

ORIGINAL RESEARCH

Office-based laryngeal laser surgery: A review of 443 cases using three wavelengths

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BACKGROUND: Unsedated office-based laser surgery (UOLS) of the larynx and trachea has significantly improved the treatment options for patients with laryngotracheal pathology including recurrent respiratory papillomas, granulomas, leukoplakia, and polypoid degeneration. UOLS delivered by flexible endoscopes has dramatically impacted office-based surgery by reducing the time, costs, and morbidity of surgery.

OBJECTIVES: To review our experience with 443 laryngotracheal cases treated by UOLS.

METHODS: The laser logbooks at the Center for Voice and Swallowing Disorders were reviewed for UOLS, and the medical and laryngological histories were detailed, as were the treatment modalities, frequencies, and complications.

RESULTS: Of the 443 cases, 406 were performed with the pulsed-dye laser, 10 with the carbon-dioxide laser, and 27 with the thulium: yttrium-aluminum-garnet laser. There were no significant complications in this series. A review of indications and wavelength selection criteria is presented.

CONCLUSION: Unsedated, office-based, upper aerodigestive tract laser surgery appears to be a safe and effective treatment option for many patients with laryngotracheal pathology.

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Unsedated office-based laser surgery (UOLS) of the upper aerodigestive tract is an exciting new surgical option for the treatment of patients with many different laryngotracheal pathologies, including recurrent respiratory papillomas (RRPs), glottal leukoplakia/dysplasia, and polypoid degeneration (Reinke edema). In the past, these conditions usually required multiple surgical procedures performed under general anesthesia; but now many of these conditions can be effectively and safely treated in the office by laser surgery using only topical anesthesia. We have previously reported that patient satisfaction with UOLS is higher than with traditional surgical methods.¹

For UOLS, we have employed three different lasers: the pulsed-dye laser (PDL),²⁻⁸ the carbon dioxide (CO₂) laser,^{9,10} and the thulium: yttrium-aluminum-garnet (Tm:

YAG) laser.¹¹ UOLS is performed by using the accessory working port of a distal-chip-camera transnasal flexible endoscope. These endoscopes are employed for treatment of lesions of the larynx, trachea, and esophagus. The purpose of this paper is to review our UOLS experience and to discuss the indications, wavelength selection, and safety.

METHODS

This retrospective study was approved by the institutional review board at Wake Forest University Health Sciences. The laser log books for the PDL (Cynosure, Inc, Westford, MA), the CO₂ laser (OmniGuide, Inc, Cambridge, MA), and the Tm:YAG laser (AllMed Systems, Inc, Pleasanton, CA) were reviewed to identify all UOLS of the larynx, trachea, or esophagus over four years (August 2002 to July 2006). The clinic charts of all study patients were also reviewed, and anonymous demographic, surgical, and outcome data were collected. All study patients were adults older than 18 years. The data were entered into an Excel (Microsoft Corporation, Redmond, WA) database, and descriptive statistics were generated with JMP IN, version 5.1 software (SAS Institute, Inc, Cary, NC).

RESULTS

In all, 99.1 percent of the procedures were performed without any complications. There was a 0.9 percent incidence of minor complications (four of 443). Specifically there were no cases of airway obstruction, web formation, vocal fold scarring, or granuloma formation (although some granulomas treated by UOLS did recur).

Pulsed-dye Laser

Four hundred six pulsed-dye laser (PDL) UOLS procedures were performed for 151 study patients. The mean age of the

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Table 1
Pulsed-dye laser UOLS cases (N = 406)

| Indication | Number of procedures (%) |
|-----------------------------------|--------------------------|
| RRP | 212 (52.2%) |
| Glottal dysplasia | 79 (19.5%) |
| Granuloma | 40 (9.9%) |
| Vocal fold lesion, unspecified | 26 (6.4%) |
| Barrett esophagus | 19 (4.7%) |
| Reinke edema | 18 (4.4%) |
| Laryngeal amyloidosis | 6 (1.5%) |
| Glottal web | 3 (0.7%) |
| Tracheobronchial mass | 2 (0.5%) |
| Tracheal stenosis | 1 (0.2%) |

RRP, Recurrent respiratory papilloma.

study group was 55 years (range 21-98 years); 88 percent were Caucasian and 75 percent were male. The most common indications for PDL were RRP in the larynx or trachea (52.2%), glottal dysplasia/leukoplakia (19.5%), and granuloma (9.9%) (Table 1).

