A Combined Carbon Dioxide/Erbium Laser for Soft and Hard Tissue Procedures

By Robert A. Convissar, DDS, FAGD, MALD; Ellen E. Goldstein, DDS

Robert A. Convissar, DDS, FAGD, MALD

Since the introduction of lasers to dentistry over a decade ago, dentists have been waiting for a single laser unit that can perform both soft and hard tissue surgeries. The ideal laser should have the clinically proven precision, accuracy, and hemostatic ability of a carbon dioxide (CO_2) unit combined with an erbium unit powerful enough for cavity preparations, yet gentle enough so that the use of anesthesia is unnecessary. The erbium unit should cut enamel and dentin as fast as a conventional high-speed handpiece. The delivery system should be reliable enough for constant daily use and be easily replaceable. This delivery system should not have to rely on expensive fiber optic cables that need to be replaced every few months at a cost of $1,500 per cable.

This article discusses the clinical uses, benefits, and advantages of a combined CO_2/erbium dental laser that is now available. The use of this unique laser is discussed in the following disciplines: periodontal therapy (including nonmembrane laser-guided tissue regeneration, soft tissue management, and surgical procedures); fixed, removable, and implant prosthetics; pediatric, adolescent, and operative dentistry; cosmetic dentistry; and oral surgery/oral medicine/oral pathology.

This article discusses the clinical uses, benefits, and advantages of a combined CO_2/erbium dental laser that is now available.

Figure 1. Preoperative photograph of drug-induced gingival hyperplasia in a 27-year-old white female.

Figure 2. Maxillary gingiva immediately after CO_2 ablation of the gingival hyperplasia.

Figure 3. One-week postoperative view of maxillary surgical site, and preoperative view of mandibular gingival hyperplasia.

Figure 4. Maxillary surgical site 2 weeks postoperatively, mandibular site 1 week postoperatively.

Figure 5. Flap raised at tooth No. 15 showing granulomatous tissue in the furcation.

Figure 6. Furcation immediately after CO_2 ablation of granulomatous material. Note the clear, dry furcation area, free of tissue tags and debris.

LASER-GUIDED TISSUE REGENERATION/OSTEOGENESIS

We all were taught in dental school that once bone is lost due to periodontal disease, it can never regenerate. Bone grafts may be used in certain sites to fill some osseous defects, but osseous regeneration has been an elusive goal. This is no longer true. The CO_2 laser is the only laser that has been proven histologically in animal studies and clinically in human studies to cause osteogenesis and cementogenesis. The CO_2 laser can grow bone and cementum. The literature is quite clear on this point. When laser de-epithelialization

Figure 7. Placement of a 250- micron laser tip in the gingival sulcus of a crown preparation during laser gingival troughing.

Figure 8. Buccal view of tooth No. 4.

Figure 9. One-week postoperative view of crown recemented after CO_2 laser surgery. Note excellent healing and no marginal shrinkage of tissues.

Figure 10. Preoperative view of maxillary epulis.

Figure 11. Immediate postoperative view of surgical site.

Figure 12. Gingival tissues grown into threads of implant body.

was performed without osseous grafts, laser-treated sites showed 1.7 mm of bone fill versus control (nonlaser treated) surgical sites, which showed zero bone fill.[1] When laser de-epithelialization was performed with osseous grafts, 3.38 mm of attachment was gained.[2] Furcations were filled in with a mean of 2.43 mm of increased attachment.[2] The CO_2 laser-guided tissue regeneration procedure does not rely on membranes for increased new attachment. The technique is simple and very effective. The exact protocol for laser de-epithelialization is beyond the scope of this article. The reader is asked to review the two references cited above, along with other studies[3-6] cited at the end of this article.

PERIODONTAL SURGERY AND SOFT TISSUE MANAGEMENT

It is an accepted tenet of dentistry that periodontitis is a bacterial infection of the periodontal tissues. The purpose of periodontal therapy is removal of the periodontal pathogenic bacteria and their exotoxins (hyaluronidases, collagenases, etc) that are responsible for both soft and hard tissue breakdown. The CO_2 laser has been shown to be an excellent instrument for bactericidal treatment of the periodontal pocket. The bactericidal ability of the CO_2 laser and its effectiveness in decreasing inflammation during periodontal therapy have been evaluated.[7,8] Zakariasen et al[9] obtained a 99.9% reduction in the viable count of *Streptococcus mutans* after a 1-second exposure of a suspension of the bacteria to CO_2 laser light. In their discussion of the use of CO_2 lasers, Pecaro and Garehime[10] state that two of the advantages of using CO_2 lasers over scalpels for oral surgical procedures are instant sterilization of the surgical site and reduced bacteremia. Wigdor et al[11] suggest that the differences between scalpel and CO_2 incisions on a microscopic level lead to the clinically observable result of less scar formation when a CO_2 laser is used for surgery.

