Office KTP Laser Treatment

Introduction/Historical Background

Advances in technology have led to the expansion of in-office procedures in recent years, particularly within the field of laryngology. With the development of fiber-based lasers that may be passed via the working channel of a flexible laryngoscope, office laser laryngeal surgery became possible. The potassium-titanyl-phosphate (KTP) laser has several features that make it ideal for laryngeal surgery, and has become the laser of choice for office management of a variety of laryngeal lesions. Its applications have expanded significantly since its introduction, with reports of new indications continuing to appear in the literature.

Lasers have advanced otolaryngologic surgery for decades, with the carbon dioxide (CO_2), argon, and dye lasers being some of the earliest used[1]. The addition of the neodymium-yttrium aluminum garnet (Nd:YAG), KTP, and holmium lasers further broadened the indications for laser surgery. The choice of laser depends on wavelength, the characteristics of the target tissue, and the energy density of the laser. The CO_2 laser was the first to be utilized in the larynx and upper airway for a variety of conditions, including both benign and malignant lesions[2]. A feature of the CO_2 laser that made it ideal for laryngeal surgery is its absorption by water, which has a high concentration in laryngeal tissues, and allowing targeting of lesions with minimal collateral tissue damage[1]. As the CO_2 laser was initially limited to mirror-reflected line of sight delivery, its application to laryngeal surgery was initially only via direct laryngoscopy in the operating room.

Office-based laser surgery in otolaryngology was first described in 2001, and employed the 585 nanometer (nm) pulsed dye laser (PDL) under topical anesthesia. Features of the PDL laser that made it advantageous for in-office laryngeal procedures included its fiber delivery system and its energy's selective absorption by oxyhemoglobin, which made it suitable for treatment of vascular lesions such as recurrent respiratory papillomatosis (RRP)[3]. Several disadvantages of the PDL included procedural bleeding due to the laser's short pulse width of approximately 0.5 milliseconds (ms), and the relatively large size of the fiber (0.6 millimeters (mm)). The fiber size resulted in damage to the working channel of laryngoscopes and difficulty with suctioning during the procedure[4].

The shortcomings of the PDL led to the use of the pulsed KTP laser for office laryngeal surgery, first described by Zeitels *et al.* in 2006. In the office setting, the KTP laser was first applied to vascular glottic epithelial lesions (dysplasia and RRP)[4]. Later investigations, including a multi-institutional study published in 2011, have shown the KTP laser to be effective in the treatment of nonvascular benign laryngeal lesions such as Reinke's edema and leukoplakia[5]. Since its introduction, the indications for office-based KTP laser laryngeal surgery have continued to expand, and this modality has grown in popularity with both surgeons and patients.

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Pathophysiology and Scientific Premise

In comparison with the PDL, the wavelength of the KTP laser (532 nm) is more strongly absorbed by oxyhemoglobin. The extended pulse width (15ms) allows for distribution of energy over a longer time period[1]. This results in more effective intravascular coagulation via slower intraluminal heating than with the PDL, and avoids photothermal injury to the superficial lamina propria (SLP)[2]. The smaller fiber size of 0.2 or 0.4 mm is another advantage of the KTP laser[3], which allows for more efficient suctioning and improved visualization during procedures.

Vascular lesions such as RRP and dysplasia are thought to respond to KTP laser treatment due to targeting of their microcirculation[1]. In the case of nonvascular lesions such as such as leukoplakia, it is hypothesized that nonspecific thermal injury to adjacent target chromophores, such as blood vessels, results in wound repair that leads to lesion regression[4]. There is limited information in the existing literature regarding the use of the KTP laser for vocal fold scar in the office setting. Animal studies do show promise, however, with KTP laser treatment being shown to increase inflammatory gene expression and matrix metalloproteinase gene expression in a rat model of vocal fold injury[5].

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Indications and Contraindications

Indications for office KTP laser treatment include RRP, leukoplakia, dysplasia, vascular lesions (ectasias and varicies), vocal fold polyps (hemorrhagic and non-hemorrhagic), laryngeal granulomas, Reinke's edema, and other miscellaneous benign lesions.

