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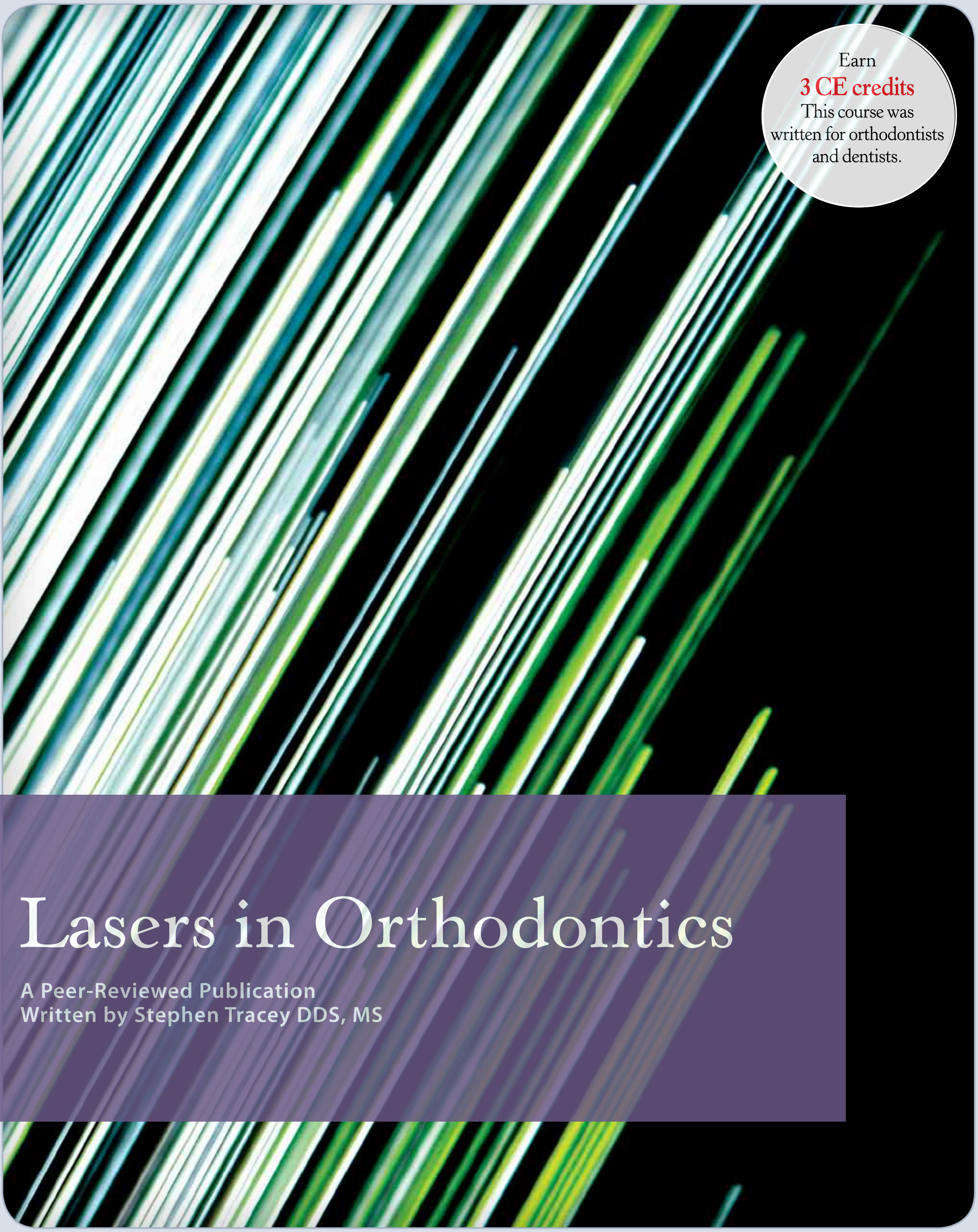

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Lasers in Orthodontics

A Peer-Reviewed Publication
Written by Stephen Tracey DDS, MS

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Educational Objectives

The overall goal of this article is to provide the reader with information on the use of lasers in orthodontics. On completion of this course, the reader will be able to do the following:

1. List and describe the development of lasers.
2. List and describe the scientific principles on which lasers are based.
3. List and describe laser setup and troubleshooting in practice.
4. List and describe periodontal considerations when using a laser.
5. List and describe the procedures for which a diode laser can be used in the orthodontic practice.

Abstract

Lasers were first conceived of almost a century ago and were introduced into dentistry in 1989. Several types of dental lasers are now available, with the diode laser being of particular interest for the orthodontic clinician. It is now possible to treat many soft tissue conditions that present as challenges in orthodontics and can impact the overall aesthetic outcome, and to treat these more easily. Before using lasers, it is necessary to understand how they work, the steps involved in setup, precautions that must be taken (such as eye protection), and troubleshooting steps. Periodontal considerations must also be known and understood. Soft tissue procedures that can benefit from use of a diode laser include frenectomy, gingival recontouring, the removal of hypertrophic tissue, and exposure of a partially erupted tooth.

Introduction

Orthodontic clinicians have long been challenged by soft tissue problems associated with treatment. Short clinical crowns prevent ideal bracket placement and compromise the effectiveness of aligner treatment, while delayed eruption of teeth often results in excessive appointments and extended treatment times. Other challenges include excessive gingival display and uneven gingival margins that can turn even the nicest treated case into one that falls short aesthetically. With the introduction of lasers to the profession in the last decade, these problems can now be addressed.

Historical Background

In 1917, Albert Einstein laid the foundation for the invention of the laser and its predecessor, the maser, when he first theorized that photoelectric amplification could emit a single frequency, or stimulated emission. The term "laser" is an acronym for light amplification by the stimulated emission of radiation and was first introduced to the public in 1959 in a paper by Columbia University graduate student Gordon Gould. In 1960, American physicist Theodore Maiman at the Hughes Research Laboratories in Malibu, California, built the first functioning laser. Since that time, lasers have become nearly ubiquitous in society. They are in computer printers and DVD players, they record prices at the grocery store, they guide weapons, and they measure distances between planets. The first surgical laser developed specifically for dentistry, a 3 W Nd:YAG laser, was introduced in 1989, and in May 1997, the United States Food and Drug Administration approved the Er:YAG laser for use on dental hard tissues such as teeth and bones.