Most practitioners would agree that the most difficult part of periodontal flap surgery is the debridement of granulomatous, diseased tissue once the flap is raised. Most clinicians have very little trouble raising and then suturing down a flap. The difficult and, ultimately, most important part of the periodontal flap procedure is the removal of the diseased tissue. Carbon dioxide lasers have been shown to be excellent surgical instruments for both flap surgery and gingivectomy. The CO_2 wavelength has the ability to cut, coagulate, and cauterize tissue in one step. The literature has numerous citations discussing the advantages of CO_2 lasers in surgical procedures.[12-15] Wigdor[11] lists the following as advantages of CO_2 lasers over scalpel blades: reduced mechanical trauma, minimal postoperative swelling and scarring, minimal postoperative pain, and dry and bloodless surgery.

Lasers are excellent instruments for soft tissue management programs. The CO_2 wavelength has been shown to destroy the bacteria in calculus and plaque.[7,16] When CO_2 lasers were placed in periodontal pockets, and then were followed by conventional scalers and curettes, a smooth surface was left, which delayed the reformation of adherent plaque.[8]

Case 1 illustrates a 27-year-old white female with a history of a kidney transplant. Medications taken by the patient included cyclosporine to prevent transplant rejection and calcium channel blockers to control blood pressure. Both drugs are known to cause gingival hyperplasia. Treatment plans were discussed, including conventional (scalpel) surgery and laser surgery. Since the patient had undergone numerous painful gingival scalpel procedures to treat the hyperplasia, she opted for laser ablation of the hyperplasia.

Two carpules of mepivicaine were infiltrated throughout her maxillary gingiva. A CO_2 laser at 4 watts of continuous power was utilized 1 mm from the tissue to ablate the tissue. Following ablation, the patient was given routine postoperative instructions and reappointed for the following week. At the following appointment, the same procedure was carried out on the patient's mandibular gingiva. No postoperative antibiotics or analgesics were prescribed. Periodontal dressings and sutures were unnecessary. Figure 1 shows the patient's gingival hyperplasia upon initial presentation. Figure 2 shows the maxillary gingiva immediately postoperatively. Figure 3 shows the 1-week postoperative results of CO_2 laser ablation of the maxillary gingival hyperplasia, and the mandibular tissue preoperatively. Figure 4 shows the maxillary surgical site 2 weeks postoperatively and the mandibular surgical site 1 week postoperatively.

The patient was ecstatic about the surgical results and related that there was no postoperative pain after either surgical procedure. It is worth noting that this case was not performed by an experienced periodontist; rather, the beautiful results achieved in this case were accomplished by first-year dental residents just 3 months after their graduation from dental school. This is important to note, as this shows that when properly trained in laser technique, general practitioners can perform laser periodontal surgical procedures quickly, efficiently, and easily, with beautiful results.

Case 2 illustrates a 52-year-old white male with 7-mm periodontal pocke

continued on page 6

A Combined Carbon Dioxide/Erbium Laser
continued from page 67

and class II furcation involvement on the buccal surface of tooth No. 15. One carpule of lidocaine with epinephrine 1:100,000 was infiltrated throughout the surgical site. A No. 15 blade was utilized to raise a flap over the affected tooth. Figure 5 shows the granulomatous tissue in the furcation. This tissue was firmly adherent to the root and difficult to remove with conventional instruments. Figure 6 shows the immediate postoperative results of laser surgery. The furcation was totally cleared of all granulomatous tissue, and the surgical site "sterilized" by the bactericidal action of the laser (discussed above). The flap was then sutured in place. The patient was given routine postoperative instructions and reappointed for suture removal 1 week later.

FIXED, REMOVABLE, AND IMPLANT PROSTHETICS

Carbon dioxide lasers have been successfully utilized in all phases of prosthetic rehabilitation for over a decade. The literature reports laser use for enhancement of fixed prosthetic results. Carbon dioxide lasers have been used for gingivoplasty, resculpting and formation of ovate pontic sites, and for troughing in place of retraction cord.[17] Figure 7 illustrates the correct placement of a 250-micron CO_2 laser tip in a sulcus as it performs a troughing procedure. Unlike electrosurgical procedures, which may create unwanted shrinkage of tissue after troughing, the laser does not cause postoperative exposure of finishing lines. Indeed, laser tissues have the ability to "bounce back" slightly after troughing. At low power settings, lasers work by dehydrating tissue. When laser troughing is performed, the crevicular fluid is removed via dehydration, leaving a clean dry sulcus. The laser then gently dehydrates a thin portion of the inner epithelial lining of the pocket, creating sufficient space for injection of the impression material into the sulcus. Once the tissues rehydrate, the sulcular tissues "bounce back" to a natural form.

