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Mini review

Application of High-power Lasers in Dentistry during COVID-19 Outbreak: An Equivocal Issue

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Abstract

High-Power Lasers (HPLs) are capable of creating a plume containing tissue debris, vapor, and viruses (HPV, HIV, etc.) which is liberated into the surrounding environment and may have a potential role in infection transmission. The employment of these dental lasers is an equivocal concern during the new Coronavirus Disease 2019 (COVID-19) outbreak. Since many oral tissues are highly potential reservoirs of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), this study was conducted to scrutinize the possibility of dissemination of this virus through the plume in dental laser treatments during the COVID-19 pandemic. The current evidence shows while the employment of laser is an effective and comfortable tool for dental treatments, it holds some inherent hazards such as producing airborne contaminants. With HPV, HIV, and other viruses already detected in laser plume and considering the presence of ACE2 receptors in the oral cavity, there is a potential risk in laser treatments to produce infectious plume, which may possibly contain SARS-CoV-2. The SARS-CoV-2 virus can potentially be liberated in the plume during dental application of HPLs in suspected or confirmed cases of COVID-19. While the amount of aerosol may be different from other routine dental instruments, this modality should be used with crucial care during the COVID-19 outbreak. In this regard, safety precautions in laser application should be rigorously maintained during the COVID-19 outbreak.

Keywords: COVID-19, SARS-CoV-2, Transmission, Lasers, Virus, Dentistry

Introduction

The COVID-19 pandemic caused by the emerging SARS-CoV-2 has tremendously influenced the dental and oral health care system. Several investigations are being performed to find the nature of the disease and proper early diagnosis, effective treatment, and efficient vaccine for it.[1,2] Recent studies declared that the main transmission routes of COVID-19 are respiratory droplets and contact transmission.[3] In addition, other potential transmission routes through aerosol[3] and body fluids such as saliva[1,4] and blood[5] can expose dentists to a high risk of COVID-19 infection.[3]

Despite the controversies on the aerosol transmission of COVID-19, possible transmission through aerosolized virus particles either in closed environments for a long period or in conditions with a high concentration of virus particles has been discussed.[6,7] Aerosols are very small (<5 mm) remnant liquid and solid particles of evaporated respiratory droplets, that are suspended in the air for minutes to even several hours.[6,7]

Lasers in different types and modalities are employed in current dental practice for diagnosis and treatments.[8] High-Power Lasers (HPLs) are used to perform soft and hard tissue surgery and other dental procedures such as caries removal, root decontamination, and so on.[9] It is crucial to note that most of these HPLs such as Er,Cr:YSGG, Er:YAG, Nd:YAG, and CO_2 (9.3 µm, 10.3 µm, and 10.6 µm) lasers are capable of generating airborne particulate matter (smoke or plume) as well as harmful gases and chemicals which are hazardous.[9,10] In addition to producing plumes, some of these lasers such as Er,Cr:YSGG, Er:YAG, and CO_2 (9.3 µm) lasers use an air-water spray as a cooling system, which may certainly produce aerosols.[9] As a consequence of the excision/incision of oral soft tissue by laser during a surgical procedure, cellular components are vaporized owing to the quick heating of fluid components in the oral tissues.[10] During this surgical procedure, airborne contaminants are considerably propelled into the air. These extremely small particles which contain carbonized, partially carbonized, and intact tissue components are clinically defined as laser smoke/plume.[10] Plumes may contain bioaerosols, viruses, blood fragments, and bacteria depending on the type of the procedure.[11] The plume produced by the thermal activity of these lasers can transmit airborne contaminants.[10] Therefore, by reviewing the relevant literature, this mini-review aims to discuss the potential ability of HPL treatments in producing infectious plumes that may possibly contain SARS-CoV-2 during the COVID-19 outbreak. The virus can potentially be liberated in the plume during dental application of HPLs in suspected or confirmed cases of COVID-19.

The Potential Hazards of HPLs

In addition to the danger of the laser beam itself which can cause tissue injury directly, there are non-beam hazards such as flammability, tissue, electrical and environmental hazards.[7,10] Inhaling airborne contaminants during laser surgical procedures can be reflected as one of its environmental hazards.[10] A recent study[12] performed in the operating rooms demonstrated all nurses and doctors present in the operating room were exposed to surgical smoke and experienced headaches, coughs, burning throats, nausea, sneezing, rhinitis, and many other complications. Previous studies have shown that particles about 5 µm or larger are deposited on the walls of the nose, pharynx, trachea, and bronchus, whilst particles smaller than 2 µm are deposited in the bronchioles and alveoli.[13-16] On the other hand, 77% of particles suspended in the laser plume are less than 1.1 µm with a mean diameter of 0.07 µm, being in the inspirable range.[16-18]