Scientific Concept

Light is a form of electromagnetic energy that can be thought of as both a particle and a wave. The elementary particle of light is called a photon and is typically described as a tiny packet of energy that travels in waves at the speed of light. A wave of photons can be defined by two basic properties: amplitude and wavelength. Amplitude correlates to the amount of energy each photon is excited to: the larger the amplitude, the greater the energy. Wavelength is defined as the horizontal distance between any two corresponding points on the wave. Ordinary light, such as that produced by an incandescent lightbulb, is composed of many wavelengths of light and is unfocused or incoherent. Laser light is different from ordinary light in that it is monochromatic and consists of a single wavelength of light. In some cases, it is invisible to the human eye. Additionally, each wave of laser light is coherent, or identical in physical size, shape, and synchronicity. The monochromatic, coherent wave of light energy that is produced by a laser is a unique source of focused electromagnetic energy that is capable of useful work.

Figure 1. Typical laser oscillator

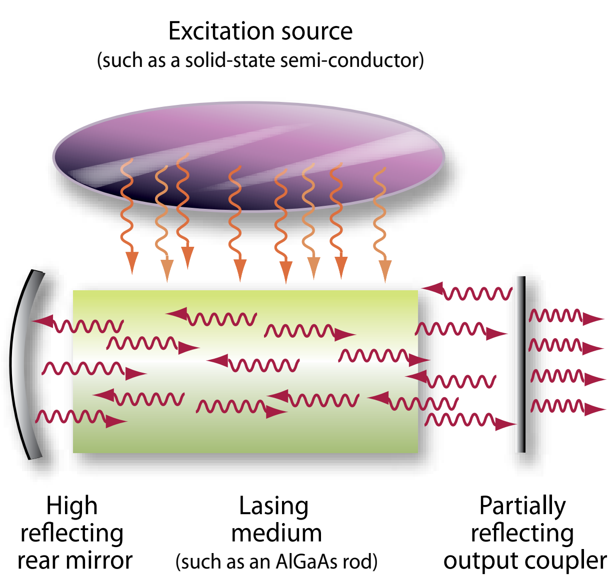
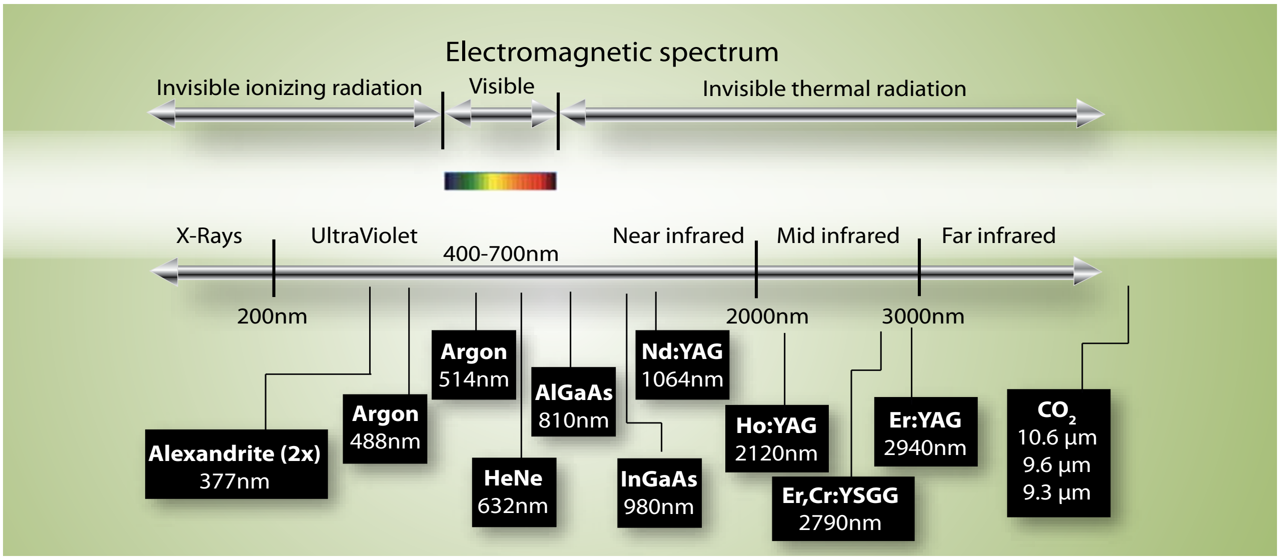


Figure 2. Wavelengths of dental lasers



A laser is composed of three principal parts: an energy source, an active lasing medium, and an optical cavity or resonator (Figure 1). In order for amplification to occur, energy is supplied to the laser system by a pumping mechanism such as a flashlamp strobe device, an electrical current, or an electrical coil. This energy is pumped into an active medium contained within an optical resonator, producing a spontaneous emission of photons. Subsequently, amplification by stimulated emission takes place as the photons are reflected back and forth through the medium by the highly reflective surfaces of the optical resonator before they exit the cavity via the output coupler. In the case of dental lasers, the laser light is delivered from the laser to the target tissue via a fiber-optic cable, hollow waveguide, or articulated arm. The wavelength and other properties of the laser are determined primarily by the composition of the active medium, which can be a gas, a crystal, or a solid-state semiconductor (Figure 2).

> A laser is composed of three principal parts: an energy source, an active lasing medium, and an optical cavity or resonator.

Laser Classification

It is generally recognized that lasers of all but the lowest powers can be potentially dangerous, particularly to human eyesight. Consequently, laser devices are classified according to their potential to cause biological damage, as follows:

Class 1. A Class 1 laser is safe under all reasonably anticipated conditions of use. Examples include laser pointers and supermarket UPC scanners.

Class 2. A Class 2 laser emits light in the visible light spectrum. It is presumed that the human blink reflex will be sufficient to prevent damaging exposure, although prolonged viewing may be dangerous. Consequently they are typically self-contained such as in laser printers and CD, DVD, and BD players and readers.

Class 3. A Class 3 laser produces light of such intensity that direct viewing of the beam can potentially cause serious harm. Consequently, use of a Class 3 laser requires special training and eye protection. One example of a Class 3 laser would be a dental argon curing light.

Class 4. Class 4 lasers produce high-powered light that is hazardous to view at all times. Exposure to the eye or skin by both direct and scattered laser beams of this intensity, even those produced by reflection from diffusing surfaces, must be avoided at all times. Nearly all medical and dental lasers fall into this category.

