DENTISTRY TODAY®
Circulation 150,000
VOLUME 28 NO. 4 THE NATION'S LEADING CLINICAL NEWS MAGAZINE FOR DENTISTS APRIL 2009

ce dentalCEtoday.com

LASERS

Test 112

The Top Ten Myths About CO_2 Lasers in Dentistry

Robert A. Convissar, DDS

Carbon dioxide (CO_2) lasers have been used for intraoral procedures since 1964. There is more than 45 years of peer-reviewed literature advocating the use of CO_2 lasers for dental use; unfortunately, there is also a great deal of misinformation about the CO_2 wavelength. The purpose of this article is to use peer-reviewed literature to address the 10 most common myths about CO_2 lasers in dentistry.

MYTH NO. 1

The CO_2 laser is too powerful for general dental use. A high-school physics textbook provides the scientific rationale for refuting this myth. Figure 1 shows the electromagnetic spectrum, from the ultrashort, ultrapowerful gamma rays to the ultralong television and radio waves. The left side of the electromagnetic spectrum is the ultraviolet part of the spectrum. This part of the spectrum consists of very short wavelengths—including gamma rays and x-rays. An inverse relationship exists between wavelength and energy; therefore these ultrashort wavelengths contain the most energy of the entire electromagnetic spectrum. The wavelengths in this part of the spectrum are potentially carcinogenic and mutagenic. Moving from left to right, the ultraviolet part of the spectrum passes into the visible part of the spectrum—the part of the spectrum that is visible to the human eye. These wavelengths, in increasing length (and therefore in decreasing energy) are violet, blue, green, yellow, orange, and red. Past the visible red part of the spectrum is the infrared part of the spectrum. This part of the spectrum includes very long (therefore very low energy) wavelengths—including radio, television, shortwave, and microwave radiation.

Figure 2 is a magnified version of the near ultraviolet, visible, and near infrared part of the spectrum. The near ultraviolet

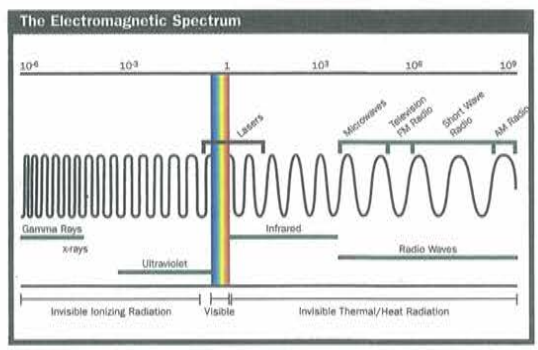

Figure 1. Electromagnetic Spectrum. Wavelength scale in µm.

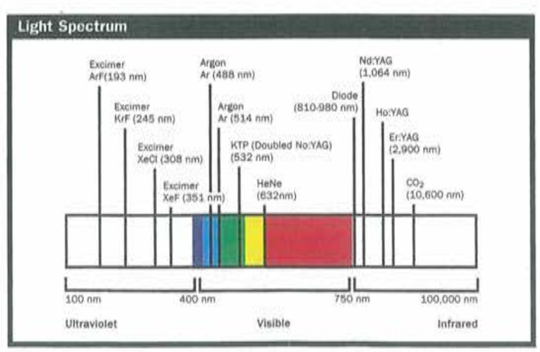

Figure 2. Close-up of the electromagnetic spectrum—note that the CO_2 wavelength is at the far right end of the infrared spectrum. This part of the spectrum contains longer wavelengths with less energy. All of the other dental lasers currently in use (Erbiums, diodes, Nd:YAG) are shorter wavelength/higher energy.

part of the spectrum includes excimer lasers, which are used by ophthalmologists for corneal reshaping. The visible part of the spectrum includes the argon lasers, used primarily for laser curing of dental materials and for vascular malformations; the frequency doubled neodymium: yttrium aluminum garnet (Nd:YAG) laser, also known as the KTP laser, used primarily for bleaching; and the helium-neon (He-Ne) lasers, used as laser pointers and as aiming beams for lasers that are not in the visible part of the spectrum. Passing into the near infrared part of the spectrum, diode lasers are found at wavelengths between 810 and 980 nanometers (nm). Proceeding further into the infrared part of the spectrum is the longer wavelength (therefore less energy content) Nd:YAG wavelength at 1,064 nm. Further along the infrared part of the spectrum are the even longer wavelength (therefore less energy content) erbium lasers, from 2,700 to 2,940 nm. Much further along the infrared part of the spectrum is the CO_2 laser, at a much longer (therefore much less energy content) wavelength than any of the other dental laser wavelengths.