HPLs are capable of generating dangerous products regardless of energy source and surgical procedure. The amount of generated airborne contaminants is correlated with the absorption of various wavelengths by the target tissue and laser application.[7,10] It is worth mentioning that CO_2 and Nd:YAG lasers are respectively the greatest plume generators. Furthermore, CO_2 and Er:YAG lasers have high-coefficient absorption due to the high water content of oral tissue.[10] Disruption of human cells due to the generated heat by laser can cause pathogens (bacteria and viruses), carbon, deoxy-ribonucleic acid (DNA), and toxic gases to become airborne.[7] Consequently, inhalation of laser smoke may cause acute and chronic inflammatory changes in the respiratory tract such as alveolar congestion, interstitial pneumonia, and bronchiolitis.[16]

Oral Cavity; A Potential Reservoir for SARS-CoV-2

Angiotensin-Converting Enzyme 2 (ACE2) has been shown to be the main host cell receptor of SARS-CoV-2 which plays a key role in infecting cells. Besides, it is demonstrated that ACE2 receptors are expressed in oral tissues, particularly tongue tissue; hence, the oral cavity may act as a reservoir site of SARS-CoV-2.[19] It was recently shown that ACE2 receptors are highly expressed in oral cavity cells compared to lung cells.[20] Moreover, furin, a pro-protein convertase involved in virus infection by cleaving viral envelope glycol-proteins, is also expressed in oral epithelial cells.[21]

Santos et al.[22] confirmed that the fibroblast cells of gingiva and periodontal ligament in rat and human tissues express ACE2 receptors. Recently, Bandran et al.[23] presumed the periodontal pocket to be a suitable reservoir for SARS-CoV-2.

Based on the result of a previous study, the mean expression level of ACE2 protein in salivary glands is even higher than that in the lung.[24] In a study on Chinese rhesus macaques, which mimics the human situation, it was shown that their $ACE2^+$ epithelial cells lining salivary gland ducts were early targets of SARS-CoV infection.[25] These evidences suggest that salivary glands may act as a potential reservoir for SARS-CoV-2. Additionally, although saliva has a potential role in the prevention of COVID-19,[26] it is documented that saliva is a reservoir of COVID-19, which is capable of transmitting SARS-CoV-2.[4] Besides, CO_2 and diode lasers have been a useful modality in excising salivary gland reactive/obstructive lesions and benign tumors.[27,28] Since many of common salivary gland diseases (mucocele, sialolithiasis etc.) are attributed to retention of saliva into salivary ducts or surrounding tissues, or proliferation of salivary epithelium,[27] employing laser in their treatments may result in vaporization and projection of many airborne contaminants. Consequently, the employment of laser in treatments of salivary glands and surrounding tissues may potentially disseminate SARS-CoV-2 and therefore should be concerned during the COVID-19 outbreak.

Current Evidence Concerning the Possibility of Virus Transmission through the Plume of High-power Lasers

There are various conflicting reports suggesting the effect of lasers on viruses, while some reports do suggest the possibility of virus transmission through the laser plume,[29,30] some authors have spoken of the anti-viral activity of lasers as well.[31,32] Several viruses such as HPV,[33-40] HIV,[29] and other viruses[30,34,41,42] have been shown to be released from various tissues during vaporization by application of different lasers such as CO_2,[29,30,33–39] KTP,[41] Nd:YAG[40] and Excimer lasers[42] (Table 1). With HPV, HIV, and other viruses already detected in laser plumes, it is possible that other viruses, such as SARS-CoV-2, may also be liberated in the plume during laser use.

The vaporized tissue forming the plume undergoes an immense amount of energy absorption[10] which may be sufficient enough to neutralize the viral load of ablated tissue. Therefore, one may suggest that laser may impair microorganism survival. On this basis, it was proposed that during the COVID-19 outbreak, using dental lasers are prior to aerosol-generating instruments due to significantly reduced levels of generated aerosols and droplets;[43] however, since the expression of ACE2 receptor is noticeably high in oral cavity tissues, many oral tissues are a highly potential reservoir of SARS-CoV-2 as well as saliva.[4,19-25] This may contradict the safety of using lasers during the outbreak. Moreover, it has been reported that high heat does not completely kill some bacterial spores regardless of the power and length of exposure.[36,44] Hence, further investigations are needed to verify if the laser is capable of destroying the virus completely in its generated smoke.

Additionally, it has been recently noted that the interaction of various types of high-power dental lasers such as Er,Cr:YSGG, Er:YAG, Nd:YAG, and CO_2 with biologic tissues that produce surgical plume is capable of carrying virus particles.[9] Therefore, concerning the current outbreak of COVID-19, special safety measures on the application of dental lasers should be considered focusing on possible biological hazards of HPLs to reduce the potential risk of airborne contaminants.[7,10] Nevertheless, the results of a clinical study would be of great relevance.

