral thermal damage (LTD) induced by this instrument. Furthermore the reliability of frozen sections collected with CO_2 WGL was analyzed by comparing frozen section histology before and after formalin embedding.

Materials and methods

From August 2015 to December 2018, we conducted a prospective pilot study on the use of CO_2 WGL with flexible fiber (Lumenis, Santa Clara, CA) at the ENT Department of Trieste, in accordance with the Declaration of Helsinki, and with the approval of the Cattinara Hospital ethics committee (Report No. 58). We selected patients who met the following inclusion criteria: age between 18 and 90 years, primary tumors located in the oral cavity and oropharynx. Exclusion criteria were: previous surgery for oral and oropharyngeal cancer, previous radiotherapy or chemotherapy for head and neck cancers, cancers involving the hypopharynx or larynx, or medical conditions contraindicating general anesthesia.

All patients referred to our outpatient clinic for lesions of the oral cavity and oropharynx clinically suspicious for malignancy underwent accurate narrow-band imaging (NBI) evaluation. In the case of positive NBI findings, a NBI-guided diagnostic incisional biopsy was performed. At our department NBI is normally used in this diagnostic phase to target the biopsy in the most suspicious area of the lesion. Then, in the case of histologic confirmation of squamous cell carcinoma (SCC), clinical staging (cTNM) was obtained by computed tomography (CT) and/or magnetic resonance imaging (MRI) or positron-emission tomography (PET)/CT for advanced tumors, in accordance with the NCCN guidelines (National Comprehensive Cancer Network). Conversely, if moderate or high-grade dysplasia was found at histology, the patient was scheduled for surgical intervention without preoperative imaging. Another situation was represented by patients with leukoplakia presenting NBI findings suspicious for dysplasia [7]: these were scheduled for surgical intervention without preoperative biopsy, following Piazza et al's procedure [8].

The patients signed a detailed informed consent form, with the privacy policy agreement. The indications for neck dissection in this series of patients followed the criteria defined by the NCCN guidelines [9].

From a surgical viewpoint, in cases of preoperative incisional biopsy positive for SCC, we followed the Steiner procedure [5]. As a first step, we performed a CO_2 WGL tattoo of the superficial resection margins at 1.5 cm from the macroscopic lesion boundaries, and then re-defined it with the help of NBI [10, 11] so as to include any suspicious lesion around the main tumor bulk [7]. The second step consisted of tumor resection using en bloc or piecemeal techniques depending on tumor dimension, site, accessibility and preoperative radiologic characteristics of spread in depth. Specifically, in the case of undefined deep growth, we transected the tumor to better understand its extension in depth thanks to the different interaction between the laser beam and the tissue [12, 13]. Irrespective of the resection technique the main surgical specimens were oriented with sutures and medical tissue-marking dye and sent to the pathologist for definitive histological examination with an explicative drawing. As a third step, we performed margin mapping as introduced by Hinni et al. [14] and described in our previous paper [13]. Both superficial and deep margins were taken from the surgical bed: superficial margins consisted of 3–4-mm-thick strips of tissue around the tumor, deep margins consisted of one or two thin slices of tissue underlying the site of the resected tumor. Staining of the most lateral surface of each surgical specimen was meticulously performed with medical tissue-marking dye and presented by the second surgeon to the pathologist for frozen section examination. If no trace of dysplasia or cancer was found on frozen section analysis, the section was considered "negative" and the procedure was stopped. If the section was considered "positive", a laser enlargement was immediately performed if possible and the staining procedure repeated. If preoperative incisional biopsy diagnosed moderate or high-grade dysplasia but not invasive cancer and in cases of leukoplakia not undergoing preoperative diagnostic incisional biopsy, margin mapping with frozen sections was not performed and surgical intervention ended following resection of the lesion. All patients were treated by the same surgeon (G.T.): depending on the lesion site and exposure, a microscope, surgical loupes or high-definition endoscopes were used as magnification instruments during the resection. All procedures were performed with CO_2 WGL with flexible fiber at 3–10 Watts in superpulsed mode. Elective ligation of the lingual and pharyngeal branches of the external carotid artery was performed in the case of tonsillar or base of tongue cancers as a way to reduce the risk of postoperative bleeding.

