

REVIEW ARTICLE

Lasers in Dentistry

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ABSTRACT

Lasers were introduced into the field of clinical dentistry with the hope of overcoming some of the drawbacks posed by the conventional methods of dental procedures. Since its first experiment for dental application in the 1960s, the use of laser has increased rapidly in the last couple of decades. At present, wide varieties of procedures are carried out using lasers. The aim of this review is to describe the application of lasers in dental hard tissue procedures. Lasers are found to be effective in cavity preparation, caries removal, restoration removal, etching, and treatment of dentinal sensitivity, caries prevention, and bleaching. Based on development in adhesive dentistry and the propagation of minimum intervention principles, lasers may revolutionize cavity design and preparation.

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INTRODUCTION

The word laser is an acronym for "light amplification by stimulated emission of radiation." A device that generates an intense beam of coherent, monochromatic light (or other electromagnetic radiation) by stimulated emission of photons from excited atoms or molecules is called laser source. Lasers are used in drilling and cutting, alignment and guidance, and in surgery.¹

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HISTORY OF LASERS IN DENTISTRY

The first ruby laser was developed in 1960 and many other lasers were created rapidly thereafter. Dental researchers began investigating lasers' potential since then: Stern and Sognnaes² reported in 1965 that a ruby laser could vaporize enamel. The thermal effects of continuous-wave lasers at that time would damage the pulp. Other wavelengths were studied over the ensuing decades for both hard and soft tissue applications.

LASERS IN DENTISTRY

- Dental lasers exert their desired clinical effect on a patient's target tissue by a process called absorption.
- Dental lasers function by producing waves of photons (quanta of light) that are specific to each laser wavelength.
- This photonic absorption within the target tissue results in an intracellular and/or intercellular change to produce the desired result.³

TYPES OF LASERS IN DENTISTRY

- Dental lasers may be divided into three basic groups:
 - Soft tissue lasers
 - Hard tissue lasers
 - Nonsurgical laser devices
- Dental lasers according to absorbed wavelengths:
 - Diode and neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers
 - Carbon dioxide lasers
 - Erbium lasers [erbium (Er): yttrium-scandium-gallium-garnet and Er:YAG]⁴

USES OF LASER IN DENTISTRY

Hard Tissue (Cutting Enamel and Dentine)

- Class I, II, III, IV, and V cavity preparation
- Caries removal
- Hard-tissue surface roughening and etching
- Enameloplasty, excavation of pits and fissures for placement of sealants⁵

Advantages

- Reduce and even eliminate the smear layer associated with traditional rotary instruments, which can improve surface adhesion and bond strength for restorations

- Prohibit the pain response
- Most procedures can be completed without the aid of injected anesthetic⁶

Soft Tissue

- Treatment of canker sores, herpetic and aphthous ulcers of the oral mucosa, and leukoplakia
- Exposure of unerupted teeth
- Flap preparation
- Frenectomy
- Gingivectomy or gingivoplasty
- Gingival troughing for crown impressions
- Hemostasis
- Vestibuloplasty⁷

Advantages

- Capability to atraumatically treat soft tissue with little to no bleeding, little edema, and positive postoperative results

Bone Surgery

- Cutting, shaving, contouring, and resection of oral osseous tissues
- Osteoplasty and osseous recontouring
- Ostectomy
- Osseous crown lengthening⁸

Advantages

- Procedure can be completed without laying a flap, suturing, or damage to the bone

Root Canal Treatment

- Root canal preparation including enlargement
- Pulpotomy
- Apicoectomy—amputation of the root end⁹

Periodontology

- Sulcular debridement (removal of diseased or inflamed soft tissue in the periodontal pocket)
- Laser soft tissue curettage of the postextraction tooth sockets or the periapical area during apical surgery
- Flap preparation¹⁰

Others

- Diagnostic laser for caries and calculus detection
- Composite curing laser
- Optical impression like computer-aided design/computer-aided manufacturing
- Teeth bleaching¹¹

INFECTION CONTROL

Specific to lasers, any reusable fibers and tips must be heat sterilized along with their handpieces, and not wiped with a high-level disinfectant.

- Any debris on the end of the tip must be removed to ensure effective sterilization
- Disposable tips must be put into sharps containers, along with cleaved pieces of the fiber
- Care should be shown to the possibility of contamination of all laser hardware (e.g., syringe covers, sensor protector sheaths); transparent universal sticky barrier covers should be utilized where possible¹²

Hazardous effects of laser depend on

- Duration of exposure
- Power density value of laser beam
- Spot size¹³

LASER OPERATION TYPES

Continuous Wave

- Energy is emitted as long as the laser is activated
- *Example:* CO₂/diode laser
- *Corrected by:* gated or chopped pulsing of continuous output

Free Running

- Like flash lamp where true pulses emanate from the device
- *Examples:* Nd:YAG, Er:YAG¹³

HAZARDS OF LASER

Ocular Damage

- *Cause:* direct exposure of the unprotected eye or diffuse reflection from mirror-like surface.
- Site of injury depends on the absorption of wavelengths by specific structures of the eye, i.e., pigmented epithelium of the retina and choroid layer.
- Ocular injury from laser accident is a retinal or corneal burn.
- Retinal injury is possible with even low intensity because of focusing effect of the lens and cornea.
- Retinal burn may cause permanent blindness due to conversion of the radiation to heat.
- Other injuries to sclera, aqueous humor, and cataract may occur.¹⁴

Tissue Damage

- Laser-induced damage to skin and other nontarget tissue (oral tissue) can result from thermal interaction of radiant energy with tissue proteins.