Shrinkage is not an issue when lasers are used for troughing. Should more tissue need to be removed to expose a deep, subgingival margin, or some of the inner epithelial lining needs to be removed to create more room in the sulcus for impression material, the laser power can be adjusted accordingly to perform such a procedure. Case 3 illustrates this point. A 48-year-old black female presented to the office with a porcelain-fused-to-metal crown and prefabricated post in her hand. The crown and post had just fallen out. Clinical and radiographic exam revealed an endodontically treated tooth with a very shallow post preparation and macerated tissue around the gingival margins of the crown (Figure 8). The patient related that she was to be a bridesmaid in a wedding the next day, and needed the crown recemented temporarily.

One carpule of lidocaine with epinephrine 1:100,000 was infiltrated around the gingival tissue. A gingivoplasty was performed around the margins to clear away the diseased tissue. A new prefabricated post was placed in the tooth, and the crown temporarily recemented. Figure 9 shows the 1-week postoperative view of the surgical site. Note the excellent healing and lack of shrinkage of the marginal tissue.

Carbon dioxide lasers have been successfully used in removable prosthetics and preprosthetic care. Lasers have been used for the following removable prosthetic/preprosthetic procedures: soft tissue tuberosity reduction, assistance in torus removal, epulis removal, denture stomatitis, and aberrant frenum removal on residual ridges.[17-19]

Case 4 illustrates a 65-year-old white female who presented to the dental clinic complaining of a growth on her maxillary anterior gingiva that interfered with placement of her denture. Figure 10 shows the maxillary epulis preoperatively. One carpule of lidocaine with epinephrine 1:100,000 was infiltrated around the epulis. A CO_2 laser was set to 4 watts of continuous power. The laser was placed 1 mm from the epulis, and the epulis was ablated. Figure 11 shows the surgical site immediately postoperatively. The patient was immediately able to place the denture in her mouth with no discomfort.

Implant recovery is a routine procedure with the CO_2 laser. The CO_2 wavelength is not absorbed by titanium, so there is no possibility of implant de-integration when using CO_2 lasers for recovery of implants. Rice[17] and Bader[8] have outlined implant recovery procedures using lasers. Lasers show their versatility in implant prosthetics when patients develop problems.

Case 5 illustrates a 47-year-old black male who had implant reconstruction. The patient presented to the dental clinic with a missing healing cap. Clinical examination revealed gingival tissue overgrown into the implant body, covering the threads (Figure 12). Removal of this tissue with a scalpel blade presents two problems. One is bleeding at the surgical site. Due to the thin, friable nature of the tissue, this tissue would bleed easily. This would decrease visibility at the surgical site, and make total removal of the tissue more challenging. This would lead to the second problem with the use of a blade in this circumstance, which is scratching of the threads by the blade.

One carpule of carbocaine was infiltrated around the implant. A CO_2 laser was set at 2 watts of continuous power. The laser was brought to within 1 mm of the implant and the tissue was ablated with laser energy. Total exposure

continued on page 7


Figure 13. Immediate postoperative view of laser ablation of tissue from the implant body.


Figure 14. Preoperative view of lower anterior teeth.


Figure 15. Seventy-two hour postoperative view of lower anterior surgical site with laminate veneers in place.


Figure 16. Preoperative view of mucocele on the lip of a 28-year-old white female.


Figure 17. Surgical site after laser removal of the mucocele.


Figure 18. Ten-day postoperative view of surgical site. Note complete absence of scar or contracture of tissue.

A Combined Carbon Dioxide/Erbium Laser
continued from page 68

time was less than 10 seconds. Figure 13 shows the immediate postoperative result. A healing cap was then placed over the implant, and the patient was reappointed for prosthetic reconstruction.

COSMETICS

Cosmetic dentistry provides many opportunities for laser use. Lasers can be used for "smile-lift" procedures, gingivectomy/crown lengthening procedures, and frenectomy in conjunction with laminate placement to close diastemas.[20] Case 6 illustrates a 32-year-old Hispanic female with malposed lower anterior teeth (Figure 14). Treatment options were discussed, including orthodontics and laminate placement with cosmetic gingival recontouring. The patient opted for laminate and gingival treatment.

