Enlightening the Path of Dentistry: Lasers – A Brief Review

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Abstract
Lasers were brought into the field of clinical dentistry with the expectation of conquering a portion of the downsides postured by the customary strategies for dental practice. One of the primary objectives in dentistry is to give the treatment as agreeable as conceivable. The laser is being utilized as a part of various dental procedures including soft tissue surgeries, cavity preparation, caries removal, and caries detection. The utilization of current normal lasers in dentistry brought about less pressure and dread in patients amid dental techniques, likewise prompting more moderate noninvasive strategies for delicate and hard tissues with insignificant discomfort and bleeding. This article will briefly elaborate uses of laser in dentistry.

Keywords: Carbon dioxide laser, diode laser, low-level laser therapy, photodynamic therapy, yttrium aluminum garnet

Introduction
Field of dentistry is a dynamic field and the search for better materials, systems, and innovation is everlasting. Laser today has turned out to be a response to numerous such journeys. The use of laser in dental procedures popularized amid the 1960s.[1] From that point, forward its utilization has advanced quickly due to its numerous favorable circumstances in a wide assortment of dental methodology.[2,3] In the mid-1990s, the usage of lasers on the oral tissues was first asserted by the Food and Drug Administration (FDA) in the United States. Use of lasers on hard tissue such as teeth or the bone of the mandible picked up an endorsement in 1996.[4] Several variations of the dental laser are being used, with the most widely recognized being diode lasers, carbon dioxide lasers, and yttrium aluminum garnet (YAG) laser.[5] Different lasers utilize diverse wavelengths more qualified for various applications.

Types of laser
Dental lasers are named depending on the dynamic medium that is empowered. The medium can be a liquid (colors) or a gas (e.g., argon and carbon dioxide), a solid-state crystal rod, for example, neodymium: YAG (Nd:YAG), erbium:YAG (Er:YAG) or a semiconductor (diode lasers).[6]

Laser production
The expression “laser” began as an acronym for “light amplification by stimulated emission of radiation.”[1] The energy of an electron orbiting a nuclear core is higher for orbits further from the nucleus. Therefore, electrons are found in at particular energy level when in their normal state. At the point of time, light (photons) or heat (phonons), energy can cause activation of this electron so that the atom is no longer in the normal state rather is in an excited state. However, since the lower the energy greater is the stability of the atom to attain such stability excited atom tend to return to its normal state. In the process of attainment of maximum stability, it undergoes spontaneous decay and emits a quantum of energy. This is known as spontaneous emission.[7] However, when it decays in the presence of an electromagnetic field, it is called as stimulated emission.

The photosensitizer initially absorbs a photon that excites it to the sparsely activated singlet state. Such an activated photosensitizer can either lose energy by florescence or by intersystem crossing to a longlasting PS state or by internal conversion to heat. This triplet PS can interact with molecular oxygen in two pathways, Type 1 and Type 2, leading to the formation of reactive oxygen species and singlet oxygen (1O2), respectively [Figure 1].[8]
MECHANISM OF ACTION

The use of phototherapy has found its way to a number of dental applications. The use of phototherapy can be further divided into a low-level laser therapy and a photodynamic therapy. Where on one hand low-level laser therapy utilizes red or near-infra red light alone a photodynamic therapy uses a photosensitizing drug. Such a drug is activated by a light source and result in an activated oxygen molecule that can destroy nearby cells including bacteria, fungi, and viruses, while a low-level laser therapy (LLLT) is used to reduce pain, inflammation, and stimulate tissue repair and regeneration.

The recent advancement in the field of nanotechnology cumulated with medicine has opened doors for the development of monoscale drug delivery system for effective killing of pathological cells and further promotes tissue healing and repair.

Phototherapy is also termed as photobiomodulation. A lot of research has been done on this. It was found that photobiomodulation affects the mitochondria of the cell, essentially cytochrome c oxidase in the electron exchange chain, and porphyrins on the cell membrane. The effects of photobiomodulation are not only from primary irradiation of tissues but also from the secondary and tertiary interaction.

CLINICAL APPLICATIONS

Caries detection

The laser of wavelength 655 nm is used as caries detection agent. Laser using fluorescence from the surface of tooth shows the amount of degree of demineralization of the teeth and the amount of tooth decay. One such tool is DIAGNOdent. DIAGNOdent is uniquely profitable for kids since it has a nonalarming appearance and has the limit of monotonous examinations. It’s even conceivable to disclose the tool to the youngster and let him handle the device, to make him or her more agreeable. It also can detect caries at an early stage when it does not even appear on radiographs.