- Elevation of temperature above 37°C causes cellular enzymes' and proteins' destruction and coagulation necrosis which affect the metabolic process.
- Final result is thermal necrosis of the tissues.¹⁵

Respiratory or Environmental Hazards

- These are also called nonbeam hazards, as they do not result from direct exposure to laser beam.
- It involves the potential inhalation of air-borne bio-hazardous materials that may be released as a result of surgical application of lasers.
- These aerosol by-products may contain viruses, bacteria, or chemicals.
- *Example:* chemical hazards.¹⁶

Chemical Hazards

May be due to:

- Escape of toxic chemicals and gases from laser itself, i.e., fluorine, hydrochloride gases, toxic dyes and solvents.
- Surgical instruments generate surgical debris containing chemicals, i.e., during composite removal, small amounts of methacrylate free monomers are released.¹⁷

Respiratory or Environmental Hazards

- Eye irritation
- Nausea and vomiting
- Breathing difficulties
- Transfer of infective bacteria and viruses¹⁸

Combustion Hazards

- In the presence of flammable materials, laser may pose other significant hazards.
- Flammable solids, liquids, and gases used within dental surgical setting can be easily ignited if exposed to laser beam.
- *Examples:* Clothes, acetone, oxygen, paper products; ethanol, nitrous oxide, plastic, methyl acrylate solvents, waxes, and resin aromatic vapors.¹⁹

Electrical Hazards

- Most laser systems involve high-current electrical supplies.
- There are several hazards that may be potentially lethal, such as electrical shock hazards, fire, or explosion hazards.
- Insulation, shielding, grounding, and housing of high-voltage electrical components provide adequate protection from electrical injury.²⁰

LASER HAZARD CONTROL MEASURES

Four categories for control measures are

1. Personal protective equipment
2. Engineering control
3. Administrative control
4. Environmental control

Personal Protective Equipment

- All people within dental treatment room must wear protective eyewear including the patient.
- The protocol for use is "patient first on and last off" as well as dental staff.
- Some factors should be considered:
 - Wavelength of emission
 - Maximum permissible exposure (MPE) limit
 - Degradation of absorbing filter
 - Optical density of eyewear
 - Need for corrective lenses
 - Comfort and fit
- Care must be taken when cleaning laser eyewear and side shields so that their protective coating is not destroyed.
- Should be washed with antibacterial soap and dried with a soft cotton cloth in-between procedures and patients.
- Disinfecting solutions generally applied to dental surfaces are too caustic and should be avoided.
- Must be inspected frequently to determine whether there is any breakdown (lifting/cracking/flaking) of the protective material that would render the eyewear to be useless.

Engineering Control

- Engineering controls are normally designed and built into the laser equipment to provide safety. Some of the engineering controls recommended in the American National Standards Institute (ANSI) standard are detailed as follows:
- *Protective Housing:* Laser should have enclosure around it that limits the access to the laser beam or radiation at or below the applicable MPE level.
- *Master Switch Control:* The switch can be operated by a key or computer code. When disabled (key or code removed), the laser cannot be operated. Also cover foot switch prevents the accidental operation.
- *Beam Stop:* Class IV lasers require a permanently attached beam stop which can reduce the output emission to a level at or below the appropriate MPE level when the laser system is on "standby."
- *Laser Activation Warning System:* An audible tone or bell and/or visual warning (such as a flashing light) is recommended as an area control for Class IIIB and IV laser.

Administrative Control

During the procedure, the administrative controller

- Establishes written standard operating procedures for the dental practice, as required by ANSI and other national standards as they may apply.
- Supervises the education and training of the dental team.
- Assists with evaluation when a new laser is needed.
- Understands the operational characteristics of the laser(s) in practice.
- Ensures the laser is being operated by authorized personnel only.
- Knows the limitations of device output.
- Ensures laser maintenance, beam alignment, and calibration of the laser device.
- Supervises medical surveillance and incident reporting.
- Keeps a log of recorded laser use and parameters employed.
- Determines the controlled area and the potential hazard and nonhazard zones.
- Ensures proper test-firing of the laser prior to admission of the patient into the operatory.
- Use of carbonized (do not absorb heat) or nonreflective instruments during procedure.

Environmental Control

- Use protective laser curtains to prevent accidental exposures to passers-by.
- Floor of operating room should be dry to avoid electrical hazards.
- Keep away all the flammable materials from the laser source.^{21,22}

CONCLUSION

Laser use in dentistry is proven to be beneficial in treating a wide range of dental conditions as well as a therapeutic tool in tissue management. The dynamics of laser energy beams pose general risks to nonoral tissues and the immediate environment. Safety measures have been devised to safeguard those personnel—staff and patients—who may be involved in dental treatment using lasers.

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