Evaluation of the Efficacy of 1940-nm Diode Laser in Tonsillectomy: Preliminary Report

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Background and Objectives

The aim of this clinical feasibility study was to assess preliminary results regarding postoperative outcomes of tonsillectomy using a laser system emitting at 1940 nm.

Materials and Methods

This clinical feasibility trial included six patients suffering from chronic tonsillitis. Tonsillectomy was performed using a 1940 nm laser with 6 W of output power. Intraoperative scoring was performed by a surgeon rating the cutting capacity of the device (5 point scale, 1-5), as well as intraoperative bleeding (3 point scale, 0-2). Patient surveys of pain and the surgeon's reports on postoperative changes in the surgical field (11 point scale, 0-10) were also analyzed on postoperative day one, and after week(s) one and two.

Results

No complications were observed in patients. The surgeon's mean rating on the cutting capacity of the laser was 4.33 ± 1.96 . Bleeding was almost absent, with a mean blood loss of 2.3 ml. Postoperative pain abruptly decreased after postoperative week one (4.83 ± 2.23 , 3.33 ± 2.65 , 1.17 ± 0.75 at postoperative day one, week one, and week two, respectively), with a statistically significant difference observed between postoperative day one and week two ($p=0.008$). Two patients required additional pain relief for five days after postoperative week one. Swelling had decreased significantly by postoperative week one ($p=0.004$), with a score of nearly 0 by postoperative week two. The mean scores for changes in scarring were 4.83 ± 0.40 , 2.83 ± 1.21 , and 1.67 ± 2.07 at postoperative day one, week one, and week two.

Conclusion

A 1940 nm laser demonstrated excellent intraoperative performances and postoperative outcomes in tonsillectomy. In addition, conduct of more large-scale and comparative studies is warranted in order to elucidate the efficacy of this laser treatment for tonsillectomy.

Key words

1940-nm; Laser; Tonsillectomy; Pain; Bleeding

INTRODUCTION

Tonsillectomy is one of the most frequently performed operations in the otolaryngology field, with postoperative pain and bleeding the most common complications for patients who undergo this procedure. Several approaches have been used to solve such problems. For instance, in terms of new surgical approaches, various novel techniques and instruments have been introduced: cold instruments, and monopolar and bipolar electrocautery are now widely used in tonsillectomies. Recently, ultrasonic instruments such as the Harmonic scalpel and Coblator have also been introduced.¹⁻³ Since, these ultrasonic instruments are operated at lower temperatures (60-100°C) than conventional bipolar electrocautery (150-400°C), it is thought that postoperative pain is likely reduced.⁴ However, the efficacy of ultrasonic devices for tonsillectomy is still debatable, although those devices have been reported to induce fewer complications if the expert surgeon uses such instruments with appropriate caution.⁵

Lasers have been widely used for intraoral soft tissue procedures and transoral endolaryngeal operations. They can be used to produce immediate and precise tissue destruction in a bloodless manner, forming an incision or ablation with minimal thermal damage to the surrounding, healthy tissue.⁶ Such properties allow lasers to be used with ease in the surgical treatment of vascular lesions, while rendering pharmacological therapy unnecessary for patients with coagulation problems. Moreover, the incisions are self-sterilizing and are formed with minimal tissue distortion while the sealing ability of the laser provides a bloodless dissection. Small blood vessels (up to 0.5 mm in diameter), lymphatic vessels, and nerve endings are sealed by the beam, which thus provides hemostasis, and contributes to a lack of intraoperative and postoperative pain. Herein, we aimed

to evaluate the efficacy of a specific type of laser, using a 1940 nm wavelength, in tonsillectomy and to report our preliminary results.

MATERIALS AND METHODS

Patients

From April to May 2015, this study prospectively enrolled six patients who underwent tonsillectomy, performed with a 1940 nm laser. All patients were diagnosed with chronic tonsillitis and followed up for two weeks after tonsillectomy. Patients under 20 years of age and with inadequate follow-up were excluded. This study was approved by the Institutional Review Board of Korea University Hospital (IRB No. MD15001).

Laser system

A laser system (Xlender-Y; Wontech, Daejeon, South Korea) emitting a wavelength of 1940 nm was used for the operation (Fig. 1). The output of a laser diode module is coupled into an optical fiber in order to deliver light to the location of the operation. The fiber-coupled diode module offers up to 12 W of output through a 600 μ m diameter optical fiber with a 0.22 numerical aperture. The output power and exposure time of the laser were accessed via a user interface to set parameters.

