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Lasers in Dentistry-Double Edged Sword

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Abstract

There has been a recent uprise in the use of lasers in the field of dentistry. This article serves to examine the risks involved with Laser use in dentistry, the regulations governing safe use and the responsibilities of personnel involved in providing treatment to patients to prevent incidence of Laser injuries.

Keywords: Laser injuries; Laser classification; Dentistry

Introduction

The word "laser" is an acronym for Light Amplification by Stimulated Emission of Radiation. Laser in dentistry can be a precise and effective way to perform many dental procedures. Lasers can be used to detect caries, preparing cavities, sealing dental tubules to reduce sensitivity, etching, curing teeth and sterilization of root canal system. There are also soft-tissue applications as the beam can be adjusted to enable it to cut, vaporize, or cauterize tissue. One of the main benefits of using dental lasers is the ability to selectively and precisely interacts with diseased tissues. Lasers also allow the clinician to reduce the amount of bacteria and other pathogens in the surgical field, [1-3] and, in the case of soft-tissue procedures, achieve good hemostasis with the reduced need for sutures [4,5], minimize postoperative swelling and scarring with minimal post operative pain [6].

With widespread increase in the scope of Lasers in dentistry, additional risks to nontarget oral tissue, skin, and eyes are also increasing. Such damage may be the result of direct exposure to the laser beam or through the combustion of chemicals, gases, and materials used in dentistry. Damage can be instantaneous and permanent [7]. The majority of Laser injuries are due to poor adherence to established safety protocols. In order to use Lasers most effectively and safely, all clinicians undertaking laser dentistry should observe safe practice. This article serves to examine the risks involved with Laser use in dentistry, the regulations governing safe use and the responsibilities of personnel involved in providing treatment to patients to prevent incidence of Laser injuries.

Laser Classification - According To Potential of Causing Biological Hazard

International Electrotechnical Commission (IEC) is a global organization that prepares and publishes international standards for all electrical, electronic and related technologies. The IEC document 60825-1 is the primary standard that outlines the safety of laser products [8] (Table 1). Safety thresholds for lasers are expressed in terms of maximum permissible exposure (MPE). Individual MPE values vary according to the varying sensitivity of possible target tissues, e.g the eye and skin and are expressed in Joules or Watts per area (J cm-2, Wcm-2).

Laser Class	Description	Safety Aspects
Class 1	Very low power lasers or encapsulated lasers Maximum power output of these lasers is 40 W (blue light) and 400 W for red light emissions. Example: compact disc (CD) players and laser caries detectors **Class 1M.** Same criteria for classification as Class 1, either collimated with large beam diameter or highly divergent	Safe Safe provided optical instruments are not used for magnification e.g telescopes and binoculars
Class 2	Visible low power lasers. The maximum output is 1 mW. Example: laser pointers. **Class 2M** Same criteria for classification as Class 2,either collimated with large beam diameter or highly divergent	Safe for accidental exposure (< 25 ms) Human blink reflex will be sufficient to prevent damaging exposure, prolonged viewing may be dangerous [9,10]. Safe for accidental exposure (< 25 ms) provided optical instruments are not used for magnification e.g telescopes and binoculars
Class 3	**Class 3R** Low power lasers. Continuous wave laser that may produce up to five times the emission limit for Class 1 or Class 2 lasers. The laser can produce no more than 5 mW in the visible region. Prior to 2007, this classification was known as 3a. **Class 3B** Medium power lasers. CW emission from such lasers at wavelengths above 315 nm must not exceed 0.5 W Examples: 'soft' medical lasers (LLLT), laser light show equipment and laser measuring device.	Safe when handled carefully. Only small hazard potential for accidental exposure. Hazardous when eye is exposed. Usually no hazard to the skin. Diffuse reflections usually safe, Environmental controls, protective eyewear, appointment of assigned safety personnel and training in laser safety are required by personnel using these lasers [11,12].
Class 4	High power lasers (typically up to 500 mW or more if CW, or 10 J • cm−2 if pulsed). Nearly all medical and dental lasers fall into this category.	Hazardous. Exposure of the eye or skin to both the direct laser beam and to scattered beams, must be avoided at all times [13]. Fire risk

Table 1: Laser classification - According to potential of causing biological hazard

Hazards associated with Laser

Beam-Related Hazards

These risks are those that are posed by exposure of non-target tissues to laser beams. The primary concern in laser safety is the possibility of eye injury. A secondary one is damage to the skin. Biological effects of laser light may depend on a number of factors including the wavelength of the light, its power, whether it possesses a continuous wave nature or is pulsed, or whether it is the result of a direct exposure of laser light rather than a diffuse reflection. Effects can range from mild skin burns to irreversible injury to the skin and eye.

