Quality Resource Guide

First Edition

Lasers in Dentistry

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Educational Objectives

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

1. Describe the basic principles of laser operation, including the concepts of monochromaticity, coherence, and the different laser delivery systems (optical fiber, hollow waveguide, and articulated arm). Explain how these principles influence the effectiveness and precision of laser procedures in dental practice.
2. Outline the safety protocols necessary for the safe use of dental lasers, including eye protection, training requirements, and the importance of compliance with state and federal regulations.
3. Describe the advantages of various laser applications, such as reduced need for anesthesia, minimized bleeding, and faster healing times.
4. Discuss the limitations and challenges associated with laser use, including equipment cost, training requirements, and restrictions in specific clinical scenarios (*e.g.*, removing amalgam or ceramic restorations).
5. Describe the mechanism of action of photobiomodulation (PBM) therapy and its applications in managing pain and promoting healing in dental conditions such as temporomandibular disorders (TMD) and oral ulcers.

MetLife designates this activity for **1.0 continuing education credits** for the review of this Quality Resource Guide and successful completion of the post test.

Published February 2025. Expiration date: February 2028.

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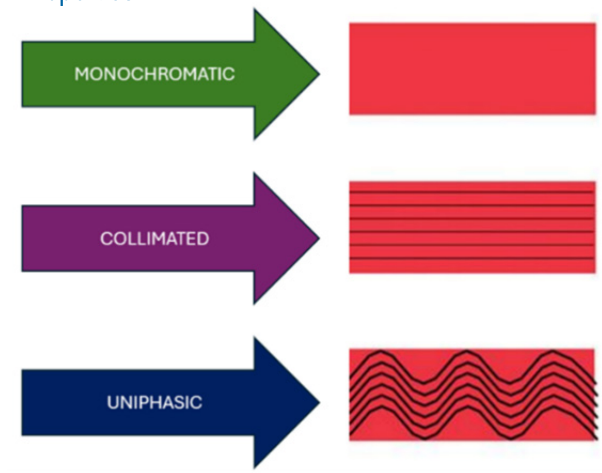
Introduction

Advances in dental technology have raised patient expectations for treatments that are less painful, more precise, minimally invasive, and conducive to faster healing. Dental lasers have revolutionized dentistry by offering a precise and minimally invasive alternative for various dental procedures. Initially developed for soft tissue oral surgery, the potential indications and marketing for laser use exist in virtually all disciplines of dentistry.[1,2] Lasers enhance patient comfort by often minimizing or negating the need for anesthesia and reducing noise, vibrations, and unpleasant odors. Finally, some laser protocols may be used to manage chronic conditions and infectious diseases. However, there are limitations to laser use, and the cost of entry and training can be substantial. The purpose of this Quality Resource Guide (QRG) is to provide a brief overview of the use of lasers in dentistry.

Lasers Physics, Terminology and Operation

Laser stands for "Light Amplification by Stimulated Emission of Radiation." Photons, the quantum units of light, travel at a constant speed and are crucial for laser operations.[1] Lasers are devices that emit light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. Lasers emit light that is monochromatic, coherent, and uniphasic (**Figure 1**). Different tissues in the mouth absorb specific wavelengths of light differently.[3] For example, soft tissue lasers (*e.g.*, diode lasers) typically operate in the infrared spectrum, which is well-absorbed by hemoglobin and melanin, making them effective for soft tissue procedures. Hard tissue lasers (*e.g.*, erbium lasers) operate at wavelengths absorbed by water and hydroxyapatite, making them suitable for cutting enamel, dentin, and bone.

Figure 1 - Laser Properties



Coherence refers to the phase uniformity of the light waves emitted by the laser. In a coherent beam, the light waves are in phase both spatially and temporally, meaning the peaks and troughs of the waves align, creating a narrow, focused beam. The coherence of laser light enables it to be highly focused, allowing for precise cutting, ablation, or coagulation of tissues. This precision reduces the damage to surrounding tissues, minimizes bleeding, and enhances healing in dental procedures. The coherent beam can be tightly focused to achieve fine incisions or defocused to allow for broader tissue ablation. The principles of monochromaticity and coherence, combined with the appropriate delivery system, significantly enhance the effectiveness and precision of laser procedures in dental practice. Laser energy is delivered to the operative site through various methods, each designed for precision and ergonomics. The three primary modalities are optical fiber, hollow waveguide, and articulated arm.[3] Basic laser terminology is summarized in **Table 1**.

