The Preliminary Assessment for the Feasibility of CO₂ Laser-assisted Phonomicrosurgery Using Computer-guided Scanner in Broad-based Vocal Polyps

Hwan Choe
Kwang-Yoon Jung
Jae-Gu Cho
Min Woo Park
Seung-Kuk Baek

Department of Otolaryngology-Head and Neck Surgery, Korea University College of Medicine, Seoul, Korea

Background and Objectives

The aim of the present study is to evaluate the efficacy and usefulness of CO₂ laser-assisted phonomicrosurgery using a computer-guided scanner (CGS) for treating broad-based vocal polyps.

Materials and Methods

Fourteen patients who underwent phonomicrosurgery for vocal polyp with broad base were enrolled for the study. The voice status of all the patients was evaluated by acoustic analysis, aerodynamic analysis, and voice handicap index before and after the operation, and the results were compared.

Results

All the voice analysis parameters were found to be normalized and improved after the operation compared with the preoperative status. In addition, all voice handicap index parameters improved after the operation.

Conclusion

The CO₂ laser-assisted phonomicrosurgery using CGS makes it possible for surgeons to perform more accurate and delicate incision with a controllable depth of beam penetration.

Key words

Phonomicrosurgery; Computer-guided scanner; CO₂ laser

Received June 3, 2013
Revised June 11, 2013
Accepted June 11, 2013

Correspondence

Seung-Kuk Baek
Department of Otolaryngology-Head and Neck Surgery, Korea University College of Medicine, 126-1, Anam-dong 5-ga, Seongbuk-gu, Seoul 136-705, Korea
Tel: +82-2-920-5486
Fax: +82-2-925-5233
E-mail: mdskbaek@gmail.com

© Korean Society for Laser Medicine and Surgery

© This is an open access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

CO₂ laser emits electromagnetic energy at a wavelength of 10.6 μm with a high coefficient of absorption for water. Since the CO₂ laser was introduced to medical community, it quickly gained popularity among otolaryngologists. Although the early CO₂ laser had some problems such as the potential for vocal fold scarring,¹ the development of micromanipulator for the CO₂ laser has made it possible to create much smaller beam diameter and little collateral thermal tissue interaction.^{2,3} In addition, a new Computer-guided scanner (CGS) recently applied to the CO₂ laser micromanipulator allows the beam to sweep a given surface with extreme rapidity. Such a rapid beam sweep makes controllable-penetrating depth of the CO₂ laser possible.⁴

Vocal polyps with broad base tend to cause much bleeding during operation because of their high vascularity, which makes it difficult to grasp them with microforceps. Furthermore, since the resected epithelium may be wider in vocal polyps with broad base, it may be especially more important to minimize the resection extent. Therefore, CO₂ laser using CGS, which can achieve hemostasis unattainable with cold instrumentations and makes controllable-penetrating depth, may be useful in broad-based vocal polyps.

The purpose of the present study is to evaluate the efficacy and usefulness of CO₂ laser-assisted phonemicsurgery using CGS in broad-based vocal polyps.

MATERIALS AND METHODS

Patients

Investigations were carried out in 76 patients who underwent phonemicsurgery for vocal polyps at the Department of Otolaryngology-Head and Neck Surgery, Anam Hospital, Korea University, Seoul, Korea, between June 2010 and June 2011. Patient selection was based on the medical records. Among these patients, 62 patients were excluded due to insufficient medical records, vocal polyps without broad base, using the other instruments, such as knife or microscissors. Thus, a total of 14 patients were included in the present study and all subjects were given informed consent. The institutional review board of our institution approved the protocol of our study.

Surgery and vocal rehabilitation

The timing of surgery was individualized according to the patient's preference, lesion characteristics, and concomitant problems, such as poor vocal hygiene. All of the patients received behavioral intervention for vocal hygiene before the surgical treatment.

All of the surgical procedures were performed under general anesthesia by the same surgeon. The operation was aimed at maximally preserving the vocal fold's layered microstructure, including the lamina propria and epithelium. CO₂ laser with CGS (Acublade™ system) was used for the incision and dissection processes. The laser settings used were 2-mm beam length, 200- μm penetration, and the superpulsed wave in repeated pulse mode. Curved incision was performed to avoid injuring

Fig. 1. The operating findings of CO₂ laser-assisted phonemicsurgery using computer-guided scanner for broad-based vocal polyp. (A) The curved shape of laser beam is used to resect vocal polyp. (B) During resecting vocal polyp, the deep margin of resection can be easily identified due to bloodless dissection and the injury of vocal cord lamina propria can be minimized by controlling the penetrating depth of laser beam.

the vocal ligament while maintaining the free edge of the vocal fold taut with micro-forceps (Fig. 1). After surgery, absolute voice rest was recommended for the first 7 days. For 2 to 3 weeks after surgery, the patients were instructed to increase their daily phonation time gradually.