Lasers in Dentistry

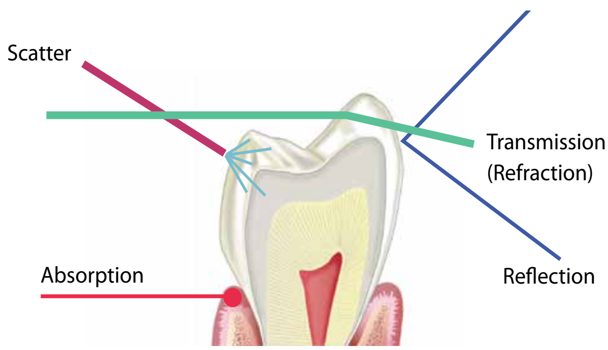
Since the development of the first laser by Maiman in 1960, dental interest in lasers has been high and research has been continuing into ways to improve dental treatment through laser application. Argon curing lasers have been around since the 1980s, diagnostic lasers have been used since the late 1990s to assist in detecting caries, and 3-D laser scanners have been used for many years to translate physical plaster models into virtual e-models. In this article, we will be focusing our attention on the use of dental lasers for surgical applications involving soft tissues.

Laser Effects on Tissue

The light energy produced by a laser can have four different interactions with a target tissue (Figure 3). The first effect is reflection, which involves redirection of the beam off the surface of the tissue, with no effect on the target tissue. The second effect is transmission of the laser energy directly through the tissue, again with no effect on the target tissue. The third effect is a scattering of the laser energy, resulting in a weakening of the intended energy and possible undesirable transfer of heat to adjacent nontarget tissue. The fourth effect is absorption of the laser energy by the target tissue. While there is always a mixture of all four interactions taking place simultaneously any time laser energy is directed at a target tissue, it is the interaction of absorption that is of primary interest. When laser light is absorbed, the temperature of the target tissue is elevated, resulting in a number of photothermal effects based upon the water content of the tissue. When a temperature of 100 degrees C is reached, vaporization of the water within the tissue occurs. Since soft tissue is composed of a very high percentage of water, ablation of soft tissue commences at this temperature. At temperatures below 100 degrees but above approximately 60 degrees, proteins begin to denature without vaporization of the underlying tissue. Conversely, at temperatures above 200 degrees, tissue is dehydrated and then burned, an undesirable effect called carbonization.

> Since soft tissue is composed of a very high percentage of water, ablation of soft tissue commences at 100 degrees C

Figure 3. The interactions of laser light



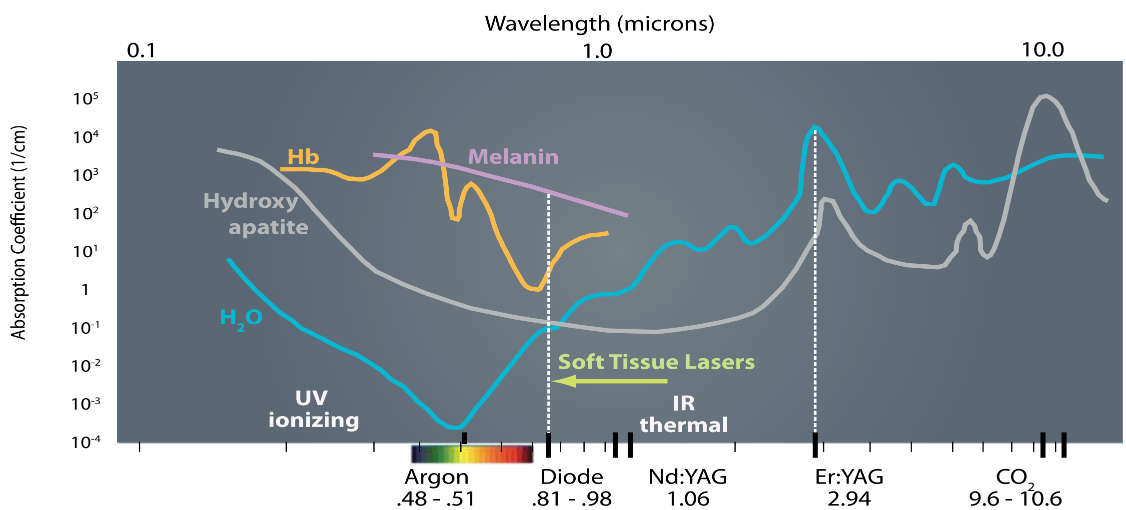
Absorption requires an absorber of light, termed a chromophore. Chromophores have a certain affinity to specific wavelengths of light: the higher the affinity, the greater the absorption of energy. The primary chromophores in intraoral soft tissue are melanin, hemoglobin, and water. Different laser wavelengths have different absorption coefficients with respect to these primary tissue components, making laser selection procedure-dependent (Figure 4).

Laser Selection for Orthodontic Applications

Many laser systems are available today, each with its own set of benefits and drawbacks. The most common lasers used in dentistry today are the CO_2 laser, the Nd:YAG laser, the erbium lasers (Er:YAG and Er,Cr:YSGG), and the diode laser. Each produces a different wavelength of light and is generically named for the active medium contained within the device. Since no single laser wavelength can be used to optimally treat all dental diseases, there is no one perfect dental laser. However, the needs of the orthodontic clinician are unique, and selection of the most appropriate laser for orthodontic applications is ideally determined by examining four important factors: procedure specificity, ease of operation, portability, and cost. CO_2 and Nd:YAG are not ideally suited for orthodontic applications and are hampered by their large size and high cost. Erbium lasers are extremely popular in dentistry today and hold the singular distinction of being able to perform both hard and soft tissue procedures. However, it is the diode laser that seems most ideal for incorporation into the orthodontic specialty practice.

With regard to procedure specificity, the diode laser's sole purpose is soft tissue surgery. It safely removes tissue without risk to adjacent tooth structure and provides excellent hemostasis. As to ease of operation, most practitioners prefer the diode laser's dry-field operation and the proprioceptive feedback provided by the light contact of the fiber tip with target tissue during ablation. Portability, or being able to easily move a laser from chair to chair or even office to office, is an especially important feature to consider when selecting a laser for the typical orthodontic practice.

Figure 4. Tissue and their net absorption



Diode lasers are the most portable of all dental lasers, with the smallest diode laser being similar in size to an electric toothbrush and weighing in at a scant 1.9 ounces. In terms of affordability, the cost of a diode laser is a mere fraction of the cost of other dental lasers, with quality diode lasers available for under $5,000. With this in mind, most orthodontic clinicians interested in purchasing a dental laser would be best served by a diode laser due to its soft tissue specificity, simple operation, small size, and relatively low cost.