Procedure

The operation was performed by a single surgeon (SK Baek). Patients were placed in a supine position under general anesthesia, and a Dingman mouth gag was applied to open each patient's mouth. The mode of the laser was set to 6 watt of power, 1,000 Hz, and 70%. An incision was made into the anterior pillar of the tonsil (Fig. 2A, 2B), and the tonsil capsule identified (Fig. 2C). A plane between the tonsil capsule and adjacent muscle was dissected using the laser (Fig. 2D, 2E), with the level

Fig. 1. Laser system. The laser system (Xlender-Y; Wontech, Korea) emitting at a wavelength of 1940 nm.

Fig. 2. Operation. (A, B) Incision on the anterior pillar of tonsil, (C) Identification of the capsule of tonsil, (D, E) Dissection of the plane between the capsule of tonsil and adjacent muscle, (F) Surgical bed after finishing the operation.

of defocusing used based on the surgeon's experience. When mild bleeding occurred, the laser was set to a defocused mode to control this. However, in the case of moderate bleeding, when the laser could not effectively stop bleeding, bipolar electrocauterization was used for better control. After extracting the tonsils, the surgical bed was re-evaluated (Fig. 2F), and further control of bleeding was performed, if necessary.

Clinical parameters

The efficacy of the 1940 nm laser was evaluated by the surgeon's rating of the cutting capacity of the device, as well as of any intraoperative bleeding. A 5 point grading scale was used for cutting capacity, where 1 = insufficient, 2 = poor, 3 = moderate, 4 = good, and 5 = very good. For bleeding, a 3 point grading scale was used, where 0 = no bleeding, 1 = mild bleeding without requiring the additional application of a laser for bleeding control, and 2 = bleeding requiring additional procedures. The number of times electrocauterization was used for the control of bleeding during an operation was also analyzed. Postoperatively, by day one, week one, and week two, the surgeon's ratings of swelling, scar contraction, and bleeding were analyzed using a 10 point grading scale. In

the same period, patients' reports on pain using a 10 point scale, and any additional days requiring pain relief after postoperative week one, were also evaluated.

RESULTS

This study included three males and three females, with a median age of 26.2 years (20-45). The diagnosis for all patients was chronic tonsillitis, with throat pain and fever recurring greater than four times per year over a five-year period. The mean operation time was 22.8 ± 5.8 minutes. All patients were discharged on postoperative day one without any complications, and without any postoperative bleeding or re-admission during the postoperative two weeks after discharge.

Table 1 summarizes intraoperative findings for each patient. The mean score for the surgeon's rating of the cutting capacity of the laser was 4.33 ± 1.96 . Among the six patients, intraoperative bleeding was rated 0 in four patients and 1 in two patients. Bleeding was almost absent, with a mean 2.3 ml of blood lost. The number of patients using bipolar electrocauterization was less than two in four.

Postoperative pain abruptly decreased after one week

Table 1. Demographics and intraoperative findings

No.	Age	Sex	Operation time (min)	Cutting capacity*	Intraoperative bleeding [†]	Amount of bleeding (ml)	Number of bipolar electrocauterization
1	27	Female	15	4	0	0	0
2	24	Male	25	4	0	5	2
3	20	Male	25	5	1	2	4
4	45	Female	20	5	0	1	1
5	20	Female	20	5	0	1	1
6	21	Male	32	3	1	5	0

*1 = insufficient, 2 = poor, 3 = moderate, 4 = good, 5 = very good.

[†]0 = no bleeding, 1 = mild bleeding without requiring additional appliance of laser for bleeding control, 2 = bleeding requiring additional procedure.

Fig. 3. Postoperative change of pain (A), swelling (B), and scarring change (C).

(4.83 ± 2.23 , 3.33 ± 2.65 , 1.17 ± 0.75 at postoperative day one, week one, and week two, respectively), with a statistically significant difference observed between postoperative day one and week two ($p=0.008$; Fig. 3A). Two patients needed additional pain relief for five days after postoperative week one. Swelling significantly decreased by postoperative week one ($p=0.004$), with a score of nearly 0 by postoperative week two (Fig. 3B). The mean scores for changes in scarring were 4.83 ± 0.40 , 2.83 ± 1.21 , and 1.67 ± 2.07 by postoperative day one, week one, and week two, respectively (Fig. 3C).