Cavity preparation

The FDA gave it an endorsement for the use of Er: YAG laser in the removal of caries and cavity preparation in 1997. With the irradiation of tooth structure with this laser evaporates the water present in enamel and dentin which incites the hazardous dislodging of the decayed structure. Clinically, the detachment of little parts of dental tissue with the activity of laser, and changes in pneumatic force around incite a popping sound. This sound is more in dental tissue with more water. This peculiarity helps the dental practitioner to specifically expel carious tissues rather than healthy ones. In contrast with wavelengths close infrared, the impact of Erbium laser brings about least amount of heat dispersion through dental tissues. The utilization of water spray as an adjunct to this laser helps in easy removal of the particle after tissue separation and provides a cooler environment for the target tissue.

Photodynamic therapy for endodontic disinfection

On account of endodontic failure, retreatment, or extraction is typically done with the utilization of anti-infection agents as adjunctive treatments; however, the long haul utilization of these agents can develop resistance in the target organism. With the overuse of such antimicrobial agents and development of drug-resistant microbes, there is a need for alternative antimicrobial therapy. The blend of regular endodontic treatment and photodynamic treatment (PDT) has been appeared as a compelling methodology in lessening bacterial load in vitro and in vivo models

Gram-negative bacteria are less susceptible to photoinactivation compared with Gram-positive species; however, photosensitizer bearing a cationic charge can increase their killing. A wide range of oral bacteria could be killed by red light after sensitization with the cationic PS toluidine blue and methylene blue (MB). Numerous investigations have demonstrated that PDT offers a productive method for annihilating microbes staying inside the root canal framework subsequent to utilizing ordinary endodontic chemomechanical therapy.

Peri-implantitis

Peri-implantitis can be defined as a condition involving the soft tissue surrounding the dental implant. The condition may range from bleeding, suppuration, and inflammation of soft tissue to the prominent amount of progressive bone loss. The primary treatment goal must be to clean and disinfect the implant surface to render it biocompatible, thus permitting healing of the inflammatory lesion and even re-osseointegration.

A significant reduction in the quantity of feasible Porphyromonas gingivalis (P.g.) was seen in the oral cavities of male Sprague Dawley with the utilization of toluidine blue-mediated photosensitization. Dörzbudak et al. treated with photodynamic therapy contaminated implant surfaces in 15 patients and evaluated the remaining levels of Aggregatibacter actinomycetemcomitans (A.a.), P.g. and Prevotella intermedia. Significant decreases in all bacterial species were observed compared to baseline levels.

The researches show that the use of antimicrobial photodynamic therapy can effectively reduce the prevalence of pathogens on implant surfaces without causing any deleterious defects on
the implant and bone surfaces. However, studies on patients are limited and clinically critical impacts of antimicrobial photodynamic therapy have not yet been established.

**Chronic periodontitis**

Chronic Periodontitis can be defined as an inflammatory condition that consist of loss of clinical attachment, alveolar bone loss, and periodontal pocket formation, is caused by mixed infections with the subgingival microbiota being organized as a biofilm.[40] Hence, the major goal of periodontal treatment is the removal of bacterial deposits and calculus from the root surfaces of affected teeth. The use of PDT offers various advantageous characteristics such as bleeding control, selective calculus ablation, as well as bactericidal and detoxification effects against periodontopathic pathogens.[41-43]

PDT along with the use of chlorine e6 has shown a critical diminishment in P.g. infected areas.[44] Among the diverse kinds of lasers tried, the erbium-doped: yttrium-aluminum garnet (Er:YAG) laser has all the earmarks of being a standout among the most encouraging for use with periodontal treatment. Many researchers have reported significant reductions in calculus and periodontopathogenic flora with the Er:YAG laser.[45-47]

Therefore, using PDT as monotherapy is not prudent, whereas its use as an adjunct to conventional mechanical SRP is supported by many studies.