Table 1. Characteristics of diode lasers

Sole purpose is soft tissue removal
No risk of damage to adjacent tooth structure
Excellent hemostasis
Dry-field operation
Light contact of the fiber tip with tissue
Proprioceptive feedback
Portability

The Diode Laser

The active medium of the diode laser is a solid-state semiconductor, made of aluminum, gallium, arsenide, and occasionally indium, that produces laser wavelengths ranging from approximately 810 nm to 980 nm. These wavelengths fall at the beginning of the near-infrared electromagnetic spectrum and are invisible to the human eye. Diode lasers deliver laser energy from the laser to the working area fiber-optically, either by fiber-optic cable or disposable fiber-optic tip, ordinarily in light contact with the target tissue for ablating procedures. All diode wavelengths are absorbed primarily by tissue pigment (melanin) and hemoglobin. Conversely, they are poorly absorbed by the hydroxyapatite and water present in enamel. Consequently, diode lasers are excellent soft tissue surgical lasers and indicated for incising, excising, and coagulating gingiva and mucosa. Due to the fact that diode laser wavelengths are poorly absorbed by tooth structure and metal, ablation procedures can safely be performed in close proximity to enamel, orthodontic appliances, and temporary anchorage devices.

Diode Laser Setup and Troubleshooting

Laser Safety

While most dental lasers are relatively simple to use, certain precautions should be taken to ensure their safe and effective operation. Of extreme importance is the use of protective eyewear by anyone in the vicinity of the laser while it is in use. This includes the doctor, chairside assistants, the patient, and any observers such as family or friends (Figure 5). It is critical that all protective eyewear worn is wavelength-specific (Figure 6). Most surgical lasers produce a wavelength of light that is outside the visible portion of the electromagnetic spectrum. Consequently, sunglasses or safety glasses designed for use with visible dental curing lights are ineffective at protecting the eye from potentially irreversible damage as a result of exposure to dental laser light. Additionally, accidental exposure of nontarget tissue can be prevented by limiting access to the surgical environment, minimizing reflective surfaces, and ensuring that the laser is in good working order with all manufactured safeguards in place. To prevent possible exposure to infectious pathogens, high-volume suction should be used to evacuate any vapor plume created during tissue ablation, and normal infection protocols should be followed. Each office should have a designated staff member act as Laser Safety Officer to supervise the proper use of the laser, coordinate staff training, oversee the use of protective eyewear, and be familiar with pertinent regulations.

The use of protective eyewear by anyone in the vicinity of the laser while it is in use is of extreme importance.

Figure 5. Protective eyewear worn by all in the operatory

Figure 6. Wavelength specific protective eyewear

Table 2. Requirements and recommendations for laser safety

Use of protective eyewear by anyone in the vicinity of the laser
Limit access to the surgical environment
Minimize reflective surfaces
Ensure that the laser is in good working order
Ensure all manufacturer safeguards are in place
Use of high-volume suction
Follow normal infection control protocols
Designated staff member as Laser Saftey Officer
Staff training

Fiber Preparation

The diode laser transmits laser light from the laser to the target tissue via a fiber-optic cable or disposable fiber-optic tip. In the case of a fiber-optic cable, a 400-micron optical fiber is recommended, as smaller diameter fibers tend to be more friable and breakable. Prior to use, a sufficient portion of protective outer cladding must be removed with an appropriately sized stripping device in order to expose the inner glass fiber (Figure 7). The amount of outer cladding removed is determined by the length of the handpiece supplied with the laser, such that any exposed fiber is completely contained within the handpiece. The fiber is then inserted into the handpiece, and a disposable plastic tip is fitted over the fiber tip and placed on the end of the handpiece, leaving approximately 3 mm of fiber exposed (Figure 8). Before each patient use, 2-3 mm is cut off the end of the fiber with ceramic scissors or a cleaving stone in order to avoid cross-contamination (Figure 9). The fiber tip is then "initiated" by placing some form of pigment on the end of the fiber in order to create a hyper-focus of usable laser energy at the tip. One of the most effective ways to deposit pigment on the tip is to lightly tap the end of the fiber onto a sheet of articulating film while the laser is activated (Figure 10). In the case of a disposable fiber-optic tip, it is not necessary to strip or cleave the fiber; however, tip initiation is still required.

Figure 7. Stripping of the protective outer cladding

Figure 8. Placement of a disposable plastic tip

Figure 9. Removal of terminal 3 mm to avoid cross-contamination

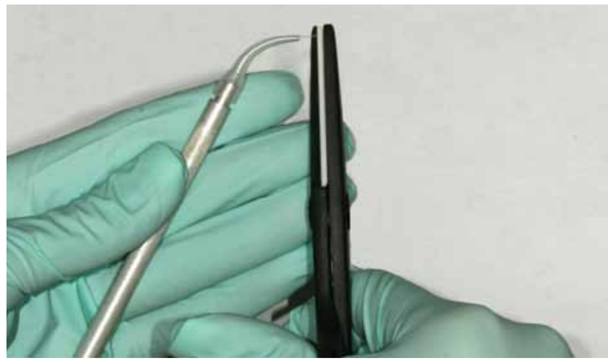
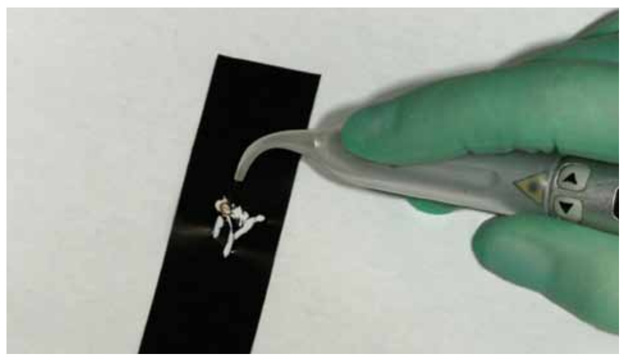


Figure 10. Depositing pigment on the tip



Basic Power Settings

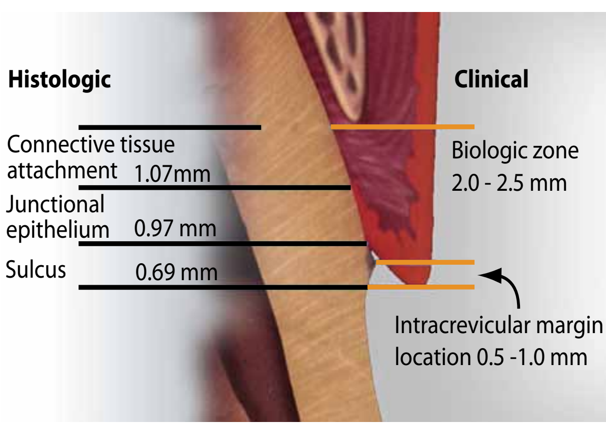
To prevent collateral thermal damage to adjacent tissue, the Academy of Laser Dentistry recommends using the least amount of power that can effectively accomplish a desired procedure. For most soft tissue ablation procedures, a setting of 1 to 1.2 watts will result in excellent tissue removal with minimal thermal degeneration of adjacent tissue. Areas of denser tissue, such as the palate and the fibrous tissue distal to the lower second molars, may require settings closer to 1.4 watts, while frenectomy procedures often require settings as high as 1.6 watts. In addition to adjusting power settings, it is also necessary to choose between operating the laser in either continuous wave mode or pulsed mode. Although some practitioners have advocated using pulsed mode to potentially reduce patient discomfort and minimize adjacent tissue damage, in actual practice there seems to be little benefit to this strategy when ablating tissue with a diode laser. In contrast to the free-running pulsed/high-peaked power light produced by Nd:YAG and erbium lasers, diode lasers produce a continuous wave of laser light that can be "pulsed" only through the use of a mechanical gate that opens and closes to disrupt the flow of light. Consequently, when a diode laser is operated in pulsed mode, the power produced per unit of time, i.e., watts, is cut in half, rendering the laser ineffective unless power settings are doubled. Since there seems to be no real advantage to operating a diode laser in pulsed mode, it is generally recommended that most ablation procedures be performed using continuous wave mode.