Laser dosimetry refers to the measurement and calculation of the dose of energy delivered to a target tissue, such as in medical or dental procedures. Proper dosimetry is crucial to ensure that the laser energy applied is sufficient to achieve the desired therapeutic effect while limiting potential damage to the surrounding tissues.[2,5,6] **Table 2** summarizes the critical determinants in laser dosimetry.

Table 1 - Laser Terminology[4]

Aiming Beam	Lasers include an aiming beam, either laser or conventional light, to show the exact target for the laser energy.
Emission Modes	Laser emissions are categorized as Continuous Wave or Free-Running Pulsed, with Gated Mode being a variant. Continuous Wave lasers emit a constant beam, while Free-Pulsed lasers produce bursts of energy.
Energy and Fluence	The total energy delivered per unit area is measured in joules (J) or millijoules (mJ), with fluence as energy per area (J/cm^2).
Power and Density	Power (watts) is work over time, while power density is power per unit area (W/cm^2).
Pulses	Defined by pulses per second (pps) or hertz, with pulse duration and interval indicating the burst length and interval.
Average and Peak Power	Average power refers to the overall tissue exposure, while peak power is the intensity of each pulse.
Beam Size	Influences fluence and power density, with variations in tip sizes and delivery systems.
Contact and Non-contact Procedures	Lasers can be used in contact mode, where the tip touches the tissues, or non-contact mode, where the beam is aimed from a distance. Each mode affects the focus and effectiveness of the laser.

Laser and Tissue Interaction

Laser tissue interaction refers to the mechanisms by which laser energy interacts with target tissues to achieve the desired clinical outcomes. The effectiveness of a laser depends on several factors, including the wavelength of the laser, the type of tissue targeted, the laser's energy settings, and the duration of exposure.[3] Lasers emit specific wavelengths of light that are selectively absorbed by different components of tissues, such as water, hemoglobin, melanin, or hydroxyapatite. Selective absorption allows for precise targeting of tissues and minimal damage to surrounding areas. The primary interactions between lasers and tissues are summarized **Table 3** and illustrated in **Figure 2**. Understanding these interactions is crucial for determining the appropriate laser settings for the various clinical applications used in dentistry, such as caries removal, soft tissue surgery, or periodontal therapy.[1-3]

Laser Classification and Laser Safety

The Food and Drug Administration's Center for Devices and Radiological Health regulates all lasers used in healthcare.[7] Lasers are classified according to their potential to cause biological damage. The pertinent parameters are laser output energy or power, wavelength, pulse duration, delivery system, and whether the laser is opened or closed (is the beam exposed to the user or is there an enclosure to confine the beams). There are four major hazard classes (I to IV) of lasers, including three subclasses (IIa, IIIa, and IIIb), see **Table 4**. The higher the classification, the more powerful the laser and the risk of serious harm if used improperly.

Ensuring laser safety entails comprehensive training, eye protection, plume control, and adherence to safety protocols.[5,6,8] This includes preventing eye injuries, avoiding skin burns, reducing fire hazards, complying with regulations, and protecting equipment and facilities. A team member is highly recommended to be assigned as the Laser Safety Officer (LSO) to oversee safety practices. Eye protection for patients and providers should be selected based on the specific device being used and worn in accordance with the manufacturer's guidelines and recommendations.