Data about pathologic tumor and node stage (pTNM), surgical intervention, kind of reconstruction (no flap, local vs free flap), need for tracheotomy and time of removal, frozen section analysis before and after formalin embedding, lateral thermal damage on resection margins of the main specimen, postoperative complications (such as bleeding, mucosal dehiscence, fistula), need for feeding tube and time of removal, were recorded.

As regards the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of frozen section analysis, we defined true positive (TP) as a positive frozen section confirmed to be positive at definitive histological examination; true negative (TN), as a negative frozen section confirmed to be negative at definitive histological examination; false positive (FP), as a positive frozen section found to be negative at definitive histological examination; false negative (FN), as a negative frozen section found to be positive at definitive histological examination.

As explained in our previous paper [15], the definition of "complete resection" was based on final margin status in the resected specimens of patients not undergoing frozen section sampling; conversely, when frozen sections were collected, confirmation of their negativity after formalin embedding was sufficient to consider the resection radical (R0) irrespective of the status of resection margins in the main surgical specimen. In the event of incomplete resections, delayed repeat surgery was scheduled after 1 month to obtain a complete resection; however, if adjuvant radiotherapy was necessary because of other adverse features or in the case of a patient's refusal or poor general status, reoperation was not performed.

Lateral thermal damage (LTD) was analyzed in cooperation with the Institute of Pathological Anatomy. We decided to analyze LTD on the main specimen to obtain precise information on the purely thermal damage induced by the laser and avoid the confounding factor induced by the freezing process [16]. All specimens were routinely processed: immersed in buffered 10% formaldehyde, sampled and processed in a solution with 70% of ethanol for 1 h, 95% for 2 h, and 100% for 1 h, followed by immersion in Xylol; each specimen was then cut using a sliding microtome into slices with a thickness of 3 microns, which were mounted on slides for staining with hematoxylin and eosin (*Mayer's hemalum* solution and 1% eosin stock solution). The pathologist reviewed three representative slides for each specimen using an optical microscope at magnifications of 2.5×, 10×, and 20× with the aim of evaluating the extension of thermally induced tissue changes in accordance with criteria established by Vescovi et al. [17]. The widest extension of the thermally induced changes, calculated perpendicularly to the surgical resection margin, was then measured by the same experienced pathologist (R.B.), who was blinded to the type of instrument used in the resection.

Postoperative bleeding was recorded following the Pollei classification into 5 degrees of bleeding (normal, minor, intermediate, major, and severe) [18], which takes into consideration the extent of bleeding, the surgical management required, and the development of life-threatening complications.

Because no clinical score exists to objectively evaluate the healing process, we assessed wound healing by means of photographs taken by a single operator using a Visera Elite System (Olympus, Tokyo, Japan) at 1, 2 and 4 weeks after surgery and then during the routine follow-up visits.

Results

A total of 48 patients (21 male and 27 female) with a mean age of 68 years were enrolled in the study. Patient demographics and tumor characteristics are summarized in Table 1. Although preoperative histology indicated the presence of moderate or high-grade dysplasia in 12 patients, we noted an increase in staging (higher grade of dysplasia or shift from dysplasia to microinvasive carcinoma) in 6 patients at definitive histology after surgery. High-grade dysplasia and carcinoma in situ were considered as a whole [19].

The original surgical plan was to ensure a totally transoral resection of the oral or oropharyngeal tumors in all patients. However, a combined transoral–transcervical approach was necessary in two patients in whom the planned marginal mandibulectomy was intraoperatively converted to a segmental mandibulectomy as the tumoral spread frankly involved the medullary bone. Nevertheless we were able to remove the mucosal part of the lesions transorally.

Data on reconstruction are reported in Table 2. In our population, 4 patients (8.3%) were reconstructed with free flaps because of segmental mandibulectomy (2 cases), wide exposure of the mandible (1 patient) and a full thickness defect of the floor of the mouth (1 patient): in all these cases cancer stage was pT4a. In 6 patients (12.5%) a local flap was harvested. Among the 38 patients eligible to heal by secondary intention, the surgical defect was considered too large in 5 patients, and consequently a tiersch (2 patients) or bovine pericardium fixed with fibrin glue (3 patients) were placed to strengthen the native mucosa and speed up the healing process. In the 33 patients undergoing secondary intention healing we took pictures at 1, 2 and 4 weeks after surgery