> To prevent collateral thermal damage to adjacent tissue, the Academy of Laser Dentistry recommends using the least amount of power that can effectively accomplish a desired procedure.

Laser Troubleshooting

Diode lasers have proven to be remarkably reliable and virtually trouble-free. However, on occasion, practitioners will encounter cases when tissue ablation seems deficient, in spite of adequate power settings. To ascertain the problem, first ensure that all power switches and key locks have been placed in the ON position. Second, confirm that the fiber-optic tip has been initiated properly, as an uninitiated tip will fail to focus enough energy at the end of the fiber to adequately ablate tissue. Third, check to see if the fiber-optic cable has been inadvertently fractured. Poor fiber management can result in a hidden break anywhere along the length of the fiber if it is stepped on or rolled over with a chair. And fourth, if the laser is being operated in pulsed mode, be sure that power settings normally used in continuous wave mode have been doubled in order to compensate for the reduction in power per unit of time.

Figure 11. Biologic width



Periodontal Considerations

When used judiciously and in the hands of a properly trained practitioner, the diode laser is a safe and effective tool. However, violation of basic periodontal principles can result in less than desirable results. Respect for maintenance of biologic width is important. Typically, biologic width as measured from the free gingival margin to the crestal bone is considered to be approximately 3 mm, consisting of, on average, 1 mm of junctional epithelium and 1 mm of connective tissue attachment combined with a gingival sulcus of approximately 1 mm (Figure 11). Should this biologic width be violated with excessive removal of gingival tissue along with placement of a restoration within that zone, unintended negative consequences may result, including chronic inflammation of the gingiva and unpredictable bone loss. Fortunately, orthodontic laser procedures rarely involve placement of restorations after tissue removal. It must be noted, however, that in the absence of a restoration, excised marginal tissue may grow back as biologic width returns to its natural state. Consequently, cases requiring a significant amount of tissue removal are best referred to a periodontal specialist for surgical crown lengthening. Another contraindication for soft tissue removal with the laser is exposure of unerupted teeth in unattached, non-keratinized gingiva, as this may result in a loss of attached gingiva once the tooth is brought into the arch form.

> When used judiciously and in the hands of a properly trained practitioner, the diode laser is a safe and effective tool; respect for maintenance of biologic width is important.

Anesthesia

In most cases, adequate soft tissue anesthesia required for laser-assisted tissue removal is obtained via application of a compounded topical anesthetic gel such as Profound PET (prilocaine 10%, lidocaine 10%, tetracaine 4%, and phenylephrine 2%). The combination of the various local anesthetics along with the vasoconstrictor phenylephrine produces profound anesthesia in a relatively short amount of time. After the target tissue is dried, topical anesthetic gel is applied to the area and left in place for approximately three to four minutes (Figure 12). Prolonged exposure beyond the recommended time may result in mild tissue sloughing as a result of the vasoconstrictive properties of the phenylephrine. Occasionally, in areas of thicker, denser tissue, as seen on the palate and on the distal of an erupting lower second molar, injection of local anesthetic solution may be required to obtain sufficient anesthesia. Once the target tissue has been sufficiently anesthetized, a periodontal probe is used to measure sulcus depth and biologic width on the teeth to be recontoured in order to determine how much tissue can be safely removed.

Figure 12. Application of topical anesthetic gel

Surgical Procedure

The operator activates the laser with a foot pedal and gently moves the tip of the fiber across the target tissue in a light-contact mode. Tissue is removed with the fiber tip held at various angles to provide ideal tissue contours (Figure 13). Careful attention must be paid to the interaction of the laser energy with the target tissue. Leaving the fiber tip in one spot too long will result in carbonization and unnecessary collateral damage, while moving the tip too quickly will result in an insufficient absorption of energy to produce ablation. During the procedure, it is imperative that high-volume aspiration is used to evacuate vapor plume and objectionable odors at the site of ablation. Once satisfactory tissue removal has been achieved, any remnants of slightly carbonized tissue remaining at the surgical margins are removed with light pressure using a micro-applicator brush soaked in 3% hydrogen peroxide solution (Figure 14). Postoperatively, patients are advised to keep the area clean and plaque-free with gentle brushing, avoid foods and liquids that may cause pain or irritation to the sensitive tissue while it is healing, and to use over-the-counter analgesics as needed.

Careful attention must be paid to the interaction of the laser energy with the target tissue - leaving the fiber tip in one spot too long will result in carbonization and unnecessary collateral damage.

Figure 13. Contouring of gingival tissue

Figure 14. Removal of slightly carbonized tissue

Clinical Applications

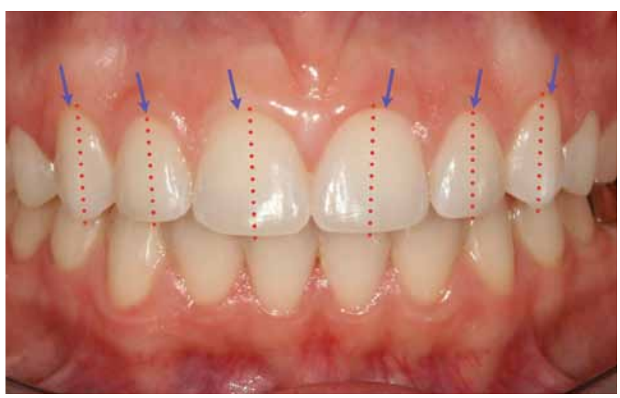
Specific procedures include aesthetic gingival recontouring, soft tissue crown lengthening, exposure of soft-tissue-impacted teeth, removal of inflamed and hypertrophic tissue, and frenectomies. Incorporating the use of lasers into my orthodontic practice has been extremely rewarding on many levels. Being able to place brackets more accurately and sooner in treatment has significantly reduced treatment times, and patients really appreciate how much better their smiles look.