**Mucocutaneous oropharyngeal candidiasis**

In HIV-contaminated people, mucocutaneous oropharyngeal candidiasis is a typical finding and is assessed that right around 84% of HIV-infected individual demonstrates the indications of this condition. Most often, the organism isolated from these patients is Candida albicans. Almost 40% of the healthy adult population is known to be a carrier, and most cases of candidiasis are endogenously procured. Methylene blue (MB)-mediated PDT was used to treat oral candidiasis in an immunosuppressed mouse model. A volume of 0.5 ml of MB solution in a concentration ranging from 250 to 500 ug/ml was administered topically in the oral cavity of the mice. Previous to this mice were cultured for baseline fungal growth. The mice were recultured after 10 min and underwent light activation with 664-nm diode laser. A complete eradication was observed when 450–500 ug/ml was used in conjunction with photodynamic therapy.[48]

**Osteomyelitis**

Bisland et al.[49] examined PDT as a conceivable treatment for osteomyelitis utilizing a bioluminescent strain of biofilm-producing Staphylococcus aureus grown onto Kirschner wires (K-wire). S. aureus-covered K-wires were presented with MB or 5-aminolevulinic acid-mediated PDT either in vitro or following implant into the tibial medullary cavity of Sprague Dawley rats. The progression of S. aureus biofilm was observed nonintrusively utilizing bioluminescence and communicated as a percentage of the signal for each sample instantly before treatment. S. aureus diseases were liable to PDT 10 days postimmunization. The result showed a significant delay in bacterial growth and inhibited biofilm formation on implants in bone.

**Disinfection of carious tissue**

In the past, dentistry was concerned about the load of bacteria that remained after cavity preparation, to avoid secondary caries development. The recommendation was to remove all carious dentine. However, subsequent research has shown that the influence of microorganisms on the development of secondary caries under these circumstances is not such an important determining factor.[50]

Nevertheless, the infected dentine, which is infected and incapable of mineralization should be removed to prevent pulp inflammation and potential pulp exposure in deep cavities. In addition to this, the presence of infected dentine decreases the adhesion proprieties of the restorative materials, reducing the retention of sealing material.[51,52] Therefore, the use of PDT reduces the number of microorganisms and subsequently reduces the chance of pulp inflammation, as well as reduces the potential loss of the restorative sealant.

Studies have found a significant mean reduction (82%) of total cariogenic bacteria in dentin carious lesions after PDT protocol mediated by phthalocyanine entrapped in cationic liposomes.[53,54] Therefore, PDT may be considered a suitable adjuvant technique to decrease cavity contamination before restorative procedures.

**Dentine hypersensitivity**

Dentine hypersensitivity, a short, sharp pain arising from exposed dentine in response to stimuli that cannot be ascribed to any other form of dental defect or pathology, is a common presentation in the dental office. The plethora of products and techniques are available for its treatment which may indicate that no single treatment is effective, and currently, there is no evidence demonstrating the superiority of any one desensitizing agent.

One of the first uses of laser for this purpose has been documented by Grossman (1935). Since then, the use of laser has come a long way with increasing predictability of treatment outcome.

Both low-level and high-level lasers are used for treating dentine hypersensitivity. LLLT includes the use of helium-neon lasers and diode lasers which are usually variants of gallium aluminum arsenide. High-level laser therapy includes Nd:YAG lasers, Er:YAG lasers, and CO2 lasers. A very commonly used laser is a CO2 laser. Its effect is based on the closure or narrowing of the dentinal tubules and a reduction in dentine permeability. Most effects are explained by laser dehydration, protein destruction, and carbonate evaporation.[55]

A novel technique to treat hypersensitivity is the combined use of laser light and bioactive glass (bioglass) paste. The application of hydroxyapatite, and the principal inorganic constituent of the tooth, also promises rapid relief from clinical pain by complete obliteration of dentinal tubules in
hypersensitive teeth. Bioglass and glass-ceramics resemble human dentinal hard tissue to a large extent and are characterized by high biocompatibility. Melting the bioglass paste and its resolidification promise a homogeneous blockage of dentinal tubules and deep precipitates in the dentinal tubules, offering a prolonged therapeutic duration.\[57,58\]

**Attenuation of gag reflex**

Nausea is typically said to be related with the p6 acupunctural point. At a separation of 1 inch from the wrist, wrinkle underside of the wrist is the actual location for a p6 point. In attenuation of gag reflex, the application of 4j energy has proven to be very successful. In patient facing a problem during radiograph film placement, rubber dam placement or during impression making it is found to be the most beneficial.\[59,60\]