Table 1 Patient distribution according to age, sex, tumor subsite, node levels included in lateral neck dissection, tumor and node pathologic staging (pTNM 7th edition)

	Oral cavity	Oropharynx
Age, mean ± SD (range)	68 ± 13 (38–87)	69 ± 12 (52–75)
Sex		
Male	17 (42.5%)	4 (50%)
Female	23 (57.5%)	4 (50%)
Subsite	Tongue 19 (47.5%) Floor of mouth 8 (20%) Gingival mucosa 8 (20%) Cheek mucosa 3 (7.5%) Hard palate 2 (5%)	Soft palate 6 (75%) Tonsil 1 (12.5%) Lateral wall 1 (12.5%)
pT stage		
T1–T2 (early)	34 (85%)	7 (87.5%)
T3–T4 (advanced)	6 (15%)	1 (12.5%)
Node levels included in neck dissection		
I–III	13 (50%)	
I–IV	12 (46.2%)	1 (100%)
I–V	1 (3.8%)	
pN stage		
N0	13 (68.4%)	0
N1	4 (21.1%)	0
N2a	0	0
N2b	2 (10.5%)	1 (100%)
N2c	0	0
N3	0	0

Data are divided according to lesion site (oral cavity and oropharynx)

SD standard deviation

Table 2 Surgical defect reconstructions

Reconstruction	No. of patients (%)
No flap	38 (79.2%)
Secondary intention	33
Tiersch	2
Bovine pericardium	3
Local flap	6 (12.5%)
FAMM	5
Submental	1
Free flap	4 (8.3%)
Ulnar	1
Radial	1
Fibula	2

FAMM facial artery musculo-mucosal flap

and then during the routine follow-up visits (Fig. 1) to attest epithelialization of the surgical defect.

Although no clinical score exists to evaluate the healing process objectively, we observed that at 1 week the surgical defects were covered by fibrinous-purulent exudate obscuring the underlying mucosa in 100% of the patients (Fig. 2); at 2 weeks granulation tissue with more or less fibrinous exudate was present in all patients, while at 4 weeks the epithelization process was completed (Fig. 3) as it was difficult to discern the exact boundary between healthy and healed tissue. This healing time was observed irrespective of tumor stage.

Twenty patients underwent 27 lateral neck dissections (13 unilateral and 7 bilateral). Among patients with oropharyngeal cancer only one underwent neck dissection, since 4 had an incisional diagnostic biopsy positive for dysplasia, 2 had previously undergone neck dissection for laryngeal cancers and one has a T1 cancer with negative nodes at imaging.

Postoperative tumor bleeding, in three patients (6.25%), was the only complication; no mucosal dehiscence or fistula formation was recorded in our series. Postoperative complications, need for tracheotomy and feeding tube and their duration are summarized in Table 3.

Frozen section analysis was performed in 33 patients for a total of 206 frozen sections collected. The choice not to perform frozen section analysis in the remaining 15 patients is justified as follows: in 12 patients the preoperative biopsy was positive for moderate or high grade dysplasia and, as previously explained in the Methods section, we do not normally collect frozen sections in these situations; the same applies to the 2 patients who underwent an excisional biopsy of NBI-positive leukoplakia without a preoperative biopsy; the remaining patient asked to be operated under

