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Diode Lasers: A Primer

A Peer-Reviewed Publication
Written by John J. Graeber DMD MAGD MALD FICD

Abstract

The diode laser has become the most commonly utilized laser in dentistry. While diodes include wavelengths from 800 through 1064 nanometers, the 810 devices predominate. Diode lasers have many advantages over traditional surgical and therapeutic techniques including less pain, faster healing and new applications. Every specialty area of dentistry can utilize the powers of laser energy. Unfortunately, even after FDA approval over 20 years ago, many dentists have little knowledge of lasers. The basics of clinical applications, advantages of lasers, and basic laser science are presented in this course.

Educational Objectives

At the end of this self-instructional educational activity participants will be able to:

- 1 Identify the primary and secondary procedures indicated for diode lasers
- 2 Make a reasonable assessment if a diode laser would be an appropriate purchase for their practice
- 3 Explain the advantages of using diode lasers over traditional techniques in dentistry
- 4 Expand the scope of services offered if a diode laser is added to the practice

Author Profile

John J. Graeber DMD MAGD MALD FICD is one of America's most experienced laser dentists. He maintains a full time comprehensive cosmetic practice in East Hanover, New Jersey utilizing Nd:YAG, Diode, Erbium:YAG and Erbium Cr:YSGG dental lasers since 1991. He has lectured internationally in many dental schools, esthetic continuums, and major dental meetings for more than 20 years on both lasers and air abrasion. He has trained thousands of new owners for most of the major dental laser manufacturers. Dr. Graeber is Vice President of the Academy of Laser Dentistry.

Author Disclosure

Dr. Graeber is the owner of Softtouch Seminars, Director of Training, CAO Group, Consultant to Patterson Dental Supply. He can be reached at hitekdr@mac.com

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Abstract

The diode laser has become the most commonly utilized laser in dentistry. While diodes include wavelengths from 800 through 1064 nanometers, the 810 devices predominate. Diode lasers have many advantages over traditional surgical and therapeutic techniques including less pain, faster healing and new applications. Every specialty area of dentistry can utilize the powers of laser energy. Unfortunately, even after FDA approval over 20 years ago, many dentists have little knowledge of lasers. The basics of clinical applications, advantages of lasers, and basic laser science are presented in this course.

What do diode lasers do?

In the 18 years since FDA approval, the diode laser has assumed a prominent role in managing soft tissue in the general delivery of dental services. Among the procedures cleared for marketing by the FDA are ablating, incising, excising and coagulation for all types of intraoral soft tissue surgery. Specific approvals include; aphthous ulcer treatment, sulcular debridement, removal of coronal pulp, adjunct to root canal procedures, pulpotomy as adjunct to root canal retreatment, tooth whitening, aid in diagnosis of dental caries, blood flow measurements, treatment of herpetic lesions, coagulation of extraction sites, reduction of bacterial levels (decontamination) and inflammation, aid in detection and localization of subgingival dental calculus, and removal of highly inflamed edematous tissue affected by bacterial penetration of the pocket lining and junctional epithelium.¹

Diode lasers are most useful for managing soft tissue while performing restorative procedures. Diseased tissue is often inflamed, enlarged and interferes with good restorative techniques. Ideally, all periodontal abnormalities should be managed prior to the restorative phase of treatment; however, this is often not possible. Inflamed tissue bleeds easily, and can prevent proper impressioning for indirect restorations and potentially cause staining of cement margins. Blood also will interfere with bonding to dental surfaces, inviting premature restoration failure. Overgrown tissue also presents challenges to good restorative results both aesthetically and functionally. Conventional means of managing inflamed tissues include injected and topically applied compounds such as epinephrine, aluminum chloride and ferric salts. These vary in side effects and efficacy.

Electrocautery is effective for coagulation of open vessels as well as removing excess tissue. Historically; however, electrocautery causes excessive thermal damage and little predictability of final tissue levels relative to restoration margins.

