REVIEW ARTICLE

doi:10.18575/msrs.sm.e.16.11
UDK: 616.31-08:621.375.826
COBISS.RS-ID: 5704472

Laser Safety in Dentistry

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ABSTRACT

Safety, mainly patient safety, has become the foundation upon which all other aspects of quality health care are built. Since lasers are progressively used in various fields of dentistry, laser safety issues have recently become of great importance. Lasers are considered effective but potentially hazardous to the patients, due to their improper use and lack of laser safety awareness. Assuming that use of lasers in dental practice will gradually increase, the aim of this study is to introduce the basics on laser safety in dentistry. Study also serves as a reminder for colleagues, who are or will be laser users, on potential laser hazards, laser safety measures and ways to ensure and improve patient safety in laser dentistry.

Key words: Dental lasers, Laser hazards, Laser safety

(Scr Med 2016:47:62-66)

Submitted: December 14th, 2015
Accepted: December 23th, 2015

Introduction

Lasers are a common and essential part of modern medicine, dentistry and everyday life.[1] In dentistry, lasers have been efficiently used for more than three decades for diagnostics, surgery and therapeutic applications.[2] Although the advantages of dental lasers are widely reported,[2] it is well known that these advantages are also considered potential hazards and significant safety threats.[3] Dental practitioners and personnel, as well as patients, may suffer from inappropriate use of lasers.

To put it simply, safety is "freedom from accidental injury" and patient safety is "prevention of harm to patients". Patient safety has become the focus of healthcare professionals and general public interest with the publication of the Institute of Medicine (IOM), where it was clearly stated that more people die each year in American hospitals as a result of preventable medical errors than in motor-vehicle accidents, from breast cancer or AIDS.[4] As a result, Australia, New Zealand, Great Britain and Canada stated that 10% of the hospitalized patients suffered from medical error.[5-8] Therefore, these and many other countries have made significant effort to improve patient safety and to promote use of health care practices that reduce the risk of harm resulting from the processes, systems, or environments of care. Up to the present time, the majority of the available literature is related to patient safety in hospitals, but this issue is becoming

more and more interesting for the dental health care, as well. [9,10]

Although laser-related accidents may vary in origin, they are characterized by several common elements; almost all involve at least some carelessness and lack of laser related knowledge and safety awareness.[1,11,12] In the study conducted by Moseley, 67% of reported laser-related accidents were related to practitioners' error, and therefore considered preventable.[13] Accordingly, complete protection against accidental laser-related injury is possible, provided that the practitioner is highly familiar with the characteristics of the laser and its mode of employment, properly trained in laser safety and follows laser safety standards and regulations.[1,10] With expansion in future application, it is expected that number of potential laser users will continue to grow, so must concerns for laser safety, too. This study should also serve as a reminder for colleagues, who are or will be laser users, on potential laser hazards, laser safety measures and ways to ensure and improve patient safety in laser dentistry.

Laser hazards and safety measures

Laser hazards are generally divided into beam hazards and non-beam hazards.[3] Beam (direct) hazards are eye/skin injuries, whereas non-beam (indirect/associated) hazards are results of the laser interaction with materials within the surgical environment, including laser plume hazards, fire hazards and electrical hazards.[3] These hazards affect dental practitioners, personnel as well as patients.

Direct hazards - Eye/skin injuries: Laser irradiation is mainly hazardous to the eye and, up to the present time, the majority of laser-related injuries described in the literature has been ophthalmic.[1,14] Individuals with eye (ocular) laser injuries experience a variety of symptoms due to the wavelength of laser device and the specific location of the injury within the eye (Table 1.). Most individuals exposed to laser emissions in the visible spectrum complain of glare or dazzle. Even though the symptoms will only last for several minutes, during this refractory time, an exposed individual is visually handicapped (driving a vehicle, reading, etc.). Depending on the laser intensity and wavelength, exposure to laser light may have temporary or permanent effects.[15] Therefore, every practitioner using dental lasers is required to wear protective eyewear (spectacles or goggles) that can protect the eyes from direct exposure to a laser beam (looking directly at the laser source), as well as from the scattered or reflected laser light (by a mirror or nearby objects). Patients and personnel who may be exposed to direct beams, specular and/or diffuse reflections must wear protective eyewear selected according to the specific type of laser. [14,15]

Table 1. Basic characteristics of major lasers in dentistry (class IV)