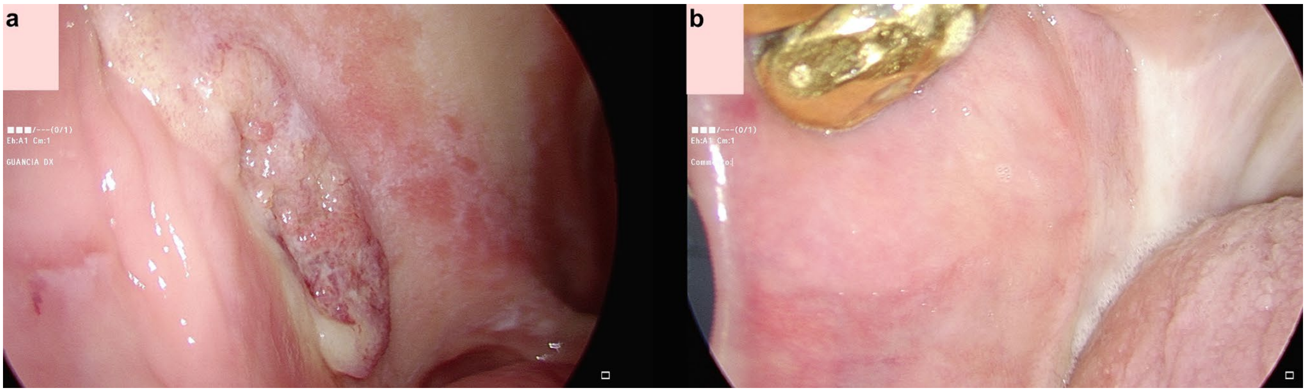

Fig. 1 **a** pT1 squamous cell carcinoma of the right cheek resected using CO_2 waveguide laser. **b** At 4 months postoperatively, complete remucosization can be seen

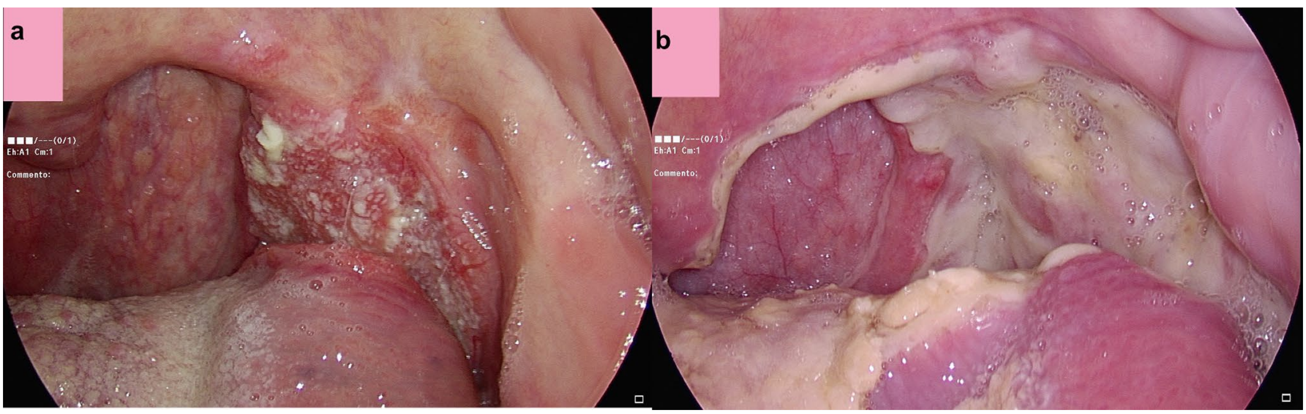

Fig. 2 **a** pT3 squamous cell carcinoma of the left tonsil resected using CO_2 waveguide laser. **b** At 1 week postoperatively, the surgical defects were covered by fibrinous-purulent exudate obscuring the underlying mucosa