Many dentists mistakenly believe that CO_2 lasers are too powerful to use in general dentistry or periodontal therapy. However, as the electromagnetic spectrum shows, the CO_2 laser wavelength contains less energy than any of the other wavelengths used in dentistry. The reason that CO_2 lasers work so well can easily be explained by laser-tissue interaction. Different tissues in the body preferentially absorb different wavelengths. In order for a wavelength to have a therapeutic effect, it must be well-absorbed by the target tissue. A wavelength that is poorly absorbed by its target tissue will have very little therapeutic effect. The CO_2 laser emits a wavelength of 10,600 nm. Water absorbs the 10,600 nm wavelength extremely well. Since oral soft tissue is 90% to 97% water, the CO_2 wavelength is the wavelength that is best absorbed by soft tissue. The CO_2 wavelength is not the most powerful wavelength; it is the most efficient wavelength for use in soft tissue in dentistry due to its superior absorption by soft tissue.

In his discussion of laser-tissue interaction, Dederich[1] emphasizes this point by stating that the CO_2 laser energy is so well-absorbed when compared to other wavelengths that "virtually none penetrates beyond 0.1 mm." His comparison of extinction depth (depth beyond which 90% of the energy of a particular wavelength is absorbed by tissue) shows that the extinction depth of Nd:YAG is 1 to 3 mm, compared to only 0.03 mm for CO_2. This comparison of extinction depths proves how efficient—not how powerful—the CO_2 wavelength is when compared to any other soft-tissue wavelength used in dentistry.

MYTH NO. 2

Periodontists in general, the American Academy of Periodontology (AAP), and the Journal of Periodontology *specifically have nothing good to say about CO_2 lasers.* Peer-reviewed papers by some of the leading periodontists in the United States, including certain articles published in the *Journal of Periodontology*, challenge this myth. More than 25 years ago the advantages of CO_2 laser periodontal surgery were enumerated by many different periodontists. In 1985, Pick, et al[2] described the advantages of using a CO_2 laser for almost completely dry, bloodless surgery; reduced surgical time; the ability to coagulate, vaporize, or cut by varying the power; instant sterilization of the area, decreasing the chances of bacteremia; no mechanical trauma to the surgical site; prompt healing with minimal postoperative swelling and scarring; and appearance of greatly reduced postoperative pain. In a subsequent paper, Pick and Pecaro[3] stated that the CO_2 laser is easier to use than a scalpel in many areas of the mouth, and that the CO_2 laser offers a viable, and in many cases improved, alternative to the scalpel.

Israel[4] listed the advantages of CO_2 laser surgery as: control of surgical and post surgical bleeding; less adjacent tissue damage; reduced postoperative edema; decreased postsurgical pain; better access to some surgical areas; and decreased or eliminated wound contraction and scarring. He lists indications for the CO_2 laser use as: gingivectomy; gingivoplasty; frenectomy; de-epithelialization; distal wedges; coagulation of graft donor sites; removal of papillomas; and treatment of fibromas, pyogenic granulomas, lichen planus, keratic lesions, inflammatory papillary hyperplasia, and hemorrhagic disorders in dental patients.

The Research, Science and Therapy Committee of the AAP[5] released a blue-ribbon panel report on lasers in dentistry in 2002 and listed clinical applications for the CO_2 laser as: gingivectomy, frenectomy, excision of soft-tissue pathology, and for de-epithelialization of flaps during and after surgery.

The AAP Academy Report on lasers in periodontics, published in the *Journal of Periodontology* in 2006, stated that the CO_2 laser is well suited for soft-tissue surgery.[6]

Figure 3 shows a preoperative view of an adolescent orthodontic patient with hypertrophic gingiva. Figure 4 shows an immediate postoperative photograph of the patient after treatment with a CO_2 laser, and Figure 5 shows a 2-week postoperative photograph of the completely healed surgical site. Note the normal tissue contours.

Figure 3. Preoperative view of an adolescent orthodontic patient with hyperplastic gingiva.

Figure 4. Immediate postoperative view of adolescent orthodontic patient.

Figure 5. Two-week postoperative view of the maxillary arch of the adolescent orthodontic patient. Note the excellent healing and natural gingival contours.

Many dentists are quite proficient with scalpels, and do not feel the need to change from a tried and true scalpel technique to a laser technique unless there is a marked increase in beneficial results. This leads to discussion of myth No. 3.

MYTH NO. 3

There is nothing a laser can do that can't be done with a scalpel. A review of the peer-reviewed literature indicates that there are some things that a laser can do that are superior to scalpel surgery. One goal of periodontal surgery is the regeneration of osseous structure and creation of a true soft-tissue connection to the root surface, rather than a long junctional epithelium. Many practitioners use a variety of membrane barrier techniques to prevent the epithelium from growing faster than the connective tissue. The principle of epithelial exclusion has been included in the periodontal literature for more than 50 years.[7] The use of membrane barriers to retard the growth of epithelium has been common for more than a decade.[8] Exclusion of the epithelium allows the connective tissue to grow, which results in new soft-tissue attachment to the root surface.

