



REVIEW ARTICLE

Dental LASER: A Boon in Dentistry & its significance in Covid-19

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Abstract

LASER stands for light amplification by stimulated emission of radiation. Einstein was the first to give the foundation for laser, however the first to give laser term was Gordon Gould. Invention of LASER has brought about a major revolution in the ways of life of people. The increasing use of laser in medicine has only been possible due to a better understanding of the interaction between laser light and living tissue. Reliably laser removes the needle, drill, and pain from the dental procedures & also reduces risk of contamination with respect to drills. Laser significantly reduces aerosols and Does not produce scratch material, thus causing less spread of debris outside the oral cavity. Blood free procedures for better recovery. Laser dentistry can be a precise and effective way to perform many dental procedures. Dental laser can be used to generate both hard and soft tissue laser energy, depending upon the patient's needs.

Keywords: LASER, dentistry, lasers & covid-19, less bleeding, light, lasers use

1 | INTRODUCTION

LASER stands for light amplification by stimulated emission of radiation. A laser differs from other sources of light in that it emits light which is coherent. Two sources are said to be coherent when the waves emitted from them have the same frequency and constant phase difference. Spatial coherence allows a laser to be focused to a tight spot, enabling applications such as laser cutting and lithography. Coherence also allows a laser beam to stay narrow over great distances (collimation), enabling applications such as laser pointers and lidar (Light Detection And Ranging).

History: The initial contribution to the history of lasers was accomplished by Albert Einstein's publications in relation to the behaviour of the electrons inside an atom. In 1918, Einstein developed a general theory of the process by which atoms emit and absorb electromagnetic radiation. This theory is the basis of lasers (stimulated emission) and shaped the development of modern quantum electrodynamics, the best-validated physical theory at present. As a rule, atoms can emit electromagnetic waves in a spontaneous way with no external intervention (1). Thus, Although Einstein did not invent the laser his work laid the foundation. It was Einstein who pointed out that stimulated emission of radiation could occur along with spontaneous emission & absorption. In

1928, German physicist Rudolf Ladenburg indirectly observed stimulated emission while studying the optical properties of neon gas at wavelengths near a transition where the gas absorbed and emitted light. This was the first evidence that stimulated emission existed (2, 3). At Columbia University in 1955, Townes worked with French physicist Alfred Kastler at the Ecole Normale Supérieure in Paris. Kastler developed the technique of “optical pumping,” a process by which light is used to raise (or pump) electrons from a lower to a higher energy level, as a new way to excite materials for microwave spectroscopy (2). Another American physicist, Gordon Gould, a Columbia graduate student in 1957, asked whether optical pumping could excite light emission. He recorded his ideas in nine handwritten pages of a laboratory notebook, with the first page titled “Some rough calculations on the feasibility of a **LASER: Light Amplification by Stimulated Emission of Radiation**”—the first time the term laser was used (2, 4).

LASER applications : Nowadays there are many applications of LASER technology that includes LASER scanners , optical discs , fibre-optic communication system , industrial use as like LASER beams can drill or cut extremely hard materials , medical applications as in surgeries in cutting tissues or in cautery or can be used in the treatment of skin conditions or dental surgery.

LASER use in Medical field : Ancient Egyptians, Chinese, and Indians used light to treat rickets, psoriasis, skin cancer, and even psychosis (5) . The applications of light were precursors to the invention and subsequent use of optical amplifier devices that generate a special form of light—lasers—in the medical field over the past decades. Invention of LASER has brought about a major revolution in the ways of life of people. The increasing use of laser in medicine has only been possible due to a better understanding of

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the interaction between laser light and living tissue. LASER can be used in the medical field from surgery to non-invasive therapeutic processes. Here in short we are describing about the use of LASER in medical world :-

- (a) The most widely spread eye-related laser application is the reshaping of the cornea of the eye for improving eyesight.
- (b) LASER angioplasty
- (c) Various kinds of cosmetic surgeries are performed using medical lasers. Certain types of birthmarks can be removed by this technology.
- (d) Permanent tattoos removal where strong dyes get bleached by LASER beam when it is directed towards the tattoos without burning the skin surrounding it
- (e) LASER lithotripsy is a technique used for breaking down urinary and biliary stones.
- (f) LASER can be used in dentistry world too , beside these applications there are many more uses of LASER nowadays in the field of medicine , surgery , cosmetics , dentistry , etc.