Table 1. Current Evidence in which Laser Plume was Evaluated to Detect the Presence of any Virus Remnants and/or Its Ability to Spread Virus Contagion

Authors (Year)	Type of laser	Disease (Type of virus)	Main findings	Ref
Garden et al. (1988)	CO_2 laser	Plantar or mosaic Verrucae (HPV)	The HPV DNA was detected in 2/7 laser plume samples.	(33)
Sawchuk et al. (1989)		Plantar warts (HPV) Bovine warts (BPV)	The HPV DNA was detected in 5/8 laser vapor samples. The BPV was detected in laser vapor samples.	(34)
Andre et al. (1990)		Genital condyloma (HPV)	The HPV DNA was detected in 2/3 laser plume samples.	(35)
Baggish et al. (1991)		AIDS (HIV)	The proviral HIV DNA was detected in laser plume samples.	(29)
Bergbrant et al. (1994)		Genital warts (HPV)	The HPV DNA was detected in 6/11 samples after laser ablation.	(37)
Garden et al. (2002)		Cutaneous fibropapillomas (BPV)	The BPV DNA was detected in laser plume samples.	(30)
Ilmarinen et al. (2012)		Laryngeal papillomatosis (HPV)	The HPV DNA was detected on gloves of 1/5 surgeons and 3/5 nurses; however, no HPV DNA was detected in the oral mucosa or on surgical masks.	(38)
Rioux et al. (2013)		Cervical and vulvar lesions (HPV)	The findings suggest that the HPV-positive tongue cancer in their patient may have been caused by inhaled HPV particles present in the laser plume.	(39)
Taravella et al. (1999)	Excimer laser	- (OPV)	The live virus was detected in laser plume samples.	(42)
Best et al. (2020)	KTP laser	MmuPV1 tail warts (MPV)	The MPV DNA in the KTP laser was detected in both plume and laser filter.	(41)
Hallmo et al. (1991)	Nd:YAG laser	Anogenital condylomata (HPV)	The findings suggest that the laryngeal papillomatosis in their patient may have been caused by inhaled HPV particles present in the laser plume.	(40)

CO_2: Carbon dioxide, KTP: Potassium Titanyl Phosphate, Nd:YAG: Neodymium-doped Yttrium Aluminium Garnet, HPV: Human Papillomavirus, BPV: Bovine Papillomavirus, AIDS: Acquired Immunodeficiency Syndrome, HIV: Human Immunodeficiency Virus, OPV: Oral Poliovirus MPV: Mouse Papillomavirus, DNA: Deoxyribonucleic Acid.

Infection Control and Safety Measures during the Application of High-power Lasers

While most laser procedures are categorized as routine or elective practice, these procedures cannot be regarded as a frontline or essential treatment modality. Hence, patient and staff safety is of utmost importance when such treatments are undertaken during the COVID-19 outbreak.[11]

Considering special safety measures, all patients should be treated as potentially COVID-19 positive. Elective laser procedures for cosmetic purposes such as aesthetic gingivectomy and crown lengthening, and so on should be postponed.[7,8] Moreover, for all laser procedures deemed to be producing laser plume, Personal Protective Equipment (PPE) such as respirators (N95, K95, FFP2, FFP3, or any equivalent standard), eye protection (goggles or face shield), full sleeve gowns, gloves and also fluid resistance aprons should be worn for all practitioners.[2,11,45] Standard surgical masks, which filter particles greater than 5 µm in size, cannot prevent the possible inhalation of electrosurgical and laser plume.[11] Prior to laser procedure, using mouth rinses containing 1% hydrogen peroxide or 0.2% povidone can help in eliminating or decreasing the load of virus in saliva.[3] Additionally, any condition that triggers gag reflex in patients during treatment procedures should be highly avoided.[46] Besides, being able to eliminate particulates to 0.1 µm, smoke/plume evacuation systems with Ultra-Low Particulate Air (ULPA) filter should be regarded.[7] It is also stated that laser handpieces must be effectively sterilized before and after us,[7] and apparently, proper hand hygiene should be respected after direct contact with instruments.[7] For high-risk or known COVID-19 patients or invasive procedures, national and international guidelines should be followed and where possible, laser procedures should be discarded or deferred.[11]

Conclusion

Since HPLs may have a potential ability to produce virus-bearing plumes and literature verified that viruses such as HPV, HIV, and other viruses have been detected in laser plumes, it is possible that other viruses such as SARS-CoV-2 may also be disseminated through the plume during laser treatments in dentistry. While the amount of aerosol may be different from other routine dental instruments, this modality should be used with crucial care during the COVID-19 outbreak.

Conflict of Interest

The authors declare that they have no conflicts interest.

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