Aesthetic Gingival Recontouring

Gingival aesthetics play a vital role in the appearance of a finished orthodontic case. Excessive gingival display, uneven gingival contours, and disproportionate crown heights and widths significantly diminish the aesthetic value of even the most perfectly aligned teeth.

As a rule, aesthetic gingival recontouring is most beneficial in the upper arch from cuspid to cuspid. Ideally, the gingival margins of the upper anterior teeth are positioned at or very near the inferior border of the upper lip in full smile. Display of gingival tissue in excess of 2 mm is generally considered to be undesirable. Additionally, the perception of tooth length and width is often influenced by the position, contour, and bulk of the marginal gingiva framing the crowns of the teeth, with uneven gingival contours causing some teeth to appear

Figure 15. Gingival form



too short and others to appear too long. The gingival margins of the upper central incisors and upper cuspids should be approximately level with each other and slightly superior to the gingival margins of the upper lateral incisors. The gingival zeniths of the upper central incisors and cuspids should fall slightly distal to their long axis centers, the gingival zeniths of the upper lateral incisors should typically coincide with their long axis centers, and gingival symmetry should exist from one side to the other (Figures 15, 16).

Figure 16a. Pre-treatment

Figure 16b. Gingivae immediately post-treatment

Figure 16c. Gingival symmetry following healing

Exposure of Unerupted and Partially Erupted Teeth

Lengthy orthodontic treatment times are often the result of delayed eruption of teeth or compromised bracket positioning due to gingival interference. Using the diode laser, both unerupted and partially erupted teeth can be exposed for bonding, and tissue interfering with ideal bracket placement can be removed. Unerupted teeth to be exposed are located by radiographic examination, visualization, and palpation. After the patient is anesthetized, it is possible to determine if bone is covering the crown of the tooth by using an explorer to puncture the overlying soft tissue and score the underlying hard tissue with a back-and-forth motion. Enamel will feel very hard and smooth, while bone will seem more porous and rough. When exposing an unerupted tooth for bonding, tissue removal should take place solely in attached gingiva, excising only enough to allow for reasonable positioning of a bracket or button (Figure 17).

Using the laser in unattached, non-keratinized gingiva to expose unerupted teeth must be avoided as this may result in a loss of attached gingiva once the tooth is brought into the arch form.

Figure 17a. Partially erupted tooth

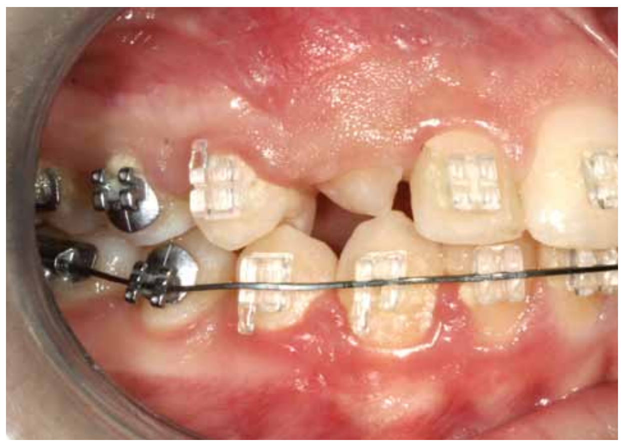
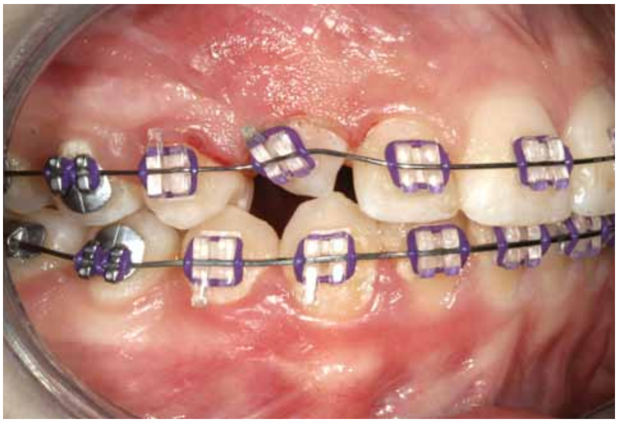


Figure 17b. Removal of tissue to sufficiently expose the tooth for a bracket

Figure 17c. Brackets, elastics and archwire in position



Removal of Inflamed and Hypertrophic Tissue

Treatment and maintenance of moderate to severe gingival hypertrophy and inflammation during orthodontic treatment is best handled by a periodontal specialist. However, isolated areas of transient tissue hypertrophy can easily be removed with the diode laser (Figure 18). In addition to excision of inflamed tissue, the laser also contributes to gingival health by sterilization of the area adjacent to the ablated tissue.

Figure 18a. Pre-treatment tissue

Figure 18b. Post-removal of distal tissue

Isolated areas of transient tissue hypertrophy can easily be removed with the diode laser.

Frenectomies

A high or thick labial frenum is often of concern when the attachment causes a midline diastema or exerts a traumatic force on the marginal gingiva. Frenectomies performed with a laser permit painless excision of frena, without bleeding, sutures, surgical packing, or special postoperative care (Figure 19). Typical power settings for performing frenectomies with a diode laser are 1.4 to 1.6 watts in continuous wave mode.

Figure 19a. Pre-treatment showing frenum

Figure 19b. Immediately following laser removal of frenum

Figure 19c. Healed tissue

A laser permits painless excision of frena, without bleeding, sutures, surgical packing, or special postoperative care.

Miscellaneous Tissue Removal

The diode laser is also very useful for a number of isolated applications such as removing tissue that has overgrown orthodontic appliances as well as replacing the need for a tissue punch when placing miniscrews in unattached gingiva (Figure 20).