Office laser procedures should be avoided in patients with allergies to lidocaine or similar anesthetics. From a general health and comorbidity standpoint, there are few

contraindications to office laryngeal surgery, although patients with comorbidities may require special considerations. Yung and Courey studied hemodynamic changes in 31 patients undergoing office-based flexible endoscopic surgery, including vocal fold injection, transnasal esophagoscopy, KTP and CO_2 laser procedures, and flexible laryngoscopy with biopsy. Twenty-nine percent of patients experienced tachycardia and 23% of patients developed severe hypertension during the procedure. Older patients and patients with existing cardiovascular comorbidities did not have greater changes in blood pressure compared to younger patients and those without comorbidities, but their baseline blood pressures were higher, placing them at greater risk for severely elevated blood pressure during the procedure. The authors suggested that clinicians consider monitoring vital signs during office procedures in order to prevent potential cardiovascular complications[1]. Morrison *et al.* studied hemodynamic changes in 100 patients undergoing awake office-based flexible endoscopic procedures. They found that severe hypertension occurred in 21% of patients, and tachycardia in 40%. In patients over 50 years of age and those undergoing esophageal or laser procedures, there were statistically significant elevations in heart rate. Patients undergoing esophageal or laser procedures also had a statistically significant elevation in diastolic blood pressure. The authors suggested monitoring vital signs in patients over 50 years of age, as well as those who may be at risk for cardiovascular complications undergoing esophageal or laser procedures[2].

Recently, a pre-procedure screening protocol was developed and applied to patients undergoing office laryngeal procedures. If baseline vital signs were within the set parameters (heart rate < 100 beats per minute, systolic blood pressure < 160 mm Hg, diastolic blood pressure < 100 mg Hg), the procedure was performed in the office setting. Patients with elevations in heart rate and blood pressure on the screening exam were referred to the primary care physician for medical management of tachycardia and/or hypertension prior to the procedure. If vital signs were within parameters the day of procedure after medical management, it was performed in the office, and if not, it was rescheduled and performed in a monitored setting[3].

Significant discomfort or anxiety during the procedure may prevent completion. Patients with very poor tolerance of the initial laryngeal examination with a rhinolaryngoscope or rigid endoscope may be deemed poor candidates for in-office procedures, or may not wish to pursue them due to anticipated discomfort. Nasal patency is another consideration in planning in-office KTP laryngeal procedures. The outer diameter of the laryngoscope with working side channel is 4.9mm; therefore, the patient must have nasal passage with adequate patency to accommodate that diameter. In patients with significant anxiety, a low dose anxiolytic medication may be prescribed and self-administered by the patient approximately 30-60 minutes prior to the procedure.

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Treatment Method

Patients are positioned seated in the upright position for in-office KTP laser laryngeal procedures. Anesthesia is topical, beginning with decongestion and anesthesia of the nasal cavity. Topical oxymetazoline is used for decongestion, followed by a topical local anesthetic such as 2% tetracaine. Two percent lidocaine may also be used, but the amount must be considered when calculating the maximum dose of lidocaine for the patient. The laryngopharyngeal complex may then be anesthetized either via a transnasal or transoral approach. With the transnasal approach, 4% lidocaine is administered via the working channel of the laryngoscope. A total of 6 cubic centimeters (cc) is typically adequate for anesthesia for therapeutic procedures such as KTP laser treatment[1]. The patient is asked to phonate (hold a long *E*) during administration of lidocaine to the vocal folds to produce a "laryngeal gargle"[2]. If evaluation of treatment of lesions within the tracheobronchial tree is planned, the patient is asked to breathe while lidocaine is dripped through the vocal folds. A transoral approach as initially described by Hogikyan is possible as well[2]. A third option for topically anesthetizing the laryngopharyngeal complex is inhaled lidocaine via nebulization. When adequate anesthesia is achieved, most patients will experience the sensation that the throat is "swollen," and swallowing may feel effortful[3].

After topical anesthesia is administered, the procedure may commence immediately. Generally, no more than 60-90 seconds are needed after anesthetic administration is completed. The channeled laryngoscope is connected to suction, and a protective metal sheath is passed via the working channel. The KTP laser fiber is passed through the protective sheath. Prior to passing the sheath and KTP laser fiber through the tip of the endoscope, the laryngoscope is passed via the patient's most patent nasal passage, advanced to the hypopharynx, and positioned superior to the target lesion(s). The sheath is then passed beyond the tip of the endoscope, and the laser fiber is then advanced distal to the tip of the sheath. At this point, the surgeon verbally indicates that the laser should be activated. The laser is operated via a foot petal controlled by the surgeon.

