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Lasers in Dentistry

Educational Objectives

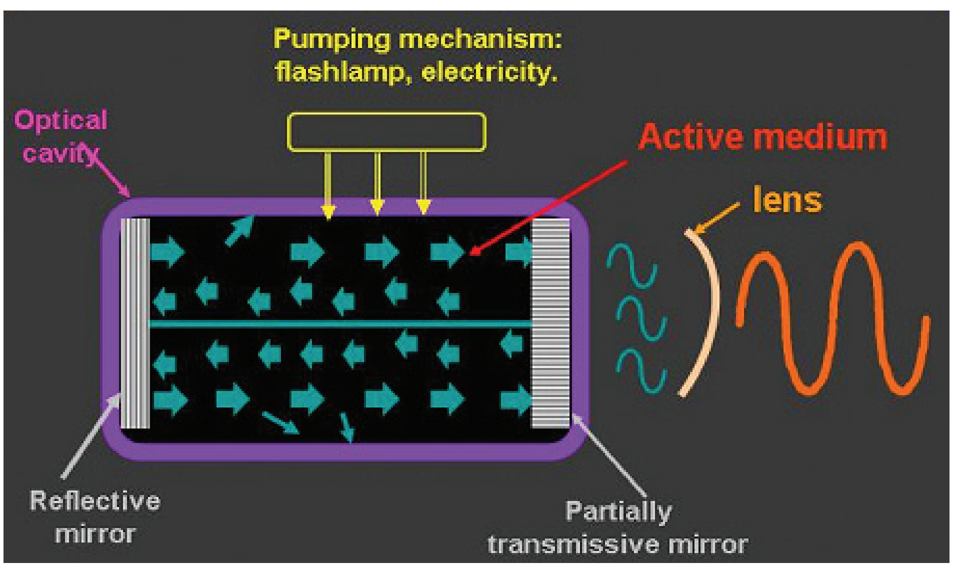
Following this unit of instruction, the practitioner should be able to:

1. Have a basic knowledge of the fundamentals of laser science and the nomenclature of different laser active medium and emission wavelength.
2. Understand the basic thermal interaction of laser energy and dental tissue.
3. Be aware of the different absorption properties of laser devices.
4. Be familiar with the features of laser instruments.
5. Understand essential elements of the safe operation of lasers.
6. Be aware of the benefits and considerations of the use of lasers.
7. Recognize how lasers are used in several clinical procedures.

Introduction

The first laser specifically designed for dentistry was cleared to market by the Food and Drug Administration (FDA) in 1989. In medicine, the technology was first used about 1975 and Carbon Dioxide (CO2) lasers were commonly employed during the 1980's for general and oral surgery.[2,3] Approximately fifteen percent of dentists worldwide own lasers, but the United States Food and Drug administration has cleared 30 indications for their use in dental therapy. Research studies continue to enumerate new possible clinical applications and unique patient benefits. This guide is intended to provide information about the basic science and tissue interactions of dental lasers, and demonstrate examples of clinical use.

Figure 1 - Laser Components



Graphic representation of a typical laser's components. Note the active medium enclosed in the optic cavity, into which energy is supplied by the excitation source. The mirrors at either end of the cavity reflect, amplify, and align the laser beam.

FOURTH EDITION

Author Acknowledgements

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Dr. Coluzzi has no relevant financial relationships to disclose.

The following commentary highlights fundamental and commonly accepted practices on the subject matter. The information is intended as a general overview and is for educational purposes only. This information does not constitute legal advice, which can only be provided by an attorney.

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Fundamental Laser Science

The word laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Light is a form of energy that travels in a wave and also exists as a particle, called a photon. Traveling at the speed of light, this wave has both energy and size. Size is termed wavelength, typically measured in meters. Useful dental wavelengths are measured in billionths of a meter, or nanometers, abbreviated nm; and current instruments have emissions in the range of 500 nm to 10,000 nm. Energy is expressed in joules, and a useful dental quantity is a millijoule, one thousandth of a joule.

Laser energy is distinguished from ordinary light by the following two properties:

- Laser energy is generated as only one color, a property called monochromaticism. Dental lasers may emit visible or invisible light.
- Waves of laser energy are coherent. Each wave is identical in physical size and shape. This monochromatic, coherent wave of light emerges from the laser device as a precise collimated beam and a uniquely efficient source of energy.

Inside the device, a process occurs called amplification by stimulated emission of radiation, which Albert Einstein theorized in 1916.[4] Chemical elements, molecules, or compounds in the core of the laser comprise the active medium. The core is usually a solid but occasionally can be a tube of gas. This core is surrounded by a pumping mechanism that supplies the initial photon energy, either in the form of an electrical current, by the use of a rapidly strobing flashlamp, or another laser. The photons interact and stimulate one another. They are amplified with the aid of mirrors and collimated by reflection and resonation to ultimately produce a laser beam. That laser beam is then focused, adjusted with various controls, and emitted. Figure 1 shows a graphic diagram of a typical laser.