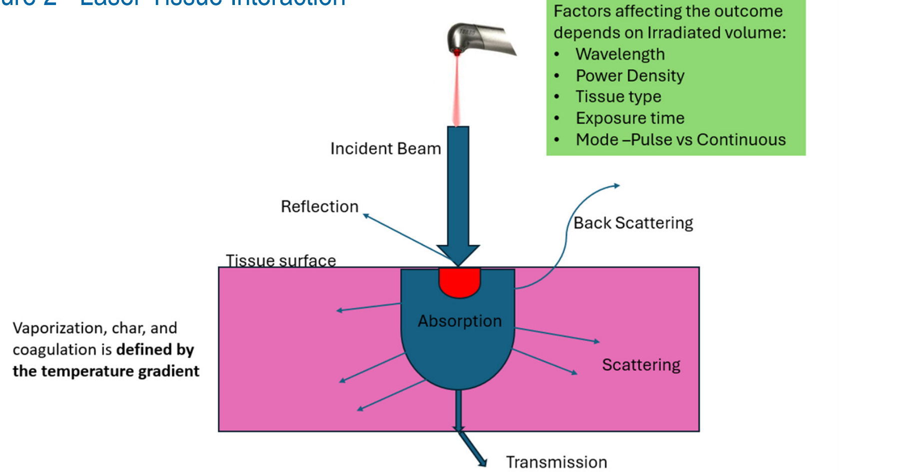
Table 2 - Determinants in Laser Dosimetry

Wavelength	Different tissues absorb different wavelengths of laser light differently. The choice of wavelength dictates the depth of penetration and the type of interaction with the tissue (*e.g.,* cutting, coagulating, ablating).
Power	Higher power can increase the rate of tissue interaction but also the risk of thermal damage.
Spot Size	The diameter of the laser beam on the tissue surface. A smaller spot size concentrates energy, increasing the intensity and depth of penetration.
Exposure Time	The duration for which the laser energy is applied to the tissue. Longer exposure times can increase the total energy delivered, affecting the extent of tissue interaction.
Pulse Duration	For pulsed lasers, the length of each pulse and the time between pulses (pulse repetition rate) influences tissue effects. Short pulses are often used for precision cutting, and longer pulses are helpful for coagulation.
Energy Density	The total energy delivered per unit area is measured in joules per square centimeter (J/cm^2). Energy density is a critical parameter in determining the therapeutic effect.
Tissue Type and Condition	Different tissues (*e.g.,* skin, bone, soft tissue) absorb laser energy differently, and factors like pigmentation, hydration, and blood supply can further influence the dose required for the desired outcome.

Table 3 - Laser and Tissue Interactions

Absorption	When a tissue absorbs laser energy, it is heated, causing various biological effects depending on the laser's wavelength and energy. In soft tissues, this heat can lead to coagulation, vaporization, or cutting. In hard tissues, such as enamel or bone, absorption can result in ablation or modification of the tissue surface.
Scattering	Scattering occurs when laser light is diffused within the tissue, which can reduce the laser's precision. Due to its complex structure, scattering is more common in hard tissues.
Reflection	Depending on the angle of the beam and the tissue properties, some laser energy can be reflected off the surface of the tissue. Reflected energy typically does not contribute to the desired clinical effect and must be managed to avoid exposure to non-targeted areas.
Transmission	Laser energy can sometimes pass through tissues without significant absorption or scattering and is more likely to occur in transparent or less dense tissues.

Figure 2 - Laser Tissue Interaction



Training and Certifiation in Laser Use

Adequate training is essential for the effective and safe use of dental lasers and understanding the legal framework governing dental lasers' use is crucial for dentists and dental hygienists. Each state's Dental Practice Act outlines what procedures dental professionals can legally perform with lasers. It is imperative to review these regulations regularly, as they may change. Dental hygienists must ensure they only perform laser procedures within their scope of practice.[6]

Laser training while in dental and hygiene school is generally limited. However, there exist numerous pathways to obtain laser training post-graduation, to include dental school CE programs, professional organization programs, and manufacturer programs. A comprehensive laser training course typically includes at least eight hours of didactic instruction and four hours of hands-on practice to develop basic competency. Taking advanced courses can help practitioners stay updated on the latest advancements and improve their proficiency in various laser applications. Manufacturers often provide basic training, but more in-depth courses are necessary to fully master the use of dental lasers and enhance patient outcomes.

