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Brief Report

Laser in Dentistry During COVID-19 Pandemic: A Brief Review of Literature

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Abstract
The novel coronavirus causing severe acute respiratory syndrome (SARS-CoV-2) induced a pandemic influencing several countries worldwide; it has also caused serious concerns in dentistry due to its routes of transmission. As compared to the beginning of dental operations, the total microbial load suspended in the air rises more than three times during dental procedures due to the aerosols contained in the saliva, blood, organic tooth particles, bacteria, or viruses. Various types of dental lasers are recognized to be already produced and used in the treatment of hard and soft dental and oral tissues. One of the benefits of the dental laser is its ability to decontaminate surfaces and destroy germs. Dental lasers produce substantially less aerosols and droplets in comparison to high-speed dental headpieces and ultrasonic devices. Therefore, it is beneficial to indicate its influence in reducing the COVID-19 contamination risk, especially in dentistry.
Keywords: COVID-19, Safety, Laser, Dentistry

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Introduction
The novel coronavirus causing severe acute respiratory syndrome (SARS-CoV-2), induced a pandemic influencing several countries around the world, initiated in December 2019 in Wuhan, China. It has caused serious concerns in dentistry due to its routes of transmission, including direct and close (average under 200 cm) contact with oral, nasal, or eye mucous membranes and via respiratory tract (coughing, sneezing, and droplet inhalation). The SARS-CoV-2 cellular invasion has been observed in salivary glands, epithelial cells of the tongue, T and B cells, fibroblasts, and epithelial oral mucosal lining, indicating that the oral cavity, as a route to the airway tract, can be affected by direct virus invasion and attachment (1). working closely with the bucco-nasopharyngeal areas makes dental professionals intent on the management and prevention of this infection (2). Due to the high risk of infection in dentistry, at the beginning of lockdowns, most dental professionals were banned from performing non-emergency procedures in many countries; this caused economic issues for dentists and their employees and resulted in a lack of health services which can affect patients both physically and mentally (3).

Aerosols are liquid or solid particle compounds that can contain saliva, blood, organic tooth particles, bacteria, or viruses (4). Particle scales range from 0.001 to > 100 µm (5,6). As compared to the beginning of treatment, the total microbial load suspended in the air rises more than three times during dental procedures due to these aerosols (7). The risk of COVID-19 increases during and after operations due to the likelihood of aerosols penetrating the dentist's, assistants', and patients' respiratory tracts and connective tissues. Considering that infected aerosols and droplets can be a major source of contamination with COVID-19, reducing the use of aerosol-generating devices in the dental office, including high-speed dental headpieces, ultrasonic instruments, and air-water syringes can minimize the risk of infection (2). Many dental operations typically performed with rotary instruments can benefit from the use of lasers to lessen the quantity of generated airborne particles (1).

Laser in Dentistry
Different types of dental lasers have already been produced and employed in the treatment of hard and soft dental and oral tissues. One of the benefits of the dental laser is the

ability to decontaminate surfaces and destroy germs (8,9). In addition, compared to high-speed dental headpieces and ultrasonic devices, dental lasers produce substantially less aerosols and droplets. These lasers often eliminate or minimize the necessity of anesthesia, resulting in minimized bleeding during surgical dental procedures (3). Various laser wavelengths are used in the medical and dental sectors. The wavelength and absorption parameters of laser beams affect their interaction with tissues or matter. Erbium family lasers (Er:YAG, Er,Cr:YSGG), Nd:YAG (yttrium aluminium garnet) and Nd:YAP (yttrium aluminium perovskite doped with neodymium crystal) lasers, diode lasers or KTP (potassium-titanyl-phosphate), and CO_2 lasers, as well as red and near-infrared (NIR) lights are among the most common lasers used in dentistry (10).

Lasers are divided into two categories. Photothermal effects are generated by high-power lasers (HPLs), which result in a spray and/or ablation plume (11,12). Low-power lasers (LPLs) modify the inflammation process, speeding up the healing process and analgesia. When used with a photosensitizer, they can also provide antimicrobial properties with the added benefit of not developing aerosol (13).

Four mechanisms explain the effects of lasers on tissues (10):

1. Tissue and matter are vaporized as a result of an explosive operation. High absorption of some wavelengths causes an explosive reaction in the target hard and soft tissues, resulting in photothermal and photomechanical ablation. Many lasers in this group work on dark matter and metals, including Er:YAG, Er,Cr:YSGG, Nd:YAP, and Nd:YAG lasers.
2. Heat production causes soft tissue vaporization and fusion, which is accompanied by hard tissue melting. CO_2 (10.6 m), diode (445 nm and 810–980 nm), and Nd:YAP and Nd:YAG lasers all operate on soft tissues in this category. Smoke is produced by the vaporization of soft tissues.
3. Photobiomodulation (PBM) in tissues. Low-energy red and NIR light interacts with cells in a non-harmful way, improving cell viability and reducing discomfort and inflammation.
4. Enhancement in chemical reactions. The absorption of laser light stimulates chemical processes and triggers the release of free radicals such as antimicrobial photodynamic therapy (aPDT), photoactivated disinfection, photodynamic inactivation, and teeth bleaching. The wavelengths of visible light are mainly included in this group because of their tendency to react with electrons.