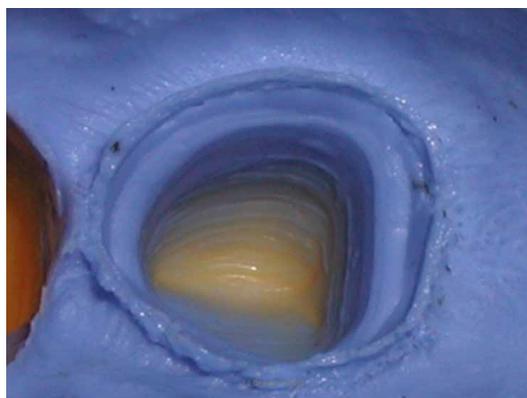
Diode lasers can overcome most of the above mentioned deficiencies of conventional techniques. Coagulation is virtually complete as the red blood cells are coagulated within blood vessels. Inflammatory and granulomatous tissues prone to bleeding during manipulation are surface ablated and coagulate easily. Due to unique absorption characteristics, diode lasers are more selective in coagulation properties. When appropriately operated, there is far less deep thermal damage, especially in normal tissue. The lasers are carried to the tissue through the tip of fiberoptic cables and only exit the fibers, in most cases, in a straight line capable of end cutting only, whereas electrons emanate in all directions from the active electrode of electrocautery units. This phenomenon may partially explain why there is less lateral thermal damage from the use of diode lasers compared to electrosurgery.

COMMONLY PERFORMED PROEDURES:

Crown Troughing:

Perhaps the most commonly performed soft tissue laser procedure is the preparation of gingival tissue for impressioning. This is often referred to as troughing. As opposed to traditional retraction techniques, the diode laser easily and thoroughly prepares a space for impression material. Traditional retraction cords require up to 5 minutes to adequately distend the tissue and create adequate space. Lasers usually require 30-60 seconds to achieve retraction which does not rebound because lasers remove the internal epithelial lining of the gingival sulcus (Figure 1).

Figure 1. VPS impression after troughing with diode laser. Laser trough is approximately 0.5 mm deep and 0.5mm wide adjacent to the bevel of the preparation.



This creates space at the expense of the vaporized epithelium and tends to remain open until the epithelium repopulates over the exposed coagulated connective tissue. Bacteria within the sulcus may also be vaporized by the action of the laser beam or are at least coagulated, preventing normal cell division.^{1,2} There are anti-inflammatory effects which helps the irradiated tissue regain normal appearance.³ Epithelium from the adjacent free

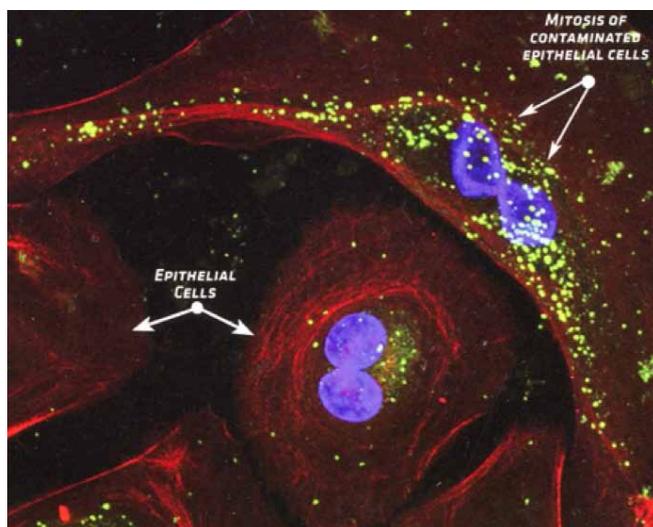
and attached gingiva migrates across the coagulated connective tissue. Studies confirm the accelerated regrowth of the vaporized epithelial cells.⁴

When the diode laser is compared to electrosurgical units, there are some similarities and a number of differences. The electrons of electrocautery machines travel from the active to the passive electrode similarly through all tissues containing water. There is no differentiation as there is with photonic emission. This will be fully explained in the section on laser-tissue interaction. There are contraindications to using electrosurgical instruments including patients with a pacemaker and usage on restorative metals. There is a plume output issue with electro-surgery which far exceeds that produced by proper laser use. Finally, loss of gingival height after troughing with electro-surgery averages about one millimeter which is somewhat unpredictable. Typical troughing with a diode laser frequently causes a slight regrowth of about ½ mm or no change.