Types of Dental Lasers

Dental lasers offer a versatile toolset for modern dentistry, enabling more precise and minimally invasive treatments with faster patient recovery times. Dental lasers can be categorized in several ways: by their power settings, such as high power or low power mode; by their clinical applications, such as hard tissue, soft tissue, all-tissue lasers, or lasers used for pain management. However, most dental manufacturers classify their products based on the type of laser medium. The most common types are outlined below.[9]

Erbium or **Er:YAG** (erbium-doped yttrium aluminum garnet crystal) and **Er,CR** or **Er,Cr:YSGG** (erbium, chromium-doped: yttrium, scandium, gallium, and garnet crystal) lasers are hard-tissue lasers highly attracted to water and hydroxyapatite, making them ideal for procedures involving tooth surfaces and bone. Due to their effectiveness in cutting hard tissues, these lasers are widely used for bone recontouring, preparing teeth for restoration (*e.g.,* fillings, crowns), crown lengthening, and exposing impacted teeth. Despite their higher cost and maintenance needs, their precision and ability to reduce patient discomfort make them a valuable tool in dental practice.

Table 4 - FDA Laser Hazard Classifications[7]

FDA Class	IEC Class	Laser Product Hazard	Examples
I	1, 1M	Considered non-hazardous. Hazard increases if viewed with optical aids, including magnifiers, binoculars, or telescopes.	Laser printer CD/DVD players
IIa, II	2, 2M	Hazard increases when viewed directly for long periods of time. Hazard increases if viewed with optical aids.	Bar code scanners
IIIa	3R	Depending on power and beam area, can be momentarily hazardous when directly viewed or when staring directly at the beam with an unaided eye. Risk of injury increases when viewed with optical aids.	Laser pointers
IIIb	3B	Immediate skin hazard from direct beam and immediate eye hazard when viewed directly.	Laser light show projectors Industrial lasers Research lasers
IV	4	Immediate skin hazard and eye hazard from exposure to either the direct or reflected beam; may also present a fire hazard.	Lasers used to perform LASIK eye surgery

Diode lasers are the most economical and versatile dental lasers. They are primarily used for soft-tissue procedures (*e.g.*, gingival recontouring, soft tissue surgery Their affordability and ease of use make them a popular choice, particularly for dental hygienists. Diode lasers are portable and easy to move between operatories,

Nd or **Nd:YAG** (neodymium-doped yttrium aluminum garnet crystal) lasers have been used in dental practice since the early 1990s and were among the first lasers adopted by clinicians before the widespread availability of diode lasers. While primarily used for soft-tissue applications, they can perform many of the same tasks as diode lasers. Though more expensive and slightly larger than diode lasers, Nd lasers remain popular due to their proven efficacy in procedures like periodontal therapy and soft tissue surgeries.[9]

CO2 (carbon dioxide) lasers are highly efficient at cutting soft tissue with minimal bleeding due to their high absorption in water. This makes them excellent for procedures requiring precise soft-tissue removal. CO2 lasers have become popular among dental professionals for their superior soft-tissue management capabilities. Some CO2 lasers cleared by the FDA for both hard- and soft-tissue procedures in dentistry, offering unique versatility and benefits for patient care.

Clinical Applications

Dental lasers offer numerous benefits to improve the quality of patient care. By eliminating the need for traditional retraction cords, lasers simplify gingival tissue management, leading to better impressions for crowns and bridges. They enable conservative cavity preparation, enhance bonding capabilities, and provide antimicrobial effects, often reducing the need for anesthesia. For Class V carious lesions, lasers ensure excellent hemostasis and strong bonding for composite materials, enhancing restoration aesthetics and longevity.[10] Lasers also offer immediate disinfection and pain relief for aphthous ulcers and improve minor surgical procedures by providing excellent hemostasis and a clean operating site.[1]

Hard-Tissue Applications

CO2 and Er YAG lasers are highly effective for procedures involving hard tissues, such as enamel, dentin, and bone.[11,12] Their applications include:

Bonding and Adhesion: Lasers can help in the bonding process by improving the surface properties of teeth and restorative materials, enhancing the adhesive bond. **Figure 3** illustrates laser use in managing abrasion causing hypersensitivity.[12]

Bone Recontouring: Lasers can reshape or remove bone during periodontal surgery or implant placement.[13]

Cavity Preparation: Lasers can precisely and more conservatively remove decayed tooth structure (**Figure 4**), alleviating the need for a drill and often eliminating the need for anesthesia.[10,14]

Crown Lengthening: Lasers can expose tooth structure by removing soft tissue and bone, aiding in restorative procedures.[13]

Enamel Remineralization: Laser treatments may enhance the remineralization of enamel and strengthen teeth. Chemical analysis of dental structures irradiated with an Er,Cr laser at subablative energies induced structural changes to the enamel surface, increasing its acid resistance by 23%.[15,16] These findings may be due to surface heating, which induces structural and chemical changes, or the vaporization of water, organic matrix, and inorganic components. Other considerations, such as photochemical effects or non-linear interactions, may also play a role.[17,18]

Endodontic Procedures: Lasers can assist in removing infected pulp tissue in primary teeth, offering a more comfortable experience for pediatric patients.[19] Lasers can be used to disinfect the root canal system by effectively removing bacteria and debris from the canal walls and root surfaces.[9] In cases where apicoectomy (surgical removal of the apex of a tooth root) is required, lasers can provide surgical precision and reduce the risk of infection.[13]

Excision of Bony Lesions: Lasers can be used to manage bony cysts and remove exostoses and tori with higher precision and less bleeding compared to traditional methods.[13]

Teeth Whitening: Diode lasers can be used to activate whitening agents, accelerating the teeth whitening process.[20]

Tooth Exposure: Lasers are ideal for exposing impacted teeth, particularly in orthodontic protocols.[13]

Soft-Tissue Applications

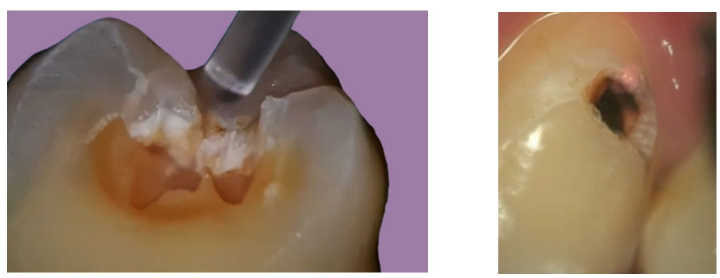
Biopsy and Lesion Removal: For soft tissue lesions, lasers provide precise removal with minimal disruption to surrounding healthy tissue.[21,22] **Figure 5** shows a step-by-step buccal fibroma removal, and **Figure 6** illustrates the multistage management of gingival leukoplakia. **Figure 7** illustrates depigmentation via laser. When using a laser to harvest a specimen for histopathologic assessment, proper technique and an adequate safety margin (0.5 mm) is necessary to ensure the lesion margin is free of laser-induced artifacts and distortions.[23,24]

Figure 3 - Management of gingival recession and abrasion

Gingival recession and abrasion

Immediate post-op. Laser used for gingivoplasty and enhanced bonding.

Figure 4 - Class 2 and Class 3 cavity preparation, created with laser



Class 2 preparation

Class 3 preparation

Figure 5 - Stepwise approach of fibroma removal using laser

Buccal fibroma

Post laser excision

Application of laser bandage

Patient discharge

One-week post-op

Frenectomy: Lasers can quickly and painlessly release tongue or lip ties.[25,26]

Gingivoplasty/Gingivectomy: Lasers can be used to reshape and remove gingival tissues with minimal discomfort and faster healing times compared to traditional methods.[1,2]

Implant Management: Lasers can clean and disinfect the implant surface and surrounding tissues, improving implant success rates.[27] Lasers can aid in the precise cutting and contouring of soft tissues around implants, ensuring better healing and tissue adaptation. Certain laser wavelengths may enhance osseointegration by promoting bone healing and reducing inflammation around implants.[2,13]