LASER in Dentistry : Lasers have been used in dentistry since 1994 to treat a number of dental problems (6) . Dentistry has benefitted a lot from laser technology. During treatment, the laser is set at such a power that eliminates the tissue that has decayed, which is softer than the enamel, which does not get affected. It takes advantage of the varying hardness of the different parts of the tooth. It acts really fast, so it does not require anaesthesia or minimal use of it .

2 | A BREF OF LASER'S USE IN THE FIELD OF DENTISTRY

Before proceeding to the applications of LASER in dental world , let us introduce us about the different kinds of LASERs used :

A. Depending upon the nature of tissue to be manipulated with LASERs –

a. Soft tissue lasers

1. Diode lasers

2. Carbon dioxide lasers
3. Nd:YAG laser

b. Soft & Hard tissue lasers

1. Er:YAG laser
2. Carbon dioxide laser
3. Er,Cr:YSGG laser

B. Depending upon the physical state properties –

a. Gas lasers

1. Argon
2. Carbon-dioxide

b. Liquid

1. Dyes

c. Solid

1. Nd:YAG
2. Erbium: yttrium aluminum garnet (Er: YAG)
3. Diode Semiconductor: Hybrid silicon laser

d. Excimers

1. Argon-fluoride
2. Krypton-fluoride
3. Xenon-fluoride

LASERs use in periodontics

Laser scaling

The development of the Er:YAG laser significantly reduced the difficulties associated with the treatment of hard tissues, as evidenced by the case of a 56- year-old woman. Scaling can be carried out using a laser by very gently striking the tooth plane with the laser tip when there is calculus on the gingival margin. This mode of treatment does not cause unpleasant vibrations and sounds for patients as do both ultrasonic and hand-held scaling instruments (7) .

Laser curettage

Laser curettage under closed conditions is demonstrated in the case of a 63- year-old woman with chronic periodontitis. Laser curettage was performed by inserting the laser tip into the periodontal pocket and moving it in a sweeping motion on the tooth crown side from a point 1 mm shallower than the premeasured PD. Calculus and diseased granulation tissue were scraped out surgically, resulting in a decrease in the PD from 7 mm to 2 mm 1 month later (7) .

Other uses in perio are like

Gingival metal tattoo removal ,
Gingival melanin removal ,
Osseous surgery ,
Gingival hyperplasia removal ,
Gingivectomy ,
Frenectomy ,

Crown Lengthening procedure - A crown-lengthening procedure is used to gain access to subgingival

caries, expose margins, and explore fractures. The procedure allows for developing a proper form for a restoration and increasing surface area for retention

Mucogingival surgery - Lasers can be used in mucogingival procedures for a variety of therapies. Donor material can be gain from the palate or other keratinized areas in the oral cavity with laser therapy. Using a laser to seal the wound when donor material is taken from these areas using blades can reduce haemorrhage significantly

Lasers in Flap Procedures - Practitioners perform periodontal flap procedures either exclusively or adjunctively with a laser.

LASERs use in endodontics

Rapid development of laser technology combined with better understanding of laser-tissue interaction has increased the spectrum of possible laser applications in endodontics.

Pulp Diagnosis - Laser Doppler flowmetry (LDF) was developed to assess blood flow in microvascular systems. It can also be used as a diagnostic system for measurements of blood flow in the dental pulp (8)

Laser Doppler Flowmetry uses low-power settings (1 to 2 mW) of helium-neon (He Ne) or diode (810 nm) light sources (9). The laser beam must be directed through the clinical crown structure to the pulpal blood vessels, where the flow of red blood cells (RBCs) causes the Doppler shifting of the frequency of the laser beam. Some of the light is backscattered out of the tooth and is detected by a photocell on the tooth surface. The output is proportional to the number and velocity of RBCs (10).