Pocket Disinfection:

Scaling and root planing is a commonly performed procedure in the general dental practice. While periodontitis has a bacterial etiology, little of the conventional technique is directed toward the causative microorganism colonies, many of which are trapped within the granulation tissue and diseased epithelial cell layer. High doses of powerful adjunctive antibiotics, with their potential side effects, are commonly used to address the causative bacteria in conventional therapy. Pigmented anaerobic microorganisms including *Prevotella intermedia* and *Porphyromonas gingivalis* are among the most common pathogens of periodontitis. The wavelengths of diode lasers are well absorbed by these bacterial types. Photonic energy penetrates into granulation tissue and diseased epithelium and causes these microorganisms to warm to coagulative temperatures and dramatically reduce their number and ability to form colonies for up to 90 days^{5,6} (Figure 2).

Figure 2. Infected sulcular epithelial cells showing presence of *P. gingivalis* within cellular structure.



Other photonic effects include anti-inflammatory and biostimulatory effects. The release of histamine-mediated inflammation is inhibited by near infrared wavelengths (750-2000 nm) utilized by the diode laser. Energy absorbed by individual cells' mitochondria translates into increased production of ATP, increasing post exposure cellular division up to 4X in the first 24 hour period.⁴

Patients receiving diode laser assisted scaling and root planing report less pain during treatment after receiving near infrared laser pre-treatment, and less post-op pain. Research indicated that patients treated with lasers in the near infrared wavelengths may experience longer lasting effects than mechanical scaling and root planing therapy alone in terms of altering the subgingival microflora.⁷

Clinically, laser patients exhibit less sensitivity to the physical stress of treatment and have less post-operative discomfort compared to scalpel surgery (Figure 3).

Figure 3. Diode laser fiber being inserted into pocket for decontamination during scaling and root planing procedure.



Gingival Contouring:

Dental aesthetics involve much more than just teeth. The gingival complement forms the surrounding anatomical features delineating height, width, coronal form and to an extent, color. Hyperplasia of the gingiva occurs from a variety of events and conditions including; prior episodes of inflammatory disease, food impaction, abrasion, pathological lesions, and orthodontic appliances, among others. A diode laser is a very useful instrument in contouring gingival tissues back to normal size and appearance. Restorations of any type are enhanced when placed into a normal gingival architecture and environment. The quality of the restoration is enhanced and the physical properties of the restoration and luting agents are optimized. Ideal impressions can also be achieved consistently when the gingiva is healthy and properly contoured. Properly contoured restorations help maintain normal form and function of the gingival complement (Figures 4, 5, 6).

Figure 4. Pre-op soft tissue crown lengthening of maxillary central incisors.



Figure 5. Immediate post-op



Figure 6. Final case appearance.



When gingivoplasty is performed with a scalpel it can be accompanied by bleeding, post-operative pain and swelling and the potential for post-operative infection. Furthermore, because of inflammatory-mediated healing, the resulting anatomical form can be unpredictable. Healing time is longer with this type of this approach as well. Most often, three months of uneventful healing is necessary for full recovery of the gingival complex. The use of long term provisionals is a less than desirable choice for the patient and clinician. In practical terms, this traditional approach is often unacceptable to patients used to having everything done for them instantaneously.

Today's diode laser is an alternative to the traditional dilemma of how to perform gingivoplasty and provide definitive restorative treatment at the same appointment. When a near-

infrared laser ablates or vaporizes tissue, the underlying connective tissue is coagulated. This coagulated layer is only a few hundred microns deep. The deeper connective tissue under this coagulated layer is relatively undisturbed. The coagulated layer becomes the protective barrier to bacterial invasion. The absence of hemorrhage does not trigger the inflammatory response to injury. Since there is no histamine release, there is no swelling, provided there has been no excessive heat buildup in the tissue. In addition, nerve endings are sealed off by the coagulative effect. The primary causes of post-operative inflammation, swelling, and the exposure of nerve endings do not occur and do not trigger pain.