Periodontal Therapy: Lasers may be used to aid in the treatment of periodontal disease by targeting and removing infected tissue and bacteria from periodontal pockets and are associated with potentially faster recovery times when compared to traditional therapies.[28,30] It should be noted that the use of lasers to manage periodontal disease remains controversial and evidence to settle the debate is conflicting[31] Proprietary protocols include the Waterlase laser minimally invasive protocol called REPAIR,[28] and the LANAP® and LAPIP™ protocols using the PerioLase® MVP-7™.[29,30]

Photobiomodulation (PBM)

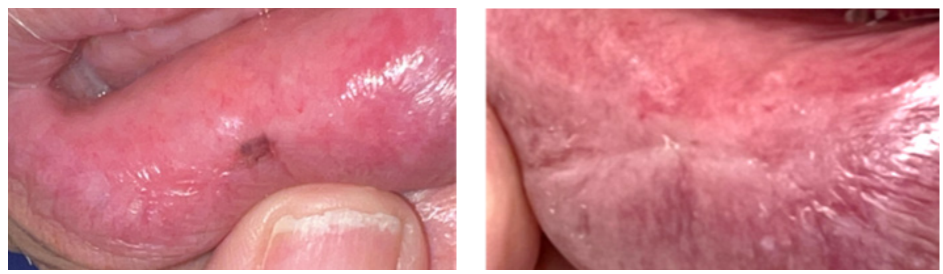
Photobiomodulation is a non-ablative low-level laser or light therapy that produces non-thermal effects on the tissues. It is an emerging therapeutic approach to alleviate pain and promote healing in various clinical contexts. It can be integrated into a comprehensive treatment plan alongside other modalities. PBM is non-invasive and generally well-tolerated. The light energy penetrates the skin and underlying tissues to stimulate mitochondrial activity, enhance cellular metabolism, promote tissue repair, accelerate healing, and alleviate pain.[32-34] Indications for PBM include:

Pain Relief: PBM has been shown to reduce pain associated with TMD by modulating pain pathways and decreasing the production of pro-inflammatory mediators. This can lead to significant improvement in patient comfort and quality of life.[33,34]

Figure 6 - Management of gingival proliferative leukoplakia in multiple phases

Clinical leukoplakia | Immediate post-laser | Post-laser healing

Figure 7 - Depigmentation melanotic lesion lower lip



Melanotic lesion | Post-laser depigmentation

Enhanced Tissue Healing: PBM may be used to accelerate lesion resolution and pain reduction in a variety of inflammatory mucosal lesions, such as recurrent aphthous ulcers,[35] recurrent herpes,[36,37] oral lichen planus,[35,38] and chemotherapy-/radiation-induced mucositis.[39]

Limitations of Laser Use

While the potential indications for laser therapy continue to grow, significant limitations persist.[1,2]

- Lasers are not suitable for removing existing restorations.
- The complete removal of carious tissue may require the use of curettes, depending on the location of the decay.
- Lasers may be contraindicated to manage interproximal caries.
- Due to irregular cavity margins created by laser ablation, restorative options are limited to a resin composite.
- Laser therapy requires extensive theoretical knowledge and practical training for effective use.
- The working time for cavity preparation is typically two to three times longer when compared to traditional rotary instrumentation. Efforts to improve laser ablation, such as increasing energy density or repetition rate are limited by potential temperature increases and patient discomfort.
- The capital costs of purchasing a laser and becoming certified in its use can be substantial.

Conclusion

The clinical applications for dental lasers continue to grow, offering potential benefits across multiple disciplines of dentistry. From conservative hard-tissue preparations to minimally invasive soft-tissue surgeries, laser therapy often represents an alternative approach to care that may enhance treatment outcomes and patient satisfaction. However, significant limitations remain regarding their use, and the requisite training and equipment cost can be substantial.

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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. Which strategy is recommended to mitigate the potential adverse effects of laser therapy?

a. Administer prophylactic antibiotics to patients before laser sessions to prevent cross-infection.
b. Choose the application spots regardless of the presence of other mucosal lesions, such as malignant tumors.
c. Use safety goggles for both the patient and the operator.
d. Use the device at its highest power level for the specific treatment protocol.