Low-level laser therapy has significant anti-inflammatory effects that have been verified by meta-analyses, and this therapy can be beneficial in the treatment of acute respiratory distress syndrome (ARDS). For decades, surgeons, physiotherapists, and nurses have used low-level laser therapy for pain relief, wound recovery, and other health problems. To achieve local and systemic impacts, laser light with a low concentration should be applied to the skin's surface. Low-level laser therapy eliminates the main inflammatory metabolites and accelerates the cytokine storm at several stages according to clinical practice, peer-reviewed research, and solid laboratory evidence in experimental animal models. Further, this type of laser therapy is a low-cost, secure, and reliable modality that can be employed in conjunction with traditional ARDS therapy (14).

High-power Lasers

Soft tissue surgery and other dental operations, including caries removal, root decontamination, and bone surgery, can be performed using HPLs. The Er,Cr:YSGG, Er:YAG, and CO_2 (9.3 m) lasers are among HPLs that utilize an air-water spray as a cooling mechanism, which may generate aerosols. Other HPLs such as diode, Nd:YAG, and CO_2 (10.3 m and 10.6 m) lasers lack a water-cooling mechanism and are mostly used in soft tissue surgery and dental decontamination (15).

CO_2 lasers (10 600 nm) are the best option for the ablation of extremely hydrated lesions such as fibrous lesions; however, for highly vascularized lesions or tissues, diode (445 nm, 810 nm, and 980 nm) and Nd:YAG (1064 nm) lasers can reduce the chance of hemorrhage due to their strong coagulation functions (16,17). Via photothermal and photomechanical/photoacoustical mechanisms, the Er:YAG and Er,Cr:YSGG lasers induce bubble dynamics, a fragmentation process, and tissue ablation (18). The accelerated expansion of the evaporated water layer causes an increase in pressure at the start of irradiation with erbium lasers. The fragmentation process can occur with or without the production of plasma. Ablation happens just after the beginning of laser irradiation in both scenarios, and a plume of small, emulsified material is released into the surrounding water (19). Increased laser energy speeds up the ablation operation, which eliminates thermal side effects. When the energy is increased, the expelled material's pressure and speed increase as well, resulting in a greater plasma creation (10). According to a pilot study by Lopez et al (20), a spray or ablation plume forms as a result of a rise in temperature produced in target cells to the point of causing membrane breakdown, along with pyrolysis and combustion (2). The existence of virus, fungal, and bacterial agents was discovered during a study of the composition of this released substance. In addition, the type of the applied laser, the used dosage, and the type of the tissue to be treated all influence the quantity and characteristics of vaporized cellular matter (21). The use of the photothermal effect, in which absorbed laser energy is transformed into heat, is a component that unites both of these wavelengths. Accordingly, a large volume of smoke is produced, necessitating continuous suction away from the surgical site (10). Given that the presence of 2019-nCoV on the oral mucosa, tongue, and saliva has been verified, photothermal lasers that emit smoke should be employed with caution considering the same procedures used for aerosol treatments.

Low-power Lasers

LPLs are applied in a variety of dental specialties, including suppressing microbial load using aPDT or speeding up tissue regeneration and enhancing analgesia, resulting in inflammatory process modulation. These lasers do not contain aerosols, thus both aPDT and PBM can be used during the pandemic (22). PBM is a medical technique that involves the use of red or NIR laser light to engage with tissues and cells in a chemical- and thermal-free condition. Tissue repair, wound healing, anti-inflammation, analgesia, and neuroregeneration are all among the effects that have been supported by several trials (23). Furthermore, PBM has the potential to destroy microorganisms such as yeasts, bacteria, and viruses. Several important studies have been performed regarding the possible efficacy of PBM, specifically against microorganisms and indirectly for the improvement of the immune response or mitigation of harm caused by the inflammatory process (24). PBM is gradually becoming more widely used in clinical practices and has significant advantages for both doctors and patients. Red and NIR lasers operating in the so-called "therapeutic window" wavelength range of 600-1400 nm are employed in PBM protocols (23). The red visible or NIR diode lasers, as well as the more penetrating Nd:YAG lasers, are the most commonly applied for PBM. Interestingly, unlike conventional high-energy surgical laser procedures, the PBM protocols do not produce heat, plum, or aerosol droplets (10). Without adverse effects or drug reactions, the PBM should be used as an adjuvant or replacement treatment in a wide range of cases (25). As a result, in probable or documented cases of COVID-19 infection, physicians may consider PBM to treat acute diseases such as chronic aphthous stomatitis and painful ulcers, temporomandibular conditions, recurrent intraoral and labial herpes, oral edema, postoperative pain after periodontal operations, oral surgery, and endodontic procedures in emergencies. Endodontists may rely on diagnosing and treating odontogenic pain, swelling, and dental alveolar traumas, and they may benefit from PBM's assistance (26). Although the critical step of correctly determining proper and standardized dosages is still unresolved, PBM's well-documented and efficient anti-inflammatory, regenerative, and analgesic applications can represent an important method for dealing with our patients' numerous emergencies in the current pandemic situation (22). Contaminated tissues must receive an appropriate dosage from LPL devices. The volume and quality of irradiation, as well as the coverage range, affect how the tissue responds to treatment. In this case, plastic membranes must be used to shield the laser's release region, which will come into contact with the biological tissue in order to avoid cross-infection (21).