At the treatment visit, the lower anterior region was infiltrated with one carpule of lidocaine with epinephrine 1:100,000. Teeth Nos. 24 and 25 were prepared for porcelain laminate veneers. Once preparation was completed, a CO_2 laser was utilized with 7 watts of pulsed power to gently recontour the gingiva around the lower anterior incisors to create an ideal gingivo-incisal length for the teeth. Immediately after laser recontouring, a final impression was made for the fabrication of porcelain laminates. Figure 15 shows the completed case 72 hours after gingival surgery.

ORAL SURGERY/ORAL MEDICINE/ORAL PATHOLOGY

There are an almost endless number of uses for CO_2 lasers in the field of oral medicine/oral surgery/oral pathology. Catone and Alling[21] have written a complete textbook on the subject. Sulewski[22] compiled a list of uses, which includes everything from aphthous ulcer treatment to mucoceles to adenomas. This author has outlined a safe and effective use of lasers for treatment of the oral manifestations of AIDS.[23] Just about any incisional/excisional procedure that can be performed with a scalpel blade can be performed with a laser.

Case 7 illustrates a 28-year-old white female who presented to the office complaining of a swelling of her lip. The patient related that she bit her lip 3 days previously, and that the lip swelled almost immediately. The swelling increased during eating and decreased only slightly after meals. Figure 16 shows the mucocele preoperatively. One carpule of lidocaine with epinephrine 1:100,000 was infiltrated around the lesion. A CO_2 laser set to 6 watts of pulsed power was brought to within 1 mm of the lesion. A circumferential cut was made around the lesion with the laser. The lesion was then punctured, drained, and curetted (Figure 17). The patient was given routine postoperative instructions, reappointed for a 10-day follow-up visit, and dismissed. Figure 18 shows the patient 10 days postoperatively. There was no sign of the lesion or any surgical scar.

PEDIATRIC, ADOLESCENT, AND OPERATIVE DENTISTRY

As with the other disciplines of dentistry, soft tissue lasers play an important role in pediatric and adolescent dentistry. Parkins[24] has discussed the use of soft tissue lasers for exposure of teeth to aid eruption and facilitate orthodontic movement. This author has reviewed the use of lasers to treat orthodontically induced gingival hyperplasia.[25] Elliot et al[24] have discussed the use of CO_2 lasers in pulpotomy in the place of formocresol. These are all excellent uses of soft tissue lasers; however, the most important development in laser dentistry is the use of erbium lasers for operative dentistry.

Gimbel[27] has written an excellent paper on the basics of erbium laser/tooth interaction. Erbium lasers have been approved for hard tissue use since 1997. The largest drawback in the development of an erbium laser to compete with a high-speed turbine handpiece has been the delivery system. Unlike other wavelengths, erbium lasers cannot be transmitted through a quartz-silica fiber. Diode and Nd.YAG (soft tissue) laser wavelengths can be transmitted through such a fiber. These fibers last for many months, and can be replaced for $150.

The erbium wavelength is transmitted through a different type of fiber. These fibers last only a few months, and may be replaced at almost 10 times the cost of a regular fiber, or almost $1,500. The combined erbium/CO_2 unit has solved this problem by avoiding the use of a fiber altogether in its delivery system. The delivery system relies on a "waveguide," a hollow tube that transmits the laser energy down its length to the handpiece. This patented waveguide technology has proven itself in over 20,000 laser units in otolaryngology, gynecology, dermatology, plastic surgery, oral and maxillofacial surgery, and veterinary medicine. This unique waveguide technology, combined with a more powerful erbium laser energy output, allows for rapid operative dentistry procedures with no need for anesthesia. Quadrant dentistry can be performed quickly and painlessly.

Case 8 illustrates a 15-year-old white male with occlusal caries on tooth No. 14. An erbium laser was utilized 1 mm from the occlusal surface of the tooth to ablate the decay (Figure 19). The preparation was then filled with a posterior composite. Occlusion in centric and all excursions was checked, the restoration was finished and polished (Figure 20), and the patient was dismissed. No anesthesia was needed for this treatment.

Figure 19. Occlusal preparation performed with an erbium laser. No anesthesia was given for this procedure.

Figure 20. Completed restoration.

CONCLUSION

Laser dentistry is unquesnably the wave of the ture. The new CO_2/erbium ser combines the best two avelengths for both soft and rd tissue laser procedures. oth general practitioners d specialists would do well investigate the myriad es of this new instrument.✦

ferences

Centty I, Blank L, Levy B, et al. Carbon dioxide laser for de-epithelialization of periodontal flaps. *J Periodontol.* 1997;68:763.

