

# Oncological and functional outcome after transoral 532-nm pulsed potassium-titanyl-phosphate laser surgery for T1a glottic carcinoma

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**Abstract** The major concerns related to transoral laser surgery (TLS) for T1a glottic carcinoma are disease control and postoperative voice. This study examines the efficacy of the excision and ablation strategy of TLS using the 532-nm pulsed potassium-titanyl-phosphate (KTP) laser as an alternative to the conventional carbon dioxide (CO<sub>2</sub>) laser in treating T1a glottis carcinoma. The tumor was excised using KTP laser, followed by circumferential ablation of the mucosa surrounding the surgical margin in a non-contact manner using the KTP laser. Local control was obtained in 22 of 24 patients (91.7 %). Mean scores on Voice-Related Quality of Life questionnaire (V-RQOL) and the Voice Handicap Index-10 (VHI-10) were 81.0 and 6.2, respectively. A highly significant correlation was observed between scores of V-RQOL and adjusted VHI-10 ( $r=0.96$ ). TLS with a KTP laser for early glottic carcinoma achieved acceptable local control and postoperative voice comparable to those with a CO<sub>2</sub> laser reported in the literature, suggesting that the procedure based on an excision and ablation strategy can be considered oncologically and functionally acceptable for this lesion.

**Keywords** Transoral laser surgery · Glottic carcinoma · Potassium-titanyl-phosphate laser · Postoperative voice · Questionnaire

## Introduction

Radiotherapy (RT) is one of the most common treatment options for primary T1aN0M0 early glottic carcinomas. The 5-year local control rate for RT in such tumors reaches 93 % [1]. However, surgery can also be considered as an initial treatment because there is a possibility of radiation-induced cancer, especially in young patients, and because RT may be required for a second primary head and neck cancer in the future. Among several surgical procedures, transoral laser surgery (TLS) is an established treatment modality for primary T1a glottic carcinoma. The carbon dioxide (CO<sub>2</sub>) laser has been classically used for this purpose [2]. However, the 532-nm pulsed potassium-titanyl-phosphate (KTP) laser, another clinically available laser, is currently receiving attention because its selectivity for hemoglobin leads to ablation of aberrant neovascularity.

One of the major concerns of TLS for primary glottic carcinoma is disease control. Another major concern is voice quality, which might play a role in decisions about treatment strategies. The present prospective report documents the oncologic and vocal results of a TLS with KTP laser (TLS-KTP) to treat primary T1a glottic carcinoma.

## Patients and methods

### Patients

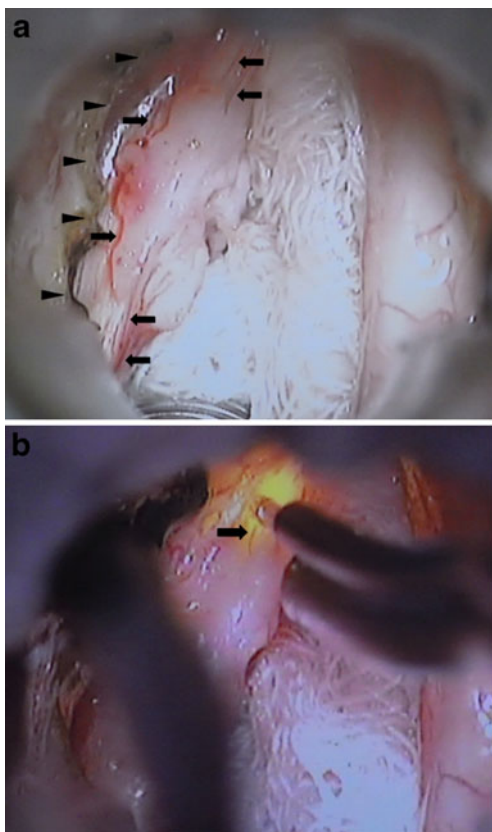
Twenty-four patients, including 23 males and 1 female, diagnosed as having primary T1a glottic squamous cell carcinoma, underwent TLS-KTP between 2002 and 2010 at Kanazawa University Hospital, Japan. Eligibility criteria for the surgery included clinically negative neck (cN0), adequate exposure of the glottic region, absence of