Anesthesia used for these cases included topical lidocaine only (sprayed into the larynx via the working channel of the endoscope; 71.4%), nebulized lidocaine (27.8%), and superior laryngeal nerve blocks (three procedures; 0.7%). After October 2004, topical anesthesia only became the exclusive method of anesthesia except for one patient with tracheal papillomas.

There were four complications (0.9%). One study patient had a vasovagal episode, two subjects had vocal fold hemorrhages, and the PDL fiber tip broke off in the trachea of one patient (and was immediately retrieved with a cup forceps).

Recurrent respiratory papillomas. Fifty-nine RRP patients underwent 212 PDL procedures, with a mean of 3.6 procedures per patient (range 1-15 procedures/patient). The median PDL power setting was 1.0 J (range 0.5-2.0 J). The mean number of pulses was 236 ± 240 (range 9-1887; median 161). Topical anesthesia only was used in 61.3 percent of cases, with nebulized lidocaine or local nerve blocks added in 37.3 percent and 1.4 percent, respectively. Every RRP patient had one conventional surgical procedure under general anesthesia to fully evaluate the larynx and trachea, and to obtain a biopsy (prior to recommending UOLS). Fifteen percent of the study patients (9 of 59) required subsequent operating room (OR)-based surgery after initiating PDL treatments, usually because the disease was too bulky for office-based treatment.

Follow-up was defined as time from first UOLS to last laryngeal examination. The mean follow-up time was 17 months (range 1-45 months). One patient's tracheal papillomas were treated via an existing tracheostomy. There were no complications associated with any of the RRP PDL procedures. One RRP patient died of an unrelated cardiac

cause and one died of lung cancer. Follow-up data were not available for 11 RRP subjects.

Glottal leukoplakia and dysplasia. The PDL was used to treat glottal dysplasia in 25 patients (79 procedures, mean 3.2/study patient, range 1-9/study patient). Fourteen had undergone one to four previous OR surgical procedures. All patients had biopsies of the dysplasia (in either the OR or the office) prior to initiating UOLS.

Nebulized lidocaine was used for 19 procedures; the rest were performed with topical lidocaine sprayed into the endolarynx. The mean PDL power setting was 1.0 J (range 0.75-1.5 J), and the mean number of pulses was 117 ± 68 (range 20-436; median 113). One patient was treated for tracheal leukoplakia, and the remaining study patients had leukoplakia isolated to the endolarynx.

There were no complications in this group. Follow-up was available for all but one study patient, with a mean of 16 months (range 3-44 months). Most (20 of 25) of these patients did not require further treatment of these lesions during the follow-up period; however, five patients required subsequent procedures in the OR for biopsies and treatment (after initiating PDL treatments). One patient went on to develop vocal fold carcinoma.

Granulomas. Twenty-three patients had 40 PDL procedures for granulomas (mean 1.6, range 1-5). Thirteen had previous OR surgeries for granulomas. All were treated with anti-reflux therapy. For PDL of this group, the mean power setting was 1.0 J (range 0.75-1.5 J), and the mean number of pulses was 137 ± 85 (range 33-403; median 119). Twenty-nine of the procedures were performed with topical anesthesia only, and nebulized lidocaine was added in 11 of the earlier procedures (prior to October 2004). All patients had glottal (vocal process) granulomas, with the exception of one subglottic and one tracheal granuloma.

There was one complication in this group: During treatment of a subglottic granuloma, the laser tip broke off and fell into the trachea. This incident occurred after the laser was used without a sheath (Cynosure, Inc, Westford, MA), which is now available and supplied with the PDL fibers to prevent injury to the fibers and/or endoscopes. The tip was easily and completely retrieved with a microcup forceps through the endoscope. There were no adverse sequelae as a result of this event. In addition, the patient with the subglottic granuloma eventually had a tracheotomy placed because of recurrence with airway obstruction (two months after last PDL).

Follow-up was available for 82 percent (19 of 23) of the granuloma patients (mean 12 months, range 1-30 months). UOLS was effective in resolving granulomas in 68 percent (13 of 19) of subjects, and six subjects needed further surgery in the OR for granuloma.

Reinke edema (polypoid degeneration). Twelve patients had 18 PDL procedures for Reinke edema (mean 1.5, range 1-3).

All Reinke edema patients were advised to quit smoking and were treated with antireflux therapy prior to UOLS. All procedures in this group were performed with topical anesthesia only. The mean power setting was 1.0 J (range 0.75–1.5 J), and the mean number of pulses was 89 ± 55 (median 94.5, range 3–199). For 10 of 12 patients, follow-up was available (mean 7.3 months, range 1–13 months). Two patients had small vocal fold hemorrhages that resolved completely. Otherwise, there were no complications.