Cleaning and Disinfecting the Root Canal System - Bacterial contamination of the root canal system is considered the principal etiological factor in the development of pulpal and periapical lesions. Creating a root canal system free of irritants is a major goal of root canal therapy, conventionally it was done by mechanical instrumentation along with irrigants. With the introduction of lasers in dentistry, there have been numerous studies also have documented that CO₂ (11) Nd:YAG (12) argon (11) Er,Cr:YSGG (13) and Er:YAG (14) laser irradiation have the ability to remove debris and the smear layer from the root canal walls after biomechanical instrumentation.

Obturation of the Root Canal System - Obturation of the prepared root canal space is done to eliminate all sources of leakage from the oral cavity or from the periradicular tissues into the root canal system and to seal within the system any irritants that cannot be fully removed during the cleaning and shaping procedures. Introducing laser technology to assist in obturating the root canal system is based on the following two assumptions about the laser's ability:

- Using the laser irradiation as a heat source for softening gutta-percha, which is employed as the obturating material
- Using the laser as a means to condition the dentinal walls before placement of an obturation bonding material.

Gekelman et al. reported significant improvement in the quality of the apical sealing of root canals using the Nd:YAG laser (100 mJ/pulse, 1 W, 10 Hz) (15).

LASERS use in Oral Surgery

The laser is a versatile surgical instrument that can be used in three basic ways: excision/incision, ablation

and coagulation.

A main composition of the oral mucosa and skin is water. Therefore, carbon dioxide laser, which is well absorbed by the water, is considered to be a laser of choice for photothermal excision and photothermal vaporization (16–18). For oral soft tissue surgery, the carbon dioxide laser does not only provide a favourable cutting speed but also less postoperative inflammation and wound contraction compared with Nd YAG laser, Erbium YAG Laser and Diode laser (800 to 900 nm) (19).

Lasers can be used for the removal of soft tissue tumors, preprosthetic surgical procedures, removal of premalignant lesions, and for soft tissue surgery associated with orthodontic or pediatric purposes. In addition, bone applications may be performed using specific lasers (Er:YAG; Er:Cr:YSGG;) especially for osteotomies, bacteria reduction, apicectomies, bone healing stimulation.

LASERS in oral lesions / oral medicine

Papilloma – Oral squamous papilloma (OSP) is a benign epithelial neoplasia associated with the proliferation of oral epithelium, which promotes a papillary or verrucous surface associated with human papilloma virus (HPV) infection. OSP and FH can be adequately managed with high power lasers. Adequate hemostasis at the surgical sites and postoperative comfort can be achieved with laser surgery. It is suggested the feasibility of performing laser removal of OSP under topical anesthesia, mostly when using the Er,Cr:YSGG laser (20). The advantages of the treatment of oral lesions with laser is that it is a safe and effective alternative to conventional surgery.

Vascular lesions – Vascular lesions, including both haemangioma and lymphangioma, can be found in the skin and in the mouth, and rarely cause symptoms. The onset of both is at birth/ congenital. These vascular lesions may be treated efficiently with lasers.

Mucocele – Oral mucoceles are common, benign lesions of minor salivary glands characterized by single or multiple nodules that are generally asymptomatic. Several clinical reports have described protocols for application of laser irradiation in the excision of oral mucoceles. The large majority have used

high power CO₂ lasers for excision or vaporization of the lesions, with a power range from 4 to 10 W. The procedure of mucocele excision using a CO₂ laser is brief in comparison with that using a scalpel, mainly because sutures are unnecessary (21, 22).

Oral leukoplakia – Leukoplakia is a white or gray patch that develops on the tongue, the inside of the cheek, or on the floor of the mouth. It is the mouth's reaction to chronic irritation of the mucous membranes of the mouth. Advantages of surgical excision of oral leukoplakia by high power lasers over conventional method include bleeding control and less bacteremia, among others, and this can be a particularly favorable technique when large areas of oral mucosa are affected, as wound healing occurs by secondary intention.