From the practical perspective, tissue may be excised to remove bulk, and the end cutting action can be used by the surgeon to sculpt the remainder of the excision by pure ablation. This provides far more surgical precision than other methods. The healing mechanism of lased wounds varies greatly from scalpel surgery. Since there is no inflammation, the first 7-8 days of traditional healing are bypassed. This allows the wound to proceed directly to tissue repair which is further enhanced by biostimulatory action on individual cell mitochondria which results in enhanced cell division. Epithelial cells migrate from the borders of the wound to close the wound faster than the traditional technique.

Periodontal Surgery:

Diodes can be of immense benefit when utilized in periodontal surgical cases including; initial incisions, degranulating defects, decontaminating diseased pockets and biostimulating tissue resulting in faster healing. The continuous wave feature of the diodes makes them very efficient. Often, full flaps are not needed for access as the diode can open sufficient subgingival space for both instrumentation and visualization of many bony defects. This alone reduces surgical time and enhances post-operative healing (Figure 7).

Figure 7. Diode laser utilized in flapless periodontal surgery for 6 mm pockets.



Oral Surgery Made Easy:

Other than simple extractions, many general practitioners do not perform routine oral surgical procedures for a variety of reasons including: little hemorrhage control, poor visualization and post-operative complication management. Diode lasers are capable of performing the same soft tissue surgeries as significantly more expensive CO₂ lasers and more easily than scalpel surgery. Surgical procedures in the vestibule, such as frenectomy and vestibuloplasty, are ideal to perform with a diode laser. Virtually no hemorrhage or post-operative infections occur and suturing is unnecessary when performed with a soft tissue laser. When biopsy isn't required, lesions of the tongue, cheek, lip and floor of the mouth such as fibromas, epulides, ranulas, and mucoceles are relatively easy to treat due to the differential ablative capability. Different tissues will absorb diode wavelengths at different rates. For example, a diode will more quickly ablate the lower density connective tissue surrounding a lesion such as the (higher density) fibrous tissue of a fibroma. Excising a lesion such as this requires a combination of the established technique of tissue tension with a newer instrument's ability to ablate tissues of different densities at different rates (Figure 8).

Figure 8. Diode laser utilized in removal of fibroma. Tissue tension applied with silk suture material.



LOW LEVEL CAPABILITIES OF DIODE LASERS

Many ulcerative and inflammatory lesions are easily managed with the diode laser utilized in "out of focus" modes. These lesions include aphthous ulcers, herpetic lesions both of the lip and intraoral tissues, angular cheilitis, denture sores, and iatrogenic inflammation of the mucosa⁸(Figure 9).

Most of these lesions can be rendered pain-free in a matter of minutes with diode wavelengths without contacting the lesion and without the need for any local or topical anesthesia. Patients with painful lesions are overwhelmed by the simplicity and relief provided by diode lasers without the need for prescription medications which are of little immediate benefit.

Figure 9. Low level laser treatment of herpetic lesion with diode laser. Post op results; 48 hours after treatment.



Diodes and Implants:

Diodes are an excellent instrument for several aspects of implant therapy. Uses include; uncovering submerged implants, creating the appropriate emergence profile through the soft tissue, or removing the soft tissue ingrowth between the fixture and the abutment or cover screw. Diodes are safe to use around implants. They create a dry, coagulated tissue surface which is much easier to work with to achieve excellent impression and cementation results (Figure 10).

Figure 10. Diode laser exposure of submerged implant.



The near infrared wavelengths of diodes are not absorbed by titanium or any other restorative material. The coagulative properties are very durable and are not disturbed by impression materials or restoration manipulation around an implant fixture. Other advantages of diode laser usage with implants are the ability to trough around abutments for consistent impressions and

disinfection of implant surfaces. Diode lasers have also been shown to be an efficient, comfortable method of performing second-stage implant surgery facilitating a faster rehabilitative phase.⁹

Diodes and Endodontics:

Disinfection of canal microorganisms remains a goal of successful endodontic treatment. In recent years, bacterial resistance has been identified as one of the causes of endodontic failure. Time honored disinfection protocols such as sodium hypochlorite irrigation are no longer considered adequate for clinical success. Alternative irrigants such as chlorhexidine with laser treatment have been mentioned in the literature as a way to deal with this issue. An erbium,chromium:YSGG laser demonstrated the ability to remove the smear layer from lateral canal walls, allowing greater lateral penetration of irrigants and laser energy.¹⁰

A diode laser with a wavelength of 810 nm demonstrated bacterial reduction, regardless of antibiotic resistance or traditional irrigants¹¹ (Figure 11).