Laser energy is a specific form of electromagnetic radiation. Its spectrum ranges from gamma rays with wavelengths only a few trillionths of a meter in length to radio waves, whose wavelengths can be thousands of meters long. Additionally, It is important to note that currently available dental instruments all produce non ionizing radiation. This is to be distinguished from ionizing radiation, which is mutagenic to cellular DNA components.[5]

A few dental lasers emit visible light: the KTP laser (named for a crystal of potassium titanyl phosphate that modifies the wavelength of the internal Nd:YAG laser) which has a green color of 532 nm; some photobiomodulation (nonsurgical power) lasers with red light emission in the range of 635-660nm; and another low-level caries detector with a similar red color at 655 nm.

All other laser devices emit invisible laser energy in the infrared portion of the electromagnetic spectrum. The other surgical instruments are, in ascending wavelength order:

- 800 nm to 830 nm diode, with a semiconductor active medium of aluminum, gallium, and arsenide;
- 940 nm diode, with a semiconductor medium of aluminum, indium, gallium and arsenide;
- 980 nm diode with a similar active medium of indium, gallium and arsenide;
- 1,064 nm diode with a similar active medium of indium, gallium, arsenide and phosphorus;
- 1,064 nm Nd:YAG, where YAG is a crystal of yttrium aluminum garnet, doped (in laser language this means coated) with the rare earth element neodymium;

Table 1
Summary of Laser Types and Procedures (current indications: December 2013)

General Type	Wavelength	Delivery System	Clinical Procedures (see note below)
KTP	532 nm	Flexible small fiber, bare ended in a handpiece	Soft tissue surgery, whitening [a]
Photobiomodulation	630-980 nm	Flexible or rigid optic fiber with accessory tips	Tissue warming, temporary pain relief and increased blood circulation; photoactivated disinfection [b]
Diode	810, 940, 980, 1064 nm	Flexible small fiber, bare ended or accessory tips in a handpiece	Soft tissue surgery, sulcular debridement [c], whitening [a]; one 940 nm diode can also be used for tissue warming, as described above.
Nd:YAG	1064 nm	Flexible small fiber, bare ended in a handpiece	Soft tissue surgery, sulcular debridement [c], laser assisted new attachment procedure [d]
Nd:YAP	1340 nm	Flexible small fiber, bare ended	Soft tissue surgery, sulcular debridement, removal of separated endodontic instruments and posts
Er,Cr:YSGG	2780nm	Semi flexible large fiber, handpiece and tips added	Soft tissue surgery, hard tissue procedures, including calculus removal, tooth preparation and osseous surgery; laser assisted new attachment procedure
Er:YAG	2940 nm	Semi flexible large fiber, hollow waveguide, articulated ararm. Handpiece and tips added	Soft tissue surgery, hard tissue procedures, including calculus removal [e], tooth preparation and osseous surgery; laser assisted new attachment procedure [d]
CO_2	9300 nm	Articulated arm, handpiece and tips added	Soft tissue surgery, tooth preparation, osseous surgery
CO_2	10600 nm	Hollow waveguide, articulated arm. Handpiece and tips added	Soft tissue surgery, sulcular debridement [c], laser assisted new attachment procedure [d]

Note: [a] through [e] are for certain, not all, instruments in the wavelength

- 1430nm Nd:YAP where YAP is a crystal of Yttrium Aluminum Perovskite;
- 2,780 nm Er,Cr:YSGG, which is a crystal of yttrium scandium, gallium, garnet doped with erbium and chromium;
- 2,940 nm Er:YAG, where the doping agent is erbium;
- 9,300nm carbon dioxide; and
- 10,600 nm carbon dioxide.[6]

For clarity, the term ‘photobiomodulation’ refers to the tissue response to certain very low levels of laser energy with resultant warming of the tissues.[7] Recent evidence has demonstrated that photobiomodulation, also known as biostimulation, can produce beneficial effects such as enhanced proliferation of fibroblasts and osteoblasts helping to accelerate wound healing.[8] In addition, the FDA has issued a marketing clearance for certain instruments that describes their use for temporary pain relief and increase in blood circulation. The mechanisms that accomplish these effects are not completely clear at this time, but do involve intracellular light interactions.[9] Devices specifically designed for photobiomodulation are available in diode lasers with emission wavelengths of 630-980nm.[10] Other visible emitting low energy lasers are employed in a technique broadly termed photodynamic therapy, and use near infrared light in combination with a photosensitized liquid to produce oxygen radicals in the tissue, providing photodisinfection.[11] A summary of laser types and their clinical application can be found in Table 1.