Figure 20a. Laser tissue removal at site for miniscrew

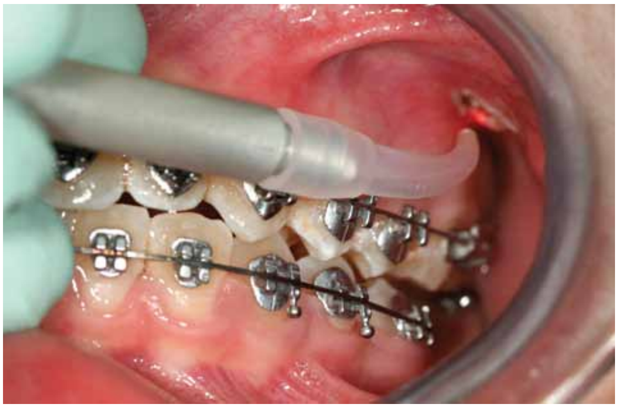
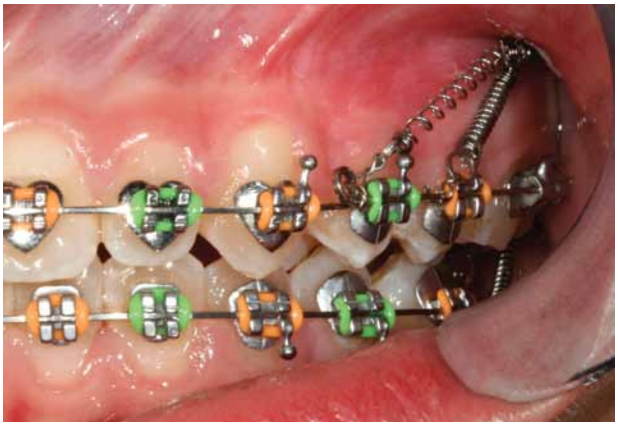


Figure 20b. Site following laser tissue removal

Figure 20c. Miniscrew and appliance



Summary

The use of lasers in orthodontics, and in particular diode lasers, has made it possible for orthodontic clinicians to more easily and ably address the challenges faced on a daily basis in orthodontic practice. With nearly a decade of experience using lasers, I can not imagine practicing without them. When used properly, lasers are effective and safe for soft tissue procedures and contribute to aesthetic outcomes for orthodontic patients.

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Author Profile

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Dr. Stephen Tracey is a native of Southern California and a graduate of Loma Linda University with a BS in Human Biology, a DDS, and a MS in Orthodontics. He is a member of the American Dental Association, the American Association of Orthodontists, the World Federation of Orthodontists, and the American Academy of Sleep Medicine. As a pioneer in the application and use of soft tissue lasers in orthodontics, Dr. Tracey is also a member of the Academy of Laser Dentistry with proficiency certification in both diode and Er:YAG lasers. He was formerly Instructor of the Year at Loma Linda University in 1995, he now serves as Visiting Professor of Orthodontics at the University of Ferrara in Ferrara, Italy. Dr. Tracey is an internationally recognized lecturer, with past presentations made in 22 countries on six continents. He has published numerous articles in a variety of professional publications, authored a chapter in a prestigious orthodontic textbook, and presently serves on the Editorial Advisory Board for Orthodontic Products. Personally, Dr. Tracey's insatiable curiosity combined with his passion for adventure have led him to such diverse places and situations as shark diving in the Bahamas, swimming from Alcatraz to San Francisco, trekking the jungles of the Amazon, summiting the peak of Mt. Rainier, and competing in the Ironman Triathlon in Kona, Hawaii.

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Questions

1. Short clinical crowns ________.
   a. prevent ideal bracket placement
   b. compromise the effectiveness of aligner treatment
   c. result in over-extrusion of teeth
   d. a and b

2. The predecessor of the laser was the ________.
   a. taser
   b. maser
   c. staser
   d. none of the above

3. The term "laser" is an acronym for ________.
   a. light acceleration by the stimulated emission of radiation
   b. light amplification by the stimulated emission of radiation
   c. light amplification by the stimulated extrusion of radiation
   d. none of the above

4. Wavelength is defined as the ________ distance between any two corresponding points on the wave.
   a. vertical
   b. horizontal
   c. diagonal
   d. three-dimensional

5. Laser light________.
   a. is monochromatic
   b. consists of a single wavelength of light
   c. may be invisible to the human eye
   d. all of the above

6. A laser is composed of an ________.
   a. energy source
   b. active lasing medium
   c. optical cavity or resonator
   d. all of the above

7. ________ is an example of a Class I laser.
   a. A laser pointer
   b. An argon curing light
   c. A dental laser
   d. all of the above

8. Class 4 lasers ________.
   a. produce high-powered light
   b. are hazardous to the eyes
   c. are hazardous to the skin
   d. all of the above

9. Nearly all dental and medical lasers are ________ lasers.
   a. Class 1
   b. Class 2
   c. Class 3
   d. Class 4

10. The interaction of a target tissue with the light energy produced by a laser can involve ________.
    a. reflection of the beam or transmission of the laser energy
    b. scattering of the laser energy
    c. absorption of the laser energy
    d. all of the above

11. Scattering of laser energy results in ________.
    a. a weakening of the intended energy
    b. possible undesirable transfer of heat to adjacent nontarget tissue
    c. a strengthening of the intended energy
    d. a and b

12. Transmission of laser energy means that it ________.
    a. goes directly through the tissue to affect non target tissue
    b. goes directly through the tissue, affecting it positively as it proceeds
    c. goes directly through the tissue, with no effect on the target tissue
    d. a and c

13. Vaporization of the water within tissue occurs when a temperature of ________ is reached.
    a. 80 degrees C
    b. 100 degrees C
    c. 120 degrees C
    d. none of the above

14. Ablation of soft tissue commences at ________.
    a. 60 degrees C
    b. 80 degrees C
    c. 100 degrees C
    d. 120 degrees C

15. At temperatures below 100 degrees but above approximately________, proteins begin to denature without vaporization of the underlying tissue.
    a. 50 degrees
    b. 60 degrees
    c. 70 degrees
    d. all of the above

16. Carbonization ________.
    a. is undesirable
    b. occurs at temperatures above 200 degrees
    c. involves tissue dehydration and burning
    d. all of the above

17. The first laser was developed by Maiman in ________ .
    a. 1950
    b. 1960
    c. 1970
    d. 1980

18. An absorber of light is termed a ________.
    a. hemaphore
    b. chromophore
    c. chromatophore
    d. none of the above

19. Lasers used in dentistry are generically named for the ________ contained within the device.
    a. reactive medium
    b. active medium
    c. passive medium
    d. all of the above

20. Selection of the most appropriate laser for orthodontic applications is ideally determined by examining ________.
    a. procedure specificity
    b. portability and ease of operation
    c. cost
    d. all of the above

21. Erbium lasers can perform ________ .
    a. only hard tissue procedures
    b. only soft tissue procedures
    c. both hard and soft tissue procedures
    d. none of the above

22. Diode lasers can perform ________ .
    a. only hard tissue procedures
    b. only soft tissue procedures
    c. both hard and soft tissue procedures
    d. none of the above

23. The smallest diode laser weighs in at ________.
    a. 1.5 ounces
    b. 1.7 ounces
    c. 1.9 ounces
    d. none of the above

24. An argon laser has a wavelength in the range of ________.
    a. 0.38 – 0.41 microns
    b. 0.43 – 0.48 microns
    c. 0.48 – 0.51 microns
    d. none of the above