DISCUSSION

This study demonstrates that tonsillectomy using a 1940 nm laser is feasible and shows excellent intraoperative performances and postoperative outcomes. The operating time using this technique was

short, with the laser showing an acceptable cutting capacity. Pain was abruptly reduced at the postoperative week one mark, with no postoperative bleeding apparent. Fig. 4 shows the postoperative healing process, with the tonsil fossa previously covered by exudative mucosa at postoperative week one, which then became completely healed by postoperative week two.

Clinically, the thulium laser was first introduced to urology for prostate resectioning,⁷⁻⁹ and is currently under study for laparoscopic partial nephrectomies.¹⁰⁻¹² It has also been used in the areas of ophthalmology,^{13,14} and neurology.¹⁵ These studies characterized the device as a precise cutting tool causing well-defined thermal damage to ensure hemostasis. In otorhinolaryngology, several studies have shown the efficacy of a 1940 nm laser in various procedures specific to this field.¹⁶⁻¹⁸ Guney et al. reported on the ablation efficacy of a 1940 nm laser in intraoral surgery.⁶ Considering that the output wavelength

Fig. 4. Pre- and postoperative photo. (A) Preoperative, (B) Postoperative 1 week, (C) Postoperative 2 weeks.

of a 1940 nm laser coincides with water's absorption peak, a flexible application is possible with a fiber-type laser; its clinical application could also be further widened, especially in the field of otorhinolaryngology with its evident anatomical complexities. Moreover, in regards to intraoral soft tissue operations, we believe that a 1940 nm laser is advantageous for the following reasons: 1) it is user-friendly, 2) has good cutting power, 3) induces relatively good coagulation, and 4) shows less collateral tissue damage.

Of the many different laser types that are currently used, CO₂ (10,600 nm), Er:YAG (erbium-doped yttrium aluminium garnet: 2940 nm), and Er, Cr:YSGG (erbium, chromium-doped: yttrium, scandium, gallium, and garnet; 2780 nm) lasers are of great interest due to their emission wavelengths being close to water absorption peaks.¹⁹ However, their wavelengths cannot be transmitted through silica fibers: CO₂ lasers utilize articulated arms or special hollow waveguides, whereas Er:YAG requires fluoride glass or sapphire fibers. In contrast, a laser with a 1940 nm emission wavelength that overlaps with one of the water absorption peaks and that can be transmitted through silica fibers is a promising tool for intraoral surgery. Ronald et al. reported that treatment of hyperplastic inferior turbinates using a 1940 nm fiber laser provided sufficient tissue reduction in a relatively short operation time and used a low total energy. Such characteristics of the 1940 nm laser highlights its excellent cutting ability, and holds great promise for intraoral surgery, including tonsillectomy.

The thermal damage zone, which is formed by the deep penetration of a 1940 nm laser into tissue, is expected to provide good hemostatic capabilities, allowing the laser to be used quickly and safely on well-perfused tissues such as tonsils.⁶ Considering postoperative bleeding is a major concern after tonsillectomy and that its prevalence

has ranged from 2.8% to 15.9% of patients,^{20,21} hemostatic potential is one of the most important factors in assessing the feasibility of surgical tools in this commonly performed procedure. Although patient numbers were small, our study demonstrated that patients did not show major postoperative bleeding.

Postoperative pain is another issue that tonsillectomy patients potentially face. A larger coagulation zone means more thermal damage to healthy tissue, which would make the application of this wavelength on delicate tissues unfeasible. However, the high absorption coefficient of a 1940 nm laser allows a shallow penetration depth, enabling precise ablation with less thermal damage.⁶ Our study showed pain decreased sharply after postoperative week one, which was comparable to other studies.²² Shallow ablations at low power may prove useful in operations in which only the outermost layers of tissue are affected, since this would minimize thermal damage to normal tissue and, presumably, also decrease postoperative pain.

Although our study had obvious limitations such as the number of patients being small, it is nevertheless valuable in that it is the first to evaluate the efficacy of a 1940 nm laser during tonsillectomy. We believe our results to be important and are a good basis for further comparable studies using larger cohorts. In conclusion, a 1940 nm laser, which shows excellent intraoperative performances and postoperative outcomes in tonsillectomy, requires further comparative studies to elucidate its efficacy in this common surgical procedure.

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