Tissue Interaction

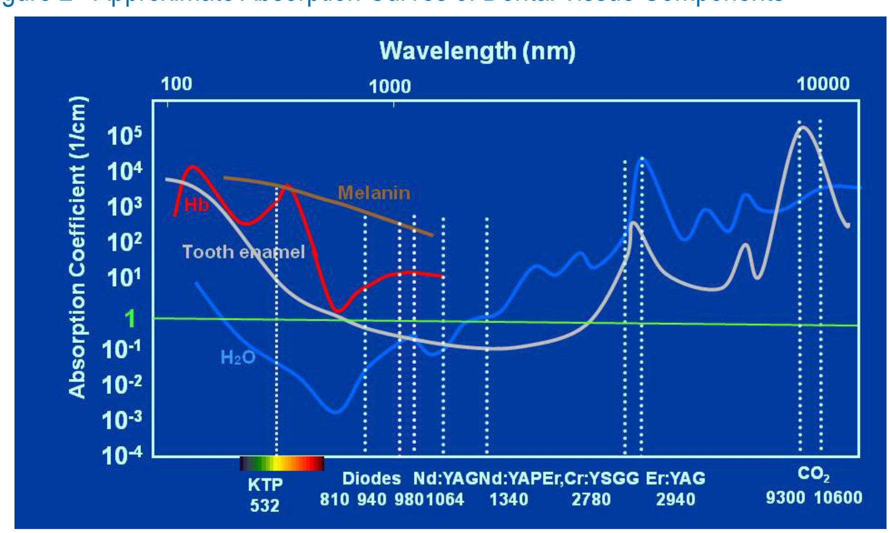
The underlying principle of laser use is for the clinician to employ the least amount of average energy or power to reach the treatment objective.[12] The primary interaction of dental tissue with laser energy is a photo thermal one; that is, the beam is absorbed and raises the temperature of the target tissue.[13] At 100º C the inter- and intracellular water boils away, causing either soft-tissue ablation, which is the change in physical state from solid to vapor, or explosive expansion and disruption of hard tissue.[14,15] If the tissue continues to absorb the laser energy, carbonization can occur and with it the possibility of significant tissue damage. At subablative temperatures, other tissue effects will be observed. Tissue can be warmed several degrees above the normal of 37º C, where photobiomodulation effects can occur. Minimal heat is needed for this effect, thus those devices are termed ‘low level lasers’. At 50º C, most non-sporulating bacteria can be inactivated, creating a disinfected surface.[16] Coagulation and protein denaturation occur at approximately 60º C, and the clinician can operate a laser in this heat range to produce hemostasis and removal of the denatured granulation debris from soft tissue.[17,18] Likewise, approximately 80º C is an effective temperature for “welding” of soft tissue incisions.[19] Because all lasers have a thermal effect on both the target and non-target tissue, the dental practitioner must pay attention to this effect during surgery to ensure that unwanted heat is controlled.

Different wavelengths have different absorption coefficients based on the varied composition of human tissue.[20] Water, which is a universally present molecule, is most interactive and maximally absorbed by the two Erbium wavelengths, and slightly less by carbon dioxide. Nd:YAP has about one-thousandth the absorption of Erbium. Conversely, the shorter wavelength lasers, including Argon, KTP, Diode, and Nd:YAG, have a high degree of transmission through water. Carbon dioxide, followed closely by the Erbium family, is highly absorbed by the apatite crystal that forms the structure for teeth and bone. Apatite crystal has very little interaction with the shorter wavelengths of 1400nm and below. However, those wavelengths (KTP, Diode, Nd:YAG, and Nd:YAP) have a high affinity for blood components such as hemoglobin and tissue pigments like melanin; the longer wavelength has little interaction with the color of tissue. Figure 2 is a chart showing relative absorption of the chief compounds of dental tissue in relation to various laser wavelengths.

Of course, human dental hard and soft tissue is a combination of all these substances. In the treatment of dental soft tissues, the practitioner has the choice of any available wavelength and different devices, because all of those mentioned will have absorption in one or more of the components of those tissues. Only the erbium family and the very recently introduced 9,300 nm carbon dioxide lasers have indications for use with hard tissues.[21]

In addition to unique absorptive optical properties, all wavelengths have different depths of penetration through tissue. The Erbium family of lasers is essentially absorbed on the surface of the target material, penetrating as little as 5 microns; whereas the diode devices can reach several thousand layers deeper into the tissue. With this knowledge, the clinician is able to treat a variety of dental pathologies using different laser devices. The laser parameters - energy, beam diameter, and duration of exposure - must be carefully monitored to produce a successful treatment result.

Figure 2 - Approximate Absorption Curves of Dental Tissue Components



Absorption curves of four of the main components of dental tissue: hemoglobin, pigment, water, and carbonated hydroxyapatite. The vertical scale is logarithmic, with a coefficient of 1 representing no interaction. Negative coefficients indicate transmission, positive ones depict absorption.

Features of Dental Lasers

Photonic energy can emanate from dental lasers in two inherent ways: as a continuous wave; and in free-running pulses.[22]

Continuous wave means that the laser energy is emitted as long as the laser is activated. This produces constant tissue interaction. Some Carbon dioxide, argon and diode lasers operate in this manner. There is an additional modification of the continuous wave lasers, called gated. Gating is accomplished by mechanically or electronically closing the opening of the mirror within the laser chamber. Several diode and carbon dioxide lasers offer very short pulse durations, produced by electronic controls. These short pulses are used to minimize some of the undesirable residual thermal effects that can be a direct result of continuous photon emission.