The first experimental use of the CO_2 laser in flap surgery instead of membrane barriers for de-epithelialization involved monkeys. Infrabony defects were artificially created bilaterally using elastics. The CO_2 laser was used on one side for de-epithelialization. Histological evaluation of the tissue showed that the CO_2 laser safely delayed epithelial growth for 14 days when compared to the control side. The authors concluded that this technique was less technically demanding and more time efficient than other currently known methods of epithelial retardation.[9]

This CO_2 laser research was continued with beagle dogs with artificially created class II furcations bilaterally. The control side was treated surgically, with the use of ePTFE membranes. The test side was given the exact same treatment, with the added step of CO_2 laser de-epithelialization. At 4 months, the animals were sacrificed and subjected to histological evaluation. The most notable histological observation of the study was on the laser treated side, where there was an abundant formation of new cementum, several layers thick. This finding was consistent across all of the laser treated sites when compared to the control sites.[10]

This preliminary histological research in 2 animal models led to human studies. Centty, et al[11] performed an in vivo study involving patients with bilateral periodontal defects, performing conventional (blade) surgery on one side, and laser de-epithelialization on the other side. This study found that the CO_2 laser eliminated sulcular and gingival (external) epithelium without disturbing underlying connective tissue, although neither laser nor blade eliminated all the epithelium. The authors concluded that CO_2 lasers have little to no effect on tissues beyond the target, and CO_2 lasers appeared to eliminate significantly more sulcular epithelium than conventional periodontal surgery. The authors noted that CO_2 laser technique will produce significantly more necrotic tissue adjacent to the wound area than conventional periodontal surgery, and that future long-term, well-controlled quantitative histologic studies are needed to evaluate the effect of repeated CO_2 laser de-epithelialization of the gingival surface of mucoperiosteal flaps at intervals during the healing period. However, it must be noted here that this study was performed with older gated-pulse CO_2 laser technology, which routinely charred tissue and caused some tissue necrosis. Such necrosis is not seen with the newer generation ultra-speed technology due to its high peak power and short pulse-width. This is discussed further in myth No. 9.

Israel and Rossmann[12] published human case reports utilizing the CO_2 laser for de-epithelialization. They concluded that CO_2 laser de-epithelialization has shown the ability to obtain clinical new attachment with bone fill in previously diseased sites. The authors believe that this technique has shown significantly better results than those obtained through conventional osseous grafting alone. Israel, et al,[13] building on previous studies, performed a pilot human histological study of laser de-epithelialization. The study involved 2 patients and 6 mandibular incisors. The teeth were splinted together and open flap debridement was performed on all teeth, and a notch was placed in the teeth at the height of the alveolar crest. The flaps were sutured in place. On the test side of the mouth, controlled de-epithelialization of the outer gingiva and inner gingival flap was accomplished with the CO_2 laser; de-epithelialization was repeated on the test side at 10, 20, and 30 days postsurgically. The control side received open debridement only. At 90 days, block sections of tissue were removed from the patients for histological analysis. In the control teeth in both patients, junctional epithelium extended the length of the root to the base of the notch. On the CO_2 laser treated side in one patient, the major portion of the notch was filled with connective tissue and limited repair cementum; this finding was not seen in any control teeth. In the second patient the test site results were similar to the control.

In his discussion of laser de-epithelialization, Pick[14] states that lasers used to de-epithelialize flaps may lead to a more predictable and desirable bone and soft-tissue result, and that the use of surgical membranes may be eliminated.[14]

Multiple researchers using 3 models—beagles, monkeys, and humans—provide histological evidence that the CO_2 laser results in the formation of new connective tissue and at least limited cementum repair. The Research, Science and Therapy Committee of the AAP concluded that the CO_2 laser has been shown to enhance periodontal therapy through an epithelial exclusion technique in conjunction with traditional flap procedures, and when the CO_2 laser is used to de-epithelialize the mucoperiosteal flap during surgery, it enhances reduction in periodontal probing depths.[5] It must be noted that these results are specific to the CO_2 wavelength, and these results may not be extrapolated or applied to other wavelengths used in dentistry.

MYTH NO. 4

CO_2 lasers might be fine for surgical procedures, but they cannot be used on root surfaces without causing extensive charring, cracking, and damage to the root surface. The *Journal of Periodontology* provides evidence indicating that the exact opposite is true. The application of CO_2 laser energy directly onto root surfaces further increases the success of periodontal surgery. Crespi, et al[15] subjected 30 single rooted human teeth to one of 3 procedures: hand scaling and root planing; CO_2 laser energy (defocused, pulsed mode) combined with scaling and root planing; and no treatment (control), then used a scanning electron microscope (SEM) to evaluate fibroblast attachment to the root surfaces. The laser group shows the highest number of fibroblasts attached to the root surfaces, with the tightly attached fibroblasts prevailing. They concluded that the CO_2 laser combined with mechanical instrumentation constitutes a useful tool to condition the root surfaces and increase fibroblast

attachment to root surfaces. This study also noted that the CO_2 laser treated group did not show any damage or morphologic alteration of the root surface.

Pant, et al[16] compared tetracycline, hydrogen peroxide, citric acid, EDTA, and CO_2 laser energy to condition root surfaces, with the goal of increasing attachment of periodontal ligament fibroblasts to periodontally involved root surfaces. A total of 84 teeth were studied, using a SEM. CO_2 laser irradiation was the most efficient, showing consistently good cell attachment, with the highest mean values of attachment.