Voice analysis

The subjects were recorded two times: before surgery and 2 months after the operation. The following variables were measured: acoustic analysis (fundamental frequency, jitter, shimmer, noise-to-harmonic ratio), aerodynamic analysis (mean flow rate, maximal phonation time, subglottic pressure), and voice handicap index (VHI). Acoustic variables were measured using the Multi-Dimensional Voice Program (MDVP) from the Computerized Speech Lab (CSL), Model 4500 (KayPENTAX, Lincoln Park, New Jersey) for a few seconds of the sustained phonation of /a/. The subjective estimation of voice quality was performed using the GRBAS scale designed by Hirano and De Bodt et al.⁵ The scale was administered by an experienced phonetician who had no information about the study design. The VHI consists of 30 questions divided by content into 3 categories: functional, physical, and emotional parameters. All of the patients completed the VHI questionnaires using a 5-point rating scale to indicate their response. The scale is ordinal and is scored from 0 (Never) to 4 (Always) for each of the questions, with a minimum score of 0 and a maximum score of 120. Higher scores indicate a more severe perception of disability because of the voice problem.

Voice therapy

All of the patients in the study group underwent two voice therapy sessions (approximately 30 minutes per session) in the fourth week after laryngeal microsurgery. Voice therapy included the general approach toward managing vocal hygiene, including voice rest, adequate hydration, the reduction/elimination of laryngeal irritants, the reduction of vocal abuse and hard glottal attacks, the reduction of vocal loudness and speech rate, and the elimination of

chronic throat clearing and coughing. Resonance voice exercises, such as humming and relaxation exercises that aimed to release musculoskeletal tension in the shoulder and neck, were also taught.

Statistics

Paired t tests were used to compare the voice outcomes and questionnaire scores before and after surgery. For all tests, a probability of < 0.05 was accepted as statistically significant. All of the statistical analyses were performed using SPSS software version 12.0 (SPSS Inc., Chicago, IL).

RESULTS

Demographics

The mean age was 51.0 years. Patients' various occupational fields were divided into two groups: occupation-related voice overuse group, such as teachers, counselors, and salespersons, and no overuse group (Table 1).

Objective effectiveness of CO₂ laser-assisted phonomicrosurgery using CGS

Among objective voice analysis including aerodynamic and acoustic analysis, even if only maximal phonation time (MPT) was significantly different between preoperative and postoperative parameters, all abnormal preoperative parameters were normalized and improved at postoperative status (Table 2).

Voice handicap index after CO₂ laser-assisted phonomicrosurgery using CGS

All voice handicap index parameters were decreased and functional parameter was especially different

Table 1. Demographics of enrolled patients

Sex (No. of cases (%))	
Female	6 (42.9)
Male	8 (57.1)
Age (mean±SD)	51.0 ± 13.9
Occupation related voice overuse	
Yes	9 (64.3)
No	5 (35.7)

Table 2. Effect of treatment on voice analysis in the patients underwent CO₂ laser-assisted phonomicrosurgery using computer-guided scanner

	Preoperative	Postoperative	p-value
Aerodynamic analysis			
MFR	233.6 ± 110.5	165.5 ± 81.8	0.79
MPT	12.0 ± 5.1	16.0 ± 6.9	0.04
Psub	14.0 ± 6.9	10.3 ± 5.0	0.11
Efficiency	119.2 ± 89.3	214.1 ± 164.7	0.04
Acoustic analysis			
Fundamental frequency	140.0 ± 27.8	159.4 ± 34.5	0.11
Jitter	4.1 ± 6.8	1.4 ± 1.0	0.19
Shimmer	5.7 ± 4.7	3.4 ± 1.7	0.09
NHR	0.2 ± 0.1	0.1 ± 0.0	0.31

MFR, mean flow rate; MPT, maximal phonation time; Psub, subglottic pressure; NHR, noise harmony ratio.

Table 3. Effect of treatment on voice handicap index in the patients underwent CO₂ laser-assisted phonomicrosurgery using computer-guided scanner

	Preoperative	Postoperative	p-value
Functional	6.6 ± 6.4	4.8 ± 5.9	0.04
Physical	18.0 ± 9.6	10.6 ± 11.6	0.08
Emotional	7.6 ± 8.3	6.5 ± 11.0	0.58
Total	32.6 ± 17.2	27.3 ± 23.1	0.16

between preoperative and postoperative parameters. These results mean the patients' symptoms were improved after phonomicrosurgery (Table 3).