Free running pulse lasers only produce very short bursts of energy. Nd:YAG, Nd:YAP, Er, Cr:YSGG, Er:YAG, and the 9300 nm Carbon Dioxide devices operate in this mode, and provide large packets of power for efficiency during a procedure. The minimum laser "on" time allows a long thermal relaxation time for the target tissue for good heat dissipation.

A short pulse duration can be a clinical advantage since it allows for higher power during the pulse, increasing efficiency. However, a short pulse (or laser 'on' time) should be accompanied by a correspondingly longer 'off' time, to allow the tissue to cool. This technique produces a low average power for the procedure, in accordance with the above mentioned fundamental of laser-tissue interaction. A number of the newer available dental lasers, whether continuous/gated or free-running pulse devices, offer very small pulse durations (measured in micro-seconds). This is especially important for surgery on both fragile soft tissue and any hard tissue to minimize harmful thermal effects.

Conversely, since achieving hemostasis ideally involves sustained heat penetrating into tissue, a pulse that is too short may cause difficulty during procedures on highly vascularized tissue.

Some instruments use small, flexible glass fibers to deliver laser energy (Figure 3), while others use more rigid, tube-like devices (Figure 4). The shorter wavelengths have small, flexible glass fiber optic delivery systems, with bare fibers that usually contact the target tissue. The technical challenges of conducting the longer Erbium and Carbon Dioxide wavelengths are demanding, and some manufacturers have chosen to use semi-flexible hollow wave-guides or rigid sectional articulated arms to deliver the laser energy to the surgical site. Some of these systems use additional small quartz or sapphire tips, which attach to the operating handpiece; other systems simply are used out of contact with the tissue. In addition, the Erbium family and the 9300nm Carbon Dioxide lasers use a water spray for hard-tissue procedures.

Laser Safety

There are numerous safety regulations that are necessary for the operation of a dental laser.[23,24] These include:

1. The presence of a designated safety officer. This person is the "keeper of the key," which allows only authorized personnel to have access to the laser instrument. The safety officer also must maintain a safe and protected surgical suite, and be familiar with the operator's manual and manufacturer's recommendations for maintenance. Furthermore, this person should oversee the inventory of supplies for laser use as well as supervise staff education and training.

2. Government specified controls on the instrument. The Food and Drug Administration through its Center for Devices and Radiologic Health, sets standards that specify certain safety features that must be installed on each laser. Some examples are a key-lock switch, an emergency stop button, interlocks, laser emission indicator, and a guarded footswitch.

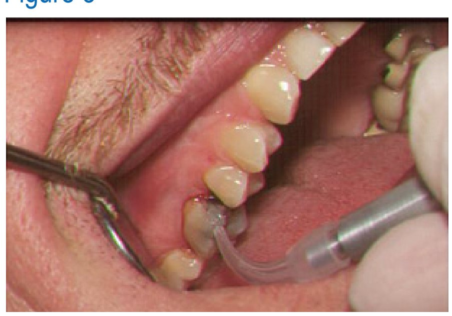
3. The use of wavelength specific protective glasses for the surgical team, the patient and any observer. The eyewear must be designed with side shields, and must minimally attenuate the laser beam to one-ten thousandth of its output power. The glasses must be clearly marked with the wavelength for which they offer the protection.

4. An operatory with limited access and minimal reflective surfaces. A sign with specific information is to be posted outside of the laser beam's hazard zone. The hazard zone is the clear area where eye and other protective measures are essential. Each laser manual has the information to determine the hazard zone.

5. High-volume evacuation of the laser plume. The laser plume may contain many biohazards, such as viruses, blood by-products, and metallic fumes, as well as odors.

6. Adherence to infection control standards for surgical devices. The standard of care for surgical devices is steam sterilization for small flexible optic fibers, handpieces, and tips. The remainder of the laser and its attached delivery system should receive a surface disinfectant protocol.

Figure 3



A small diameter glass fiber placed in the periodontal pocket.

Figure 4

An articulated arm that delivers laser energy coupled to a handpiece (not shown).

Benefits and Considerations

One of the main advantages of using dental lasers is their ability to selectively and precisely interact with diseased tissues. Lasers also allow the clinician to reduce the amount of bacteria and other pathogens in the surgical field,[25,26] and, in the case of soft-tissue procedures, achieve good hemostasis with the reduced need for sutures.[27] The hard tissue devices can selectively remove diseased tooth structure since carious lesions have a much higher water content than healthy tissue, and water is very well absorbed by these wavelengths of laser energy.[28,29] Studies with the Erbium family instruments have shown advantages over conventional high-speed handpiece inter- action of the tooth surface.[30] For example, there were no undesirable thermal effects such as surface cracking or carbonization on the enamel or dentin surfaces. The laser actually decreased the pulpal temperature in one study[31] and had a significantly lower temperature rise compared to a handpiece in another study.[32] Moreover, it has been reported that laser etching is beneficial to bond strength.[33,34] Osseous tissue removal and contouring can proceed easily with the Erbium family of instruments[35,36] and the 9,300 carbon dioxide laser is equally efficient for teeth and bone.[37] Some clinicians report that they utilize less injectable anesthesia while during laser treatments. There are several well-documented case reports describing successful and comfortable treatment, but no rigorous statistical studies have been published to date. While all of the described lasers have various degrees of portability, some current models of diode lasers have been reduced in size to that of a large ballpoint pen. These lasers feature fingertip control and use disposable tips to contact the tissue. They, along with other diode lasers are powered by batteries; moreover, some of the 'desktop' models have wireless foot controls for maximum ease of use.