After appropriate mechanical preparation, diode laser fibers can be inserted to within 3 mm of the apex and be used approximately one minute per canal for added disinfection. In vitro visualization of this irradiation technique shows significant transmission and reflection of the energy through the entire root. Grossly infected teeth and endodontic re-treatments are among the most appropriate indications for laser intervention. Proper power settings are critical to avoid excessive heat buildup with the potential of damaging periodontal membrane and osseous tissue.

Other endodontic applications of the diode wavelengths include coagulation and disinfection of pulpal exposures, pulpotomy, and disinfection and degranulation of periapical tissues during endodontic surgery.

Figure 11. Pulpotomy of primary molar with diode laser



Orthodontics and the Diode Laser:

The diode laser can play a role in the management soft tissues before, during and after orthodontic treatment. The diode laser can be utilized pre-treatment to remove soft tissue roadblocks such as aberrant frenula, and gingival tissue around partially

erupted teeth. Full soft tissue impacted teeth can be exposed for bonded attachment placement. These techniques allow immediate bonding of the brackets into a dry, bloodless field at the time of surgery. Diode surgery can often be accomplished painlessly with the aid of topical anesthetics or a minimal amount of injected local anesthetic. During treatment, hyperplastic tissue of the gingival papillae can be reduced to allow space closure. Early orthodontic movement can be facilitated by removing overlying tissue, reducing the need to rebond brackets as the tooth erupts (Figure 12).

Figure 12. Diode laser exposure of unerupted cuspid.



Additionally, post-treatment gingival alteration from orthodontic appliances and bacteria-mediated gingival hyperplasia is easily addressed in a bloodless field utilizing diode lasers.¹²

Laser Theory:

The supporting theories which led to the eventual development of lasers evolved from the work of Neils Bohr on quantum theory and the description of the atom. Bohr came up with the idea of Spontaneous Emission which states that electrons surrounding a nucleus are capable of absorbing energy from an external source and then releasing that energy spontaneously in the form of a photon. The photon is the smallest packet of energy known. Soon after the acceptance of the Spontaneous Emission Theory, Albert Einstein postulated his Theory of Stimulated Emission. Einstein stated that an atom in the excited state could absorb a second photon of external energy and this additional energy is released naturally. The 2 photons of energy released would be unique in that the energy would be of the same wavelength. Photons of the same wavelength could then stimulate atoms nearby and cause a chain reaction to occur. The chamber which contained all of this photonic activity could have a slight opening to allow the excess photon out and be harnessed to do work.

Quantum theories of the early 20th century sat virtually dormant during 2 world wars and the great depression until mid-century when radar and microwave forms of energy were developed. In fact, when the first true laser was finally built by Theodore Maiman in 1960, his colleagues criticized him for inventing something which seemingly had no function.

LASER is an acronym: Light Amplification by Stimulated Emission of Radiation. Many different wavelengths are utilized in medicine: Maiman's ruby laser (690 nm) in dermatology, carbon dioxide (10,600 nm) in general surgery, and the Nd:YAG (1064 nm) in ophthalmology, among others. The key for dentistry is the identification of those particular wavelengths which are most useful in the oral cavity. The first such wavelength, 1064 nm, was approved by the FDA specifically for dentistry in 1989. The key to the usefulness of the Nd:YAG is that this wavelength is highly absorbed in oral soft tissue.