Crespi, et al[17] surgically induced 36 class III periodontal furcations in beagles. All furcations measured 3 mm deep from the highest point of the furcation to the alveolar bone level. After a period of 6 to 8 weeks of plaque accumulation, the mean depth of the defects was 6.8 mm. At the bottom of each defect, a notch was made on the root surface to serve as a reference point from which expected regenerated tissue would initiate growth. The beagles were divided into 3 treatment groups: periodontal surgery including CO_2 laser treatment of the root surfaces; periodontal surgery including Gore-Tex membrane placement; and scaling and root planing. The distance between the notch level and the fornix was 6 to 7 mm in all 3 groups, revealing "through and through" class III defects at both buccal and lingual sites. At 6 months post-surgery the animals were sacrificed and histologically evaluated. The results showed a mean new attachment formation (as measured from the notch level) of 0.2 mm +/- 0.4 mm in the Gore-Tex group; 0.2 mm +/- 0.5 mm in the scaling/root planing group; and 1.9 mm +/- 0.5 mm in the CO_2 laser group. The authors concluded that CO_2 laser treatment of class III furcations induced formation of new periodontal ligament, cementum, and bone.

Crespi, et al[18] continued this line of research with human studies involving teeth with pocket depths of 6 to 9 mm, clinical attachment level of 4 mm, and bleeding upon probing in 3 patients. The purpose of this pilot study was to evaluate periodontal tissue repair when treating severe periodontal defects with CO_2 laser application as an adjunct to conventional periodontal surgery. All patients in the study had their pocket depths reduced by 4 mm, and clinical attachment gains of 3 to 5 mm. The study concluded that CO_2 laser treatment may induce predictable clinical improvements when used as an adjunct to conventional periodontal surgery.

Figure 6 is a maxillary second molar with a deep furcation involvement between the buccal roots. Figure 7 is the root surface after a flap is raised. Note the ball of diseased tissue in the furcation between the buccal roots. Elimination of this diseased tissue is critical to the success of the surgical procedure. Figure 8 is the root surface immediately after CO_2 laser ablation of the diseased tissue and treatment of the root surface according to the protocols of Barone, Crespi, and others.[15,19] Figure 9 is the surgical site 3 months postoperative. Note the complete healing of the furcation area.

This research seems to contradict older research and misconceptions about the use of CO_2 lasers directly on root surfaces. Earlier studies showed cracking and charring of the root surface when laser energy was applied directly to the root surface. The difference in results between the earlier studies showing damage and the newer studies showing increased fibroblast attachment is quite simple to explain. The CO_2 laser was invented in 1964. Its original temporal emission mode was continuous wave (CW); as long as the dentist was pushing down on the foot pedal, a CW of energy was emitted from the laser. Advances in CO_2 laser technology created a "gated" or "chopped" pulse emission, where the CW was chopped (gated) by a mechanical shutter into packets of energy. The net effect on the tissue, however, was exactly the same. The newer generation CO_2 lasers have far more sophisticated microprocessor-controlled temporal emission modes, which allow for much lower energy densities per square centimeter of tissue being irradiated. Ultra-speed CO_2 lasers can generate peak powers of over 320 watts (W), with pulse widths as short as 0.2 milliseconds. These pulse widths of from 0.2 milliseconds to as much as 80 milliseconds can be delivered in pulse speeds of 30 to 80 microseconds. This decreases the energy densities (amount of energy absorbed per square millimeter of tissue—also called fluence) to the point where damage to the root surface does not occur.

This critically important point of using appropriate energy densities to treat root surfaces was illustrated by Barone, et al.[19] They divided 30 teeth into 3 groups: CO_2 laser treatment using 8-W CW focused; CO_2 laser treatment using 2-W nonfocused, pulsed at 4-Hertz, and; untreated controls. Their results showed severe damages to dentin surfaces such as heat cracking, fissuring, and pronounced roughness in the CW group. However, in the pulsed group the dentin appeared as a melted layer, with a flat, smooth surface and apparent fusion of the surface of the smear layer, without causing any damages to the root surfaces. They then compared the surface of the untreated controls with the nonfocused laser group. The control (untreated) teeth showed residual bacterial cells on the root surfaces. The

Figure 6. Preoperative view of a maxillary left second molar with a large furcation involvement.

Figure 7. Flap opened over the tooth—note the bolus of granulomatous tissue in the furcation.

Figure 8. Laser used to denude the root surface of diseased soft tissue.

Figure 9. Three-month postoperative view of the healed surgical area—note the healed furcation.

laser pulsed group showed an absence of residual bacterial cells on all lased specimens. This study illustrates not only the importance of using appropriate laser energies in dentistry, but also how critically important laser training is when considering the purchase of a laser. The most skilled dentists in the world will not obtain the best results for their patients unless they are properly trained to use the correct instrument in the correct manner with the correct parameters for the specific procedure at hand.