For the 10 patients with follow-up available, all experienced virtually complete resolution of the Reinke edema with dramatic improvement of voice quality. No patients developed an adynamic vocal fold segment (as confirmed by videostroboscopy), and no patient required surgery in the OR after PDL treatments.

Flexible CO₂ Laser

Two patients had a total of 10 procedures in the office with the flexible CO₂ laser (hollow-core photonic bandgap optical fibers from OmniGuide, Inc, Cambridge, MA). Both subjects had severe RRP; one (a 53-year-old man with extensive endolaryngeal RRP) was very difficult to expose with direct laryngoscopy in the OR, and the other (a 58-year-old woman with extensive, airway-obstructing laryngeal and tracheal RRP) was virtually impossible to expose. The latter patient was the world's first patient to be treated with flexible CO₂ laser technique (to do this procedure, we obtained a special "compassionate use" exemption from the Food and Drug Administration). Previously, she had been treated monthly with the PDL, but the volume of bulky exophytic RRP disease was such that the PDL was barely effective in maintaining her airway, even with long (1–3 hour) UOLS sessions. She had seven procedures with the CO₂ laser over a 2-year period to control her life-threatening tracheal papillomas. Both topical anesthesia and nebulized lidocaine were used, and the laser was used at a variety of settings, from 8 to 17 W. There were no complications. In later cases, she had CO₂ laser surgery to remove the bulk of disease, followed by PDL for the superficial disease.

The other patient weighed 175 kg and had difficult anatomy (short neck and retroplaced chin/jaw). Prior to initiating flexible CO₂ laser treatment, we treated him with both the PDL and the Tm:YAG laser. Interestingly, his papillomas did not respond to PDL. The Tm:YAG laser was a good alternative to the CO₂ laser for disease (not in the vocal fold striking zones) because we were concerned that the laser might cause vocal fold scarring related to thermal damage. This patient had three flexible CO₂ laser treatments over a 1-year period with significant improvement.

Thulium: YAG Laser

The Tm:YAG ("LISA") laser was used in the office for 27 procedures in 17 patients. Twelve patients (71%) were male, and five patients were female (29%). The mean age was 55 years, ranging from 29 to 80 years. The most common indication was RRP (33%), followed by granu-

Table 2
Thulium: YAG laser UOLS cases (N = 27)

| Indication | Number of procedures (%) |
|-------------------|--------------------------|
| RRP | 9 (33%) |
| Granuloma | 7 (26%) |
| Amyloid | 4 (15%) |
| Vocal fold lesion | 3 (11%) |
| Dystonia | 3 (11%) |
| Glottal web | 1 (4%) |

YAG, Yttrium-aluminum-garnet; UOLS, unsedated office-based laser surgery; RRP, recurrent respiratory papilloma.

loma (26%) (Table 2). Eleven (65%) of the patients had previous treatments in the OR for the same laryngeal pathology. The average length of follow-up after Tm:YAG procedures was 5.6 months. One study patient experienced a vocal fold hematoma after Tm:YAG treatment for vocal fold RRP. This complication resolved with conservative therapy, and no adynamic segment was noted on videostroboscopy after healing. Otherwise, there were no complications in the Tm:YAG group.

DISCUSSION

UOLS is both less costly and more expedient for patients, especially those with upper aerodigestive tract pathology that requires multiple procedures, such as RRP.^{1,12} The major advantages of UOLS over traditional surgery are avoidance of general anesthesia, lower cost, more efficient use of the patient's and surgeon's time, patient satisfaction, and improved outcomes.

In a previous retrospective survey of 89 subjects who underwent PDL in the office,¹ discomfort with UOLS was perceived as minimal and localized to the throat rather than the nose. Fifty-four of these subjects had previous OR surgeries for the same pathology, and 87 percent stated they preferred UOLS over OR surgeries. Eighty-three percent indicated they had less discomfort with UOLS than with OR surgeries.

There are other advantages to UOLS. For RRP patients, the PDL allows bilateral, simultaneous treatment of the anterior commissure without the risk of web formation. After UOLS, patients can drive themselves home and return to work immediately. Notably, in our experience, no patient has ever been admitted to the hospital after UOLS for any reason.