Usually the laser of choice for oral leukoplakia treatment is the CO₂ laser as it is efficient in cutting oral soft tissues and only produces superficial thermal damage, resulting from the intense energy absorption of this particular wavelength (10 600 nm) by its main chromophore, water, abundant in the oral mucosa (23).

Other lesions include that can be treated with lasers are like Actinic cheilitis, Herpes lesions, Oral erythroplakia, Oral lichen planus, etc.

LASERS in Operative dentistry

Caries prevention – Tooth caries is the most common infectious disease that affects dental tissues. The pain and oral dysfunction caused by caries burdens patients economically, physically and mentally. Therefore, caries prevention and treatment in the initial phases of the disease is of serious priority in each population. Lasers are nowadays subject of vast research and public interest in different fields of health service, including dentistry. Some lasers are presented as useful for caries prevention

To prevent dental caries, the energy generated by the lasers must be highly absorbed by the dental substrates and efficiently converted into thermal energy, which is confined to the surface and can modify the structure and chemical composition of these substrates to promote increased acid resistance (24). Rechmann et al. have also shown an 86% reduction in dental enamel smooth surface demineralization in

vivo following short-pulsed, 9.6- μ m CO₂ laser irradiation. Specific microsecond short-pulsed 9.6- μ m CO₂ laser irradiation markedly inhibited caries progression in pits and fissures in comparison to fluoride varnish alone over 12 months (25).

Cavity preparation – The advantages of the use of laser in cavity preparations and caries treatments are attractive due to the possibility to treat teeth without using anesthesia, the ability of this laser beam to disinfect the irradiated dentinal surfaces, its ability to remove more selectively decayed tissues and finally, because of it is more accepted by phobic patients due to the absence of the use of a dental bur.

Laser fluorescence in caries detection

Dental bleaching

LASERS in Dentinal hypersensitivity

Dentine hypersensitivity is an exacerbated response of the healthy tooth to thermal, chemical, or tactile stimuli, and is characterized by an acute, non-spontaneous, short or long lasting pain that appears suddenly in a specific location, which cannot be attributed to any other dental pathology.

The laser energy used for dentin dehypersensitivity are lower than the thresholds of dental hard tissue ablation, and it is believed that Er:YAG laser evaporates the superficial layers of the dentinal fluid and decreases the rate flow. The Er family laser Er:YAG(2940 nm) and Er,Cr:YSGG(2780 nm) laser appear to be effective and safe for the treatment of hard tissues without thermal effects (26).

There are many more applications of laser in dental sciences as like in Low Level Laser Therapy for hyposalivation, Optical diagnosis of cancer and potentially malignant lesions, Antimicrobial photodynamic therapy in cancer patients, Recurrent aphthous ulcers management, use in Implantodontology, High power lasers in apical surgery, etc.

3 | SAFETY AND STANDARDS IN LASER –

Laser use in dentistry is considerably growing around the world. Users should acquire the basic knowledge about laser safety to prevent accidents. The standards of the lasers, there are two main stan-

dards of laser use

1. International standard,
2. United States standard.

International Electrotechnical Commission (IEC) is a global organization that provides international standards for all electrical, electronic and related technologies. The IEC 60825-1 Ed 3.0: 2014 that has been used world wide is applicable to the safety of laser products emitting laser radiation in the wavelength range 180 nm to 1mm (27, 28).

IEC 60825.1-2014 Classification of Lasers

Class 1 Safe when used under reasonably foreseeable range.

Class 1C The laser radiation when used in contact with (or very close to) the skin or internal body tissue is safe under reasonably foreseeable range.

Class 1M Wavelength between 302.5 nm and 4000 nm are safe, including long-term direct intra beam viewing for the naked eye (unaided eye). The MPE can be exceeded and

eye injury may occur following exposure with telescopic optics, such as binoculars for a collimated beam with a diameter larger than the measurement diameter.

Class 2 The visible radiation in the wavelength range from 400 nm to 700 nm that are safe for momentary exposures but can be hazardous for deliberate staring into the beam. The

time base of 0.25 s is inherent in the definition of the class and presumption is that there is very low risk of injury for momentary exposures that are somewhat longer.