Rossmann J, Israel M. Laser de-epithelialization for enhanced guided tissue regeneration: a paradigm shift? *Dentl Clin N Amer.* 2000;44(4):793-810.

Rossman J, Mcquade M, Turunen D. Retardation of epithelial migration in monkeys using a carbon dioxide laser. *J Periodontol.* 1992;63:902.

Rossmann J, Parlar A, Ghaffar K, et al. Use of the carbon dioxide laser in guided tissue regeneration wound healing in the beagle dog. *Proc SPIE.* 1996;2672:52.

Israel M, Rossmann J. An epithelial exclusion technique using the CO_2 laser for the treatment of periodontal defects. *Compend Contin Educ Dent.* 1998;19:86-88,90,92-95.

Israel M, Rossmann J, Froum S. Use of the carbon dioxide laser in retarding epithelial migration: a pilot histological human study utilizing case reports. *J Periodontol.* 1995;66:197.

Coffelt DW, Cobb CM, MacNeill S, et al. Determination of energy density threshold for laser ablation of bacteria: an in-vitro study. *J Clin Periodontol.* 1997;24:1-7.

Bader H. Use of lasers in periodontics. *Dent Clin N Amer.* 2000;44(4):779-792.

Zakariasen K, Dederich D, Tulip J et al. Bactericidal action of carbon dioxide laser radiation in experimental dental root canals. *Can J Microbiol.* 1986;32:942-946.

Pecaro B, Garehime W. The CO_2 laser in oral and maxillofacial surgery. *J Oral Maxillofac Surg.* 1983;41:725.

Wigdor H, Walsh J, Featherstone JDB, et al. Lasers in dentistry. *Lasers Surg Med.* 1995;16:103-133.

Walsh LJ. Utilization of a carbon dioxide laser for periodontal surgery: a three year longitudinal study. *Periodontology.* 1995;16:3-7.

Pick R, Colvard M. Current status of lasers in soft tissue dental surgery. *J Periodontol.* 1993;64:589-602.

Israel M. Use of the CO_2 laser in soft tissue and periodontal surgery. *Pract Periodont Aesthet Denti* 1994;6:57-64.

15. Pick RM. Lasers in dental surgery. *J California Dent Assoc.* 1993;124:37-47.
16. Gopin BW, Cobb CM, Rapley JW, et al. Histological evaluation of soft tissue attachment to CO_2 laser-treated root surfaces: an in-vitro study. *Int J Periodontol Restor Dent.* 1997;17:316-325.
17. Rice JH. Laser use in fixed, removable, and implant dentistry. *Dent Clin N Amer.* 2000;44(4):767-778.
18. Pogrel MA. The carbon dioxide laser in soft tissue preprosthetic surgery. *J Prosthet Dent.* 1989;61:203-207.
19. Convissar R, Gharemani E. Laser use as an adjunct to removable prosthetic care. *Gen Dent.* 1995;42(4):336-341.
20. Sun G. The role of lasers in cosmetic dentistry. *Dent Clin N Amer.* 2000;44(4):831-850.
21. Catone G, Alling C. *Laser Applications in Oral and Maxillofacial Surgery.* Philadelphia, Pa: WB Saunders; 1997.
22. Sulewski J. Historical survey of laser dentistry. *Dental Clinics of N Amer.* October, 2000;44(4):717-752.
23. Convissar R. Lasers in a hospital-based dental practice. *Dent Clin N Amer.* 2000;44(4):875-888.
24. Parkins F. Lasers in pediatric and adolescent dentistry. *Dent Clin N Amer.* 2000;44(4):821-830.
25. Convissar R, Diamond L, Fazekas C. Laser treatment of orthodontically induced gingival hyperplasia. *Gen Dent.* 1996;44(1):47-51.
26. Elliot RD, Burkes EJ, et al. CO_2 laser and formocresol pulpotomy effects on human primary pulp [abstract]. *J Dent Res.* 1999;78:386.
27. Gimbel C. Hard tissue laser procedures. *Dent Clin N Amer.* 2000;44(4):931-954.

obert A. Convissar, DDS, AGD, MALD, is a pioneer in e field of laser dentistry. He as one of the first dentists in e nation to incorporate lasers to a general practice. The uthor of numerous papers dealg with laser dentistry, Dr. onvissar is proud to have erved as guest editor of the *ental Clinics of North America* sue on Lasers and Light mplification in Dentistry, which as published by W.B. aunders in October of 2000. r. Convissar practices laser, osmetic, and restorative denstry with his wife and coauthor, **llen E. Goldstein, DDS**, in ew York City.