**Treatment for surgical operations and injuries**

Patients undergoing a surgical procedure advantages from laser therapy of the concerned area preceding medical procedure. This strategy brings about a diminishment of postsurgical medical pain and inflammation. The impact of the laser on wound healing is mainly because of its interaction with cell components and cell membrane. Laser therapy on delicate soft tissue brings about a reduction in the amount of inflammation and pain and to aide further stimulates the immune system.\[61\]

**Temporomandibular joint and facial pain**

PBM (photobiomodulation) is an incredible device in the treatment of temporomandibular joint (TMJ) disorders or in facial pain. From straightforward and intense cases like a facial pain to incessant TMJ cases, laser treatment will help curtail pain and inflammation. In numerous TMJ cases, a blend of lasers and bunches of light-emitting diodes are the best for treatment. A recent report showed that laser treatment mellowed excessively tense and hard muscles by augmenting circulation and evacuating harmful deposits related to hypertension of the tissue. The author hypothesized that the enhancement of microcirculatory flow and volume results in the relaxation of muscle and further normalize the intramuscular pressure in sensory nerve ending.\[62\]

**Neuropathic pain**

PBM now allows numerous patients to carry on with an existence free from neurogenic facial pain. A recent report examining the utilization of PBM in the treatment of trigeminal neuralgia found that patients who got laser therapy had an extensively diminished utilization of analgesics and ought to be considered as an option and additionally supplementary treatment to customary treatment methods.\[63\]

Trismus and facial swelling following careful extraction of the third molar was found to be significantly less in the group that received laser therapy.\[64\]

The impact of laser therapy on e-filaments, osteoblasts, endorphins levels, and odontoblasts make PBM a great instrument in restorative dentistry.\[64-67\]

**Frenectomy**

A frenum can be defined as a fold of mucous membrane that appsends the check and the lips to the alveolar mucosa, the gingiva, and the underlying periosteum. Sometimes, abnormality in this frenum may lead various problems such as midline diastema, trauma, and poor oral hygiene. This leads to the surgical removal of the frenum which is known as Frenectomy. The laser is one surgical tool that provides a bloodless field, clear and simple technique, no need of suture, and with the excellent postsurgical healing of the tissue. Erbium laser is mostly used with simultaneous water spray. 30–40 Hz of frequencies is commonly used.\[68-70\]

**Ankyloglossia**

It is all the more regularly known as tongue tie and is an intrinsic variation from the norm seen in children’s with the diminished versatility of tongue. It is essentially caused by a thick, unusually short lingual frenum that associates the tongue with the floor of the mouth. Laser treatment is the treatment of choice in such circumstances as it allows the medical procedure to be done without utilization of anesthesia or tranquilizers. While performing such laser therapy, dental specialist and patients eyes should be protected with suitable eyewares.\[71\]

**Gingival remodeling and gingivectomy**

Laser therapy also has proven a history of success as a most appropriate line of treatment in a condition requiring gingival recontouring or gingivectomy. An erbium laser with frequency 20–30 Hz and energy ranging from 55 to 80 mj can be used without the utilization of water spray.\[72\]

**Conclusion**

Development of rapid, painless, andatraumatic dental treatments is a trend in modern dentistry. Eradication of bacterial pathogens with a noninvasive method is an important issue for oral care and therapeutics. For this purpose, new techniques are evolving every day. The laser has been adopted in dentistry as a solution to many challenges that it faces today. Use of lasers is rapidly becoming popular in the form of PDT which uses high-level laser and as photobiomodulation that uses an LLLT.

Although first utilized as a part of the mid 1900s, PDT in the cutting edge sense is a genuinely new, advancing science. Future of dentistry can see extensive use of PDT because of its distinct advantages over conventional methods like better patient acceptance, especially in pediatric dentistry, targeted approach, atraumatic removal of unwanted cells or tissues, its distinct capacity for repair and regeneration, especially when combined with nanotechnology. Recently, medical treatment with LLLT at various intensities has been found to stimulate or to inhibit an assortment of cellular processes. The biomedical applications of LLLT are tremendously diverse. It is only in relatively recent years that the basic molecular and cellular mechanisms of LLLT have begun to be understood. The realization that LLLT seems to have preferential action
on various types of stem cells causing them to proliferate, migrate, and differentiate adds to many of its beneficial effects. As LLLT grows in acceptance in the future, it is likely that more and more serious diseases will become amenable to phototherapy approaches.

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**Conflicts of interest**

There are no conflicts of interest.

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