There are some disadvantages to the currently available dental laser instruments. They are relatively high cost and require training. Instruction can vary with each manufacturer, but the clinician should insist on completion of rigorous hands-on simulation exercises to gain an adequate understanding of laser-tissue interaction for the various procedures that he/ she intends to perform. The author recommends achieving Standard Competency Certification by participating in a scientifically based course. Because a majority of dental instruments are both side- and end-cutting, a modification of clinical technique will be required. Also, no single wavelength will optimally treat all dental disease. Accessibility to the surgical area can sometimes be a problem with some current delivery systems, and the clinician must prevent overheating the tissue while attempting to complete a procedure. One additional drawback of the erbium family and 9300nm Carbon Dioxide lasers is the inability to remove defective metallic and cast porcelain restorations. Of course, this limitation in some cases could be quite beneficial when treating small areas of recurrent decay around otherwise sound restorations.

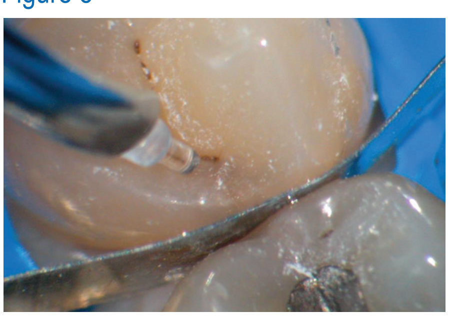
Examples of Clinical Procedures

Caries removal, tooth preparation, and removal of defective composite filling material can be accomplished with Erbium and the 9300nm Carbon Dioxide lasers. The laser only acts in an 'end cutting' mode, so the clinician must be aware that removal of tooth structure is accomplished by making a series of shallow craters by moving back and forth along the surface. Once these craters are connected, they can be increased in depth. This is quite different that the conventional high speed burr, whose abrasive action grinds sideways.

When using an erbium laser, the higher the water content of the target tissue, the easier ablation will occur. Diseased tooth structure has greater water content than healthy enamel or dentin, so the laser interacts selectively with the carious lesion. On the other hand, if a fluoride ion has widely replaced the hydroxyl group, the laser energy will have to be increased to be effective. The 9300nm Carbon Dioxide's photons are well absorbed by carbonated hydroxyapatite as well as water, and that wavelength will remove healthy enamel along with the carious lesion. Figures 5 through 10 show both the erbium and 9300nm Carbon Dioxide lasers used in restorative dentistry. (Figures 8 through 10 courtesy of Convergent Dental, Natick MA.)

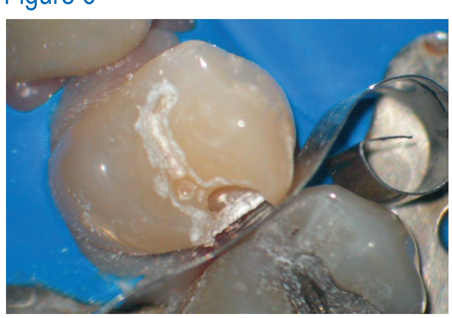
Soft-tissue excisions are easily performed with a laser. The targeted lesion is grasped with forceps or a similar instrument, and the laser beam is directed toward the lesion's connection with the

Figure 5



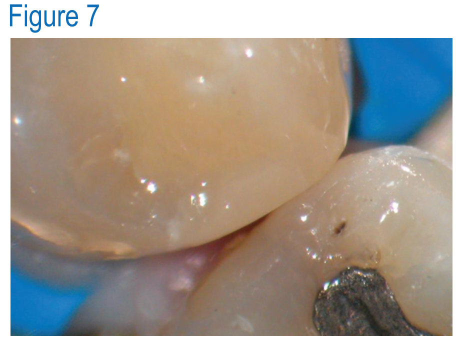
The Erbium laser is about to begin removing carious tooth structure.

Figure 6



The lesion is clean and the preparation is finished.

Figure 7



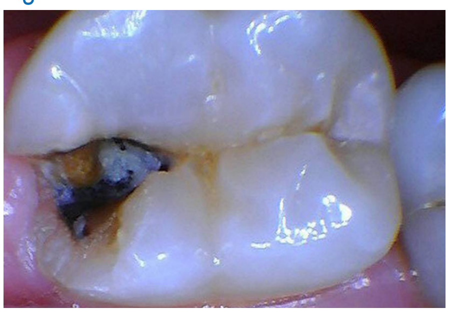
The tooth is restored.

healthy portion of the tissue. The clinician must allow the thermal reaction to proceed and to be careful not to tear the tissue, remembering how the tissue is absorbing the laser wavelength. Generally speaking, sutures are not usually necessary, and the wound will heal well by secondary intention. Figures 11 through 13 show an erbium:YAG laser removal of a fibroma, and Figures 14 through 16 show an Nd:YAG laser frenum revision.