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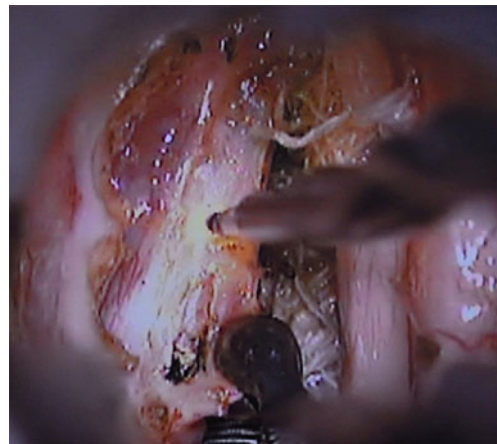
contraindications to general anesthesia, the ability to understand and willingness to sign a written informed consent document, and absence of previous surgery or RT for laryngeal cancer. All patients in this series fulfilled these criteria. Eleven patients who did not agree to the surgical treatment were treated with radiotherapy.

### Surgical procedure

Ipsilateral vestibulotomy was performed in all cases prior to cordectomy in order to evaluate the extension of the tumor (Fig. 1a). Then, dilated microvessels surrounding the tumor were ablated using the KTP laser (4.5 W, pulsed mode; Fig. 1b). Surgical procedures included 20 type II, namely, subligamental, cordectomies, and 4 type III, namely, transmuscular, cordectomies, according to the European Laryngological Society Working Committee [3]. Although the definition of transmuscular cordectomy includes resection of either superficial or deep muscle layer, all four procedures were the former. Tumor resection with a surgical margin of at least 2 mm was performed using the KTP laser (4.5 W; Fig. 2).



**Fig. 1** Pre-cordectomy microlaryngoscopic image after ipsilateral vestibulotomy is shown (a). Arrowheads indicate the resection margin of vestibulotomy. Arrows indicate vascular dilatation around the glottic carcinoma. Gauze was introduced into subglottic space. Ablation of dilated microvessels was performed prior to resection of the tumor (b). Gauze was introduced into subglottic space

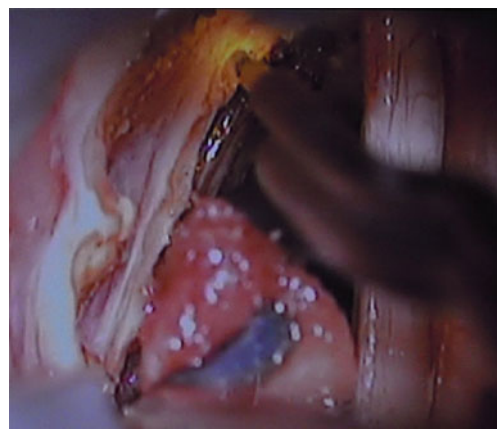


**Fig. 2** KTP laser excision of glottic carcinoma. The tumor was retracted medially. Gauze was introduced into the subglottic space

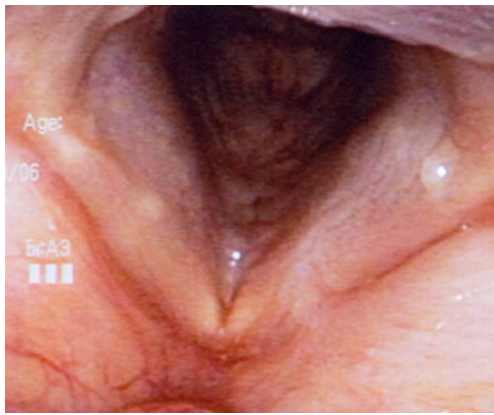
Surgical resection was basically performed with pulsed mode; however, continuous mode was also used in an area where deep invasion was suspected. The resection margins and bed of each tumor were pathologically confirmed by examination of frozen sections. After removal of the tumor, the remaining microvessels surrounding the resection margin were further ablated using a KTP laser in a non-contact manner (4.5 W, pulsed mode; Fig. 3). The postoperative appearance of vocal cord became almost normal within a couple of months in most cases (Fig. 4).