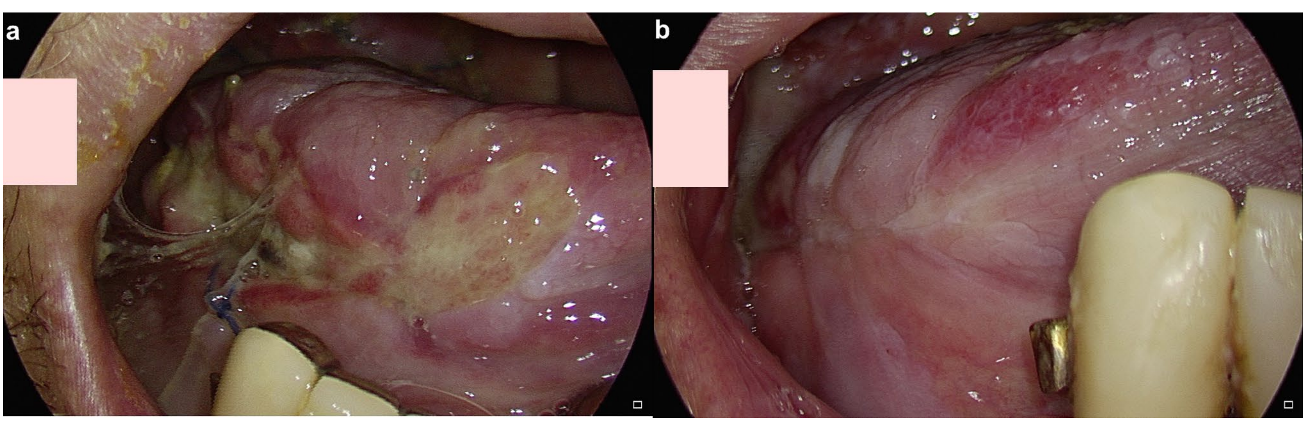

Fig. 3 pT1 squamous cell carcinoma of the righ tongue margin resected using CO_2 waveguide laser and healed by secondary intention. **a** At 2 weeks postoperatively, fibrin is visible. **b** At 4 weeks postoperatively, the healing process is complete

local anesthesia and we preferred not to prolong the procedure too much. Comparing frozen section histology before and after formalin embedding we found 5 TP, 170 TN, 4 FP and 4 FN, with a consequent sensitivity, specificity, PPV, NPV and accuracy of 55.6%, 98%, 55.6%, 98%, and 96.1%, respectively.

Table 3 Tracheotomy (number and duration), feeding tube (placement and duration) and postoperative complications (postoperative bleeding and classification, mucosal dehiscence and fistula formation) in our cohort

Postoperative complications	No. of patients (%)
Postoperative bleeding	
Minor	0
Intermediate	3 (6.25%)
Major	0
Severe	0
Mucosal dehiscence	0
Fistula formation	0

	No. of patients (%)	Duration, days (mean ± SD)
Feeding tube	39 (81.3%)	9 ± 5
Tracheotomy	24 (50%)	10 ± 6

SD standard deviation

Among the 15 patients treated without intraoperative margin mapping we observed 6 incomplete resections during the first surgery; 4 of them achieved surgical radicality at the delayed repeat surgery after 1 month, while 2 refused the procedure and were closely followed up. In the group undergoing intraoperative margin mapping we registered an incomplete resection in 3 patients with four FN cases: we decided for a close follow-up with NBI for 2 patients with moderate dysplasia on superficial margins, while 1 patient did not undergo delayed surgical enlargement because of his poor general condition. At the end, a complete resection as defined in the Methods section was obtained with the first surgery in 39 patients overall (81.3%). Specifically, based on frozen section negativity after formalin embedding, a complete resection was obtained in 30 of 33 patients (90.9%) undergoing complete margin mapping. It should be noted that in the four FP cases the intraoperative surgical enlargement did not change the reconstructive option.

The mean LTD was 164.7 ± 92.4 µm.

Discussion

Many cutting and sealing instruments have become available for head and neck surgeons, each with its advantages and disadvantages. Among them, one of the most recent innovations is the CO_2 WGL, a very thin tool that is highly suited to ENT surgeons as it allows resections to be performed in non-contact mode, 1 mm away from the target tissue and, more importantly, at any operating angle (i.e, following the surgeon's wrist movements). It can reach all sites and subsites of the upper aerodigestive tract, and can be coupled with a variety of magnification instruments [20], resulting in a more intuitive surgery [21].

Unlike the laser with micromanipulator whose use in head and neck oncologic surgery has been widely documented [14, 22, 23], use of the CO_2 WGL in the treatment of benign and premalignant lesions of the upper aerodigestive tract has been described only once [21] and, if we exclude the experimental report on the combination of CO_2 WGL and surgical robot in four patients [24], no published studies have specifically investigated the exclusive use of CO_2 WGL in the transoral surgical treatment of malignant oral and oropharyngeal lesions. Consequently we specifically analyzed the advantages and disadvantages of the use of this new instrument on the basis of our experience (Table 4).

We used CO_2 WGL for the transoral surgery of both early and advanced cancers located in all different oral and oropharyngeal subsites.