Active medium	Type of lasers/wavelenghts	Emissions	Organs effected
Gas lasers	Carbon dioxide (CO^2) / 9.3/10.6 nm	far infrared	cornea; skin
	Helium-Neon (He-Ne) / 637 nm	visible red	retina
	Argon / 457-514 nm	visible blue/green	retina
Diode lasers	Ga-Al-As / 670-830 nm	visible red/near infrared	retina, lens, skin
	Ga-As / 840, 904 nm	near infrared	
	In-Ga-As / 980 nm		
Solid state lasers	Ho:YAG / 2080 nm	near infrared	cornea, aqueous, lens, skin
	Nd:YAG / 1064 nm		retina, lens, skin
	Er:YAG / 2940 nm	mid infrared	
	Er,Cr:YSGG / 2940 nm		cornea, aqueous, lens, skin

Accidental skin exposure to laser energy is another potential hazard. The skin is usually much less sensitive to laser light than the eye, but excessive exposure to laser radiation of high energy can cause short- and long-term effects similar to sunburns, especially to anesthetized or sedated patients.[16]

Indirect/associated hazards - Laser plumes: Laser plumes are products of laser-tissue interaction during laser surgical procedures and are recognized as potentially hazardous. Besides vapors, smoke and particulate debris, plume can contain biological contaminants generated by laser, such as carcinogens, mutagens, irritants, fine dusts, viral DNA molecules, such as human papillomavirus (HPV) and human immunodeficiency (HIV) DNA molecules, blood parts, viable bacterial cells and spores.[17-22] Furthermore, plume can contain various toxic gases such as carbon monoxide and polyaromatic hydrocarbons and chemicals such as formaldehyde, acrolein and benzene.[21] In vivo studies have demonstrated that laser plume debris contain easily spreading particles and gases that are hazardous to the respiratory tract causing eye, nose and throat irritation, nasal congestion, bronchiolitis, congestive interstitial pneumonia and emphysema in rat lungs exposed to laser plume for different period of time.[21] Furthermore, it is stated that laser plume can

also cause potential bacterial and viral dissemination and infection.[20, 22] Therefore, it is necessary to efficiently avoid laser plume with safe laser operational procedures. General precautions for controlling gaseous and particulate emissions from laser surgery should be the following: the usage of protective equipment (protective clothing, gloves, laser goggles and appropriate respirators), proper ventilation (operating room wall suction), smoke evacuation and filtration.[23]

Indirect/associated hazards - Fire hazards: This type of patient safety issue is rare, but real.[24] Fires caused by lasers, in oxygen- or nitrous oxyde-enriched enviroment can ignite even a fire-resistant materials, including a patient, consequently producing serious and fatal results.[25] Laser fire hazards can be successfully prevented by ongoing education, a discussion of risks and detailed predetermined procedures for fire prevention and extinguishment.[25]

Discussion

Patient safety should be more in focus in laser dentistry and a stone corner of quality dental health care. Possible explanation for minor interest for patient safety in general dentistry could lie in the fact that the harm produced in dentistry is generally considered less severe (compared to hospitals); that there is a great dispersion of dental clinics making data collection difficult; that dental clinics are mostly privately owned and private practitioners are afraid that reporting an adverse events can affect the profits of the clinics.[26] Nevertheless, in order to minimize the risk and improve patient safety in laser dentistry, establishing a system with focus on safety, which includes all participants in the process, is dominant. Problems arise because during daily practice, time pressure, haste, acquired habits, fatigue and inertia sometimes obliterate this common sense. As aspects of general organizational culture have been found to be strongly related to safety climate, strategies that promote group orientation and reduce the influence of hierarchy, such as the use of multidisciplinary team training, continuous quality improvement tools and innovative human resources practices and policies, are supported as making positive contributions. Developing and introducing team resource management programs and evidence-based clinical interventions, ongoing efforts to minimize variations among health care settings and the sharing of successful experiences are also suggested to be beneficial.

Some of the suggestions are:

1. Enacting legal requirements regarding safe use of laser: Enactment of a law specifically targeting lasers, describing their classifications, laser hazards, physical and technical requirements for safe use of lasers (such as: environment, access, laser safety features (Table 2.), risk assessment and precautionary measures), appointment of an authorized person, etc.

2. Adopting safety and quality standards in laser dentistry: Safety and quality standards in laser dentistry could lead to further improvement of patient safety and quality of care. Regulators and accreditation bodies can define minimum patient safety standards and performance levels for healthcare professionals and organizations in licensing, certification, and accreditation processes. Standards should, at least, cover the five risk areas toward which risk-reduction strategies should be directed in laser dentistry. These are: leadership process and accountability, competent and capable workforce, safe environment for staff and patients, clinical care of patients, improvement of quality and safety (Joint Commission International Consulting, International essentials of health care quality and patient safety, 2008, Joint Commission International).