Hard data for clinical outcomes are difficult to establish with RRP patients because of the inherent variability that characterizes the course of RRP and the lack of a standardized method to quantify original disease load. In addition, some of our tertiary-referral RRP patients were lost to follow-up after successful treatment. Conversely, we found that some RRP patients came for treatment more often (ie, as soon as they began to experience a decline in voice) so

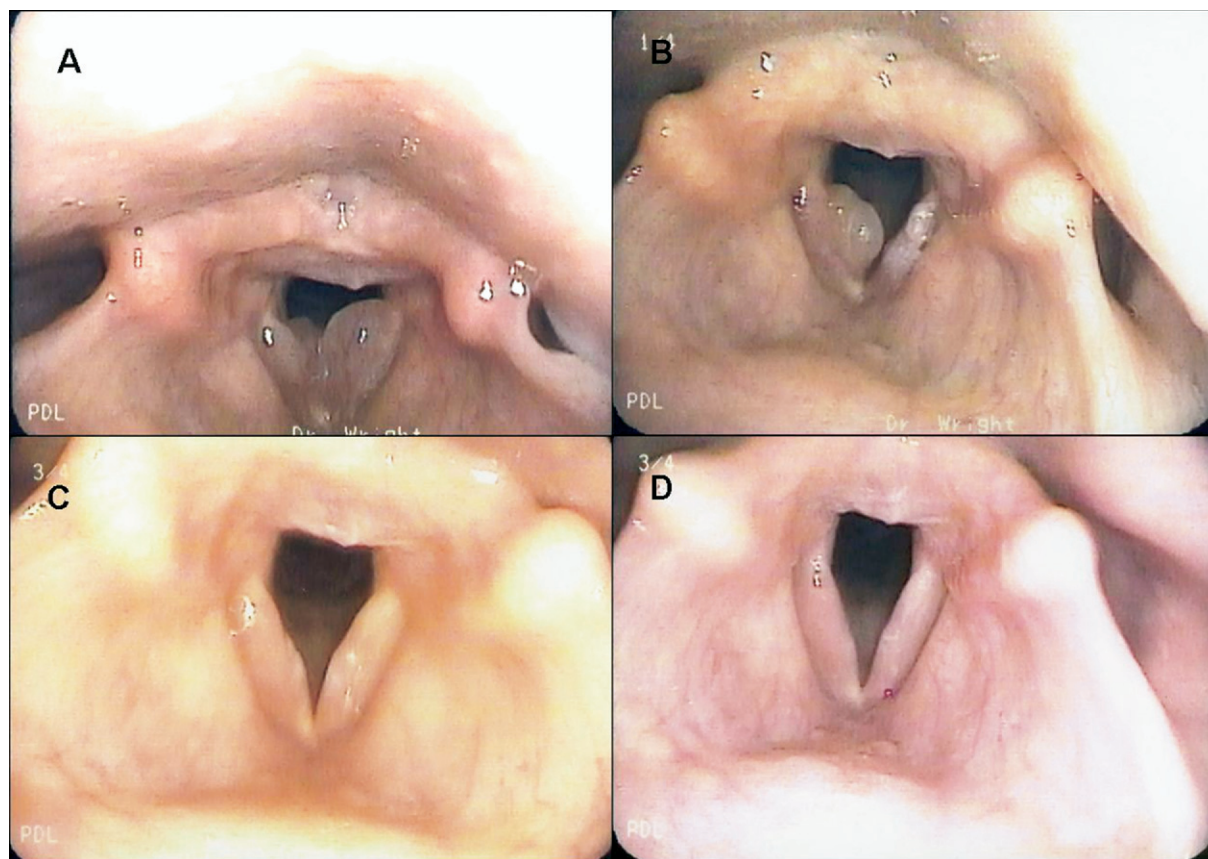


Figure 1 Treatment of Reinke edema with PDL. (A) Preoperative. (B) Four-week status post-PDL to left vocal fold. The right vocal fold is treated at this visit. (C) Five-week status post-PDL to right vocal fold. (D) Four-month status post-treatment initiation.

that treatment frequency appeared to sometimes be independent of severity of disease.

We have followed 10 long-term RRP patients from this series for more than 5 years. As noted above, with our RRP patients we found that the intervals between surgeries were shorter for UOLS than for prior OR-based surgery (3.5 months vs. 6.5 months). Not only were patients more likely to come for early treatment (as soon as there was a change of voice), but also, because of less lost time from work and fewer out-of-pocket expenses, they returned for treatment more often. Most stated that they simply preferred PDL because it was easier and more effective than traditional surgery.

The results of PDL in polypoid degeneration patients are quite impressive; patients essentially experienced resolution and normalization of voice. Formal study of UOLS outcomes for Reinke edema is currently underway. Figure 1 shows such a patient preoperatively and post-PDL treatment over the course of four months. Although we have never had a patient with airway obstruction after UOLS for Reinke edema, we recommend treating one side of the larynx at a time to avoid this possibility because the vocal fold may become very stiff and swollen for up to four weeks following PDL for Reinke edema. In addition, during that same period, the voice can get worse, sometimes aphonic. Then usually, by 6 to 8 weeks, the swelling resolves, as do the

polypoid changes, with simultaneous voice improvement. In the authors' experience, UOLS treatment of polypoid degeneration produced results that are superior to any other method.