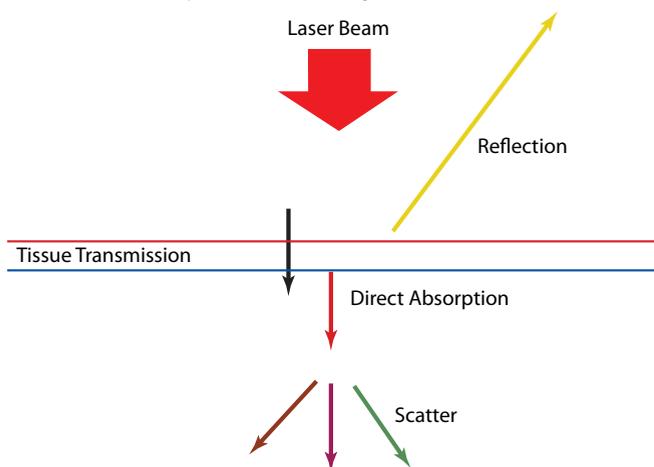
A few years later, semiconductors utilizing aluminum, gallium and arsenide, capable of emitting laser energy in the 800 nm range became available. This wavelength is very similar to the Nd:YAG laser in how it is absorbed by oral tissue.

Diodes cost significantly less than the older units and they can be made into a size similar to a dental handpiece. Today, diode lasers can cost as little as an electrocautery or ultrasonic scaling unit.

Laser-Tissue Interaction:

Perhaps the most important principle of lasers for a practitioner to understand is laser-tissue interaction. First, it is important to understand that the laser is not just a hot instrument. Heat is not produced until the tissue absorbs a particular wavelength. The absorbed energy causes the tissue temperature to rise slowly, causing a series of tissue changes. First, simple warming occurs from normal body temperature of 37 degrees centigrade up to 60 degrees centigrade. The next warming stage (60-90 degrees) brings about coagulation and protein denaturation. Finally at 100 degrees centigrade, vaporization begins as the intra and extracellular water of each cell begins to boil away. Each of these stages has specific biologic phenomena. Coagulation prevents hemorrhage, protein denaturation prevents bacterial cell division as well as sealing of nerve endings. Vaporization facilitates incision into tissue, ablation of structures and sterilization of the surface. Laser energy that is not absorbed will simultaneously be reflected, transmitted and scattered (Figure 13).

Figure 13. Diagram of laser-tissue interaction depicting reflection, transmission, absorption and scattering.



The occurrence of these phenomena depends on the tissue composition as well as the melanin, blood, mineral, and water content of the irradiated tissue.

Most of the Nd:YAG lasers are naturally pulsed, i.e., the energy emitted is interrupted. Pulsing any laser beam will lower the average power, decreasing efficiency and speed of ablation. Diode lasers are emitted in a continuous wave and may be pulsed whenever more control is indicated. This follows Einstein's Theory of Stimulated Emission. The semiconductor lasers such as the diode are true continuous wave devices; however, they may also be pulsed. Today they are primarily pulsed by electronic means, thus the time that a laser beam is actually interacting with tissue can be adjusted. The length of each pulse can be controlled and the interval of time between each pulse can be adjusted. Many of the newest diode lasers have these features. The most basic devices available today have a fixed pulse rate, interval and duration, essentially limiting the use of the beam to about 50% of the time.

Most procedures performed by diode lasers can be divided into continuous wave mode, used for most surgical procedures, and pulsed mode where more control over laser output is desirable such as troughing very thin tissue or disinfecting the periodontal pocket. Each device should be used according to the manufacturer's directions.

All of the diode laser beams are carried to the target tissue through quartz glass fibers. This is the simplest and most cost effective means of conducting laser energy from its origin in the device to the oral cavity. The relatively thin fibers are between 200 and 400 microns in diameter. There may be disposable fiberoptic tips added on some models. Thicker fibers produce wider incisions and thinner fibers provide the opposite. The average width of an incision will be about 50% greater than the width of the fiber. Diode laser fibers are in focus with the target tissue when they are in slight contact. Attempting to use the sharp end of the fiber to aid in cutting is to be avoided. Allowing the laser to do the cutting is perhaps the hardest lesson to learn for a novice laser operator.

When the laser fiber tip is held in a non-contact or out of focus position, the low level effects of the particular wavelength can be realized. Bacterial decontamination, coagulation of smaller vessels, analgesia, and deeper penetration of the beam are examples of out of focus effects. Changing the power settings (wattage) will also produce various laser tissue effects. Under no circumstances should the power setting be sufficient to cause charring or burning of the tissue. Only the minimum power should be utilized to achieve a particular clinical outcome. Burning of the surface tissue will cause extreme post-operative pain and edema and tissue sloughing. There are no clinical applications which require charring.