### QOL questionnaires

The Voice-Related Quality of Life questionnaire (V-RQOL) is a ten-item self-administered validated voice outcome measure [4]. Scores are reported in two domains (social–emotional and physical functioning), and total score ranges from 0 to 100. A higher score indicates a better voice-related QOL. The Voice Handicap Index-10 (VHI-10) scale, a short form of the Voice Handicap Index, is a ten-item self-administered validated



**Fig. 3** KTP laser ablation of surrounding microvessels in the resection margin after excision of glottic carcinoma



**Fig. 4** Postoperative endoscopic view. Almost normal appearance of the vocal cord was observed except for tiny scar formation between the vocal cord and false vocal cord

instrument that measures patient disability as a result of voice disorders [5]. Scores range from 0 to 40, in which a lower score indicates a better voice-related QOL. An adjusted VHI-10, ranging from 0 to 100, in which a higher index indicates a better voice-related QOL, was also calculated to assess the correlation with the V-RQOL score. Patients were asked to complete both questionnaires 6 months after TLS-KTP.

## Results

The mean and median ages of patients were 67.8 and 73 years, respectively (range, 41–82 years). The postoperative follow-up period for patients ranged from 12 to 84 months (mean, 40.6 months; median, 40 months). Of 24 patients, local control was obtained in 22 patients (91.7 %) after the initial TLS-KTP. The remaining two patients were rescued by the second TLS-KTP. There were two deaths due to lung cancer 14 and 20 months after the initial TLS-KTP without any sign of recurrent glottic cancer.

The surgical margin evaluated using resected tissue containing glottic tumor demonstrated a negative margin in 17 procedures. In the remaining seven procedures, tumor was close to, but not exposed to, the surgical margin, which was defined as a marginal margin. Both of the two recurrent cases had demonstrated a marginal surgical margin. Both recurrences developed contiguous to the anterior commissure.

Mean V-RQOL score (total) was 81.0 (Table 1). Mean social–emotional domain and physical functioning domain of V-RQOL scores were 84.4 and 78.8, respectively (Table 1). Mean VHI-10 score was 6.2 (Table 1). Unfortunately, this series does not contain a sufficient number of patients treated with either RT or TLS using CO<sub>2</sub> laser (TLS-CO<sub>2</sub>) for comparison. A strong significant correlation was observed between V-RQOL and adjusted VHI-10 scores ( $r=0.96$  by Spearman's rank correlation coefficient).

**Table 1** Voice evaluation after TLS-KTP

Type of questionnaire	Score (mean)
Voice-Related QOL questionnaire score	81.0
Social–emotional domain	84.4
Physical functioning domain	78.8
Voice Handicap Index-10	6.2

*TLS-KTP* transoral laser surgery using KTP laser

## Discussion

Oncological outcome is the most important concern in the treatment of laryngeal cancer. TLS-CO<sub>2</sub> provides a rate of local control comparable to that of RT for primary early glottic carcinoma as Gallo et al. reported that local control was achieved in 110 of 117 cases (94 %) [6]. Although the procedures for cordectomy were usually type IV (total cordectomy) in that study, Goor et al. also reported that local control for type I (submucosal) or type II cordectomy was achieved in 51 of 54 cases (91.4 %) of T1a glottic carcinoma [7], suggesting that total cordectomy is not necessarily required for all T1a lesions.

Lasers of different wavelengths produce energy that is absorbed by different substances within a tissue. Therefore, CO<sub>2</sub> laser and KTP laser have different degrees of penetration, scatter and thermal effect in tissues [8]. CO<sub>2</sub> laser has a wavelength in the infrared region (10,600 nm) and is absorbed primarily by water. It has been found in rat tongue epithelia to result in a microscopic damage zone with an average depth of 250 to 500 μm [9], suggesting less thermal damage to the surrounding tissues. This seems to be why the CO<sub>2</sub> laser has been preferentially used in TLS for T1a glottic carcinoma.

KTP laser has a wavelength in the visible region (532 nm) and is absorbed by pigments containing its complementary colors, such as hemoglobin and melanin. Therefore, the KTP laser can be used for photoangiolysis (also known as microvascular ablation) based on the concept of selective photothermolysis [10]. It was previously reported that varices and ectasia of the vocal folds have been successfully treated with KTP laser [11]. Furthermore, laryngeal papillomatosis was recently shown to be successfully treated with KTP laser [12].