Discussion

The coronavirus pandemic has wreaked havoc on public health, social relations, and the environment all over the world. Coronavirus 2 (SARS-CoV-2) causes an extreme acute respiratory syndrome, which is an infectious respiratory illness. The virus's primary mode of transmission is by airborne particles. Both symptomatic and asymptomatic patients will spread the virus by contaminating their surrounding air by sneezing, coughing, and breathing. Coughs, which are not shielded, will send droplets as far as 4 meters. Uninfected people inhale the droplets and aerosols generated by these infected people. SARS-CoV-2 has been shown to survive in aerosols in experiments (27). Considering that the spread of the SARs-CoV-2 virus is extremely high, dentists need to take more stringent biosafety precautions in their everyday routines (22).

Lasers are commonly used in everyday activities and can be employed more widely because LPLs do not emit aerosols and can be considered for modulating the inflammatory mechanism, improving tissue regeneration, and providing analgesia. Therefore, performing surveys to indicate the safe ways of using laser and avoiding cross-infection is of significant importance (21).

Biosafety recommendations must be simply and scientifically disseminated so that health practitioners, including dentists, are informed of the new behavior they must adopt. Several viruses associate with salivary elements, and viral transmission can be related to saliva. According to Table 1, clinicians and patients are concerned about the need to follow regulations to protect them from infection by aerosols generated in workplaces, which must be addressed with much greater rigor after the pandemic. In a dental practice, water spray is a major element in aerosolization and splatter, which can disperse infectious viruses such as the common cold and influenza viruses, herpes viruses, pathogenic streptococci, staphylococci, and the like (28).

LPLs are applied in a variety of dental specialties. Given that these lasers do not contain aerosols, both aPDT and PBM may be used throughout this pandemic phase; they are well indicated as supporting agents in dental treatments. On the other hand, HPLs create aerosols by forming a mist, ablation plume, or vaporization as a result of their elevated temperature (11,12). Studies depicting the biosafety of lasers in a dental office are listed in Table 2.

In a study on laser usage during the pandemic in 2020, Kaur et al indicated that dental lasers use 74% less air pressure and 67-83% less water flow in comparison to drills. As a result, the risk of virus transmission through aerosolization and splatter (e.g., COVID-19) is greatly reduced by a dental laser rather than a drill. Using the Er:YAG laser rather than rotary instruments such as high- and low-speed drills or an electric drill is superior. Some of these procedures can be performed by a dentist using only the cooling water system and no air spray, eliminating the chance of aerosol pollution (28).

Abdelkarim-Elafifi et al studied aerosol generation using the Er,Cr:YSGG laser in comparison with rotary

Table 1. Summary of Studies that Included Aerosol Virus Transmission in Dentistry