MYTH NO. 5

CO_2 lasers cannot be used near implants, for fear that the implant will de-integrate. This myth is not supported by the peer-reviewed literature. Deppe, et al[20] placed 60 implants in beagle dogs and induced peri-implantitis. The lesions were then decontaminated via one of 3 techniques: Group 1—air abrasion alone; Group 2—air abrasion in combination with CO_2 laser; Group 3—CO_2 laser alone. He concluded that the CO_2 laser is safe and suitable for peri-implant gingival treatment. In another study Stubinger, et al[21] again placed 60 implants in beagle dogs and induced peri-implant lesions. He divided the 60 implants into 3 groups as in the previous paper. Four months after treatment, the animals were sacrificed and the mandibles evaluated histologically. Group 1 showed minimal bone formation. The laser treated groups showed large amounts of rapidly formed lamellar bone, with active bone formation still occurring. Some areas showed evidence of new direct bone-to-bone implant contact with no intervening soft tissue. There was no sign of thermal damage to any of the laser treated implants. Radiographically, the amount of reestablished bone to implant contact was significantly greater in both laser treated groups when compared to the conventionally treated groups. Stubinger, et al[21] concluded that laser-assisted decontaminated implants showed reintegration, and that CO_2 lasers can be used for implant sterilization and regeneration of moderate amounts of bone. This compares favorably to other laser wavelengths.

Schwarz, et al[22] found that erbium laser treatment of peri-implantitis was not sufficient for maintenance of failing implants. Walsh[23], Block, et al[24], and Chu, et al[25] all concluded that since Nd:YAG ablates the titanium on implant surfaces, transmits heat to the bone, and pits and melts the implant surface, it is unsafe for peri-implantitis treatment. Figure 10 shows gingival swelling and peri-implantitis around tooth No. 8. Figure 11 shows the healing peri-implant lesion 48 hours after *just one* laser treatment.

Figure 10. Preoperative view of peri-implantitis on tooth No. 8. Note severe marginal gingival swelling.

Figure 11. The 48-hour postoperative view of healing peri-implant lesion. Swelling is markedly reduced after one laser decontamination procedure.

Figure 12. Preoperative view of lingually positioned canine tooth. A laser gingivoplasty is planned to create a more aesthetic smile line.

Figure 13. Postoperative view of restored canine tooth. Note the excellent emergence profile from the surgically enhanced smile line.

Figure 14. Preoperative view of 26-year-old kidney transplant patient with cyclosporine induced gingival hyperplasia.

Figure 15. Immediate postoperative view of maxillary anterior gingiva.

MYTH NO. 6

Even if CO_2 lasers are useful for periodontics and implantology, they have very little use in a restorative or cosmetics-oriented practice. Even if a general practitioner refers 100% of periodontal and implant treatment to specialists, the use of lasers in fixed and removable prosthetics is more than sufficient to warrant an investment in this technology. A survey in May 2005[26] described how laser dentists use their devices; 87% of laser dentists use their lasers for cosmetic gingival contouring, including around crown and laminate margins; 81% use their laser for gingival retraction/troughing.[26] Rice[27] describes the use of CO_2 lasers for sulcular gingivoplasty. She lists many advantages of laser use over conventional procedures, including a healthier gingival sulcus. Parker[28] states that laser gingival management of prosthetic cases includes: removal of excess or intrusive tissue relative to restorative margins; enhancement of the aesthetics of a pontic space; and establishment of increased clinical crown length. His discussion of lasers in prosthetics includes illustrating the use of a CO_2 laser for crown lengthening in the aesthetic zone. Figure 12 shows a preoperative view of a mandibular right canine that is lingually erupted. A CO_2 laser was used to resculpt the marginal gingiva prior to placement of a laminate veneer. Figure 13 shows the restored tooth 72 hours after completed treatment.

Convissar and Gharemani[29] list many uses for CO_2 lasers as an adjunct in removable prosthetic care, including: soft-tissue tuberosity reduction; assistance in torus reduction; removal of epulis without scar or contraction of the vestibule; soft tissue residual ridge modification; and treatment of denture stomatitis. Kesler[30] and Pogrel[31] both describe multiple uses for CO_2 lasers in removable prosthetic treatment. Whenever soft-tissue procedures are involved in fixed or removable restorative dentistry treatment plans, CO_2 lasers may be used to enhance the final result.

MYTH NO. 7

CO_2 lasers are good for gross debulking, but are useless for fine tissue procedures such as

Figure 19. Aberrant mandibular frenum.

Figure 20. Slow healing one-week postoperatively.

Figure 21. Complete healing at 2 weeks.

Figure 22. Aberrant mandibular frenum.

Figure 23. Completely healed surgical site at one-week postoperatively.

rates of laser dentists in their purchase of this technology.

Once a dentist has decided on which wavelength is best for his/her practice, there are still many important criteria to evaluate before the purchase. The first criterion is which manufacturer has the best instrument for that particular wavelength. Some CO_2 lasers have state-of-the-art 21st century ultraspeed technology, whereas others have 40-year-old technology that has been "tweaked" to give the illusion of more pulse variability.