Soft-tissue retraction and removal for placing restorations and implant fixtures also spotlight the usefulness of a dental laser. When the proper parameters are followed, final impressions for the restorative procedure can be taken immediately, with confidence that the tissue will remain at its treated height and contour. Figures 17 through 21 demonstrate the use of a diode laser in creating a dry field for a perfect impression. (Photos courtesy Dr. John Graeber, East Hanover, NJ)

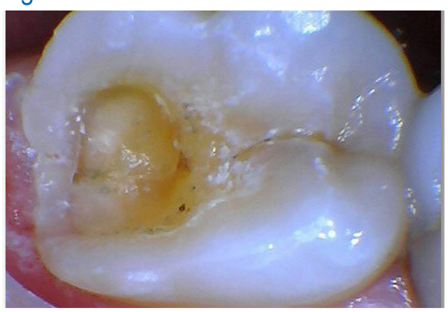
Many prescription medications can cause fibrous gingival overgrowth, and the removal of that tissue can be accomplished with any laser. If the clinician uses one of the shorter wavelength instruments, there will be minimal interaction with dental enamel and cementum. However, some fibrotic areas with minimal vascularity might be more efficiently ablated with longer wavelength lasers, although care must be taken to protect the adjacent tooth structure. Furthermore, any dental laser can be used for removal of the gingival tissue to uncover an implant. While no dental laser can actually cut metal, the surgeon should always use a technique that can prevent or at least minimize heat build-up

Figure 8



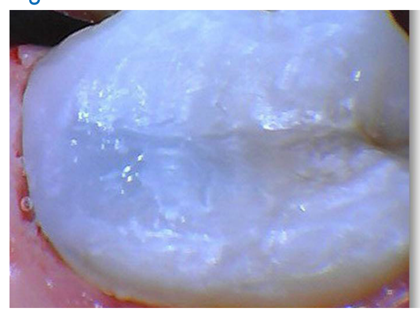
Pre operative photo of a large carious lesion with a small amount of distal gingival tissue impinging on the margin.

Figure 9



Using the 9300nm Carbon Dioxide laser, the gingival tissue is contoured and the preparation is completed.

Figure 10



The build up material is placed.

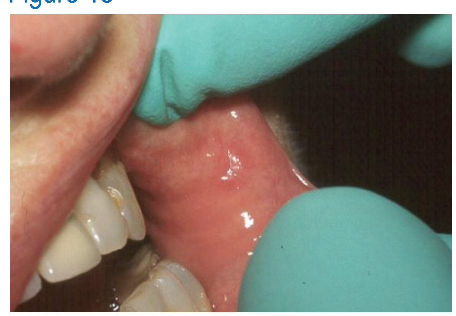
Figure 11

Preoperative view of irritation fibroma in need of removal.

Figure 12

Immediate post-operative view of the surgical site where the erbium laser was used.

Figure 13



One week post-operative view showing good healing.

Figure 14

Preoperative view of mandibular anterior frenum in need of revision.

Figure 15

Immediate post-operative view of the surgical site where an Nd:YAG laster was used.

Figure 16

Two week post-operative view showing good healing.

on the implant fixture. Figures 22 through 24 show how a diode laser can be used in uncovering the integrated fixtures for implant restorations.

Recent studies have shown that lasers may be used for adjunctive treatment of periodontal and peri implant disease with good results.[38-41] The Erbium laser can remove calculus, disinfect the pocket, and be used adjunctively for surgery,[42-44] and other wavelengths can be adjunctively used on the diseased epithelial sulcular tissue.[45-51] As mentioned above, photo activated disinfection can also be added to the periodontal therapeutic protocol.[52,53] Figures 25 through 27 show pocket reduction therapy using a diode laser, figures 28-30 show pocket depth reduction for periimplant mucositis, and figures 31-33 illustrate a technique for photo activated disinfection.

Esthetic or restorative crown lengthening procedures also demonstrate the laser's precision and versatility. Once again, the KTP, diode, Nd:YAG and Nd:YAP instruments can easily remove soft tissue with very little tooth interaction, and the Erbium family along with the 9300nm Carbon Dioxide lasers will remove bone to remodel and restore the periodontium. The tissue removal must be carefully planned so that biological width is maintained. If bone

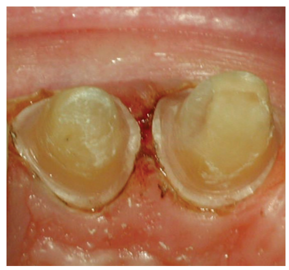
Figure 17

Pre-operative view of maxillary left central and lateral incisors that are treatment planned for crown restorations.

Figure 18

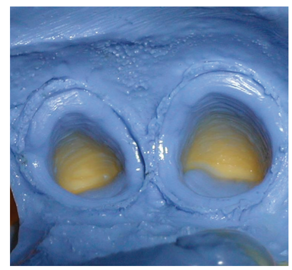
Preparations are completed.

Figure 19



Diode laser used for tissue retraction and hemostasis. Note the completely dry field.