Diode Laser Safety Concerns:

There are downsides to every treatment modality. With lasers, and in particular the diode wavelengths, the laser beam may damage the retina and lens of the eye. While a direct beam will

cause definitive damage, reflected beams can also cause eye damage to operator, staff and observers. Most laser beams are invisible to the human eye which makes them dangerous. Every person within direct visualization of any laser beam should be given safety glasses specifically rated for the particular wavelength and device in use (Figure 14). This is mandated by all governmental agencies.

Figure 14. Various wavelength laser filters for dental magnifying loupes.



In addition to visual safety concerns, vaporization also produces a plume which has been shown to contain bacteria, gases and virus particles among others. Face masks should be used which filter particle size down to 1/10 of a micron.¹³

Practice Integration:

Proper use of diode lasers can make a significant difference by providing more comfortable dental treatment for patients. Lasers provide an opportunity for practitioners to expand the scope of procedures they offer. Lasers are the future of dentistry.

Barriers to full integration include inadequate doctor training, inefficient work flow operations, and lack of understanding of the benefits of lasers in dentistry.

Laser Training:

This course should not suffice for anyone to begin utilizing dental lasers. Most device manufacturers offer training on their units. It is recommended that new users attend the training programs offered by their particular device manufacturer. Hands on training is the gold standard. In addition to training provided by the manufacturer, excellent training courses are available from the Academy of Laser Dentistry, the Academy of General Dentistry and the American Dental Association, among others.

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Author Profile

John J. Graeber DMD MAGD MALD FICD is one of America's most experienced laser dentists. He maintains a full time comprehensive cosmetic practice in East Hanover, New Jersey utilizing Nd:YAG, Diode, Erbium:YAG and Erbium Cr:YSGG dental lasers since 1991. He has lectured internationally in many dental schools, esthetic continuums, and major dental meetings for more than 20 years on both lasers and air abrasion. He has trained thousands of new owners for most of the major dental laser manufacturers. Dr. Graeber is Vice President of the Academy of Laser Dentistry.