Class 2M The visible radiation in the wavelength range from 400 nm to 700 nm that are safe for short time exposure only for the naked (unaided) eye. The MPE can be exceeded and eye injury may occur following exposure with

Telescopic optics such as binoculars for a collimated beam with a diameter larger than the measurement.

Class 3R The eEmits radiation that can exceed the MPE under direct intra beam viewing, but the risk of

injury in most cases is relatively low. The AEL for Class 3R is limited to 5 times the AEL of Class 2 (visible laser radiation) or 5 times the AEL of Class 1 (for non-visible laser radiation).

Class 3B Normally hazardous when intra beam ocular exposure occurs (i.e. within the NOHD) including accidental short time exposure. Viewing diffuse reflections is normally

safe. Class 3B lasers which approach the AEL for Class 3B may produce minor skin injuries or even pose a risk of igniting flammable materials. However, this is only likely if

the beam has a small diameter or is focussed.

Class 4 Intra beam viewing and skin exposure is hazardous and for which the viewing of diffuse reflections may be hazardous. These lasers also often represent a fire hazard.

LASER use in the oral cavity ; standards

Since the oral cavity is a narrow and special environment, care must be taken when laser treatment is conducted. The several factors of accidents and countermeasures are indicated.10–13 In addition, the oral fields are near the eye; doctors, patients and codental stuff should wear the protective goggles corresponding to OD value (29, 30). Table 1

Optical Density (OD)	Transmittance	Attenuation Rate	Protective Function
0	100%	0	
1	10%	1/10	
2	1%	1/100	
3	0.1%	1/1000	
4	0.01%	1/10000	
5	0.001%	1/100000	
6	0.0001%	1/1000000	

FIGURE 1: OpticalDensity

Optical transmission commonly expressed in percentage and indicated by logarithm is the OD value (optical density). Optical density (OD) is the attenuation rate of incident light that passes through the optical filter, in this case laser protective eyewear.

The larger the OD value, the larger the attenuation rate of incident light, thus providing higher protective function.

If the OD value increases, then the transmittance decreases. Table 1

During laser emission, the controlled area and throughways access to the laser operative zone must be delineated with warning signs that specify the risk. Windows, doors and all surfaces should be non-reflective, depending on regulations in each country.

These regulations are also required safety measures, such as labeling lasers with specific warnings, and wearing laser safety goggles when operating lasers. The laser product may also need other information on a label such as power, wavelength, manufacturer, pulse duration, if applicable etc. Various laser warning sign and product labelling (31, 32).

The protective goggles corresponding to the wavelength must be worn.

4 | ADVANTAGES OF DENTAL LASERS –

- **Pain Reduction**

Lasers in dentistry reduce the amount of pain that a patient feels during treatment. Dentistry becomes safer when there is less need for anesthesia. Lasers have not eliminated the need for anesthesia, but fillings may no longer require a shot before the procedure begins.

- **Less Bleeding**

Procedures involving soft tissues in dental work cause bleeding with traditional cutting methods. Lasers cut into soft tissue to perform the dental procedure, but the blood vessels are sealed while the laser cuts the tissue. This eliminates the blood loss that is typical during these procedures.

- **Eliminates Anxiety**

The dentist's drill causes anxiety in some dental patients. Lasers offer patients a safe and effective treatment option that does not produce the same anxiety and nervousness. Reducing anxiety and helping patients feel better about visiting the dentist may help some patients get the dental treatment that they need.

- **Speed**

Dentists are able to perform laser treatments faster than traditional methods. This allows the dentist to see more patients in a day. Patients also spend less time in the dentist's chair with laser technology.

- **Bacterial Free Environment**

A laser is a photo-thermal device that produces a monochromatic, coherent, and collimated light with a specific wavelength. It does not have the specific lock-and-key chemical target. It acts directly on cellular structures, destroying cell walls, altering DNA, modifying metabolic processes, and ungluing the polysaccharide structure of the biofilm (33). Some have reported reduction of subgingival bacterial flora in vitro (34) Others have examined the in vivo bactericidal effect of certain lasers, which could significantly reduce the levels of some subgingival periodontal pathogens (35, 36). The chance for bacterial infections is lower because the laser sterilizes the area. High temperatures have profound effects on the structural and physiological properties of sporulating and non-sporulating bacteria, with membranes, RNA, DNA, ribosomes, protein and enzymes all affected.