Figure 20

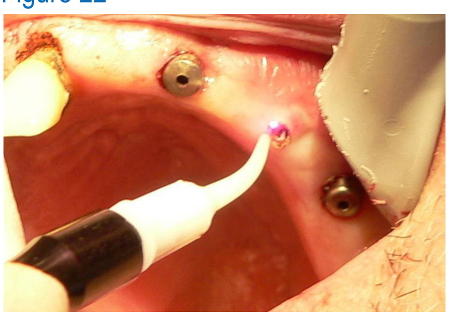


Impression taken immediately after laser treatment shows excellent marginal detail.

Figure 21

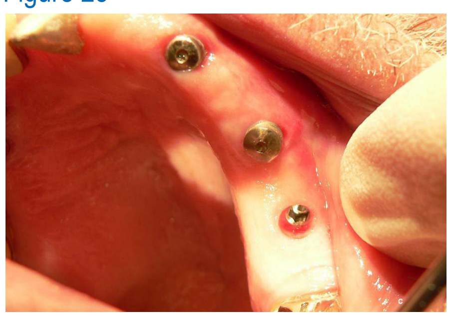
Two week post-operative view showing good marginal adaptation. There was no tissue loss or rebound after the laser treatment.

Figure 22



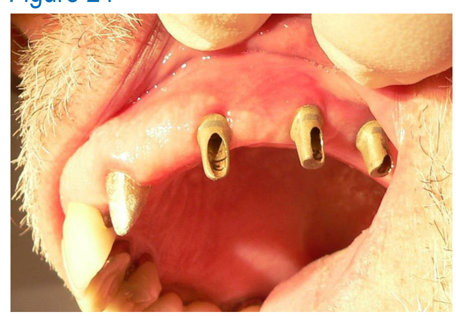
Diode laser beginning to uncover the last of three implant fixtures placed six months prior.

Figure 23



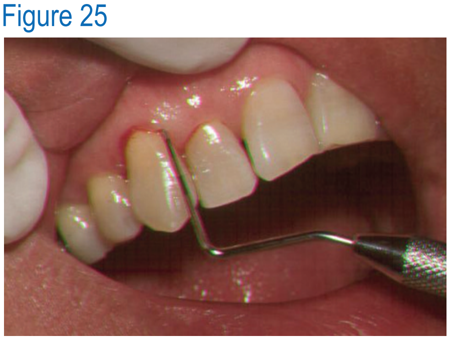
Two week post-operative view of the healed and well contoured soft tissue around the fixtures. The healing cap is removed from the distal most fixture to show the excellent tissue tone.

Figure 24



Final abutment copings in place.

Figure 25



Pre-operative view of inflamed periodontal pocket. No calculus is present.

Figure 26

Diode laser used for removal of diseased epithelial lining of the pocket, bacterial reduction and hemostasis.

Figure 27

Six months post-operative view of periodontal health. Note the lack of tissue recession.

is removed, the water spray must be switched on. Figures 34 through 36 demonstrate a diode laser used for soft tissue removal for esthetics. Figures 37 through 39 depict an osseous removal procedure to provide adequate tooth structure for a crown. Figures 40 through 42 illustrate removing impinging gingiva to access a carious lesion removal. (Figures 40-42 courtesy of Convergent Dental, Natick, MA.)

There are other clinical procedures that can utilize a laser. There is one device (Diagnodent, KaVo Dental, Lake Zurich, IL) that uses a visible red laser beam to detect fluorescence of dental caries and a sensor that detects the difference between the light reflected from sound and diseased tooth structure. Another technology, generally termed optical coherence tomography (OCT) uses a near infrared laser beam that is split to produce a three dimensional image. Devices such as these have the ability to aid in more accurate diagnosis of carious lesions compared to conventional techniques.[50,51] For endodontics, the ability to significantly reduce root canal system bacteria is a tremendous advantage of the laser,[56,57] and further development of specific intra-canal tips will enhance the device's utility.[58]

Figure 28

Pre-operative view of peri-implant mucositis with inflammation surrounding the implant.

Figure 29

Diode laser used for removal of diseased pocket lining, bacterial reduction, and hemostasis. Biofilm and other accretions removed from the implant with hand instruments prior to laser use.

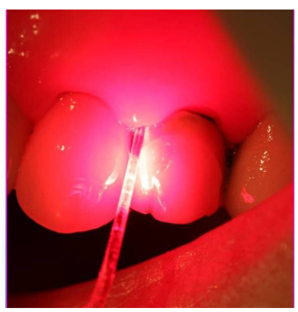
Figure 30

Four month post treatment probing shows healthy tissue and implant stability.

Figure 31

After conventional periodontal therapy, a photo-sensitizer solution (methylene blue) is applied into periodontal pocket and surrounding gingiva.

Figure 32



Visible red laser energy applied to enable photo-activated disinfection.

Figure 33

One week post therapy view shows lack of inflammation.

Figure 34

Pre-operative view of excessive gingival tissue.

Figure 35

Immediate post-operative view of diode laser gingivoplasty. Biological width was measured before surgery to ensure availability of tissue for excision. Note contours placed with the laser.