The second criterion relates to the laser manufacturer itself. Some CO_2 lasers are made by large corporations that are world leaders in medical, dental, and industrial lasers, whereas other lasers are made by companies that are new to the field and do not have a proven track record. Some laser manufacturers have recently entered the US market and do not have a national distribution network, whereas other laser manufacturers have been in the US market for a number of years. Is the laser manufacturer financially solvent? Will the laser manufacturer be in the US market in 3 or 4 years when your unit may need service? Or will the laser manufacturer pull out of the US dental market (as we have seen with a few dental laser companies), leading to uncertainty regarding warranty service, repairs, spare and replacement parts, etc? Or will the laser manufacturer declare bankruptcy and totally close operations? (as has already happened with more than one dental laser company.)

The third important criterion is education and training. Some laser manufacturers simply provide the purchaser with an instructional CD, whereas other manufacturers mandate that the dentist achieve Academy of Laser Dentistry Standard Proficiency as part of the training program. Does the education include hands-on training in the dentist's office? Is there a list of mentors available from the laser company when you have questions about a new procedure or technique? All of these questions must be answered before the serious laser purchaser signs on the dotted line.

CONCLUSION

Lasers have been used by general dentists for more than 20 years. There are many excellent laser wavelengths and manufacturers in the market. Just as every dental practice is unique, every dentist's utilization of this remarkable technology will be different. There is no single wavelength that is perfectly suited for every dentist. Only by critically examining the peer-reviewed literature and carefully evaluating manufacturers' advertising claims will a dentist be able to begin evaluating which wavelength is best for his/her practice.

There are many excellent resources dentists can turn to, including textbooks, continuing education (CE) courses, and organizations. When taking a CE course on laser dentistry, make certain the speaker discloses any financial relationship with the laser companies, as well as his/her clinical experience with all of the various wavelengths. Avoid lecturers who have extensive experience with just one wavelength and who decide that their wavelength is "best." Try to find laser mentors who own multiple wavelengths. Take courses where all of the wavelengths are discussed, rather than one particular wavelength. Subscribe to laser journals, or borrow them from dental libraries. A list of suggested resources follows. ✦

References

1. Dederich DN. Laser/tissue interaction: what happens to laser light when is strikes tissue? *J Am Dent Assoc.* 1993;124:57-61.
2. Pick RM, Pecaro BC, Silberman CJ. The laser gingivectomy. The use of the CO_2 laser for the removal of phenytoin hyperplasia. *J Periodontol.* 1985;56:492-496.
3. Pick RM, Pecaro BC. Use of the CO_2 laser in soft tissue dental surgery. *Lasers Surg Med.* 1987;7:207-213.
4. Israel M. Use of the CO_2 laser in soft tissue and periodontal surgery. *Pract Periodontics Aesthet Dent.* 1994;6:57-64.
5. Research, Science and Therapy Committee of the American Academy of Periodontology. Lasers in periodontics. *J Periodontol.* 2002;73:1231-1239.
6. Cobb CM. Lasers in periodontics: a review of the literature. *J Periodontol.* 2006;77:545-564.
7. Goldman HM. A rationale for the treatment of the intrabony pocket; one method of treatment, subgingival curettage. *J Periodontol Res.* 1949;20:83-91.
8. Pritlove-Carson S, Palmer RM, Floyd PD, et al. Immunohistochemical analysis of tissues regenerated from within periodontal defects treated with expanded polytetrafluoroethylene membranes. *J Periodontol.* 1994;65:134-138.
9. Rossmann JA, McQuade MJ, Turunen DE. Retardation of epithelial migration in monkeys using a carbon dioxide laser: an animal study. *J Periodontol.* 1992;63:902-907.
10. Rossmann JA, Parlar A, Abdel-Ghaffar KA, et al. Use of the carbon dioxide laser in guided tissue-regeneration wound healing in the beagle dog. *Proc SPIE.* 1996;2672:52-61.
11. Centty IG, Blank LW, Levy BA, et al. Carbon dioxide laser for de-epithelialization of periodontal flaps. *J Periodontol.* 1997;68:763-769.
12. Israel M, Rossmann JA. An epithelial exclusion technique using the CO_2 laser for the treatment of periodontal defects. *Compend Contin Educ Dent.* 1998;19:86-95.
13. Israel M, Rossmann JA, Froum SJ. Use of the carbon dioxide laser in retarding epithelial migration: a pilot histological human study utilizing case reports. *J Periodontol.* 1995;66:197-204.
14. Pick R. The use of lasers for treatment of gingival disease. *Oral Maxillofac Clin North Am.* 1997;9:1-19.
15. Crespi R, Barone A, Covani U, et al. Effects of CO_2 laser treatment on fibroblast attachment to root surfaces. A scanning electron microscopy analysis. *J Periodontol.* 2002;73:1308-1312.
16. Pant V, Dixit J, Agrawal AK, et al. Behavior of human periodontal ligament cells on CO_2 laser irradiated dental root surfaces: an in vitro study. *J Periodontal Res.* 2004;39:373-379.
17. Crespi R, Covani U, Margarone JE, et al. Periodontal tissue regeneration in beagle dogs after laser therapy. *Lasers Surg Med.* 1997;21:395-402.
18. Crespi R, Covani U, Romanos G, et al. CO_2 laser effects on root surfaces in periodontal treatment: case reports. *J Oral Laser Applications.* 2004;4:109-117.
19. Barone A, Covani U, Crespi R, et al. Root surface morphological changes after focused versus defocused CO_2 laser irradiation: a scanning electron microscopy analysis. *J Periodontol.* 2002;73:370-373.
20. Deppe H, Horch HH, Henke J, et al. Per-implant care of ailing implants with the carbon dioxide laser. *Int J Oral Maxillofac Implants.* 2001;16:659-667.
21. Stubinger S, Henke J, Donath K, et