References	Authors	Study Design	Method	Results
(29)	Volgenant and de Soet	Descriptive	It provides the most recent information on risks related to the transmission of (pathogenic) microorganisms in the dental office.	The risk of the transmission of pathogens in a dental office is still unknown, but it cannot be considered insignificant. Thus, infection control in the dental office must be considered an essential issue.
(30)	Li et al	Descriptive	It suggests some protective measures that can help reduce the risk of saliva-related transmission in order to prevent the possible spread of SARS-CoV-2 among patients, visitors, and dentists.	The control of saliva-related transmission in the dental clinic is essential, especially in the epidemic period of COVID-19.
(31)	Odeh et al	Descriptive	It addresses several issues related to the COVID-19 pandemic that are directly related to dental practice in terms of prevention, treatment, and orofacial clinical manifestations.	Dentists must always competently follow the cross-infection control protocols, but especially during this critical period, they must do their utmost to decide on the emergency cases indicated for dental treatment. Dentists should also be updated on how this pandemic is related to their profession in order to be well oriented and prepared in this regard.
(13)	Peng et al	Descriptive	Recommendations for infection control measures during dental practice to block transmission routes from person to person in dental clinics and hospitals.	The 2019-nCoV person-to-person transmission routes included direct transmission, including coughing, sneezing, droplet inhalation transmission, and contact transmission such as contact with the oral, nasal, and ocular mucous membranes. 2019-nCoV can also be transmitted via saliva, and oral-fetal routes can also be a potential route of transmission from person to person. Dental practice participants are exposed to tremendous risk of infection by 2019-nCoV due to face-to-face communication and exposure to saliva, blood, and other body fluids, and the handling of sharp instruments.
(32)	Ge et al	Descriptive	It was a survey of works showing the forms of viral transmission in the dental offices.	So far, there is no report of infection in dental offices. She reports that the oral cavity is a place of high risk of transmission of the Sars-Cov-2 virus and that the best way to avoid cross-infection is the use of personal protective equipment, washing hands, using absolute isolation, in addition to indicating strategies for some dental specialties.
(33)	Fallahi et al	Descriptive	Information collected so far about the virus according to the guidelines of international health institutions, providing a comprehensive protocol to manage possible exposure to patients or suspicious of having the coronavirus.	Face-to-face communication and consistent exposure to body fluids such as blood and saliva predispose dental care professionals to serious health problems. The risk of infection with 2019-nCoV. Dental practices can be a potential risk for the dental team, and there is a high risk of cross-infection.

Table 2. Summary of Studies on Biosafety in the Use of Laser

References	Authors	Study Design	Method	Results
(21)	Rodrigues et al	Observational	It evaluates the interference of protective materials in the light output of low-power lasers.	All groups had reduced output power after placing protective material when related to the time factor. When compared to the materials used for protection, the protective material containing polyethylene showed a greater reduction in output power than the protective material of polyvinyl chloride for red and infrared wavelengths.
(11)	Pierce et al	Descriptive	It analyzes the published literature regarding the chemical and physical composition of the laser-induced plume, health effects, and control methods.	Few studies have attempted to characterize the effects of the type of the laser system, power, and treated tissues with regard to exposure to airborne contaminants generated by the LGACs. In addition, current control strategies do not seem to be adequate in preventing occupational exposure to LGACs.
(34)	Lopez et al	Observational	It estimates the exposure of particulate matter to two simulated laser medical procedures using a near-field/far-field model.	The results indicate that the concentrations in the simulated scenarios are similar to those obtained in limited field evaluations performed in the hospital's operating rooms.
(12)	Lopez et al	Observational	It aims to determine the effect of laser operating parameters on the emission rate of the specific mass size of particulate material generated by laser through medical procedures simulated in the laboratory.	The results provide a basis for future research to better estimate size-specific mass emission rates and particle characteristics for additional laser operating parameters in order to estimate occupational exposure and inform control strategies.
(35)	Lippert et al	Observational	It establishes a methodology to estimate the emission rates of LGACs using an emission chamber and to perform a screening study to differentiate the effects of three laser operating parameters.	Confined to the experimental conditions of this screening study, the results revealed that the beam diameter was statistically influential, and the marginal power was statistically significant in the CO_2 emission rates when using the Ho: YAG laser, but not with the carbon dioxide laser; the pulse repetition frequency did not influence the emission rates of these contaminants in the gas phase.

Abbreviation: LGACs, laser-generated air contaminants.

instruments. They reported that during the procedure of class I cavity preparation, the contaminated area is reduced by 70% using Er,Cr:YSGG laser compared to a high-speed turbine. A slightly higher contamination rate was also observed in 80% versus 40% of water laser groups (1).

Several experiments have attempted to determine the composition of the laser surgical plume, focusing on its chemical components and particles, as well as infectious agents (21). Unfortunately, few studies remain, although the most current one was conducted in 2015, implying that they are related to before the pandemic of 2020. Accordingly, no records of the composition of SARS-CoV-2-infected plumes exist; although it can be assumed that if lasers are used in patients infected with COVID-19, the virus would be present in the plume. Peng et al (13) and Ge et al (28) reported the virus in the oral cavity. Because of the seriousness and ease with which the virus causing COVID-19 can be transmitted, this study contributes to the current knowledge about the need for further research into the relationship between lasers and viruses, as well as how to avoid contamination in laser clinics.

Authors' Contribution

HZ screened the titles and selected the qualified articles. MM was the plan supervisor and the main author. HZ was the corresponding author.

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

Ethical Statement

This study was approved by the Ethics Committee of Isfahan University of Medical Sciences.

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