DISCUSSION

Among benign vocal fold mucosal disorders, broad-based vocal polyps may make larger loss of epithelial surface of vocal cord than the others, including small vocal nodules or polyps. Thus, it is very important to reduce the resected epithelium and lamina propria, for which bloodless surgical resection may be essential. Especially, since broad-based vocal polyps tend to cause more bleeding during phonomicrosurgery using cold instruments, CO₂ laser may be effective in this case.

The CO₂ laser as one of the gas lasers has a high coefficient of absorption for water. The advantage of CO₂ laser is that it induces little collateral thermal damage to surrounding tissue. Furthermore, the thermal penetration of the CO₂ laser ranges in microns, whereas that of the other lasers ranges in millimeters.^{2,6} In addition, better hemostatic effect and decreased risk of postoperative bleeding are also potential benefits.⁷

The micromanipulator, connecting the operating microscope and the laser arm, yields the beam diameter with a very small size of 250 µm for a focal length of 400 nm. Thus, it makes possible the more accurate incision and dissection of tissue.⁸⁻¹⁰ However, single pulse dissection using the Acuspot micromanipulator does not attain an incision as regular as that achieved with micro-scissors and is impossible to control the depth of dissection due to the characteristics of CO₂ laser such as rectilinear propagation.

CGS with rotating mirrors allows the laser beam to sweep a given surface with extreme rapidity.^{11,12} This laser beam sweeping, with which a few microns of in-depth thermal penetration is achieved during each beam sweep, makes the controllable depth of dissection possible. Additionally, it makes it possible for the scanner-assisted beam to travel across the target as a straight or curved

incision line.

Therefore, vocal polyps with broad base, where mucosal preservation, accurate resection, and bloodless dissection are very important, may be a good indication of CO₂ laser using CGS system.

In the present study, we evaluated the usefulness of the CO₂ laser with CGS in vocal polyps with broad base. Although the study has a limitation due to small sample size and simple examination, the CO₂ laser assisted phonomicrosurgery using CGS provided an accurate incision controlling the thermal penetration depth, while achieving hemostasis unattainable with cold instrumentations. Additionally, the postoperative voice outcome of all patients was improved without any complications.

In conclusion, the CGS is the most effective and useful tool for the CO₂ laser-assisted phonomicrosurgery. It helps achieve more accurate and delicate incision with the controllable depth of beam penetration. Additionally, since the beam shape is adjustable, lineal and curved incision and round ablation are possible.

REFERENCES

1. Benninger MS. Laser surgery for nodules and other benign laryngeal lesions. *Curr Opin Otolaryngol Head Neck Surg* 2009;17:440-4.
2. Remacle M, Lawson G, Watelet JB. Carbon dioxide laser microsurgery of benign vocal fold lesions: indications, techniques, and results in 251 patients. *Ann Otol Rhinol Laryngol* 1999;108:156-64.
3. Remacle M, Lawson G, Degols JC, Evrard I, Jamart J. Microsurgery of sulcus vergeture with carbon dioxide laser and injectable collagen. *Ann Otol Rhinol Laryngol* 2000;109:141-8.
4. Remacle M, Hassan F, Cohen D, Lawson G, Delos M. New computer-guided scanner for improving CO₂ laser-assisted microincision. *Eur Arch Otorhinolaryngol* 2005;262:113-9.
5. De Bodt MS, Wuyts FL, Van de Heyning PH, Croux C. Test-retest study of the GRBAS scale: influence of experience and professional background on perceptual rating of voice quality. *J Voice* 1997;11:74-80.
6. Reinisch L. Laser physics and tissue interactions. *Otolaryngol Clin North Am* 1996;29:893-914.
7. Reinisch L, Ossoff RH. Laser applications in otolaryngology. *Otolaryngol Clin North Am* 1996;29:891-2.
8. Keilmann A, Biermann G, Hörmann K. CO₂ laser versus conventional microlaryngoscopy in benign changes of the vocal cords. *Laryngorhinootologie* 1997;76:484-9.
9. Remacle M, Lawson G, Watelet JB. Carbon dioxide laser microsurgery of benign vocal fold lesions: indications,

- techniques, and results in 251 patients. *Ann Otol Rhinol Laryngol* 1999;108:156-64.
10. Remacle M, Lawson G, Degols JC, Evrard I, Jamart J. Microsurgery of sulcus vergeture with carbon dioxide laser and injectable collagen. *Ann Otol Rhinol Laryngol* 2000;109:141-8.
 11. Ossoff RH, Werkhaven JA, Raif J, Abraham M. Advanced microspot microslad for the CO₂ laser. *Otolaryngol Head Neck Surg* 1991;105:411-4.
 12. Papadakis CE, Skoulakis CE, Nikolidakis AA, Velegrakis GA, Bizakis JG, Helidonis ES. Swiftlase inferior turbino-plasty. *Am J Rhinol* 1999;13:479-82.