25. A diode laser has a wavelength in the range of ________.
    a. 0.51 – 0.68 microns
    b. 0.61 – 0.78 microns
    c. 0.71 – 0.88 microns
    d. 0.81 – 0.98 microns

26. The active medium of the diode laser is a solid-state semiconductor, made of ________.
    a. aluminum, gallium, arsenide, and occasionally indium
    b. aluminum, selium, arsenicum, and occasionally indium
    c. zinc, aluminum, silicate and occasionally iridium
    d. aluminum, gallium, arsenide, and occasionally selenium

27. All diode wavelengths are absorbed primarily by ________.
    a. melatonin and hemoglobin
    b. proteins and hemoglobin
    c. hemoglobin and lipids
    d. melanin and hemoglobin

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Questions

28. ________ can be performed using a diode laser.
    a. Gingival recontouring
    b. Soft tissue crown lengthening
    c. Exposure of soft-tissue-impacted teeth
    d. all of the above

29. Ablation procedures can safely be performed in close proximity to enamel, orthodontic appliances, and temporary anchorage devices because diode laser wavelengths are ________.
    a. not absorbed by tooth structure and metal
    b. poorly absorbed by tooth structure and metal
    c. well absorbed by tooth structure and metal
    d. none of the above

30. It is critical that all protective eyewear worn is ________.
    a. generic for all wavelengths
    b. wavelength-specific
    c. light-specific
    d. a and c

31. Sunglasses and safety glasses designed for use with visible dental curing lights are ________ at protecting the eye from potentially irreversible damage as a result of exposure to dental laser light.
    a. highly effective
    b. moderately effective
    c. ineffective
    d. effective depending on the manufacturer of the sunglasses

32. ________ can help prevent accidental exposure of nontarget tissue.
    a. Limiting access to the surgical environment
    b. Minimizing reflective surfaces
    c. Ensuring that the laser is in good working order with all manufacturer safeguards in place
    d. all of the above

33. High-volume suction should be used to ________.
    a. evacuate any vapor plume created during tissue ablation
    b. prevent possible exposure to infectious pathogens
    c. remove objectionable odors
    d. all of the above

34. Each office should have a designated staff member ________.
    a. supervise the proper use of the laser
    b. oversee the use of protective eyewear
    c. be familiar with pertinent regulations and coordinate staff training
    d. all of the above

35. When a fiber-optic cable is used with a diode laser to transmit laser light to the target tissue, a ________ optical fiber is recommended.
    a. 200-micron
    b. 400-micron
    c. 600-micron
    d. 800-micron

36. The amount of outer cladding removed is determined by the ________.
    a. width of the fiber
    b. width of the handpiece
    c. length of the handpiece
    d. a and b

37. A disposable plastic tip is fitted over the fiber tip and placed on the end of the handpiece, leaving approximately ________ exposed.
    a. 2 mm of fiber
    b. 3 mm of fiber
    c. 4 mm of fiber
    d. 5 mm of fiber

38. Before each patient use, 2-3 mm is cut off the end of the fiber with ________ in order to avoid cross-contamination.
    a. ceramic scissors
    b. a cleaving stone
    c. sterile stainless steel scissors
    d. a or b

39. The fiber tip is "initiated" by placing some form of ________ on the end of the fiber.
    a. activated liquid
    b. liquefied gas
    c. pigment
    d. none of the above

40. To prevent collateral thermal damage to adjacent tissue, the Academy of Laser Dentistry recommends using ________.
    a. the most refracted power that can effectively accomplish a desired procedure
    b. attenuated energy sources
    c. the least amount of power that can effectively accomplish a desired procedure
    d. all of the above

41. For most soft tissue ablation procedures, a setting of ________ will result in excellent tissue removal with minimal thermal degeneration of adjacent tissue.
    a. 1 to 1.2 watts
    b. 2 to 2.2 watts
    c. 3 to 3.2 watts
    d. 4 to 4.2 watts

42. Frenectomy procedures often require settings as high as ________.
    a. 1.2 watts
    b. 1.4 watts
    c. 1.6 watts
    d. 1.8 watts

43. Diode lasers produce a continuous wave of laser light that can be "pulsed" only through the use of a ________.
    a. mechanical gate
    b. chemical gate
    c. biomechanical gate
    d. biochemical gate

44. Leaving the fiber tip in one spot too long will result in ________.
    a. unnecessary collateral damage
    b. carbonization
    c. too little tissue being removed
    d. a and b

45. Moving the tip too quickly will result in ________.
    a. poor contours
    b. scattering of energy
    c. insufficient absorption of energy to produce ablation
    d. none of the above

46. Any remnants of slightly carbonized tissue remaining at the surgical margins are removed with light pressure using a micro-applicator brush soaked in _______ solution.
    a. 3% carbamide peroxide
    b. 3% hydrogen peroxide
    c. 3% chlorhexidine gluconate solution
    d. 3% povidone iodine

47. Postoperatively, patients are advised to ________.
    a. keep the area clean and plaque-free with gentle brushing
    b. avoid foods and liquids that may cause pain or irritation to the sensitive tissue while it is healing
    c. use over-the-counter analgesics as needed
    d. all of the above

48. Isolated areas of transient tissue hypertrophy can easily be removed with the ________.
    a. air abrasion device
    b. scalpel
    c. diode laser
    d. all of the above

49. Use of a soft tissue laser contributes to gingival health by ________ of the area adjacent to the ablated tissue.
    a. carbonization
    b. sterilization
    c. recontouring
    d. none of the above

50. When used properly, lasers________.
    a. are effective for soft tissue procedures for orthodontic patients
    b. are safe for soft tissue procedures for orthodontic patients
    c. contribute to aesthetic outcomes for orthodontic patients
    d. all of the above

ANSWER SHEET

Lasers in Orthodontics

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Educational Objectives

1. List and describe the development of lasers.
2. List and describe the scientific principles on which lasers are based.
3. List and describe laser setup and troubleshooting in practice.
4. List and describe periodontal considerations when using a laser.
5. List and describe the procedures for which a diode laser can be used in the orthodontic practice.

Course Evaluation

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

1. Were the individual course objectives met? Objective #1: Yes No; Objective #2: Yes No; Objective #3: Yes No; Objective #4: Yes No; Objective #5: Yes No

2. To what extent were the course objectives accomplished overall?	5	4	3	2	1	0
3. Please rate your personal mastery of the course objectives.	5	4	3	2	1	0
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5. How do you rate the author's grasp of the topic?	5	4	3	2	1	0
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4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	31.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	32.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	33.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	34.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	35.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	36.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	37.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	38.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	39.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	40.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	41.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	42.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	43.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	44.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	45.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	46.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	47.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	48.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	49.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	50.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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