smile design. Sun[32] states that CO_2 lasers can vaporize soft tissue precisely and quickly for cosmetic dentistry. Adams and Pang[33] describe the use of a CO_2 laser for smile design to correct a patient's presentation of short, wide maxillary teeth. The patient's length-to-width ratio of 100% on the maxillary central incisors was reduced to a more acceptable 75% to 78% using a CO_2 laser. Figure 14 shows a preoperative view of a 26-year-old kidney transplant recipient who was taking cyclosporine to prevent rejection of the kidney, resulting in hyperplastic tissue in both the maxillary and mandibular arches. Figure 15 shows the maxillary arch immediately after CO_2 laser ablation of the hyperplastic tissue. Figure 16 shows the maxillary arch one week postoperatively, and the mandibular arch immediately preoperatively. Figure 17 shows the maxillary arch one-week postoperatively and the mandibular arch immediately postoperatively. Figure 18 shows the maxillary arch 2 weeks postoperatively and the mandibular arch one-week postoperatively. The CO_2 laser is equally adept at both gross debulking of tissue as well as the fine detailing used to create the ideal gingival architecture in gingival hyperplasia patients.

MYTH NO. 8

Since a CO_2 laser is good for soft tissue but not for operative dentistry, I should simply purchase an "all-tissue laser" instead of a CO_2 laser. This myth is analogous to the statement: I have an "all purpose bur"...this one bur is all I need to perform all of my dental procedures. This bur can be used for class I decay to class V decay. I can also use this bur for laminate preparations, full crown preparations, inlay and onlay preparations. This bur can also be used for osseous recontouring during periodontal surgery and for sectioning crowns during oral surgery. This bur is a 557 cross-cut fissure bur. True? Of course it can be used for all of the above procedures, but is it ideal for all of the procedures? The answer is no. I may use it for class I and class II decay, but I use an inverted cone bur for class III and class V decay. I have a variety of diamond instruments for my laminate and crown and bridge preparations. I have long shank burs for sectioning teeth, and I have round burs for osseous recontouring.

Although a well-trained laser dentist may be able to use one wavelength for both hard and soft-tissue procedures, there is currently no wavelength on the market that will work equally well on both hard and soft tissues. Erbium lasers are excellent lasers; however, there is very little peer-reviewed literature when compared to the 45 years of peer-reviewed literature that supports the use of the CO_2 laser for many soft-tissue procedures. As discussed earlier, erbium lasers have been shown to be ineffective in treatment of peri-implantitis. There is no literature to support the use of erbium lasers for de-epithelialization of flaps. There is very little literature that states that the erbium laser decreases periodontal probing depths. CO_2 lasers are ideal for soft-tissue surgery, have 45 years of peer-reviewed literature to support their use, and are half the cost of so-called "all-tissue" lasers.

MYTH NO. 9

CO_2 lasers always char tissue. This was absolutely true—in 1964 when the CO_2 laser was invented. A review of CO_2 clinical case photographs will usually show charred tissue immediately postoperatively. As was discussed in myth No. 4, the original CO_2 laser temporal emission mode was either CW, or gated pulse. These emission modes always created overheated, charred tissue. These emission modes gave way to superpulse mode, which was followed by ultraspeed mode. With the high peak powers and extremely fast pulse durations available in ultraspeed mode, the CO_2 lasers no longer deliver long pulses of energy that overheat and char the tissue. The earlier gated pulses are in the range of milliseconds (20 thousandth of a second). The ultraspeed mode creates pulses that are exponentially faster—as fast as 20 millionths of a second. These ultrafast pulses ablate tissue much too quickly to permit any overheating of tissue to occur, therefore preventing any charring of the tissue. This leads to faster healing with less char.

A comparison of earlier CO_2 clinical case photographs and current ultraspeed CO_2 clinical case photographs demonstrate a tremendous difference in immediate postoperative results. Figure 19 shows an aberrant mandibular frenum. Figure 20 shows the healing one week after surgery with a gated-pulse CO_2 laser. Figure 21 shows 2-week healing. This case may be compared with Figure 22, which also shows an aberrant mandibular frenum. Figure 23 shows the completely healed surgical site at one week postoperatively after treatment with an ultraspeed CO_2 laser.

