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Laser Hazards & Safety in Dentistry

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Dentistry is unique field in the profession of healthcare industry where most of the dental surgeons work as solo practitioners in private office settings. For the most part, their use of lasers is not monitored. Whereas, within the medical community, laser use is more strictly controlled by institutional review boards, credentialing, and hospital surgical privilege committees. Furthermore, the level of training and experience of the dental staff is generally far less than that of the laser surgical nurse or hospital laser safety officer.

There are various laser hazards which can be classified in various categories, which could be harmful to individual and can lead to potential damage of human body. Hence, dental laser safety is an important part of laser dentistry.

According to **Walsh L J** (2003),based on potential hazards, laser can be classified as[1],

Class	Risk	Example
I	Fully enclosed system	Nd: YAG laser welding system used a dental laboratory
II	Visible low power laser protected by the blink reflex	Visible red arming beam of a surgi laser
IIIa	Visible laser above I milliwatt	No dental examples
IIIb	Higher power laser unit which may or may not visible. Direct viewing hazardous to the eyes.	Low power diode laser used for l stimulation
IV	Damage to eyes and skin possible, direct or indir viewing hazardous to the eyes.	All lasers used for oral surge whitening and cavity preparation

According to the CDRH and ANSI system of classification, ***class IV lasers*** are defined as those devices that pose a biologic hazard from either direct or diffuse reflection[2]. Generally, any laser capable of emitting power greater than 500-mW continuous wave output belongs in this class.

Dental lasers belong to category IV which is the most hazardous of all the lasers. According to **Miserendino L *et al.*,** (1995)[3]the types of hazards that can be encountered within the clinical practice of dentistry are grouped as follows:

1) Ocular injury
2) Tissue damage
3) Respiratory hazards
4) Fire and explosion
5) Electrical shock

1. Ocular injury/ Hazards

Potential injury to the eye can occur either by direct emission from the laser or by reflection from a specular (mirror like) surface. According to **Miserendinoet al.,** (1995), Dental instruments have been capable of producing reflections that may result in tissue damage to both operator and patient.

Sosis(1990)recommended the use of carbonized or nonreflective instruments has been recommended during laser treatment by some authorities.

The primary ocular injury that may result from a laser accident is a retinal or corneal burn.[4]

This is possible with emission in the visible (400-780nm) and infrared (780-1400) spectral regions. Direct and specular reflections of relatively low intensity are capable of causing retinal damage because of the focusing effect of the lens and cornea.[5]

Due to focusing effect, Incident radiation passing through the pupil may be increased up to 100,000 times at the retina due to the focusing action of the eye. (Laser Institute of America, 1993) To prevent the ocular injury, exposure can be given at short pulses. But even then, there could be adverse effect, hence for eye protection, protective laser spectacles has been recommended which has been discussed in next chapter.Damage to the sclera, corneal surface can occur from exposure to radiant energy within the far ultraviolet (<300 nm) and far infrared (>7000 nm) ranges. [6]

The following table has been referred from ANSI Z-136.3, which compares the various wavelengths and their maximum permissible exposure limits.

2. Tissue hazards

Miserendino L *et al.,* (1995)briefed that tissue hazards could be of two types of reactions[7], Thermal interaction and Nonthermal interactions.

1) Thermal Interactions:

Laser induced damage to skin and other nontarget tissue can result from the thermal interaction of energy with tissue proteins. Temperature elevations of 21°C or above normal body temperature (37°C) can lead to cell destruction by denaturation of cellular enzymes and structural proteins. Exposures of 1 sec. or more than that can lead to vascular perfusion and leads to thermal diffusion of heat energy within the tissue. In case of wavelength more than 400 nm, there could be thermal coagulation necrosis.

2) Nonthermal tissue interaction:

It induces tissue injury by photochemical and photoacoustic mechanism. This type of interaction is most likely to occur with single or repetitive pulses of very short duration (less than 10 psec). It can cause radiant exposures within the ultraviolet spectrum such as those with excimer lasers.

Hence, laser induced tissue injury is primarily dependent on the extent of absorption of radiation by tissue. However, it is important to know that there are certain factors that affect the extent of laser tissue interaction like –

(1) the relative amount of absorption, transmission, and scatter of the particular wavelength; (2) the pulse duration and pulse repetition rate; (3) the level of radiant exposure (energy density or exposure dose); and (4) the relative degree of vascularity of the tissue.

During ablation of oral tissue with the carbon dioxide laser a carbonized layer of tissue residue, or char layer forms on the surface. This carbon material is a strong absorber of laser wavelength. It acts as a heat sink that transfers energy to surrounding tissues.

Mode of delivery of laser wavelength is an important factor to induce nature of interaction. Lasers like Nd: YAG with noncontact system will produce different effect with more penetration into deeper structures as compared to that of a contact tip laser scalpel.

3. Environmental Hazards

Miserendino L *et al.,* (1995)described another type of hazards which involves the inhalation of airborne biohazardous materials that is released during surgical procedure of laser.

These types of hazards are sometimes referred as Nonbeam hazards as they don't cause tissue injury from direct exposure to the laser beam. Inhaled air borne contaminants can be emitted in form of smoke or plume generated through the thermal interaction of surgical lasers.[8]

It is important to know that most surgical lasers used in dentistry are capable of smoke generation, toxic gases and chemicals which are more common hazard in dental research. (E.g. Excimer laser)

During ablation or incision of oral soft tissue, cellular products are vaporized due to the rapid heating of the liquid components in the tissue. In the process, extremely small fragments of carbonized, partially carbonized, and relatively intact tissue elements are violently projected into the area, creating airborne contaminants that are observed clinically as smoke or what is commonly called the ***laser plume.***

Baggish et al (1991)stated that inhalation of such material is hazardous to patients and operating room. Some of the chemical found in laser plum after soft tissue vaporization are as follows[9]:

Laser Plume Chemicals

Water	Carbon dioxide
Formaldehyde	Benzene
Acrolein	Methane
Cyanates	Acetone
Cyclohexane	Toluene
Fatty acid esters	Alkanes
Xylene	Acetaldehyde

The extent of plume generation depends up on the absorption of various wavelengths by the target tissue. The greatest producers of smoke are the carbon dioxide and erbium lasers and then Nd: YAG laser. Carbon dioxide and Er: YAG lasers have high coefficient absorption because of the high-water content of oral tissue.

4. Combustion hazards

Flammable materials while using laser can play significant role to cause this kind of hazards. Flammable solids, liquids, and gases used within the surgical setting can be easily ignited if exposed to the laser beam.Here, nitrous oxide is generally considered as nonflammable material but will support combustion. **Sosis**(1990) did not recommend it in laser surgery.

5. Electrical hazards

According to **Miserendino L *et al.,*** (1995), class IV lasers need high currents and high voltage power supplies. They sub grouped Electrical hazards of lasers as electrical shock hazards, electrical fire hazards or explosion hazards. Laser system may get exposed to conductive liquids that may contribute to an electrical hazard.

Hence, since the invention of lasers, it was recognized that it could be potentially dangerous to oral tissues and human body. Today, even low power laser with only a few milliwatt of output power can be hazardous to human eyesight. After reviewing various hazards related to laser practice, it is important for clinician to establish various safety measures against complication or laser hazards. Hence it is important to know the guidelines suggested for safety measures and to overcome laser hazards. To avoid laser hazards to human body, specific recommendations have been given. Certain clinical skill and training is required and also various laser organizations have recommended laser safety control measures.

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