Table 2. Recommendations on safe use of lasers

SAFE ENVIROMENT
• Labeling of the place where laser is in use
• Door, windows and non-reflective surface furniture
• Safe place for laser key and laser accessorize
• Easy access to fire extinguishers
• Protective eyewear
• Laser safety officer
• Further laser education and training
• High volume suction
• Local rules in the dental office
LIMITED ACCESS
• Key or password protection to prevent the laser from being operated when authorized personnel are not present • Locked unit panels to prevent unauthorized access to internal machinery
SAFETY FEATURES OF LASERS
• Delayed response from the foot switch (to prevent accidental operation-unintentional stepping on the foot switch) Delayed response from the foot switch (to prevent accidental operation-unintentional stepping on the foot switch) • Remote interlocks (a connection between a closed door and the laser) Should the door be opened during laser operation, the remote interlock will shut down the laser

- Emission port shutters to prevent laser emission until the correct delivery system is attached
- Emergency stop switch or button – visible and easily located so that the laser can be shut down in an instant
- Control panel and display to ensure correct emission parameters
- Audible sound that is distinctive to the laser when it is in operation
- Visible signs on the laser, such as lights which warn whether the laser is in standby mode or is being used

3. Providing sufficient education and training: Proper education and training of personnel that uses lasers are basic requirements. Up to the present time, number of organizations, such as American Society for Laser Medicine and Surgery, Laser Institute of America and Rockwell Laser Industries, have published guidelines or printed materials on the safe use of lasers. An emphasis should be put on laser safety education in medical schools' and dental faculties' curriculum. Also, professional societies should provide continuous education on patient safety in laser dentistry, conduct research, set evidence-based practice guidelines, disseminate information and communicate about patient safety with their members and the public.

4. Appointment of laser safety officer (LSO): LSO holds authority and responsibility to monitor and enforce the control of laser hazards, to evaluate laser hazards and implement standard operating procedures. LSO is strongly recommended wherever dental lasers are used. Taking into consideration the experience of countries in which the appointment is mandatory, LSO should not be the person who uses the laser (not a dentist, but a dental technician).

5. Reporting laser-related adverse events: The average number of reported laser-related adverse events in USA is 35 per year. Although practitioners are highly encouraged to report laser-related adverse events, general fear is that most of these adverse events and near-misses go unreported.[27] Nevertheless, reporting of laser-related adverse events should be professional and, furthermore, a personal moral responsibility of every dental practitioner. Good example is Dr. Decker, who made a report on laser-related injury he suffered himself, in order to remind his colleagues of the consequences of careless action, and hopefully, increase vigilance.[28] Special attention should be given to the collection of adverse events data, in order to enable proper surveillance and evaluation by professional societies, further making data transparent to all laser users.

These simple steps allow us to create conditions to secure and improve patient safety in dental ambulances and clinics using lasers. Anyone who uses lasers or is responsible for potentially hazardous laser equipment should be properly educated about safe use of lasers. Furthermore, they should understand the nature of risks caused by lasers, procedures which need to be applied in order to mitigate risks and to reduce the incidence of adverse events and errors by reporting the adverse events.

Systematic approach and involvement of interested parties in this field are crucial.

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Sigurna primjena lasera u stomatologiji

SAŽETAK

Sigurnost, naročito pacijenata, postaoje temelj na kojem su izgrađeni svi ostali aspekti kvalitete zdravstvene zaštite. Budući da se laseri postupno koriste u raznim područjima stomatologije, lasersko pitanje sigurnosti od nedavno je postalo od velike važnosti. Laseri se smatraju djeletvornim, ali zbog nepravilne upotrebe i nedostatka sigurnosti poznavanja terapijskih mogućnosti lasera, smatraju se i potencijalno opasnim za pacijente. Uz pretpostavku da će se upotreba lasera u stomatološkoj praksi postupno povećati, cilj ovog rada je predstaviti osnove o sigurnosti lasera u stomatologiji. Studija je također namjenjena kolegama koje koriste ili će koristiti laser u dentalnoj medicini kao podsjetnik opotencijalnim opasnostima lasera, sigurnosnim mjerama i načinima da se objezbjedi i poboljša sigurnost pacijenata u stomatologiji.

Ključne riječi: zubni laseri, opasnosti lasera, sigurnost lasera