MYTH NO. 10

All lasers (not just CO_2) are too expensive. The return on investment is just not there. The 2005 survey[26] cited previously challenges this myth. When asked what contributed to the increased revenue in their practices as a result of purchasing the laser, 67% of laser dentists attributed the increase in revenue to new procedures that were previously referred out to specialists; 66% attributed increased revenue to enabling the dentist to increase productivity, including a decrease in postoperative patient consultations; more than one third of the dentists cited the acquisition of new patients as the cause of increasing their bottom line; and a quarter of all laser dentists cited the ability to perform higher end procedures as a result of acquiring the laser. This is why surveys of laser dentists always show extremely high (more than 75%) satisfaction

Figure 16. One-week postoperative view of maxillary anterior gingiva and immediate preoperative view of mandibular anterior gingiva.

Figure 17. One-week postoperative view of maxillary anterior gingiva and immediate postoperative view of mandibular anterior gingiva.

Figure 18. Two-week postoperative view of maxillary anterior gingiva and one-week postoperative view of mandibular anterior gingiva. Note the excellent gingival contours.

al. Bone regeneration after peri-implant care with the CO_2 laser: a fluorescence microscopy study. *Int J Oral Maxillofac Implants.* 2005;20: 203-210.
22. Schwarz F, Bieling K, Nuesry E, et al. Clinical and histological healing pattern of peri-implantitis lesions following non-surgical treatment with an Er:YAG laser. *Lasers Surg Med.* 2006;38:663-671.
23. Walsh LJ. The use of lasers in implantology: an overview. *J Oral Implantol.* 1992;18:335-340.
24. Block CM, Mayo JA, Evans GH. Effects of the Nd:YAG dental laser on plasma-sprayed and hydroxyapatite-coated titanium dental implants: surface alteration and attempted sterilization. *Int J Oral Maxillofac Implants.* 1992;7:441-449.
25. Chu RT, Watanabe L, White JM, et al. Temperature rises and surface modification of lased titanium cylinders. *J Dent Res.*1992;71(Abstract # 312):144.
26. Goff S. April 2005 dental products report laser dentistry survey. *Dental Products Report* Survey of *Laser Dentists.* 2005;39:26-33.
27. Rice JH. Laser use in fixed, removable, and implant dentistry. *Dent Clin North Am.* 2000;44:767-777.
28. Parker S. The use of lasers in fixed prosthodontics. *Dent Clin North Am.* 2004;48:971-998.
29. Convissar RA, Gharemani EH. Laser treatment as an adjunct to removable prosthetic care. *Gen Dent.* 1995;43: 336-341.
30. Kesler G. Clinical applications of lasers during removable prosthetic reconstruction. *Dent Clin North Am.* 2004;48:963-969.
31. Pogrel MA. The carbon dioxide laser in soft tissue preprosthetic surgery. *J Prosthet Dent.* 1989;61:203-208.
32. Sun G. The role of lasers in cosmetic dentistry. *Dent Clin North Am.* 2000; 44:831-850.
33. Adams TC, Pang PK. Lasers in aesthetic dentistry. *Dent Clin North Am.* 2004;48:833-860.

Suggested Publications

Coluzzi DJ, Convissar RA. *Atlas of Laser Applications in Dentistry.* Chicago, IL: Quintessence; 2007.

Moritz AF, Beer F, Goharkhay K, et al. *Oral Laser Application.* Chicago, IL: Quintessence; 2006.

Gutknecht N. *Proceedings of the 1st International Workshop of Evidence Based Dentistry on Lasers in Dentistry.* Chicago, IL: Quintessence; 2007.

Suggested Journals

Lasers in clinical dentistry. *Dent Clin North Am.* 2004;48:751-1160. This and other issues may be purchased at dental.theclinics.com.

Journal of Oral Laser Applications—official publication of the European Society for Oral Laser Applications. For subscription information, go to quintpub.com and click on "journals".

Lasers in Surgery and Medicine—official journal of the American Society for Laser Medicine and Surgery. For subscription information, go to aslms.org.

PhotoMedicine and Laser Surgery—official journal of the World Association for Laser Therapy and the North American Association for Laser Therapy. For subscription information, go to liebertpub.com.

Lasers in Medical Science—official journal of the World Federation for Laser Dentistry, the British Medical Laser Association, and the International Academy for Laser Medicine and Surgery. For subscription information, e-mail: journals-ny@springer.com.

Dr. Convissar is a pioneer in laser dentistry. An internationally acclaimed lecturer with 20 years laser experience, he has presented more than 100 CE courses worldwide on 5 continents. He has published 14 peer-reviewed papers and authored the textbooks *Lasers and Light Amplification in Dentistry* (October 2000), *Lasers in Clinical Dentistry* (October 2004), and *Clinical Atlas of Laser Applications in Dentistry* (2007). Dr. Convissar practices laser, cosmetic, and restorative dentistry in New York. He can be reached at (212) 255-5730 or laserbobdds@msn.com.

Disclosure: Over the past 20 years, Dr. Convissar has received honoraria in the form of cash, or free or discounted goods from the following laser companies: American Dental Lasers; Biolase; Biolitec; Deka; Elexxion; Hoya/Conbio; Ivoclar Vivadent; Lares Research; Lumenis; Luxar; Millennium; OpusDent; Premier Laser Systems; Spectra Lasers; Union Medical Lasers; Zap Lasers.