The versatility of KTP laser is shown by its use in treating dysplasia of the vocal cord [13]. However, there have been only a limited number of reports describing the availability of KTP laser for early laryngeal carcinoma [14]. It was emphasized that KTP laser is available for bilateral glottic carcinoma, which included conventional resection for the predominant side and laser photoangiolysis for the other less involved side. Photoangiolysis for neoplastic lesion is based on the concept of tumor angiogenesis process

proposed by Folkman [15], implying that microinvasive carcinoma would be a good indication for the procedure; however, gross lesion itself would not be an indication. An experimental study using an established animal model demonstrated that complete resolution of mucosal squamous cell carcinoma in hamster cheek pouch following laser photoangiolytic treatments was observed in all lesions measuring less than 2 mm, in two of six lesions measuring between 2 and 5 mm, and in none of three lesions greater than 5 mm [16]. In the present study, we utilized a combination of KTP laser excision accompanied by photoangiolytic ablation of the circumferential microvessels for gross unilateral glottic carcinoma. Because certain removal of tumor by excision as well as diminished opportunity for angiogenesis by ablation is achieved, the excision and ablation strategy is rational and is expected to be widely used.

There were two recurrences in the present series, both of which occurred contiguously to the anterior commissure. This indicates that the ablation during TLS-KTP was not sufficient near the anterior commissure owing to hesitancy in performing vigorous treatment at the region in order to prevent glottic webbing. However, Burns et al. reported that none of the 51 patients with laryngeal papillomatosis who presented with anterior commissure involvement developed new webbing or synechia after KTP laser treatment [12], suggesting that further improvement of local control can be achieved with TLS-KTP.

Thus, oncological availability of TLS-KTP was demonstrated in the present study. Therefore, if the functional outcome of TLS-KTP is at least equal to that of TLS-CO<sub>2</sub>, the excision and ablation strategy in the present study may have further potential as an alternative to, or even a substitute for, TLS-CO<sub>2</sub>.

Functional outcome is another major concern during the treatment of laryngeal cancer. There are several ways to evaluate postoperative voice including auditory perceptual analysis and acoustic voice parameters; however, both correlate poorly with patient-perceived vocal outcome [17, 18]. How a patient regards voice impairment varies according to the individual; therefore, patient-based outcome assessments may have much greater importance. Several questionnaires could be used to assess posttreatment voice outcome in laryngeal cancer [19–24]. We attempted to evaluate voice-related QOL in T1a glottic carcinoma patients treated with TLS-KTP using two questionnaires, namely, VHI-10 and V-RQOL, both of which are also available in Japanese.

A meta-analysis review demonstrated that VHI, the original version of VHI-10, provides reliable assessment of posttreatment voice outcomes for early glottic carcinoma [25]. In addition, the development of VHI-10 provides a powerful representation of VHI that takes less time for the patient to complete without loss of validity, indicating that VHI-10 can replace VHI as an instrument to quantify the patient's perception of their voice handicap [5]. Rosen et al.

reported that VHI-10 scores for control subjects, patients with Reinke edema, and patients with recurrent nerve paralysis were 3.38, 18.30, and 25.72, respectively [5]. Therefore, the mean VHI-10 score of patients obtained in the present study is considered acceptable.

The other questionnaire used in the present study, V-RQOL, has been reported to perform well in tests of reliability, validity, and responsiveness [4]. In that report, V-RQOL scores for voice-related patients and non-voice-related patients were 98.0 and 53.5, respectively. Furthermore, average V-RQOL scores for patients whose self-assessments of voice quality were poor/fair, good, and excellent/very good were 53.1, 83.1, and 95.0, respectively. Fung et al. reported that the V-RQOL scores for healthy volunteers and laryngeal cancer patients who had received chemoradiotherapy were 98.0 and 80.3, respectively [22]. Therefore, the mean V-RQOL score of patients obtained in the present study is also considered acceptable. Scores of adjusted VHI-10 and V-RQOL correlated well in the present study, suggesting that these two questionnaires could be used to evaluate postoperative voice after TLS-KTP.

## Conclusions

The present data imply that TLS-KTP for early glottic carcinoma achieved acceptable local control and postoperative voice comparable to those with TLS-CO<sub>2</sub> reported in the literature, suggesting that the excision and ablation strategy in the present study can be considered oncologically and functionally acceptable.

**Conflict of interest** None

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