The device was found to allow a very precise cut. This is not achievable with cutting tools with bulky blades (i.e., radiofrequency and ultrasound instruments) and is particularly important when it is mandatory to save healthy tissue to avoid postoperative functional impairment (i.e., velopharyngeal incompetence after soft palate resection), when the resection has to be performed close to sensitive structures such as vessels and nerves, or when the surgeon needs to dissect major salivary gland ducts. Moreover CO_2 WGL facilitates the resection of tumors located in areas difficult to approach with the laser with micromanipulator such as the gingival or the anterior hard palate mucosa. In our opinion, its precision is also crucial when resecting precancerous lesions like moderate and high grade dysplasia or leukoplakia: it allows a resection with low morbidity while improving the diagnostic yield. In fact, in our cohort we observed an upstaging after complete removal of precancerous lesions in 50% of patients, a proportion in line with that previously reported by Vu et al. [25]. The presence of the umbrella effect [26] and the fact that diagnostic incisional biopsy is taken in an area that could be not entirely representative of the histology of the whole lesion, may justify this result.

Precise cutting is also strategic in following the margin mapping system introduced by Hinni et al. [4] and followed at our department. Indeed, using WGL, we were able to meticulously collect frozen sections as 3–4 mm tissue strips from superficial margins and thin slices of tissue from the deep one, allowing a precise margin mapping procedure. Especially for the deep margin, the use of different tools with bulky blades (such as radiofrequency and ultrasound instruments) would have made this procedure very challenging. We also consider the possibility of obtaining very thin resections to be important in tailoring our surgery: if the NBI-positive areas surrounding the tumor present a vascular pattern indicative of dysplasia [7], the surgeon can

Table 4 Advantages and disadvantages of the CO_2 waveguide laser

Advantages	Disadvantages
Precision: Cuts close to sensitive structures Accurate resection and dissection without damage Precise collection of frozen sections	Low coagulation ability: Risk of bleeding in highly vascularized areas (base of tongue)
Can reach areas difficult to approach with a microscope	Time consuming
Low thermal damage: Drawing the NBI-guided surgical tattoo Reliability of frozen sections	High costs

maintain his resection more superficial, with a consequent lower impact on functionality.

Furthermore we verified the different interaction of WGL with cancer or healthy tissue: while tumoral tissue is harder to cut and tends to carbonize with a typical sparkles effect, healthy tissue is cut easily and without carbonization: this difference could help to understand the deep extension of the tumor [13].

It is well known that the main goal in oral and oropharyngeal cancer surgery is to perform a tumor resection with clear margins (i.e., complete excision) as this provides the best chance of achieving local control. Failure to achieve clear surgical margins leads to significantly high rates (up to 63%) of locoregional recurrence [27] and potentially decreases survival [28]. A problem faced by the surgeon and especially by the pathologist is the thermal injury caused by the energy-based devices used for tumor resection, which could compromise the histopathological assessment of margins [29, 30, 31]. This aspect is particularly crucial in transoral laser surgery as radicality is assessed step by step on the basis of frozen section analysis. Several reports have investigated the thermal damage caused by CO_2 lasers on tissues, and a wide range of results (20–570 µm) have been reported [32, 33]. Remacle et al. [24] evaluated the thermal injury on surgical margins of the new CO_2 WGL in transoral robotic surgery and found that CO_2 WGL (superpulsed or continuous mode, 7–15 Watts) caused a "mean coagulation depth" of 200 µm (100–300 µm). Another recent study by Hanby et al. [34] investigated the thermal injury caused by the same instrument at various power settings (13, 16, 18 Watts) to cadaver tongue, obtaining similar results (mean thermal damage, 300 µm). With a power setting ranging between 3 and 10 W we obtained a mean LTD of 164.7 ± 92.4 µm; this result is in line with those found by previous reports. We can note the difference between these mean values and those reported for other cutting tools: the mean LTD of monopolar cautery at 30 W could reach 1700 µm [35] while it is reported to be 1000 µm with the new radiofrequency tools [36] and 690 µm using ultrasound [34]. The extremely low LTD found in our series with CO_2WGL allows frozen section histology to be confirmed after formalin embedding, justifying the accuracy of 95.8% in our series, in line with previously reported results [37].

Considering that tissue damage is also related to the freezing process itself [16], it is essential to choose surgical instruments that produce minimal thermal damage to avoid compromising the histopathological assessment of margins [38]. Furthermore we could argue that, whereas CO_2 laser causes only LTD as it has no direct interaction with tissues, with the other energy-based tools, like radiofrequency or ultrasonic scalpels, the mechanical/thermal damage caused by the blades (2–4 mm) should be added to the LTD.