Laser settings may vary by pathology and surgeon preference. The KTP laser has three settings that may be varied: the power (measured in watts), pulse width (measured in ms), and pulses per second (pps). There is variation in recommended laser settings in the literature. Mallur *et al.* proposed settings of 20 watts, 15 ms pulse width, and 2 pps for treatment of vascular lesions such as ectasias, varices, and vessels associated with vocal fold lesions. The authors recommended settings of 35 watts, 15 ms pulse width, and 2pps for nonvascular lesions such as leukoplakia, papilloma, or granulomas[4]. Zeitels *et al.* used a 15 ms pulse width and 5.25 joules (J) per pulse maximum output for in-office KTP laser procedures treating papillomatosis and keratosis with dysplasia[5]. Sheu *et al.* recommended settings of 6-8 watts and a pulse width between 15-25 ms for treatment of benign laryngeal lesions[6]. Sridharan *et al.* used settings of 15-20 watts with a pulse width of 20-30 ms with a mean of 88.3 J for 31 patients with vocal fold polyps[7]. As evidenced in the literature, settings can be varied depending on the targeted pathology and surgeon preference.

In general, the tip of the laser fiber is positioned 2-4 mm above the target lesion and fired until the lesion blanches[8], and in some cases the fiber may be placed in contact with the lesion. The exact technique and details of each procedure will vary. If tissue removal is desired, lesions or portions of lesions can be removed with contact by the laser fiber, or with suction via the endoscope.

Once treatment has been completed or the effects of the topical anesthetic subside, the procedure is concluded. The laser fiber and sheath should be drawn back into the working channel prior to removal of the endoscope. The patient is then given any post-procedure instructions and discharged.

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Management of Complications

Multiple studies of a variety of in-office procedures have demonstrated extremely low rates of complications. A clear advantage of in-office laryngeal procedures is that they avoid the risks of general anesthesia, as well as common risks and complications of suspension laryngoscopy such as injury to teeth, throat pain, tongue discomfort/paresthesia, and dysgeusia. In a review of 443 office-based laser procedures, Koufman *et al.* found a minor complication rate of 0.9% and no major complications[1]. A recent study of 145 in-office KTP laser laryngeal procedures found a minor complication rate of 4.8% (vasovagal episodes and patient intolerance) and no major complications[2].

Recognizing early signs of vasovagal reactions will allow the clinician to terminate the procedure and provide appropriate treatment to the patient to prevent syncope. Symptoms including nausea, sweating, lightheadedness, and paresthesias indicate impending syncope[1,3]. The procedure should be discontinued, and the patient placed in a reclined or supine position, or with the head between the legs. Vital signs should be monitored[4].

Local anesthetic toxicity is a potentially serious complication. The maximum dose of lidocaine is 3-5 mg/kg[4]. Lidocaine toxicity effects both the central nervous system (CNS) and cardiovascular system. Early symptoms of toxicity include lightheadedness and dizziness. progresses to generalized seizures, followed by coma and respiratory depression. If lidocaine toxicity is suspected, any administration of local anesthetic should be terminated, as should the procedure. The patient should be placed on supplemental oxygen and hemodynamic

monitoring should be initiated. The patient should then be transferred to a facility with anesthesia and intensive care support[5].

Allergic reaction to lidocaine is another potential complication, although this has not been reported with topical lidocaine administration during endoscopic procedures[4]. Methemoglobinemia is another potential complication of topical anesthetic use. Methemoglobinemia has been reported with lidocaine when used with benzocaine for bronchoscopy. Symptoms of methemoglobinemia include anxiety, headaches, fatigue, and coma; death may occur if untreated. Treatment is discontinuation of the causative medication and oxygen administration. Severe cases may be treated with methylene blue at a dose of 1-2 mg/kg administered intravenously[6].

Laser injury to the patient, surgeon, or other staff is another potential complication of in-office KTP laser procedures. The doors and windows of the room in which the laser is being used should be closed and/or covered with a barrier such as a screen or curtain. Signs should be displayed at any entrance to the room stating that the laser is in use. Laser goggles should be placed outside the door(s) as well, so that any personnel who may need to enter the room during the procedure will have access to appropriate eyewear[7]. All individuals present for the procedure should wear protective goggles or glasses that provide protection against the wavelength of the KTP laser (532 nm). The laser should be active only when it has been passed through the endoscope, positioned within the laryngopharynx, and the surgeon is immediately ready to use it for treatment. A theoretical complication of in-office KTP laser laryngeal procedures is laser fire. This complication has not been reported in the literature for in-office procedures, but is a well-documented complication of otolaryngologic surgery in the operating room[8].

Failure to complete the planned treatment, either due to patient intolerance or procedural difficulty (size and/or location of lesion, for example) requiring performance of the procedure in the operating room is another potential complication. Even with successful procedures, multiple treatments may be necessary, and patients should be counseled as such.

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