Figure 36

Six months post-operative view. Note good tissue tone, contour and esthetic result.

Tooth whitening agents can be accelerated by various laser wavelengths; the catalyst simply needs to interact with the light, whether visible or invisible.[59] This method of tooth whitening is as effective as other methods[56] with one study showing the achievement of a lighter shade with the laser compared to a halogen light.[61]

In the future, new instruments now in development will provide new and exciting applications. For example, a deep blue light laser, approximately 400 nm, is being studied for the selective removal of dental calculus and caries.[62] A very short pulsed carbon dioxide laser, along with fluoride varnish, has shown promising results for prevention of carious lesions.[63,64]

Conclusion

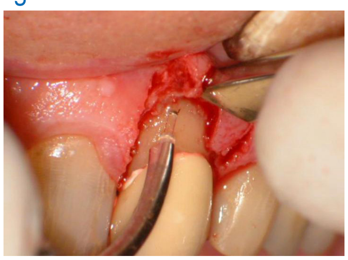
There are several resources for more information on lasers. Journals and textbooks are listed in the reference section. As with all dental materials and instruments, the practitioner must use clinical experience, receive proper training, become very familiar with the operating manual, and proceed within the scope of his or her practice.[65]

Keeping in mind the different absorption characteristics of laser energy as well as the varied composition of dental tissues, there is no one perfect laser.

Figure 37

Pre-operative view; determination of inadequate biological width.

Figure 38



Erbium laser used to remove bone and establish new osseous contour.

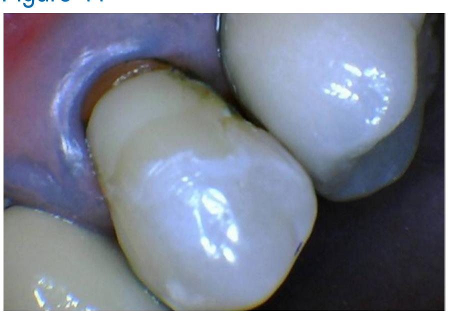
Figure 39

Six week post-operative view showing tissue healed

Figure 40

Eight week post-operative view immediately after crown cementation.

Figure 41



Pre operative view of a composite restoration with a recurrent carious lesion extending subgingivally.

Figure 42

9300nm Carbon Dioxide laser used for a gingivectormy, composite removal, and tooth preparation.

Figure 43

Restoration placed with excellent tissue management.

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POST-TEST

Internet Users: This page is intended to assist you in fast and accurate testing when completing the "Online Exam." We suggest reviewing the questions and then circling your answers on this page prior to completing the online exam.

(1.0 CE Credit Contact Hour) Please circle the correct answer. 70% equals passing grade.

1. Good safety practices should be standard protocol during surgical laser procedures. Which of the following is NOT necessary for a safe laser procedure?

a. Use of rubber dam
b. Laser-in-use signs
c. Protective glasses
d. High-volume evacuation

2. The basic emission modes of dental lasers are:

a. plasma pulsed and mode locked.
b. continuous wave and free running pulsed.
c. ultra speed and constant.
d. ultraviolet and infrared.

3. As soft issue temperature rises, various effects occur:

a. tissue welding
b. deep tissue carbonization
c. tissue vaporization
d. protein denaturation and blood coagulation

4. Laser excisional surgery is accomplished at what temperature?

a. 50 degrees Celsius
b. 60 degrees Celsius
c. 100 degrees Celsius
d. 100 degrees Fahrenheit

5. The primary laser-tissue interaction is:

a. photoacoustic
b. photo-disruptive
c. photothermal
d. photo-plasmic

6. Which of the following characteristic(s) could be used to describe laser energy?

a. totally reflected from the target
b. contains very high thermal energy
c. never divergent
d. monochromatic and coherent

7. When performing a laser procedure, the clinician should:

a. Begin the procedure by using the maximum out power of the instrument.
b. Begin the procedure by using a minimum power setting suggested by the operating manual.
c. Carefully observe the interaction of the laser and the target tissue and adjust the laser parameters accordingly.
d. B and C

8. Bacteria and other pathogens in tissue just exposed to laser energy:

a. are markedly reduced.
b. are unaffected.
c. Multiply rapidly.
d. mutate into resistant strains.

9. Laser energy is most effective when it is absorbed by the target tissue. Which of the following statements is true?

a. Diode and Nd:YAG wavelengths are readily absorbed in dental hard tissue.
b. Diode and Nd:YAG wavelengths are readily absorbed in blood components and tissue and bacterial pigments.
c. The Carbon Dioxide wavelength does not interact with soft tissue.
d. All laser wavelengths are well absorbed by water.

10. In general, laser dentistry offers a number of advantages over conventional dental treatment. Which of the following statements is true regarding the use of lasers in dentistry?

a. Lasers provide hemostasis by sealing small blood vessels.
b. The Erbium laser can easily and rapidly remove a defective cast gold crown.
c. The Nd:YAG laser is able to recontour bone and eliminate more complex surgical methods.
d. Lasers remove tissue by side cutting, very similar to a dental burr.

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