Ocular injuries: The eye is the part of the body most vulnerable to laser hazards. Changes to the eye can occur at much lower laser power levels than changes to the skin. Major cause of ocular injuries is due to operator error [14]. Longer wavelengths interact with structures in front of the eye, causing ablation, scarring and distortion of vision [15]. Wavelengths from 400-1,400 nm (visible and near- infrared) can pass through the transparent structures at the front of the eye and impact on the retina. Longer wavelengths (2,780-10,600 nm, mid- to far-infrared) will interact with the cornea [16,17]. In terms of the scope for repair, retinal injuries are more serious [18-21].

Skin risks: Low wavelength UV lasers (<400 nm) not used in dentistry. All other laser wavelengths can cause 'skin burns' [22,23] due to ablative interaction with target chromophores. Different wavelengths of light penetrate to different depths of the skin, the most penetrating being from 700-1200 nm. The UV-B range of lasers can be the most injurious, resulting not only in thermal damage but possibly in carcinogenesis. UV-A can cause hyper pigmentation and erythema. UV- C seems to have the least effect on the skin due to its short wavelength which is absorbed by the epidermis. Thermal burns to the skin are rare. They usually require exposure to high energy beams for an extended period of time. The resulting burn may be first degree (reddening), second degree (blistering) or third degree (charring).

Non-Beam Hazards

They pertain to the indirect injury from Laser beam. These risks are associated with possible physical damage arising from moveable components of a laser, electrical shock and mains supplies (pressurized air, water). Fire risks, through the ignition of tubing, some anesthetic gases or chemicals (e.g. alcoholic disinfectants), should be identified and avoided [24-28]. In addition, the products of tissue ablation (plume) represent a considerable hazard that can affect the clinician, auxiliary personnel and the patient. Suitable fine mesh face masks specific to surgical laser use, gloves and high-speed suction aspiration must be used to control the spread of all laser tissue ablation products.

Environmental hazards: Potential inhalation of airborne hazardous materials that may be released as a result of laser therapy may cause respiratory hazards. Some lasers contain inert gases (argon, krypton or xenon) mixed with toxic gases such as fluorine or hydrogen chloride as the active medium. Inhalation of toxic material in the form of aerosols has been found potentially damaging to the respiratory system. Greatest producers of smoke are carbon dioxide and Nd: YAG laser.

Laser Plume

Products of laser tissue ablation are collectively termed a 'laser plume' Whenever non-calcified tissue is ablated, such as in caries removal and all soft tissue surgery, a complex chemical mixture is emitted which is composed of water vapour, bacterial and viral bodies, carbon monoxide and dioxide and hydrocarbons. Plume carries potential risk of nausea, breathing problems, bacterial inoculation [29-32]. Laser plume from infra-red lasers are less harmful and can be considered similar to the debris that is produced with an airturbine.

Electrical hazards: Electric hazards of Lasers may occur from contact with exposed utility power utilization, device control, and power supply conductors operating at potentials of 50 volts or more. These exposures can occur during laser set-up or installation, maintenance and service. The effect can range from a minor tingle to serious personal injury or death. Electrical hazards of lasers can be grouped as electrical shock hazards, electric fire hazards or explosion hazards. Insulated circuitry, shielding, grounding and housing of high voltage electrical components provide protection under most circumstances from electrical injury. All equipment should be installed in accordance with OSHA and the National Electrical Code. Person working with Laser should be knowledgeable of first aid and CPR [33].

Combustion Hazards: Class 4 laser systems represent a fire hazard. Enclosure of Class 3 laser beams can result in potential fire hazards if enclosure materials are likely to be exposed to irradiances exceeding 10 watts/cm2. Flammable solids, liquids and gases used within the surgical setting can be easily ignited if exposed to the laser beam. The use of flame resistant materials and other precautions therefore is recommended. Opaque laser barriers (e.g., curtains) can be used to block the laser beam from exiting the work area during certain operations. Users of commercially available laser barriers should obtain appropriate fire prevention information from the manufacturer. Avoid alcohol based topical anesthetic or other inflammable materials in operating area Protect tissues adjacent to the surgical site. Nitrous oxide supports combustion and should not be used during laser surgery.

Laser Safety Measures

The ANSI Z136 series of laser safety standards provide a detailed description of control measures which can be put into place to protect against potential accidents. These control measures are divided into two distinctive categories, Engineering Controls and Administrative/Procedural Controls. The focus of these controls is to provide adequate education and training, provisions for protective equipment, and procedures related to the operation, maintenance and servicing of the laser. Apart from these two control personnel protective measures are also necessary to ensure safety from Laser.

Engineering Control Measures

Some of the important engineering controls recommended by the ANSI are as follows: [34]

Laser Barriers and Protective Curtains: Important in the design is the factor of flammability of the barrier. It is essential that the barrier not support combustion and be consumed by flames following an exposure.

Protective Housing: A Laser shall have an enclosure around the laser which limits access laser radiation at or below the applicable MPE level.

Master Switch Control: All Class IV lasers and laser systems require a master switch control. Only authorized system operators are to be permitted access to the key or code. Inclusion of the master switch control on Class IIIB lasers and laser systems is also recommended but not required.