The highly precise cut and the low thermal damage makes CO_2 WGL a suitable instrument for marking with a tattoo the superficial margins of the resection, by precisely following the cancer boundaries and the surrounding dysplastic areas.

According to Hinni et al. [4], if frozen sections are confirmed negative after formalin embedding, the resection can be considered complete, independently from the status of the surgical margins in the main specimen. In our series a complete resection was obtained with a single surgical intervention in 90.9% of patients undergoing complete margin mapping.

As underlined by Remacle et al. [21], the low coagulation capability represents a disadvantage of this tool. This limit should be considered both intraoperatively, during tumor resection, and postoperatively as a possible cause of postoperative bleeding. In the first situation, if vessels larger than 0.5 mm are encountered, the use of bipolar cauterization is mandatory, with a consequent increase in surgical time. This fact is especially crucial during transoral resection of oropharyngeal cancers when the intraoperative bleeding could impact on visualization of the surgical field making the second surgeon's assistance (with aspiration and bipolar cautery) crucial. As regards the postoperative bleeding, considering that studies specifically focused on CO_2 WGL in oral and oropharyngeal cancer are lacking and that a low coagulation capability is a common weakness of lasers in general, we can compare our bleeding rates with those reported with CO_2 laser. The postoperative bleeding rate in transoral laser surgery has been reported to be between 1.4 and 9% [39–41]: the heterogeneity of data (tumor site and location, different laser settings) could justify the high variability of results. In our series we observed intermediate-grade bleeding in three patients (6.25%), treated with bipolar cautery. Since elective ligation or clipping of the lingual and pharyngeal branches of the external carotid artery has been reported as a way to reduce the severity of bleeding in the oropharynx, we are used to performing this procedure during neck dissection for each case of tonsil and base of tongue carcinoma treated transorally.

Considering that the literature offers no general rules to help decide if a safety tracheotomy needs to be performed and that CO_2 WGL is still a relatively new tool, we prefer to perform a safety elective tracheotomy as a first surgical step in all cases of advanced oropharyngeal cancer, in oral cancer patients who need to maintain platelet aggregation inhibitors or anticoagulant therapy or, irrespective of the tool, if a radical or bilateral neck dissection is scheduled. In our experience tracheotomy does not significantly increase the duration of surgery, is easily reversible and does not impact patient recovery times. In the present series a temporary elective tracheotomy was performed in 50% of patients, with a mean duration of 10 ± 6 days.

If possible, a secondary intention healing should be the main goal in transoral surgery [1], as it enshrines the concept of minimally invasive surgery: indeed the use of a free flap could reduce the benefits for patients coming from this kind of surgery. Nevertheless if resections are large enough to create a full thickness defect or exposure of the mandible or large vessels, a reconstruction should be planned [42]. In our population, 68.8% of patients underwent secondary intention healing: serial photographs clearly showed a mean time of 4 weeks to complete the healing process after CO_2 WGL, irrespective of tumor stage and consequent width of the surgical defect. This is consistent with the available literature investigating this aspect using different CO_2 laser equipment [43–45].

To prevent food from coming into contact with the surgical wound with the risk of local infections and, in parallel, to speed up the healing process a feeding tube was placed in 81.3% of patients (mean duration, 9 ± 5 days). This procedure was only omitted if the surgical defect was very small and superficial. None of the patients required placement of a gastrostomy tube.

We had a mean hospital stay of 14.6 days, longer than the one reported by Remacle et al. in his four patients [24], but the larger population and the presence of both early and advanced tumors in our experience, the advanced age of several patients and the related comorbidities, could explain this difference.

Conclusions

The present series represents the first experiences with the exclusive use of the CO_2 WGL for the transoral resection of oral and oropharyngeal cancers. Our impression is that CO_2WGL is a very manageable tool which facilitates access to each subsite of the oral cavity and oropharynx. Furthermore it allows a very refined and precise cut while the thermal damage on tissue is very low. This makes it an ideal tool to collect very thin strips of tissue to perform reliable frozen sections. The healing process in our experience was quite fast enabling secondary intention healings. On the flip side we should consider the high cost and the inability to re-use the fibers. Furthermore the low coagulation capability with the consequent need for frequent bipolar cauterization is likely to result in an increase in operating time. Lastly, when using a long handpiece the tremor of the fiber is amplified if the microscope is used for magnification.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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