- There is potentially a decreased need for sutures with soft tissue lasers.

- With some procedures, anesthesia is unnecessary.

- There is potentially a decreased need for sutures with soft tissue lasers.

- Fast healing

The procedures may involve less damage to the surrounding tissues. Wounds can heal faster, and it's possible for tissue to regenerate. Other factor for good healing with laser use is that procedures may involve less damage to the surrounding tissues.

5 | DISADVANTAGES OF DENTAL LASER –

• Cost

Laser dental procedures are expensive when compared to the cost of traditional treatment. The cost of the equipment to perform laser procedures requires dentists to pass this cost on to patients.

• Limited Use

A disadvantage of lasers is the limited use that they currently have in dentistry. The technology is still evolving and it is only a matter of time before lasers completely innovate the way that dentistry is performed.

6 | DENTAL LASERS & COVID-19

Before proceeding to the end of discussion on this review article of Dental LASERS : A Boon in Dentistry & its significance in Covid-19 we would like to tell about the recent significance of LASER in covid-19 .There is a full impact of the COVID-19 pandemic on the medical community. The guidelines for the dental community are evolving, but the considerations are clear – reducing the risk of virus and bacteria transmission between patients and staff is a top priority in COVID-19 environment.

Water spray is a significant factor in aerosolization and splatter in a dental practice, which can cause the spread of harmful viruses, such as the common cold and influenza viruses, herpes viruses, pathogenic streptococci and staphylococci etc.

Dental laser uses 74% less air pressure and 67-83% less water flow when compared to drills. So, the risk of aerosolization and splatter causing transmission of viruses, including COVID-19, is significantly lower with dental laser other than the drill. It is safer to use the Er:YAG Laser instead of using rotary tools like the high speed and low speed drills or electric drill. Dentist can perform some of these treatments using the Laser with only the cooling water system and without air-spray, reducing the risk of aerosol contamination (37)

Dental laser vaporizes tooth structure using thermal energy as opposed to the mechanical process of conventional drills. Viruses and bacteria are destroyed at temperatures above 60° C which means dental laser kills any virus or bacteria with which the beam comes in contact.

Dental laser allows dentists to treat without the need for local anesthetic. Dental lasers provides dental practices significant benefits for both hard and soft tissue procedures as compared to the traditional drill. This all-tissue dental laser significantly reduces aerosols and splatter through less water flow and air pressure. Laser kills viruses and bacteria wherever the beam comes in contact (38, 39), and thus, can reduce PPE usage and enable efficiencies to save time and money.

As practices begin opening their doors, Dental laser should be considered as a likely safer option than the drill for dentists and their patients.

7 | CONCLUSION

Dental lasers are now well established instruments. Ongoing research is showing the many benefits of laser therapy. A thorough understanding of laser physics and biological effects is mandatory for any provider. Comprehensive beginner and ongoing training is imperative to use these devices effectively and safely. In a COVID-19 emergency environment Laser, compared to the drill, significantly reduces aerosols and splash. Laser disinfects and does not spread scratch material from the oral cavity to the environment. Dental offices in which lasers are incorporated into treatment plans are considered and have a unique psychological and promotional advantage over those that do not offer such services. Laser use in dentistry has expanded and improved treatment options. The practitioner must receive proper training, maintain an adequate level of clinical experience, and proceed within the scope of the practice. The only difficulty in adopting dental lasers is its high cost. Otherwise, in overall dental lasers with the advancement of technology will going to be a boon in future decades or infact many dentists are adopting nowadays to laser assisted treatment plan. The

potential for laser to improve dental procedures rests in the dentist's ability to control power output and the duration of exposure on the tissue, allowing for treatment of a highly specific area of focus without damaging surrounding tissues.

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