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Questions

1. What does the acronym LASER stand for?
 - a. Light absorption through special emitted radiation
 - b. Light amplification by stimulated emission of radiation
 - c. Light amplification through stepped electric reproduction
 - d. Light activated by spontaneous energy radiation
2. A photon is:
 - a. An element which can enter into a chemical reaction
 - b. The elementary quantity, or quantum, or radiant energy
 - c. The combination of two electrically or magnetically charged particles
 - d. The internal energy of the atom
3. Besides absorption, laser beams are also:
 - a. Transmitted
 - b. Scattered
 - c. Reflected
 - d. All of the above
4. The respective energy emissions of the diode and Nd:YAG laser systems are:
 - a. 810 and 1,064 nanometers
 - b. 0.810 and 1.064 nanometers
 - c. 8,100 and 10,640 nanometers
 - d. 8.1 and 10.6 nanometers
5. Laser power is expressed in:
 - a. Joules (J)
 - b. Watts (W)
 - c. Hertz (H)
 - d. Nanometers (nm)
6. Diode laser beams are conducted by:
 - a. Quartz fiberoptics
 - b. Hollow wave guides
 - c. Articulated arms
 - d. None of the above
7. When tissue is heated to just above 60 degrees centigrade:
 - a. There is no change in the tissue
 - b. Vaporization occurs
 - c. Proteins begin to denature
 - d. Charring occurs
8. A gingival margin trimmed with a diode soft tissue laser:
 - a. Shrinks back further
 - b. Experiences slight re-growth or no change
 - c. Hypertrophies
 - d. Deteriorates
9. Dental soft tissues are usually affected by laser energy in a very specific manner. Which of the following statements is true?
 - a. Lasers ionize cellular DNA replication
 - b. Mechanical energy of the photon striking the target tissue reduces cellular size
 - c. Thermal energy vaporizes the target tissue by rapidly boiling away intra and extracellular fluid
 - d. Lasers selectively remove inorganic cellular components through thermal energy
10. Both diode lasers and electrocautery achieve the treatment objective of cutting and coagulating intraoral soft tissue. Which of the following statements is false?
 - a. Diode lasers utilize photonic energy
 - b. Coagulation of soft tissue begins at approximately 60 degrees centigrade
 - c. Electrocautery utilizes electrons.
 - d. Electrosurgery is about as painless as diode laser energy post-operatively
11. The ablation technique:
 - a. Is more efficient in bulk removal of tissue
 - b. Is the best utilization of diode laser energy
 - c. Should be minimized with diode lasers
 - d. Is more associated with electrosurgery
12. For safe use of diode lasers:
 - a. Avoid use of any anesthesia prior to laser surgery
 - b. Keep the laser on its ready mode when not in use
 - c. Cover all target tissue with protective material specific to the particular wavelength being used
 - d. Use the shortest amount of tissue exposure time for the desired result to be achieved
13. Light amplification by stimulated emission of radiation was postulated by?
 - a. Albert Einstein
 - b. Neils Bohr
 - c. Thomas Edison
 - d. T.H. Maiman
14. Which of the following lasers have specific indication for use and a published clinical study to demonstrate pocket depth reduction?
 - a. Argon
 - b. Electrosurgery
 - c. Ho:YAG
 - d. Nd:YAG and diode
15. Specific safety equipment needed for laser operation include:
 - a. Protective eyewear
 - b. High volume evacuation
 - c. Laser in use sign
 - d. All of the above
16. Which of the following lasers are near infrared systems?
 - a. CO₂
 - b. Erbium
 - c. Diode
 - d. HeNe
17. When performing periodontal pocket decontamination, diode lasers:
 - a. Can remove calculus
 - b. Interact with the melanin in bacteria
 - c. Cool the tissue
 - d. Should always char the epithelium
18. Laser safety glasses:
 - a. Are unnecessary
 - b. Must be specific to the wavelength of the laser device
 - c. Can be polarized sunglasses
 - d. Only are needed by the patient
19. Dental practitioners should limit the use of the laser to procedures which:
 - a. Are within the scope and license of their practice
 - b. Are within their education and training
 - c. Are within their clinical experience
 - d. All of the above
20. Diode lasers used in endodontic treatment:
 - a. Help enlarge the canals
 - b. Are used to perforate the apex
 - c. Are antimicrobial
 - d. Are capable of vaporizing all intra-canal tissue
21. The 810 nm wavelength is most useful in the oral cavity for:
 - a. Cutting crown preps
 - b. Preparing cavities
 - c. Ablating bone
 - d. Soft tissue excisions
22. The most common procedure utilizing diode lasers is:
 - a. Pulpotomy
 - b. Aphthous ulcers
 - c. Troughing for impressions
 - d. Fibroma removal
23. Contraindications to the intraoral use of the diode laser include:
 - a. Pacemaker patients
 - b. Pregnancy
 - c. Diabetic patients
 - d. None of the above
24. Photonic tissue effects include all of the following except:
 - a. Anti-inflammatory
 - b. Inflammatory
 - c. Biostimulatory
 - d. Coagulation
25. Gingival contouring with a diode laser:
 - a. May be performed at the same visit as restorative procedures
 - b. Facilitates predictable tissue heights
 - c. Is usually a bloodless procedure
 - d. All of the above
26. Diode laser energy:
 - a. Causes increased ATP output in cell mitochondria
 - b. Causes increased cell division
 - c. Can shorten healing time
 - d. All of the above
27. When a diode laser is used for periodontal surgery, its purpose is to:
 - a. Ablate bone
 - b. Harden grafting materials
 - c. Cause scar tissue formation
 - d. Reduce bacterial load
28. Advantages of using a diode laser when performing a frenectomy include:
 - a. Little to no hemorrhage
 - b. Cannot cut the muscle fibers
 - c. Is contraindicated
 - d. Suturing is always necessary
29. Diode laser indications for use on implants include all of the following except:
 - a. Osteotomy
 - b. Emergence profile creation
 - c. Disinfection of the infected fixture,
 - d. Removing hyperplastic soft tissue
30. Orthodontic practitioners utilize the diode lasers:
 - a. To improve the placement of brackets on erupting teeth
 - b. To remove hyperplastic tissue post operatively
 - c. To expose soft tissue impacted teeth
 - d. All of the above