Appropriate topical anesthesia is a critical part of UOLS. Early on in our UOLS experience, we used superior laryngeal nerve blocks and nebulized lidocaine in addition to routine topical anesthesia. With experience we found that those measures were not necessary. Actually we sometimes found that too much anesthesia could make the procedure more difficult because of coughing from aspiration of saliva.

Since October 2004, we have used only topical anesthesia, which involves lidocaine or cocaine in the nose (spray or soaked cottonoids) and 4 percent lidocaine sprayed into the larynx through the working channel of the endoscope. Sometimes if the patient had a strong gag reflex, we would have the patient gargle and swallow 5 cc of 2 percent viscous lidocaine.

We typically use a 5.1-mm Pentax transnasal esophagoscope with a 2-mm working channel for UOLS (PENTAX Medical Company, KayPentax, Lincoln Park, NJ) (Fig 2). Currently we employ three wavelength lasers. The PDL wavelength (585 nm) is preferentially absorbed by hemoglobin, which gives the PDL its relative tissue-sparing and microvascular-specific properties. The CO₂ laser, on the other hand, has a wavelength (10,600 nm) that is not colo-



Figure 2 Basic setup for UOLS. The examiner is facing the patient and viewing the larynx/trachea on the video monitor (out of picture). The surgeon, patient, and staff are wearing laser-specific eye protection.

rimetrically absorbed, but that is absorbed by water. Thus, laryngeal soft-tissue with its high percentage of intracellular water is vaporized by absorption of CO₂ laser energy. The Tm:YAG laser (2000-nm wavelength) has intermediate properties between the PDL and CO₂ lasers,¹³ but its tissue-interactive properties are closer to that of the CO₂ laser with greater thermal penetration in soft tissue.

The clinical applications of the three different lasers are related to the differential absorption of the 3 wavelengths. However, some of the clinical applications are counterintuitive. Polypoid degeneration, a seemingly rather avascular lesion, responds to PDL energy in impressive fashion, and amyloid responds well to the Tm:YAG laser.

Inevitably each of these wavelengths (and others) will have its place in the UOLS armamentarium; however, laser characteristics and specific applications should merge. Which laser should be used, and when? Bulky nonvascular lesions (eg, exophytic papillomas or supraglottic cysts) are best excised/ablated with the CO₂ or the Tm:YAG laser. However, if hemostasis is a concern, the Tm:YAG is preferred, such as for large inflamed vocal process granulomas. For leukoplakia, dysplasia, Reinke edema, nonbulky papillomas, and especially papillomas at the anterior commissure, in our experience the PDL is preferred.

In the past year, we have used different wavelengths in combination. These wavelengths are complementary (eg, for papillomas). For bulky papillomas, such as for the patient with extensive tracheobronchial disease, we employed the CO₂ laser for debulking; then at the same sitting, we followed up with the PDL to treat diffuse mucosal disease.

By no means are we implying that the utility of the standard CO₂ laser with the micromanipulator that has long been the workhorse laser for laryngology is defunct; however, the flexible fiber technology (OmniGuide, Inc, Cambridge, MA) is an exciting advance. It works with a photonic bandgap fiber assembly, which allows the CO₂ laser to

be used via the working channel of a flexible endoscope for UOLS. The flexible CO₂ laser is well-suited for both cutting and ablation applications. We have recently begun to use this laser to treat some carefully selected cases of subglottic and tracheal stenosis by UOLS.

The Tm:YAG (LISA) laser is a useful laser for ablative procedures that require good hemostasis. We use it for supraglottic cysts: The cyst is unroofed and then the base is vaporized. We have also begun to use the Tm:YAG laser to perform partial thyroarytenoid myectomies for spasmodic dysphonia in the office.

The role of these lasers and of UOLS in general will continue to evolve. The ease of anesthesia, coupled with the brilliant high-resolution, distal-chip-camera endoscopic technology and a very low (minor) complication rate with lasers delivered by fiber, makes UOLS highly appealing in many ways. Last year the senior author (J.A.K.) and her fellow (S.C.W.) performed a total of 350 endoscopic laryngotracheal surgical procedures; 57 percent (200 of 350) were performed by UOLS. We believe that UOLS is likely to continue to be an important emerging part of otolaryngology.

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FINANCIAL DISCLOSURE

None.

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