2. The prime safety concern when using lasers in clinical practice is _____.

a. eye damage
b. thermal damage
c. the use of anodized instruments
d. the use of non-reflective instruments

3. Er and Er,Cr Lasers are highly attracted to hemoglobin pigments.

a. True
b. False

4. What is specifically targeted for absorption by Diode lasers?

a. collagen and elastin
b. water molecules
c. bone tissue
d. hemoglobin and melanin

5. Laser light is best described as being

a. coherent, monochromatic, collimated.
b. polarized, non-coherent, collimated.
c. coherent, multiple frequency, monochromatic.
d. polarized, visible, monochromatic.

6. Laser dosimetry is important to:

a. to determine the cost of laser procedures.
B. to ensure proper calibration of dental equipment.
C. to establish appropriate energy levels for safe and effective treatment.
D. to measure the power dentistry of the treated tissue.

7. Ensuring laser safety entails:

a. eye protection
b. plume control
c. adherence to safety protocols
d. All the above

8. Comprehensive laser training is typically provided during dental / hygiene school, and there are many postgraduate resources for obtaining laser training.

a. The first part of the statement is true, but the second part is false.
b. The first part of the statement is false, but the second part is true.
c. Both parts of the statement are true.
d. Both parts of the statement are false.

9. Scattering occurs when laser light is diffused within the tissue, which can increase the laser's precision.

a. The first part of the statement is true, but the second part is false.
b. The first part of the statement is false, but the second part is true.
c. Both parts of the statement are true.
d. Both parts of the statement are false.

10. Which class of laser presents the greatest risk of hazardous exposure due to diffusely reflected radiation?

a. Class II
b. Class IIIa
c. Class IIIb
d. Class IV

Registration/Certification Information (Necessary for proper certification)

Name (Last, First, Middle Initial): ______________________

PLEASE PRINT CLEARLY

Street Address: ______________________ Suite/Apt. Number ________

City: ______________________ State: ____________ Zip: ____________

Telephone: ______________________ Email: ______________________

State(s) of Licensure: ______________________ License Number(s): ______________________

Preferred Dentist Program ID Number: ______________________ ☐ Check Box If Not A PDP Member

AGD Mastership: ☐ Yes ☐ No

AGD Fellowship: ☐ Yes ☐ No Date: ____________

Please Check One: ☐ General Practitioner ☐ Specialist ☐ Dental Hygienist ☐ Other

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Evaluation - Lasers in Dentistry 1st Edition

Providing dentists with the opportunity for continuing dental education is an essential part of MetLife's commitment to helping dentists improve the oral health of their patients through education. You can help in this effort by providing feedback regarding the continuing education offering you have just completed.

Please respond to the statements below by checking the appropriate box, using the scale on the right.

	1 = POOR 1	2	3	4	5 = Excellent 5	
1. How well did this course meet its stated educational objectives?	☐	☐	☐	☐	☐	
2. How would you rate the quality of the content?	☐	☐	☐	☐	☐	
3. Please rate the effectiveness of the author.	☐	☐	☐	☐	☐	
4. Please rate the written materials and visual aids used.	☐	☐	☐	☐	☐	
5. The use of evidence-based dentistry on the topic when applicable.	☐	☐	☐	☐	☐	☐ N/A
6. How relevant was the course material to your practice?	☐	☐	☐	☐	☐	
7. The extent to which the course enhanced your current knowledge or skill?	☐	☐	☐	☐	☐	
8. The level to which your personal objectives were satisfied.	☐	☐	☐	☐	☐	
9. Please rate the administrative arrangements for this course.	☐	☐	☐	☐	☐	

10. How likely are you to recommend MetLife's CE program to a friend or colleague? *(please circle one number below:)*

10 **9** **8** **7** **6** **5** **4** **3** **2** **1** **0**

extremely likely — neutral — not likely at all

What is the primary reason for your 0-10 recommendation rating above?

11. Please identify future topics that you would like to see:

Thank you for your time and feedback.

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