Optical Viewing System Safety: Interlocks, filters or attenuators are to be incorporated in conjunction with beam shutters when optical viewing systems such as telescopes, microscopes, viewing ports or screens are used to view the beam or beam reflection area. Such optical filter interlocks are required for all but Class I lasers

Beam Stop or Attenuator: Class IV lasers require a permanently attached beam stop or attenuator which can reduce the output emission to a level at or below the appropriate MPE level when the laser system is on "standby." Such an beam stop or attenuator is also recommended for Class IIIA and Class III Blasers.

Interlock Requirements: Interlocks which cause beam termination or reduction of the beam to MPE levels must be provided on all panels intended to be opened during operation and maintenance of all Class IIIA, Class IIIB and Class IV lasers. The interlocks are typically electrically connected to a beam shutter and, upon removal or displacement of the panel, closes the shutter and eliminates the possibility of hazardous exposures.

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 laser operation. Such a warning system is mandatory for Class IV lasers. Such warning devices are to be activated upon system start up and are to be uniquely identified with the laser operation.

Remote Interlock Connector: All Class IV lasers or laser systems are to be provided with a remote interlock connector to allow electrical connections to an emergency master disconnect ("Button panic button") interlock or to room, door or fixture interlocks. When open circuited, the interlock shall cause the accessible laser radiation to be maintained below the appropriate MPE level. The remote interlock connector is also recommended for Class III Blaser.

Administration Controls

To aid in managing the risk associated with the use of lasers, the following administration controls are to be implemented where lasers are used:

Appointing a laser safety officer: A Laser Safety Officer (LSO) is a designated school/departmental staff member who has received training to an appropriate level and is knowledgeable in the evaluation and control of laser hazards. The LSO would have responsibility for the suitable training of laser users and oversight of the control of laser hazards.

Safe working procedures: Appropriate protective eyewear for the patient and the entire surgical team must be worn when the laser is operating so that any reflected energy does no damage. The surgical environment has a warning sign and limited access. High volume suction must be used to evacuate the plume formed by tissue ablation, and normal infection protocol must be followed. The laser itself must be in good working order so that the manufactured safeguards prevent accidental laser exposure.

Training and education: All staff members should receive objective and recognized training in the safety aspects of laser use within dentistry, as with other specialties [35]. Dentists should use the devices within their licensed scope of practice, training and experience.
For personnel who work with Class 3b and 4 lasers, the training will included the following topics:

- The biological effects of laser radiation
- The physical principles of lasers
- Classification of lasers
- Basic safety rules
- Use of protective equipment
- Control of related hazards including electrical safety, fire safety, and chemical safety
- Emergency response procedures

Correct labelling of device: The laser hazard symbol shall be a sunburst pattern consisting of two sets of radial spokes of different length and one longer spoke radiating from a common center. The color, dimensions, and location of the symbol within the sign shall be consistent with the specifications in ANSI Z136.1-2007.

Eye and skin examinations: Medical surveillance of personnel working in a laser environment should be consistent with those recommended in ANSI Z136.1-2007.

User registration and Record keeping

Personal Protective Equipment

Eye protection: Adequate eye protection must be worn by the operator:

It is considered advisable to cover the patient's eyes with damp gauze for long wavelength peri- oral procedures [36]. They are available in the form of safety goggles or screening devices. Details on protective eyewear can be found in AS/NZS 1337.4 and AS/NZS 1337.5.

Eyewear Requirements:

a) The eyewear must be labeled with the wavelength to be attenuated and the optical density (OD) for each wavelength [37-39]. The OD refers to the ability of a material to reduce laser energy of a specific wavelength to a safe level below the MPE. The OD value should be '5.0' or above for adequate protection.
b) All eyewear should be inspected every six months to ensure that there is no damage, such as cracks, scratches, holes, or discoloration.
c) All eyewear should fit the user well.
d) Damage Threshold of the eyewear (the maximum irradiance or beam power that the eyewear will protect against for at least 5seconds
e) Visual transmittance of the eyewear (how much visible light is transmitted to the eye)
f) Field of view and curvature of the lens Goggles large enough to accommodate prescription eyewear
g) Ventilation to prevent fogging and general comfort

Laser filtration masks - for the prevention of air borne contamination.

Hand and clothing protection

Surgical gloves should be worn by the user when they are operating the laser as a means of controlling infection. Special clothing, including gloves may need to be worn in circumstances where personnel are required to have their hands in close proximity to the laser beam. These gloves will need to offer the wearer flexibility and freedom of movement, especially in terms of finger dexterity. In the case of class 4 lasers should also include protective clothing and footwear.

Conclusion

Lasers have emerged as powerful weapon in the hands of modern dentistry. But a clinician cannot afford to ignore potential risks associated with the use of Lasers. It is most important for the dental practitioner to be aware of the nature of laser hazards, procedures and safeguards that need to be implemented, have clinical experience, and have received proper laser training. Most of the Laser injuries can be avoided by establishing an adequate safety policy for the management and control of risks arising from the use of laser equipment.

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